

**Stroke Drivers'  
Screening Assessment**

**USA Version**

**Revised Manual**

**2011**

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## **Introduction**

The Stroke Drivers Screening Assessment (SDSA) was developed as part of a research programme on driving skills after stroke (Nouri 1991). In the development, stroke patients who wished to resume driving were given a battery of cognitive tests and tested on the road by a professional driving instructor. Discriminant function analysis was used to identify those tests that best predicted driving performance on the road (Nouri, Tinson & Lincoln 1987, Nouri and Lincoln 1992). These tests were compiled together as the Stroke Drivers Screening Assessment (SDSA). The predictive value of the SDSA was compared with existing assessment procedures. The SDSA was significantly better than routine assessments, involving advice from general practitioners and the DVLA, at identifying those who were found to be unsafe to drive on the road (Nouri & Lincoln 1993).

The SDSA was designed to be used as a screening tool for identifying cognitive problems, which may affect a person's safety to drive. The SDSA is usually administered to stroke patients who wish to resume driving at a time when they are considered to have recovered to a point when they could be assessed on the road. This is usually between 1 and 6 months after stroke. Patients who have hemianopia, visual neglect, poor acuity, epilepsy or other conditions, which preclude driving, were excluded from the original validation studies and therefore assessment on the SDSA is not appropriate for them. The validation was only conducted on stroke patients who had previously been driving and who were assessed on the road in a car. There is no information available to indicate whether the SDSA can be used to predict ability to drive other vehicles or to learn to drive.

## **Test Administration**

The tests are administered in a quiet room with the client seated at a table. Tests are administered in the order given and if possible should all be administered in a single session. In the validation studies the SDSA

was always administered in one session. However if the test has to be administered over two sessions, for reasons other than fatigue or poor concentration, the results are still likely to be valid. If the patient requires two sessions because of fatigue or poor concentration, their driving will probably also be affected by these factors. It would not be sensible to give patients with fatigue and concentration problems rests between SDSA tasks, as this would artificially raise their level of performance and not reflect the fatigue and concentration difficulties.

No feedback about performance is given until the end of the session. People are encouraged to persevere by giving non-specific feedback, such as 'that's fine'. The testing session can be introduced with an explanation that the tasks have been found to indicate whether people who have had a stroke are likely to encounter problems when driving. Also used is:

*"Some people have problems with concentration, reasoning and their interpretation of the things they see after a stroke. These may affect their ability to drive a car. Some of the tasks will be easy and some more difficult. We wish to identify whether you have any problems as a result of your stroke, which affect your ability to drive a car."*

For each test standard instructions are provided. These may be repeated once if the client seems not to understand or has difficulty remembering what he/she is required to do. No additional information may be given. If the client asks for further instructions a phrase such as *"I am not able to give you any more information"* or *"Do what you think is right"* should be used. The instructions were intentionally kept short so that minimal language comprehension would be required. In all the validation studies the instructions used have been those provided in the manual. Any deviation from these may affect the scores obtained and therefore the predictive validity of the test. Gestures are used to supplement the verbal instructions. These are intended to help those with communication problems, but should be used for all clients.

## **Dot Cancellation**

### **Equipment**

Photocopy of Dot cancellation master, pen, stopwatch, scoring template. A felt pen is easy for clients to use and easier to mark than a pencil or biro.

### **Method**

Place the photocopied dot cancellation sheet on the table centrally in front of the client. Explain the test as follows:

*"You will see that there are groups of dots arranged in rows. Some of the groups have 3 dots, some 4 and some 5 dots (indicate examples on the practice row). I want you to cross out every group of 4 dots."*

*"I want you to complete the first row as a practice."*

If the client is unsure what to do cross out the first set of 4 dots as an example and then ask the client to continue with the practice row. Check the practice row. If the client makes any errors point them out, by saying for example *"you have missed a set of 4 dots here"* or *"you have crossed out a group of 3 dots but the task is to cross out all the groups of 4 dots"*.

Then say

*"The task is timed but it is more important to be accurate than fast. Start when you are ready"*.

Start the stopwatch as soon as the client starts to attempt the task.

If the client seems to have forgotten the instructions or requests a repetition, the instructions can be repeated once using the same wording as given at the beginning of the task. After that no further explanation should be given.

### **Time Limit**

15 minutes.

If the client has not completed the task after 15 minutes has elapsed, indicate that the task is complete by a phrase such as

*"That's fine, you have done enough now and can stop".*

If the client continues beyond the time limit, despite being asked to stop working, note the point reached at the time limit and mark on the score sheet afterwards. However it is reasonable to allow a client to finish the task if very close to the end but to record the point reached at the 15-minute time limit and score as if the client had been stopped at that point.

