

Experiment 38: Interference of Stimuli on Associative Tasks - The Stroop Effect

Background

In his doctoral thesis published in 1935, J.R. Stroop reported that the completion of a task could be strongly influenced by stimuli from another task to which it is associated. In his work, Stroop found that a subject's ability to read words was influenced by the color in which the words were printed. Likewise, the subject's ability to name the colors in which the words were printed was influenced by the actual words. Each task, naming colors and reading words, received interference from stimuli associated with the other task.

Stroop conducted tests in which subjects were asked to read words that identify specific colors, however, the words were printed in a color that was different than the color identified by the word. For example, when the word "Green" was printed with blue ink, the subject was asked to read the word "Green". When compared to the control task of reading color words printed in black, the increase in the time taken by the subject to react to words printed in conflicting colors was an indication of the interference of color stimuli on the task of reading words. Stroop also proposed the strength of the interference was an indication of the strength of the association between the two tasks.

In another test, subjects were asked to name the conflicting color in which the color word was printed. For example, the word "Red" was printed in green and the subject was asked to name the color "Green". When compared to the control task of naming the colors in which the same nondescript symbol was printed, the increase in the time taken by the subject to react to the colors of conflicting words was an indication of the interference of word stimuli on the task of naming colors. Go to the fourth column on Table 8-3 on page 7 and name the colors in which the words are printed. It's not that easy, is it? Through your experience, you have been taught that the meaning of a word is more important than the color in which it is printed. When you try to pay attention to a color and name it, the word stimuli interferes with the task.

In this experiment, subjects will perform tasks that demonstrate the Stroop Effect in several different ways: the effect of word stimuli on color naming, the effect of color stimuli on reading words, the effect of word stimuli on naming directions, and stimuli of your own choice or design. The completion time of each task will be used as an indicator of the strength of the

interference of the stimuli on the task; Stroop correlated longer completion times to higher degrees of interference.

Since these tasks are also stressors, the heart rate and skin conductance level of each subject will be recorded before, during, and after each task (Figure 8-1 on page 1). Do you think the stress indicators will correlate to the level of interference during a task?

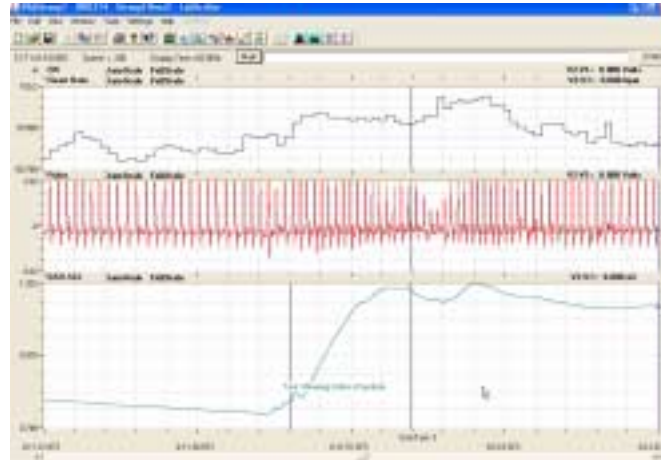


Figure 8-1: Heart rate (HR), pulse, and skin conductance level (SCL) of subject performing the task of naming the colors of symbols printed in a list. From 6 seconds before the beginning of the task to 6 seconds after the completion of the task, the subject's heart rate increases by 40% and SCL increases by 50%.

Equipment Required

- PC Computer
- iWorx unit, and USB or serial cable
- PT-104 Pulse plethysmograph
- GSR-100/200 GSR amplifier, electrodes, and extension cable
- Tables of words and symbols

Equipment Setup

- 1 Connect the iWorx unit to the computer (described in Chapter 1).
- 2 Select a person from your group to be the subject.
- 3 Locate the DIN connector on the end of the plethysmograph cable and plug it into Channel 3 (Figure 8-2 on page 2).
- 4 Place the plethysmograph on the volar surface (where the fingerprints are located) of the distal segment of the middle finger, and wrap the Velcro strap around the end of the finger to attach the unit firmly in place.
- 5 Plug one end of a male DIN-male DIN cable into the GSR amplifier. Connect the other end of the same cable to Channel 4 (Figure 8-2 on page 2).

