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Spatial Cueing

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Spatial Cueing

Overview

Attention refers to the limited human ability to select some information for processing at the expense of other stimuli in the environment. Attention operates in all sensory modalities: seeing, hearing, touch, even taste and smell. It is most often studied in the visual domain though. A common way to study visual attention is with a spatial cueing paradigm. This paradigm allows researchers to measure the consequences of focusing visual attention in some locations and not others. This paradigm was developed by psychologist Michael Posner in the late 70s and early 80s in a series of papers in which he likened attention to a spotlight, selectively illuminating some portion of a scene. ~~—like having an attentional spotlight.~~ This video demonstrates standard procedures for a spatial cueing experiment to investigate visual attention.

Commented [JS1]: Please provide a reference to Posner.
References:
Posner, M. I. (1980). Orienting of attention. *Quarterly journal of experimental psychology*, *32*(1), 3-25.

Posner, M. I., Snyder, C. R., & Davidson, B. J. (1980). Attention and the detection of signals. *Journal of experimental psychology: General*, *109*(2), 160.

Procedure

1. Equipment

1.1. The experiment requires a computer and experiment implementation software such as E-Prime, or a programming environment such as MATLAB or PsychoPy.

2. Stimulus and Experiment Design

2.1. The experiment involves short trials in which participants must detect and report a brief visual target. Each trial comprises three frames. **Figure 1** depicts the frames.

2.2. In frame 1 there are two green boxes, 1 inch ~~x~~by 1 inch on either side of the display, centered vertically. In addition, there is a red fixation cross made of 0.5½ inch long lines, located exactly in the center of the display. The green boxes should be about 1.5 inches away from the edges of the display.

2.3. In the second frame, the fixation cross is replaced by a cue, an arrow that points at one of the two green boxes. Make the arrow red, and easy to see, as shown in **Figure 1**.

2.4. In frame 3, a 'T' or 'L' is added to one of the two boxes, and the arrow from frame 2 is~~are~~ replaced by the reappearance of the fixation cross.

2.4.1. The participant's task is to indicate whether the letter in the box is an 'L' or a 'T' using the appropriate keys. Each letter will appear 50% of the time.

2.4.2. In 80% of the trials, the letter appears in the box that the arrow points to in frame 2. These are called 'c~~C~~ongruent' trials. In the remaining 20% of

trials, the letter appears opposite the arrow's direction. These are called 'iIncongruent' trials.

2.4.2.1.1. Overall, the letters will appear equally often on the right or left.

2.5. Sequence the experiment, just as described, to include the correct proportions of cCongruent and iIncongruent trials in a random order. Include 400 trials total (320 cCongruent and 80 iIncongruent).

2.6. Frame 1 should remain present in each trial for 100 ms, frame 2 for 100 ms, and frame 3 should remain present until a response is recorded.

2.7. Finally, be sure to program the experiment to collect relevant data. The output file should have a header like that shown in the table in **Figure 2**, with each row including the data from one trial: the trial number, the position of the letter that appeared (lLeft or rRight), the specific letter that appeared (L or T), whether the trial was cCongruent or iIncongruent (called the cCondition), the keypress made by the participant, and importantly, the reaction time—the time it took for the participant to make a keypress, measured from the onset of the letter. (This number should be recorded in milliseconds, and expected to range between 50 and 500).

3. Running the Experiment

3.1. To run the experiment, recruit 10 to 20 participants.

3.2. When a participant arrives in the lab, explain that the experiment they will do is designed to investigate the nature of visual attention, and ask them to complete an informed consent agreement.

3.3. Seat the participant in front of your testing computer, with the back of their chair 60 cm away from the monitor.

3.4. Explain the instructions to them in detail:

3.4.1. "Each trial of this experiment will be more or less the same. You will see a red fixation cross at the beginning of each trial. It is important that you keep your eyes fixated at that position at all times. After 100 ms, the fixation cross will be replaced by a red arrow pointing at one of the two green boxes that will also be in the display. Finally, after 100 ms, the arrow will disappear and a letter will appear in one of the two boxes. It will always be an L or a T, and your job is to report which one it is using the appropriate key. We want you to make a keypress as quickly as possible, without sacrificing accuracy, so it is a good idea to keep your right index finger on the L key and your left index finger on the T key at all times. After you make a response, there will be a half-second delay

before the next trial begins. Note that the red arrow will not always point to the place where the letter will eventually appear. You will do 400 trials of the experiment, which should take only about 5 to 10 minutes. There will be a short break of two minutes when you are halfway through. Do you have any questions?"