It may be necessary to stop the paper slipping while the client is writing. A sheet of 'Dycem' can be used. Also for those using their non-dominant hand for writing a wide pen or a sponge cuff on the pen may be helpful.

## **Score**

Record the following on the Summary Score Sheet:

- The time taken to complete the task (except the practice row) in seconds. If the client did not complete the task in the time limit, the time taken is recorded as 900 seconds.
- The number of groups of 4 dots not crossed out (errors). This can be simplified by preparing a marking template, using the master marking sheet photocopied onto an overhead projector acetate sheet. This score is not included in the predictive equation.
- The number of groups of 3 and 5 dots cancelled in error (false positives).

An item is scored if a pencil/pen mark goes through some point of the group of dots. So for example if the client just marks one dot in a group of 4, this would count as having crossed out the group. Similarly if a client

scribbles across the pages, all those groups crossed through by chance would count in the score even though the client was not performing the task of crossing out groups of dots.

## **Square Matrices Directions**

### **Equipment**

Matrix Board, Lorry/car cards, stopwatch.

### **Method**

Position the arrow cards on the Matrix Board as shown below. Place the pile of car/lorry cards at the bottom of the grid with the example card on the top of the pile. The cards under the example card are shuffled between assessments so that they are in random order.

Explain the test as follows.

*"The large arrows correspond to the lorries and the small arrows to the cars. Each arrow indicates a direction of travel."* (Demonstrate right, left, upwards as away and downwards as towards). Arrows facing 'north' indicate the vehicle is travelling away from the client, arrows facing 'south' indicate the vehicle is travelling towards the client.

*"I want you to position these cards (indicate the car/lorry cards) so that each car is travelling in the direction indicated by the small arrow and each lorry in the direction indicated by the large arrow. I will do the first one as an example"*

Position the card marked example to demonstrate the task. Then indicate to the client to start and begin timing. Score the responses when the client indicates he/she has finished. If the client seems to have forgotten the instructions or requests a repetition the instructions can be repeated once using the same wording as given at the beginning of the task. After that no further explanation should be given.

### **Time Limit**

5 minutes.

If the client has not completed the task after 5 minutes have elapsed, stop the client using a phrase such as "*That's fine, you have done enough now and can stop*".

If the client continues beyond the time limit, despite being asked to stop working, note the score obtained at the time limit.

### **Score**

1 point for each correctly positioned car. 1 point for each correctly positioned lorry. The score includes the practice item, so the maximum possible score is 32.

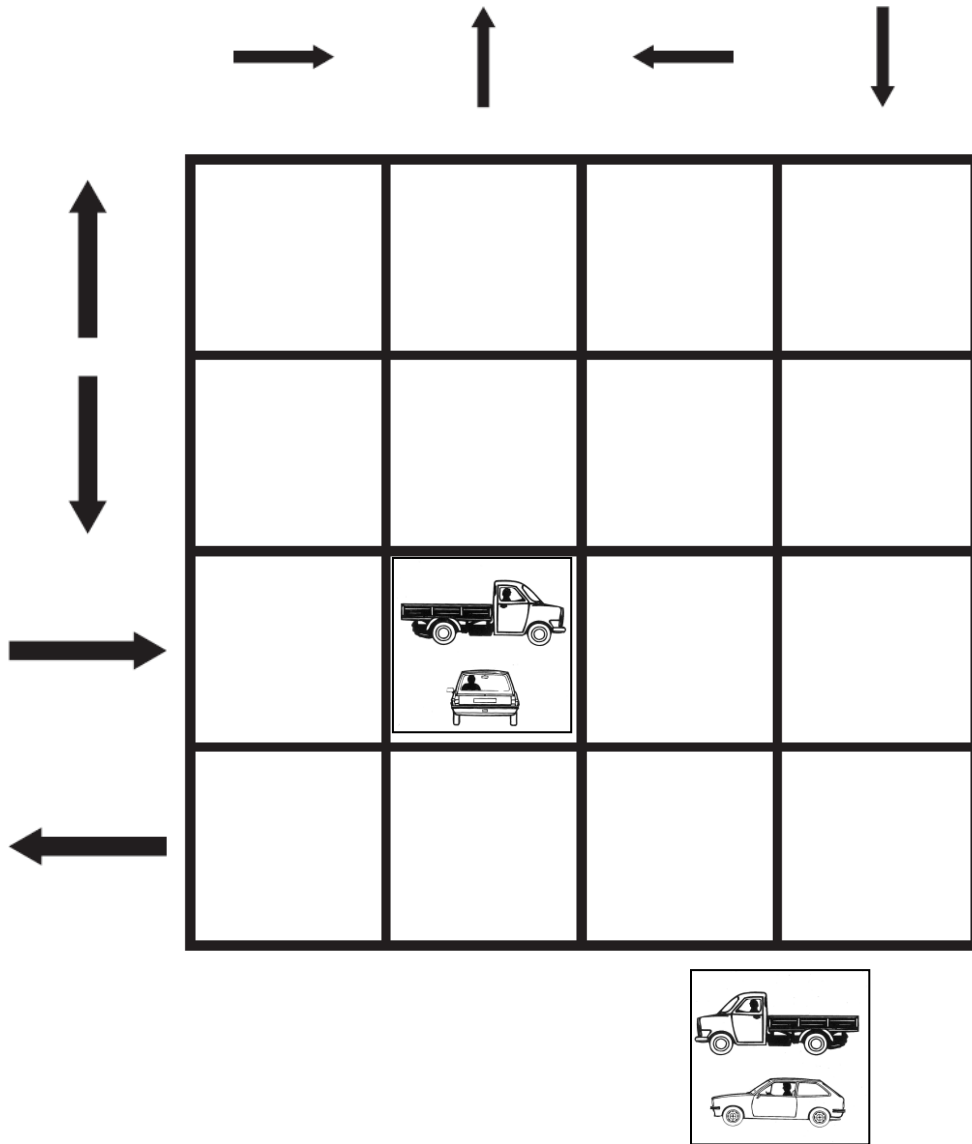
The easiest way to score the task is to score all the lorries first then all the cars. If the cards are piled on top of each other all cards in the pile are scored.