- Pull down the **Window** menu on the LabScribe Main window and select **Preview**. Click the arrows at the top of **Preview** window to select the on-line display of the **GSR** channel (CH 4). Use the offset knob on the GSR amplifier to move the observed output to zero. Click the **OK** button on the **Preview** window.
- The GSR-200 amplifier is factory calibrated so that an output of 1 Volt is equal to 5 microSiemens (μS).
- To enter this conversion factor into the recording settings, pull down the **Edit** menu in the **Main** window, and select **Preferences** and go to the **Channels** window.
- Under the **Calibration** section of the **Channels** window, the following settings should be used:

Calibration			
Raw		Cal	Unit
1	=>	5	μS
0	=>	0	

These settings mean that 1 Volt (raw unit) is set equal to 5 μS (calibrated unit), and 0 Volt is set equal to 0 μS .

- Connect the GSR electrodes to the BNC connector on the GSR amplifier.
- Attach the GSR electrodes to the volar surface of the distal finger segment of the subject's index finger and ring finger. Attach the electrodes with the Velcro straps so that the straps are snug, but not overly tight.

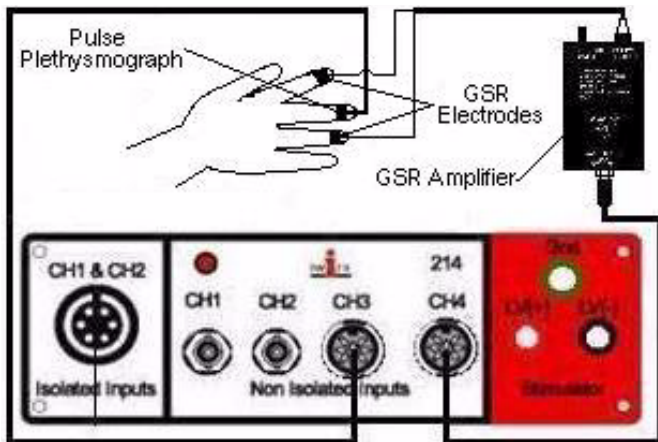


Figure 8-2: The equipment needed to record heart rate and skin conductance.

Start the Software

- Click the Windows Start menu, move the cursor to **Programs** and then to the **iWorx** folder and select **LabScribe**; or click on the LabScribe icon on the Desktop.
- When the program opens, select **Load Group** from the **Settings** menu.
- When the dialog box appears, select **AddedLabs.iws**. Click **Load**.
- Click on the **Settings** menu again and select the **Stroop-Effect** settings file.

- After a short time, LabScribe will appear on the computer screen as configured by the **StroopEffect** settings.

Exercise 1: Interference of Color Stimuli on Reading.

Aim: To determine the effect of the color in which a word is printed on the subject's ability to read the word.