3.5. Once you answer any questions, start the program, and observe the participant for a few trials to make sure they understood the instructions. Then you can leave the testing room until the experiment is complete.

4. Analyzing the Results

4.1. Your program should automatically populate the cells in your results table for each participant as the experiment progresses. Thus at the end of the experiment, you will have a table with 400 rows representing 400 trials for each participant.

4.2. First, check that the responses provided are accurate. To do this add a column to the table called 'Accuracy.' **Figure 3** shows a populated data table.

4.2.1. To determine whether the response given was correct, compare responses given with the actual identities of the letters show. Recall that the table includes a column for each of these.

4.2.1.1. Excel (or other software) is able to automatically determine whether responses are correct by inputting the following formula into the new column called 'Accuracy:':
=if("Letter Type"= "Response Given",1,0)
This means that if the character in the Letter Type column is the same as the one in the Response Given column, there will be a 1 in the accuracy column. Otherwise, there will be a 0, indicating an incorrect response.

4.2.1.2. Compute average accuracy for each participant by averaging together the values in the new 'Accuracy' column. If the proportion of correct responses for a participant is less than 0.8, do not further analyze the participant's results; this suggests that the participant either misunderstood the instructions, or did not place priority on performing accurately.

4.2.2. Now the measure of interest can be computed. Average together the reaction time for a participant in all the cCongruent trials, and separately, in all the iIncongruent trials. Then compute a cCongruent and iIncongruent average for all the participants grouped together.

Representative Result

Figure 4 shows average reaction time for a group of participants, comparing cCongruent and iIncongruent trials. Participants were, on average, about 200 ms faster to respond in cCongruent trials. This shows the advantages associated with the location where one attends and the costs to

other locations. The arrow gave participants 80% reliable information about where the letter would appear in each trial~~s~~, so participants directed visual attention to the positions pointed to by the arrow. When the letter then appeared in that position, which it did most of the time, the participants could process and identify it quickly. When the letter appeared opposite though, participants needed to shift their attention across the screen in order to then process and identify the letter presented, a shift of attention that seemed~~s~~ to have taken about 200 ms, on average.

Applications

Since it was introduced in the late 1970s, the spatial cueing task has been used widely by researchers, for example, in order to identify the kinds of stimuli that might automatically cause attention to shift. For example, researchers have investigated whether bright flashes and loud sounds automatically cause attention to shift. In these experiments the letters that need to be identified are sometimes preceded by unexpected lights and sounds. Researchers can then compare compare detection speeds when a bright flash, for instance, precedes a letter in the same position or in a different position. A cost associated with a flash in an opposite position implies that the flash automatically captured attention. ~~, and in order to understand how brain damage might affect the voluntary control of visual attention.~~

Commented [JS2]: Can you expand upon this idea with a concrete example?

In the 1990s and after, the task became an important one for use in conjunction with fMRI (functional magnetic resonance imaging) in order to identify the neurological centers involved in the control of spatial attention. By contrasting brain activity in c~~C~~ongruent and i~~I~~ncongruent conditions, researchers have discovered that regions of the parietal lobe are involved in the additional attentional shift that takes place in i~~I~~ncongruent trials compared to c~~C~~ongruent ones.

Legend:

Figure 1. Sequence of events in the spatial cueing paradigm used to measure the consequences of visual attention. Each trial begins the same way, as shown in frame 1, with a central fixation cross and two green boxes on either side. In frame 2, the fixation cross is replaced by an arrow, pointing to one of the two boxes (50% of the time each). Finally, in frame 3 a letter is shown ~~–~~—either an L or a T—~~–~~in one of the two boxes. In the example shown, the letter is an L. In the right panel example, the letter appears in the box that the arrow points to, producing a congruent trial. In the panel on the left, the letter appears opposite the arrow, producing an incongruent trial. The measure of interest is the time it takes a participant to make a correct response (the reaction time), in particular, the average difference between congruent and incongruent trials.

Figure 2. **Sample table for organizing data output in a spatial cueing experiment**. The primary measure of interest is the reaction time on each trial. In addition, the c~~C~~ondition needs to be recorded in order to compare reaction time in c~~C~~ongruent and i~~I~~ncongruent trials, and the l~~L~~etter t~~T~~ype and r~~R~~esponse ~~G~~gi~~i~~ven are necessary in order to evaluate response accuracy. It is also a good idea to record l~~L~~etter p~~P~~osition to ensure that trials appear in the correct proportions.