Record the score on the Summary Score Sheet.

This score is not included in the predictive equation.



Fig 1 Square Matrices Directions Layout



## Square Matrices Compass

### Equipment

Matrix Board, Roundabout cards, Stopwatch.

### Method

Position the compass cards on the Matrix Board as indicated in Fig 2.

Shuffle the roundabout cards into a random order. Ensure the first three cards are cards which will fit on the grid, and arrange on the top of the pile, with the example card on top of them. The roundabout sign should be at the bottom on all cards.

Explain the test as follows:

*"This time the black arm of the compass indicates a direction of travel"*

Demonstrate the directions by pointing to each card and indicating the direction it shows

.

*"Can you now, as you did before, position these cards on the grid, so that each of the vehicles on these cards (point to the pile of Directions cards) goes in the direction indicated on the compass cards? (Point to the Compass cards). The roundabout sign (Point to the roundabout sign) is always at the bottom. There are more cards than available spaces, so some of the cards will not fit in. I will do the first one as an example."*

Position the card marked 'example' on the reverse to demonstrate the task. This should involve pointing to each vehicle and the corresponding Compass card in turn. Then indicate to the client to start and begin timing.

If the client seems to have forgotten the instructions or requests a repetition, the instructions can be repeated once using the same wording as given at the beginning of the task. After that no further explanation should be given.

Score the responses when the client indicates he/she has finished.

### **Time Limit**

5 minutes.

If the client has not completed the task after 5 minutes have elapsed, stop the client using a phrase such as "*That's fine, you have done enough now and can stop*".