Procedure

- Ask the subject to sit quietly at a table, out of view of the computer monitor, and in a position to read from Table 8-3 on page 7. The subject should rest the hand with the electrodes comfortably on his or her lap.
- Click **Start**. Click **AutoScale** on the **Pulse** channel to optimize the size of the pulse signal. This will permit the heart rate displayed on Channel 2 (Heart Rate) to be calculated accurately.
- Type the subject's first name and the words "Task 1: Read Words in Black" on the comment line to the right of the **Mark** button. Record until the skin conductance level of the subject, recorded on Channel 4 (**GSR-SCL**), has reached a stable baseline.
- Instruct the subject to read aloud, as quickly as possible, the words in the first column of Table 8-3 on page 7. Press the **Enter** key on the keyboard as soon as the subject begins reading the list. Quickly type the word "End" on the comment line.
- Press the **Enter** key on the keyboard as soon as the subject has read the last word in the first column. Continue to record.
- Type the words "Task 2: Read Words in Conflicting Colors" on the comment line, as the subject relaxes for 1 to 2 minutes.
- Instruct the subject to read aloud, as quickly as possible, the words in the second column of Table 8-3 on page 7. Press the **Enter** key on the keyboard as soon as the subject begins reading the list. Quickly type the word "End" on the comment line.
- Press the **Enter** key on the keyboard as soon as the subject has read the last word in the second column. Continue to record as the subject relaxes for a minute.
- Begin Exercise 2 at the end of a 1 to 2 minute relaxation period.

Exercise 2: Interference of Word Stimuli on Naming.

Aim: To determine the effect of words on the subject's ability to name the colors in which the words are printed.

Procedure

- Type the words "Task 3: Name Color of Symbols" on the comment line, as the subject is relaxing.

- 2 Instruct the subject name aloud, as quickly as possible, the colors in which the symbols in the third column of Table 8-3 on page 7. Press the **Enter** key on the keyboard as soon as the subject begins naming the colors in the list. Quickly type the word “End” on the comment line.
- 3 Press the **Enter** key on the keyboard as soon as the subject has named the color of the last symbol in the third column. Continue to record.
- 4 Type the words “Task 4: Name Color of Conflicting Words” on the comment line, as the subject relaxes for 1 to 2 minutes.
- 5 Instruct the subject to name aloud, as quickly as possible, the colors in which the words in the fourth column of Table 8-3 on page 7. Press the **Enter** key on the keyboard as soon as the subject begins naming the colors in the list. Quickly type the word “End” on the comment line.
- 6 Press the **Enter** key on the keyboard as soon as the subject has named the color of the last word in the fourth column.
- 7 Continue to record for 1 to 2 minutes.
- 8 Click **Stop** to halt the recording.
- 9 Select **Save As** in the **File** menu, type a name for the file. Choose a destination on the computer in which to save the file (e.g. the **iWorx** or class folder). Click the **Save** button to save the file (as an *.iwd file).

Analysis-Skin Conductance Level (SCL) & Heart Rate

- 1 Go to the segment of the recording that is before Task 1.
- 2 Use the **Display Time** icons on the **LabScribe** toolbar (Figure 8-3 on page 3) to adjust the time displayed on the **Main** window, so that the segment before Task 1 can be viewed on the screen.
- 3 Click the **2-Cursor** icon (Figure 8-3 on page 3) so that two blue vertical lines appear on the **Main** window. Use the cursors to select the complete segment before Task 1.

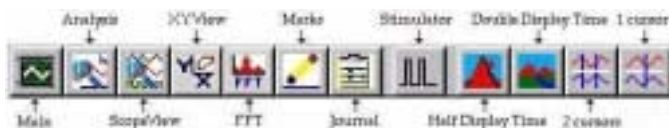


Figure 8-3: The **LabScribe** toolbar

- 4 Click the **Analysis** icon (Figure 8-3 on page 3) to open the **Analysis** window.
- 5 Display the **Heart Rate** and **GSR-SCL** channels (Channels 2 and 4) in the **Analysis** window by selecting them from the **Display Channels** menu on the left side of the **Analysis** window (Figure 8-4 on page 3). Use the **Windows Control-Click** function to make the selection.
- 6 Use the mouse to click and drag a cursor to each edge of the **Analysis** window. Select **Title**, **Max**, **Min**, **Mean**, and **Max-Min** from the **Table Functions** list and **GSR-SCL** from the **Value from Channel** menu. The values displayed in the table across the top of the **Analysis** window will be the

subject's skin conductance level values for this segment.