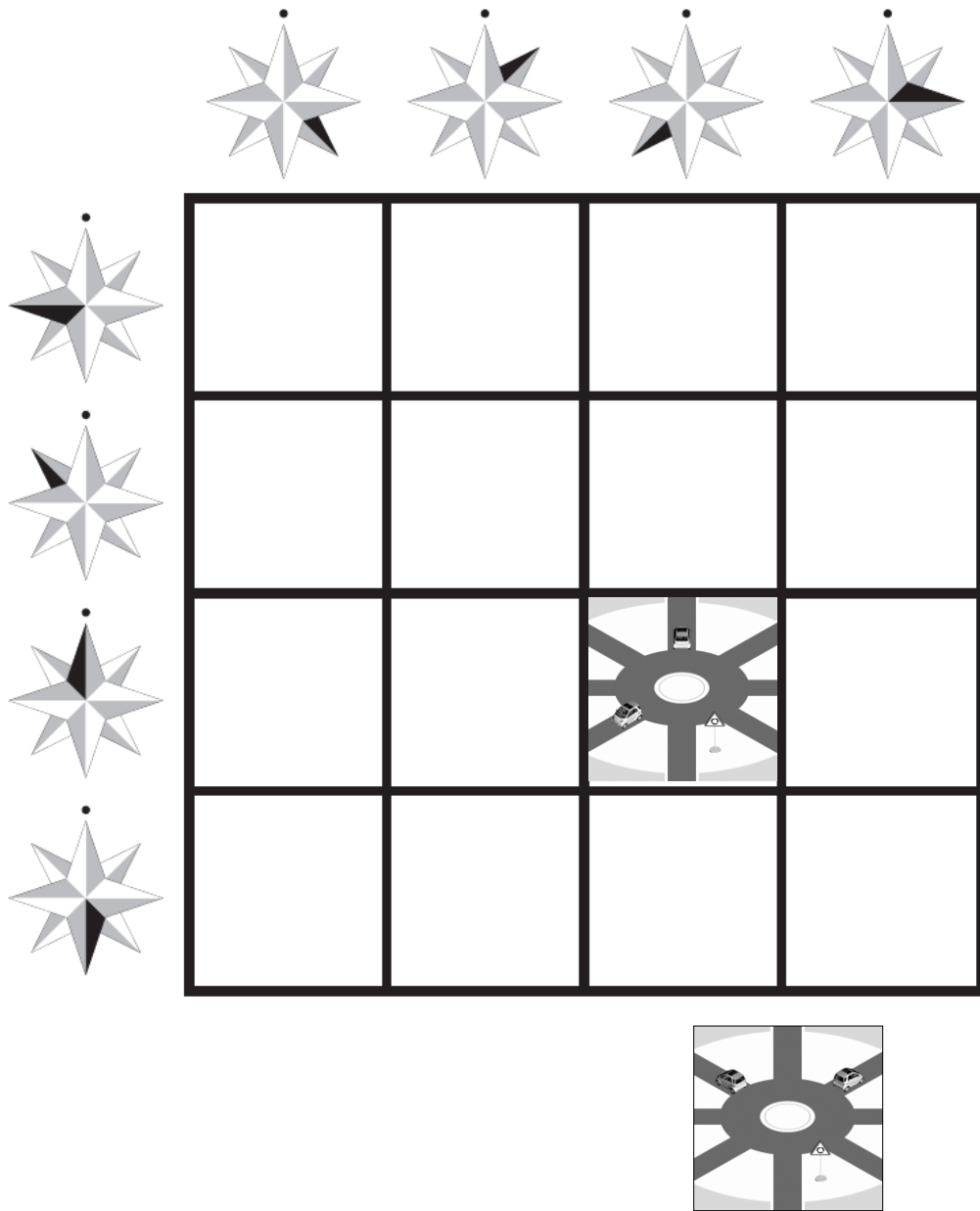
If the client continues beyond the time limit, despite being asked to stop working, note the score obtained at the time limit.

### **Score**

1 point for each vehicle correctly placed i.e. a maximum of 2 points per card. This includes the demonstration item, so the maximum possible score is 32 points. It is easiest to score by counting one vehicle for each row and then one vehicle for each column separately.

Record the score on the Summary Score Sheet.

Fig 2 Square Matrices Compass Layout



## Road Sign Recognition

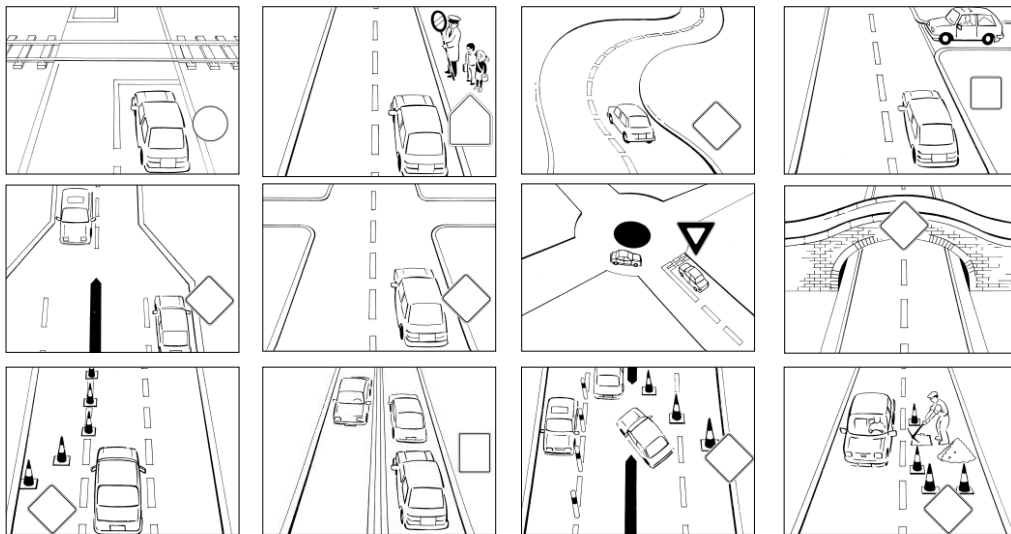
### Equipment

Road situation cards, Road sign cards, stopwatch.

### Method

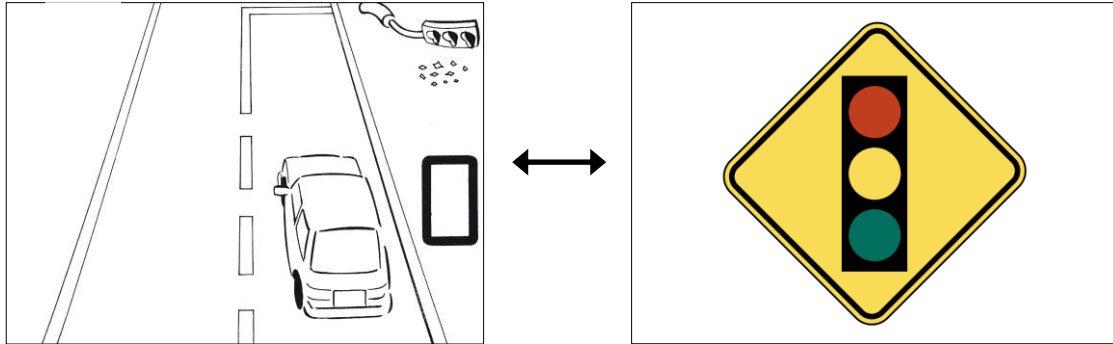
Place the 12 road situation cards in a four by three grid in front of the client as shown in Fig 3. Place the practice road situation (broken traffic lights) card to one side of the four by three grid. The order of presentation of the road sign recognition cards was not standardised in the original validation and therefore has not been specified. Spread the road signs below the road situations.

Fig 3 Road Sign Recognition Layout



Explain the test as follows:

*"I would like you to put each road sign on the picture of the road situation which it matches best. This card shows a broken traffic light (point to the example road situation card). The sign which best matches this situation is the one indicating a traffic light out of action (pick out the broken traffic light road sign). So this sign (broken traffic light) goes with this picture. (Place the broken traffic light road sign on the example card and move to one side). Now you do the rest."* Put the example card with the example sign on top of it to one side.



Begin timing. Score the responses when the client indicates he/she has finished.

If the client seems to have forgotten the instructions or requests a repetition, the instructions can be repeated once using the same wording as given at the beginning of the task. After that no further explanation should be given.

### **Time limit**

3 minutes

If the client has not completed the task after 3 minutes have elapsed, stop the client using a phrase such as *"That's fine, you have done enough now and can stop"*.

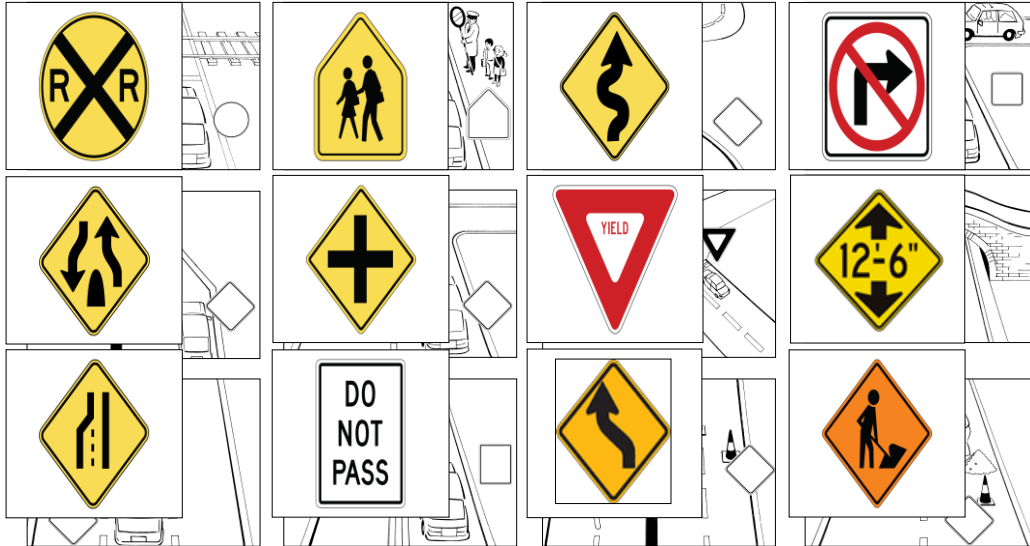
If the client continues beyond the time limit, despite being asked to stop working, note the score obtained at the time limit.

### **Score**

One point for each sign correctly matched. The example is not included in the score. If the client puts several cards in a pile, score only the top card on the pile. Maximum score 12 points.