- 7 Enter data into the **Journal** by either typing the titles and values directly or by using the **right-click** menu. Place the cursors to take measurements; then, select **Add Title to Journal** or **Add Data to Journal** from the **right-click** menu to add the measurements to the **Journal**.

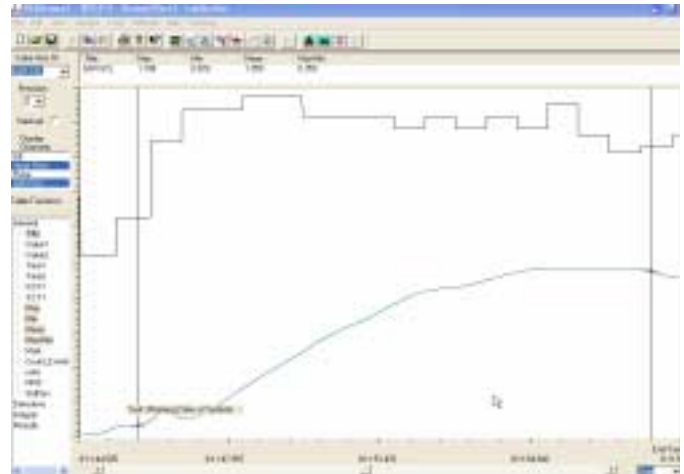


Figure 8-4: Heart rate (HR) and skin conductance level (SCL) data for Task 3 (Naming Colors of Symbols), as displayed in the **Analysis** window. The subject took 11.830 seconds to complete this task. During the task, the subject's SCL rose 43.3%, from 0.829 to 1.188 μ Siemens.

- 8 Select **Heart Rate** from the **Value from Channel** menu. The values displayed in the table across the top of the **Analysis** window will be the subject's heart rate values for this segment.
- 9 Enter this data into the **Journal** using the same techniques used in Step 7. Put a notation in the **Journal** that these values are from the segment before Task 1.
- 10 Click **Save** in the **File** menu to save the contents of the **Journal**.

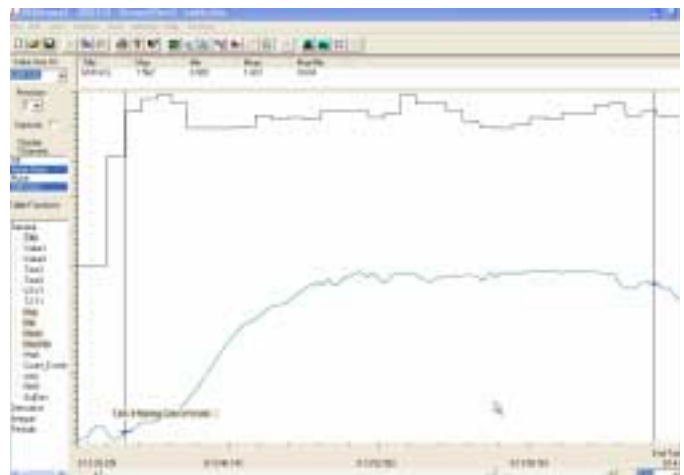


Figure 8-5: Heart rate (HR) and skin conductance level (SCL) data for Task 4 (Naming Colors of Words), as displayed in the **Analysis** window. The subject took 23.904 seconds to complete this task. During the task, the subject's SCL rose 68.3%, from 0.928 to 1.562 μ Siemens.

11 Repeat Steps 1 through 10 of this analysis for the other segments in Exercises 1 and 2:

- Task 1,
- Time between Tasks 1 and 2,
- Task 2,
- Time between Task 2 and 3,
- Task 3 (Figure 8-4 on page 3),
- Time between Tasks 3 and 4,
- Task 4 (Figure 8-5 on page 3),
- Time after Task 4.

12 Enter the subject's data into Table 8-1 on page 4.

Analysis-Task Completion Times and Differentials

- 1 Go to the recording of Task 1.
- 2 Use the **Display Time** icons on the LabScribe toolbar (Figure 8-3 on page 3) to adjust the time displayed on the **Main** window, so that the marks that define the beginning and end of Task 1 can be viewed on the screen.
- 3 Click the **2-Cursor** icon (Figure 8-3 on page 3) so that two blue vertical lines appear on the **Main** window. Place the cursors on the marks at the beginning and end of Task 1.
- 4 Read the time difference (T2-T1) between the positions of the two cursors from the upper left corner of the **Main** window. The value for T2-T1 is the time taken by the subject to complete the task.
- 5 Record the completion time for this task in the **Journal** by typing it directly into that window.
- 6 Click **Save** in the **File** menu to save the contents of the **Journal**.
- 7 Repeat Steps 1 through 6 for Tasks 2, 3, and 4 in this exercise.

8 Enter the completion times into Table 8-1 on page 4.

9 Determine the differences between the completion times of Task 2 and Task 1, and Task 4 and Task 3. Report these values in Table 8-1 on page 4.

Questions

- 1 Is there a difference between the changes in the subject's skin conductance level (SCL) in Tasks 1 and 2? Is there a difference between the subject's heart rate in Tasks 1 and 2?
- 2 Did the subject take longer to complete Task 1 or Task 2? Did the color stimuli interfere with reading words?
- 3 Is there a difference between the changes in the subject's skin conductance level (SCL) in Tasks 3 and 4? Is there a difference between the subject's heart rate in Tasks 3 and 4?
- 4 Did the subject take longer to complete Task 3 or Task 4? Did the word stimuli interfere with naming colors?
- 5 Did the subject take longer to complete Task 2 or Task 4? Did the word stimuli make color naming more difficult or did the color stimuli make reading words more difficult? Why is this so?

Predictions

- 1 What would happen if the order of the colors in the list of words for Task 2 (Reading Colored Words) was repetitive?
- 2 What would happen if the order of the colors in the list for Task 3 (Naming Colors of Symbols) was repetitive?
- 3 What would happen if the order of the colors in the list of words for Task 4 (Naming Colors of Words) was repetitive?
- 4 What would happen in Task 4 if the subject was a child who had not yet learned to read?
- 5 What would happen in Task 4 if the subject was just beginning to speak English?

Table 8-1: Skin conductance levels, heart rates, and completion times during Tasks 1 through 4.

Task	Skin Conductance (μ S)				Heart Rate (BPM)				Times (secs)	
	Max	Min	Mean	Max-Min	Max	Min	Mean	Max-Min	Completion of Task	Differential
Before Task 1										
Task 1: Read in Black Print										
Between Tasks 1 and 2										
Task 2: Read in Different Color										
Between Tasks 2 and 3										
Task 3: Name Color of Symbol										
Between Tasks 3 and 4										
Task 4: Name Color of Word										
After Task 4										

Exercise 3: Interference of Word Stimuli on Determining Direction

Aim: To determine the effect of words on the subject's ability to name the location of a word in a frame.

Procedure

- 1 Ask the subject to sit quietly at a table, out of view of the computer monitor, and in a position to examine Table 8-4 on page 8. The subject should rest the hand with the electrodes comfortably on his or her lap.
- 2 Click **Start**. Click **AutoScale** on the **Pulse** channel to optimize the size of the pulse signal. This will permit the heart rate displayed on Channel 2 (Heart Rate) to be calculated accurately.
- 3 Type the subject's first name and the words "Task 5: Name Position of Same Word" on the comment line to the right of the **Mark** button. Record until the skin conductance level of the subject, recorded on Channel 4 (**GSR-SCL**), has reached a stable baseline.
- 4 Instruct the subject to name the position of the word in each frame on Table 8-4 on page 8 aloud, as quickly as possible. Press the **Enter** key on the keyboard as soon as the subject begins naming the position of the word. Quickly type the word "End" on the comment line.
- 5 Press the **Enter** key on the keyboard as soon as the subject has named the last position on Table 3. Continue to record.
- 6 Type the words "Task 6: Name Position of Different Words" on the comment line, as the subject relaxes for 1 to 2 minutes.
- 7 Instruct the subject to name the position of the word in each frame on Table 8-5 on page 9 aloud, as quickly as possible. Press the **Enter** key on the keyboard as soon as the subject begins naming the position of the word. Quickly type the word "End" on the comment line.
- 8 Press the **Enter** key on the keyboard as soon as the subject has named the last position on Table 4. Continue to record as the subject relaxes for 1 to 2 minutes.