The correct answers are:

Fig 4. Road Sign Recognition Test Correct Signs



Transfer the score to the Summary Score Sheet

## Scoring and Interpretation

The scores obtained are inserted on the Summary Score Sheet.

Multiply the scores in the predictive equation by the coefficients given on the Summary Score Sheet. Add these together and then subtract the constant. This is performed separately for the 'Pass' equation and the 'Fail' equation.

Pass equation:

$$(\text{Dot cancellation time} \times 0.012) + (\text{Dot cancellation false positives} \times 0.216) + (\text{Square Matrices Compass} \times 0.409) + (\text{Road Sign Recognition} \times 1.168) - 13.79 =$$

Fail equation:

$$(\text{Dot cancellation time} \times 0.017) + (\text{Dot cancellation false positives} \times 0.035) + (\text{Square Matrices Compass} \times 0.185) + (\text{Road Sign Recognition} \times 0.813) - 10.042 =$$

An Excel spreadsheet is provided to calculate the equation scores at [http://www.nottingham.ac.uk/iwho/research/published\\_tests.php](http://www.nottingham.ac.uk/iwho/research/published_tests.php)

The higher value indicates the recommended decision. If the client has a higher value for the pass equation this indicates the client's cognitive abilities are such that driving is feasible, but physical and medical aspects will need to be checked by a medical practitioner or through a specialist disabled driving centre.

If the client has a higher value for the fail equation then he/she should be advised not to drive. These recommendations have been found to be about 80% accurate. Therefore it may be necessary to take into account other aspects of performance, including the scores on individual tests.

The performance on the individual tests may be compared with scores given in Table 1 for stroke patients who were assessed in the original



validation studies (Nouri, Tinson & Lincoln, 1987; Nouri & Lincoln, 1992). Stroke patients were graded as pass, borderline and fail on a road test. The scores on the individual tests of the SDSA were compared between these groups. If an individual's score is within one standard deviation of the mean of the fail group, then the scores suggest impairment on this test. So for example if a client scores more than 80 errors ( $46.3 + 33.6 = 79.9$  errors) then it is likely that the client has impaired ability on the Dot cancellation errors. It should be noted that there is substantial overlap between the distribution of scores of the Pass and Fail groups on the individual tests and therefore conclusions should not be based on the individual tests on their own.

The Dot Cancellation errors and Square Matrices Directions are not included in the predictive equation, as they did not improve the prediction provided by the remaining SDSA tests. However, comparison of these scores with the criterion groups in Table 1 provides additional information, which may aid the interpretation of why a client has failed the assessment. The Square Matrices Directions was also retained as it provides a practice for the Square Matrices Compass task.

**Table 1. Comparison between Test Scores according to Driving Grades**

Tests	Driving Grades							
	Pass n=34		Borderline n=12		Fail n=33		Comparison	
	Mean	SD	Mean	SD	Mean	SD	F ratio+	p
Dot								
cancellation	518.3	152.1	567.3	129.2	733.7	268.8	9.45	***
- Time (secs)	18.9	18.4	20.0	19.7	46.3	33.6	6.34	**
- Errors	1.2	4.5	0.1	0.3	3.3	9.1	1.45	NS
- False positives								
Square								
Matrices	28.6	7.7	23.8	12.3	23.9	9.8	2.37	NS
- Directions	22.8	8.3	15.7	9.3	10.6	4.5	24.35	***
- Compass								
Road Sign Recognition	8.2	2.4	5.5	2.5	2.4	2.4	16.84	***

SD Standard Deviation    NS not significant  $p > 0.05$     \*\* significant  $p < 0.01$   
 \*\*\* significant  $p < 0.001$     + degrees of freedom 2,39

The SDSA has been administered to 27 healthy elderly people, aged 61-82 (mean 68.9 SD 6.0) years who were all found safe to drive on the road. The distribution of their scores is shown in Table 2.

**Table 2 Scores of Healthy Elderly People**

Tests	Healthy Elderly n= 27		
	Mean	SD	Range
Dot cancellation			
- Time (secs)	518.3	152.1	278-779
- Errors	18.9	18.4	1-41
- False positives	1.2	4.5	0-3
Square Matrices			
- Directions	28.6	7.7	19-32
- Compass	22.8	8.3	12-32
Road Sign Recognition	8.2	2.4	2-12

In the original research to develop the SDSA the tasks were chosen because of their predictive validity, content validity was not checked. However, the Dot cancellation task is primarily a measure of attention. It assesses sustained attention (concentration), selective attention and lateralised attention (unilateral inattention). Radford et al. (2002) evaluated the content validity of the Square Matrices and Road Sign Recognition tests and suggested that they are both probably measures of attention, non-verbal reasoning and spatial abilities. However, further studies of the content validity are needed.