Analysis-Skin Conductance Level (SCL) & Heart Rate

- 1 Go to the segment of the recording that is before Task 5.
- 2 Use the **Display Time** icons on the **LabScribe** toolbar (Figure 8-3 on page 3) to adjust the time displayed on the **Main** window, so that the segment before Task 5 can be viewed on the screen.
- 3 Click the **2-Cursor** icon (Figure 8-3 on page 3) so that two blue vertical lines appear on the **Main** window. Use the cursors to select the complete segment before Task 5.
- 4 Click the **Analysis** icon (Figure 8-3 on page 3) to open the **Analysis** window.
- 5 Display the **Heart Rate** and **GSR-SCL** channels (Channels 2 and 4) in the **Analysis** window by selecting them from the **Display Channels** menu on the left side of the **Analysis** window. Use the **Windows Control-Click** function to make

the selection.

- 6 Use the mouse to click and drag a cursor to each edge of the **Analysis** window. Select **Title**, **Max**, **Min**, **Mean**, and **Max-Min** from the **Table Functions** list and **GSR-SCL** from the **Value from Channel** menu. The values displayed in the table across the top of the **Analysis** window will be the subject's skin conductance level values for this segment.
- 7 Enter data into the **Journal** by either typing the titles and values directly or by using the **right-click** menu. Place the cursors to take measurements; then, select **Add Title to Journal** or **Add Data to Journal** from the **right-click** menu to add the measurements to the **Journal**.
- 8 Select **Heart Rate** from the **Value from Channel** menu. The values displayed in the table across the top of the **Analysis** window will be the subject's heart rate values for this segment.
- 9 Enter this data into the **Journal** using the same techniques used in Step 7. Put a notation in the **Journal** that these values are from the segment before Task 5.
- 10 Click **Save** in the **File** menu to save the contents of the **Journal**.
- 11 Repeat Steps 1 through 10 of this analysis for the other segments in Exercise 3:
 - Task 5,
 - Time between Tasks 5 and 6,
 - Task 6,
 - Time after Task 6.
- 12 Enter the subject's data into Table 8-2 on page 6.

Analysis-Task Completion Times and Differentials

- 1 Go to the recording of Task 5.
- 2 Use the **Display Time** icons on the **LabScribe** toolbar (Figure 8-3 on page 3) to adjust the time displayed on the **Main** window, so that the marks that define the beginning and end of Task 5 can be viewed on the screen.
- 3 Click the **2-Cursor** icon (Figure 8-3 on page 3) so that two blue vertical lines appear on the **Main** window. Place the cursors on the marks at the beginning and end of Task 5.
- 4 Read the time difference (T2-T1) between the positions of the two cursors from the upper left corner of the **Main** window. The value for T2-T1 is the time taken by the subject to complete the task.
- 5 Record the completion time for this task in the **Journal** by typing it directly into that window.
- 6 Click **Save** in the **File** menu to save the contents of the **Journal**.
- 7 Repeat Steps 1 through 6 for Task 6.
- 8 Enter the completion times into Table 8-2 on page 6.
- 9 Determine the differences between the times of Task 6 and Task 5. Report these values in Table 8-2 on page 6.