The purpose of the SDSA was to screen patients prior to referral to a specialist driving assessment centre. Those who passed the test were then advised they had the cognitive skills needed for driving and might be referred for assessment of physical abilities in relation to driving. Those who failed the SDSA were advised they were not safe to drive. They were reassessed 3-4 months later if it seemed likely that recovery of their cognitive impairments could have occurred. The SDSA is a screening assessment and should be used in conjunction with clinical judgement. It is not intended to provide a decision on safety to drive but to provide a

recommendation for further action. In most cases the information is passed on to a general practitioner or stroke physician to inform their recommendation to the driving authorities. However, it is important to note that the validation of the SDSA is far more rigorous than for most other assessment methods used in clinical practice to determine safety to drive.

## **Retest**

If a stroke patient fails the Stroke Drivers Screening Assessment and it is likely that the patient's cognitive abilities will change, then the patient may be reassessed on the SDSA. The test retest validity was checked over a six-week interval (Lincoln & Fanthome, 1994) and found to be acceptable. However there is some practice effect. It is therefore not recommended to retest a person on the SDSA after less than 6 weeks has elapsed. In practice the usual retest period used is about 3-4 months. Improvements that may be attributed to practice are shown in Table 2. If a client has improved more than the amount indicated in Table 3 column +/- 1 SD then it is likely that improvement has occurred. If they have improved more than the amount indicated in column +/- 2 SD then it is very likely that significant improvement has occurred. For example a reduction in the time on Dot Cancellation by greater than 214 seconds suggests improvement has occurred. If the time is more than 358 seconds shorter then it is very likely that improvement has occurred. If the pass equation is also greater than the fail equation, then the client may be considered to have cognitive abilities in the range of those found fit to drive.

**Table 3 Change Expected on Repeat Assessment**

Test	Range of Changes +/- 1 SD	Range of Changes +/- 2 SD
Dot cancellation		
- Time (secs)	-214 to +74	-358 to + 218
- Errors	-8 to +19	-32 to +22
- False positives	-2 to +2	-3 to +2
Square Matrices		
- Directions	-5 to +9	-13 to +16
- Compass	-6 to +5	-11 to +11
Road Sign Recognition	-1 to +2	-2 to +5
Overall Discrepancy Pass - Fail	-1 to +2	-3 to +3

## **Other neurological conditions**

The development of the SDSA was based on results from 79 stroke patients referred for assessment of their fitness to drive. Any patients who would not have been allowed to drive for reasons other than the stroke, such as epilepsy, inability to read a number plate at 20.5 metres, hemianopia or severe visual neglect were excluded. It is therefore not appropriate to use the SDSA on people who would be excluded from driving for these reasons. The original research was on stroke patients and therefore the predictive equation only applies to people who have had a stroke. The average age of the sample was 61 years. Therefore the results for very young e.g. under 18 years or very elderly e.g. over 80 years, stroke patients may be less accurate.

Studies have been conducted using the SDSA with patients with other neurological conditions (Radford, 2000; Radford, Lincoln & Murray–Leslie, 2004; Lincoln & Radford, 2008). The equation developed for stroke patients is not accurate for those with other neurological conditions. Other equations have been developed for people with traumatic brain injury, multiple sclerosis and dementia, but require the administration of additional cognitive tests and not just the SDSA. These are shown below. However it should be noted that apart from the equation for people with dementia, these equations have been developed on a single sample and not independently verified.

### **Traumatic Brain Injury Radford et al. (2004)**

PASS = (SDSA Dot cancellation time x 0.095) + (SDSA Dot cancellation errors x 0.148) + (SDSA Directions x 0.162) + (SDSA Compass x 0.224) + (SDSA Road Sign Recognition x 2.745) + (Stroop Colour word score x 0.274) + (AMIPB Information Processing Task B Adjusted score x 0.181) + 50.221 (Constant)

$$\text{FAIL} = (\text{SDSA Dot cancellation time} \times 0.095) + (\text{SDSA Dot cancellation errors} \times 0.171) - (\text{SDSA Directions} \times 0.074) + (\text{SDSA Compass} \times 0.293) + (\text{SDSA Road Sign Recognition} \times 2.379) + (\text{Stroop Colour word score} \times 0.248) + (\text{AMIPB Information Processing Task B adjusted score} \times 0.139) + 48.937 \text{ (Constant)}$$