Table 8-2: Skin conductance levels, heart rates, and completion times during Tasks 5 and 6.

Task	Skin Conductance (μS)				Heart Rate (BPM)				Times (secs)	
	Max	Min	Mean	Max-Min	Max	Min	Mean	Max-Min	Completion of Task	Differential
Before Task 5										
Task 5: Name Same Direction										
Between Tasks 5 and 6										
Task 6: Name Different Direction										
After Task 6										

Questions

- 1 Is there a difference between the changes in the subject's skin conductance level (SCL) in Tasks 5 and 6? Is there a difference between the subject's heart rate in Tasks 5 and 6?
- 2 Did the subject take longer to complete Task 5 or Task 6? Did the word stimuli interfere with naming directions?

- Devise your own test on tasks that think are associated.
 - Test one of the predictions made earlier in this experiment.
- 2 Record the same parameters, skin conductance level and heart rate and test completion time, used in Exercises 1, 2, and 3.

Exercise 4: Additional interferences

Aim: To perform another test for interference between associative tasks.

Procedure

- 1 Find or devise an additional test for interference between tasks that seem to be associated.
- Additional tests to demonstrate the "Stroop Effect" can be found by searching the Internet. You should be able to find tests that demonstrate other interferences: word stimuli on counting, word stimuli on naming pictures, and audio stimuli on naming.

Analysis

- 1 Use the same methods employed in Exercises 1, 2, and 3 to analyze the data collected from this additional Stroop test.
- 2 Construct a table to display the results of your test. Share these results with other groups in your class.
- 3 Compare the strength of interference of this additional stimuli to the strength of interference of the additional stimuli used by other groups of students.
- 4 Compare the strength of interference of this additional stimuli to the strengths of interference demonstrated in Exercises 1, 2, and 3.

Table 8-3: Lists of colored words used in Exercises 1 and 2 of Experiment 38: The Stroop Effect.

Task1	Task 2	Task 3	Task 4
BLUE	BLUE	XXXX	RED
GREEN	GREEN	XXXX	BLUE
RED	BLACK	XXXX	GREEN
GREEN	BLUE	XXXX	BLUE
RED	GREEN	XXXX	BLACK
RED	RED	XXXX	BLUE
BLUE	GREEN	XXXX	GREEN
GREEN	RED	XXXX	RED
BLUE	BLUE	XXXX	GREEN
BLACK	BLACK	XXXX	RED
BLUE	BLUE	XXXX	BLUE
BLACK	GREEN	XXXX	BLACK
BLUE	RED	XXXX	BLUE
GREEN	BLUE	XXXX	GREEN
BLUE	GREEN	XXXX	BLACK
GREEN	BLUE	XXXX	BLUE
BLACK	BLACK	XXXX	RED
BLUE	BLUE	XXXX	GREEN
GREEN	BLACK	XXXX	RED
RED	BLUE	XXXX	BLUE
BLACK	RED	XXXX	GREEN
BLUE	GREEN	XXXX	BLACK
RED	RED	XXXX	BLUE
GREEN	GREEN	XXXX	GREEN
RED	RED	XXXX	RED

Table 8-4: Frames with identical words and positions used in Exercise 3 of Experiment 38.

UP	LEFT	DOWN	LEFT	RIGHT
LEFT	UP	RIGHT	DOWN	UP
UP	DOWN	RIGHT	UP	LEFT
DOWN	LEFT	UP	RIGHT	DOWN
LEFT	RIGHT	DOWN	UP	RIGHT

Table 8-5: Frames with different words and positions used in Exercise 3 of Experiment 38.

	LEFT			RIGHT
UP		DOWN		
			LEFT	
		RIGHT	DOWN	UP
LEFT	UP			
	DOWN		UP	
UP				
		RIGHT		LEFT
			RIGHT	
DOWN	LEFT UP			DOWN
	RIGHT			
LEFT		DOWN	UP RIGHT	