Proportion correctly classified 86.5%

### **Multiple Sclerosis Lincoln & Radford (2008)**

$$\text{Pass} = (\text{SDSA Dot cancellation time} \times 0.057) + (\text{SDSA Dot cancellation errors} \times 0.17) - (\text{SDSA Dot cancellation false positives} \times 0.181) + (\text{SDSA Road Sign Recognition} \times 1.337) + (\text{AMIPB Design Learning total} \times 0.163) + (\text{AMIPB Information Processing Task B adjusted score} \times 0.427) - 36.926.$$

$$\text{Fail} = (\text{SDSA Dot cancellation time} \times 0.047) + (\text{SDSA Dot cancellation errors} \times 0.163) - (\text{SDSA Dot cancellation false positives} \times 0.142) + (\text{SDSA Road Sign Recognition} \times 0.718) + (\text{AMIPB Design Learning total} \times 0.319) + (\text{AMIPB Information Processing Task B adjusted score} \times 0.343) - 28.595.$$

Proportion correctly classified 88%



## **Dementia Lincoln et al (2006), Lincoln et al (2009)**

Fail = (Dot cancellation time \* 0.0332)+(Dot cancellation errors \* 0.817)+(Square Matrices Directions \*0.437)+(Square Matrices Compass \* 0.247)+(Road Sign Recognition \*0.0238)+(MMSE \* 4.272)+(BADs Rule shift profile score \*1.412)-(BADs Key Search Profile score \* 4.82)+(VOSP Incomplete letters total score \* 6.906)+(SORT Words Immediate \* 1.244)-(SORT Words Delayed \* 3.058)+(Information Processing A adjusted score \* 0.0525)+(Information Processing B adjusted score \* 0.627)-(Stroop \* 0.265)-135.994.

Pass = (Dot cancellation time \* 0.0269)+(Dot cancellation errors\* 0.788)-(Square Matrices Directions \*0.494)+(Square Matrices Compass \* 0.239)+(Road Sign Recognition \* 1.12)+(MMSE \* 5.165)+(BADs Rule shift profile score \* 0.448)-(BADs Key Search Profile score \* 3.775)+(VOSP Incomplete letters total score \* 6.593)+(SORT Words Immediate \* 2.488)-(SORT Words Delayed \* 4.556)-(Information Processing A adjusted score \* 0.194)+(Information Processing B adjusted score \* 0.744)+(Stroop \* 0.260)-141.674.

Proportion correctly classified 92% (Lincoln et al 2006) and 79% (Lincoln et al 2009)

Feedback on the assessment is always useful and comments should be submitted to [Nadina.lincoln@nottingham.ac.uk](mailto:Nadina.lincoln@nottingham.ac.uk).

The test materials are available for purchase from the University of Nottingham. The cost is £150.

## References

- Lincoln NB, Fanthome Y. Reliability of the Stroke Drivers Screening Assessment. *Clinical Rehabilitation* 1994; 8:157-160.
- Lincoln NB Radford KA. Cognitive abilities as predictors of safety to drive in people with multiple sclerosis. *Multiple Sclerosis* 2008; 14: 123-128.
- Lincoln NB, Radford KA, Lee E and Reay AC. The assessment of fitness to drive in people with dementia. *International Journal of Geriatric Psychiatry* 2006; 21: 1-8.
- Lincoln NB, Taylor JL, Vella K, Bouman WP & Radford KA. A prospective study of cognitive tests to predict performance on a standardized road test in people with dementia. *International Journal of Geriatric Psychiatry*. 2009; 25; 489-496.
- Nouri FM. Driving after Stroke PhD Thesis University of Nottingham 1991.
- Nouri FM, Lincoln NB. Validation of a cognitive assessment predictive driving performance after stroke. *Clinical Rehabilitation*. 1992;6:275-281.
- Nouri FM, Lincoln NB. Predicting driving performance after stroke. *British Medical Journal* 1993; 307:482-483.
- Nouri FM, Tinson D, Lincoln NB. Cognitive ability and driving after stroke. *International Disability Studies* 1987; 9: 110-115.
- Radford KA Validation of the Stroke Drivers Screening Assessment for patients with an acquired neurological disability (2000) University of Nottingham, PhD Thesis.
- Radford KA, Lincoln NB Concurrent validity of the Stroke Drivers Screening Assessment. *Archives of Physical Medicine and Rehabilitation* 2004; 85: 324-8.
- Radford KA, Lincoln NB, Murray-Leslie C Validation of the Stroke Drivers Screening Assessment for people with Traumatic Brain Injury. *Brain Injury* 2004; 18: 775-786
- Radford KA, Lincoln NB, Lennox G. The Effects of Cognitive Abilities on Driving in People with Parkinson's Disease. *Disability and Rehabilitation* 2004; 26: 65-70.