Figure 3. **A data table populated with results from 25 spatial cueing trials.** The final column, labelled ‘Accuracy,’ was added after the experiment was completed, and a formula was used to automate an accuracy check.

Figure 4. **Reaction time results of a spatial cueing experiment**. Participants generally

responded more quickly in cCongruent compared to iIncongruent trials. In cCongruent trials, the cue arrow pointed to the place where a letter eventually appeared. But in iIncongruent trials, it pointed opposite. The difference in reaction times suggests that the arrow led participants to attend to the box pointed to by the arrow, allowing them to more quickly process and identify the letter when it appeared there.

Photo or Graphic File
Click here to download Photo or Graphic File: Flombaum_spatial_cue_fig4.png

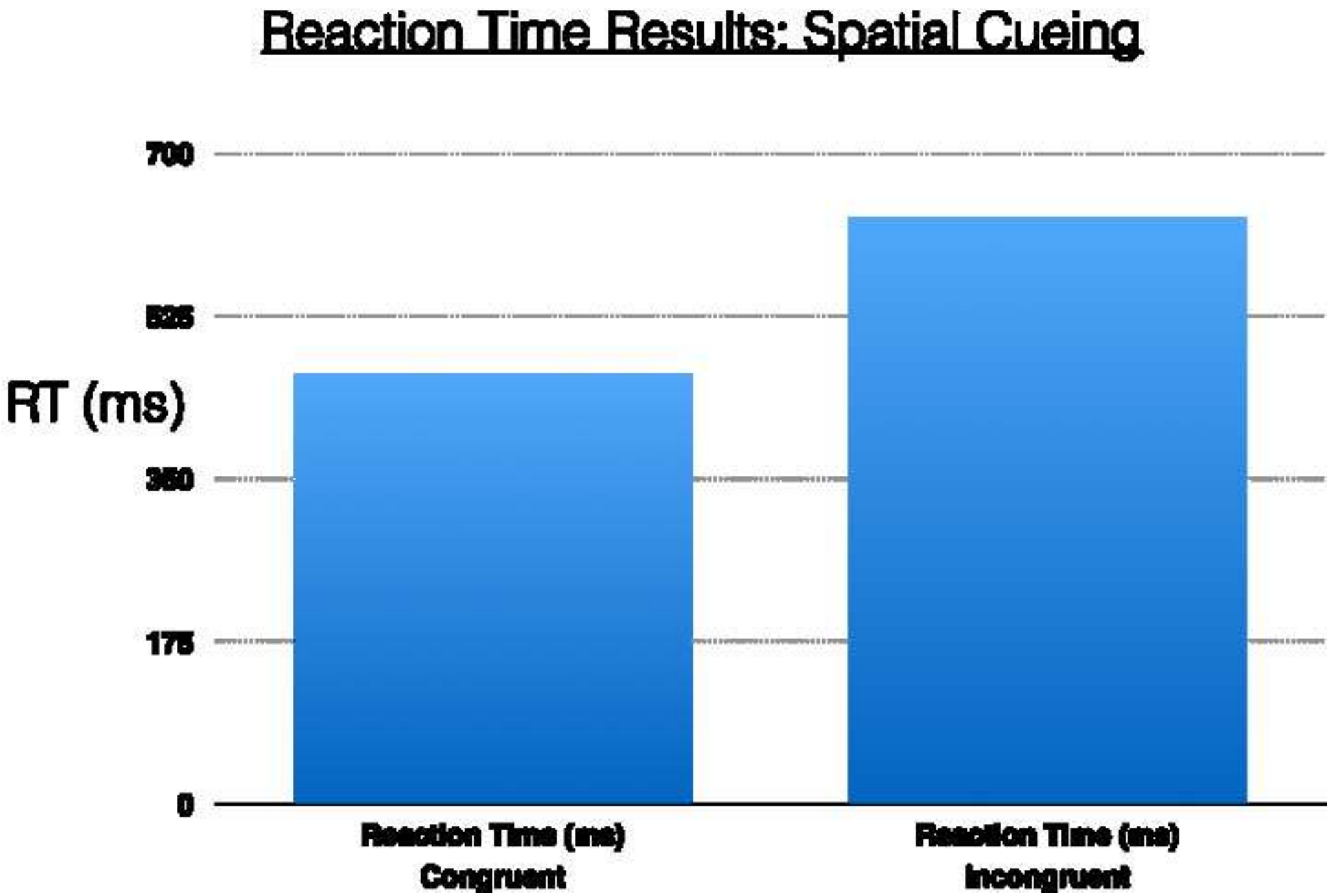

Photo or Graphic File
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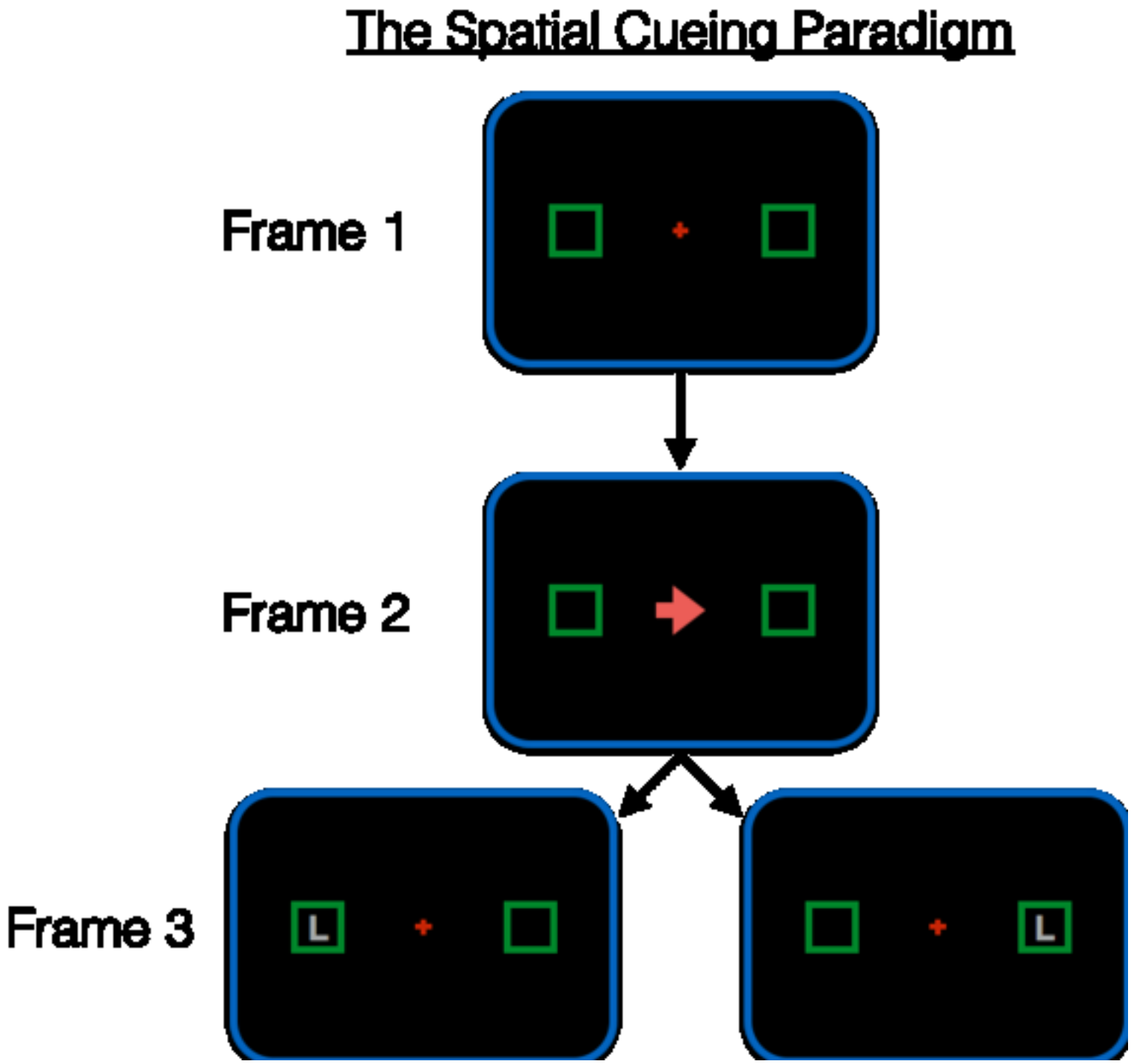

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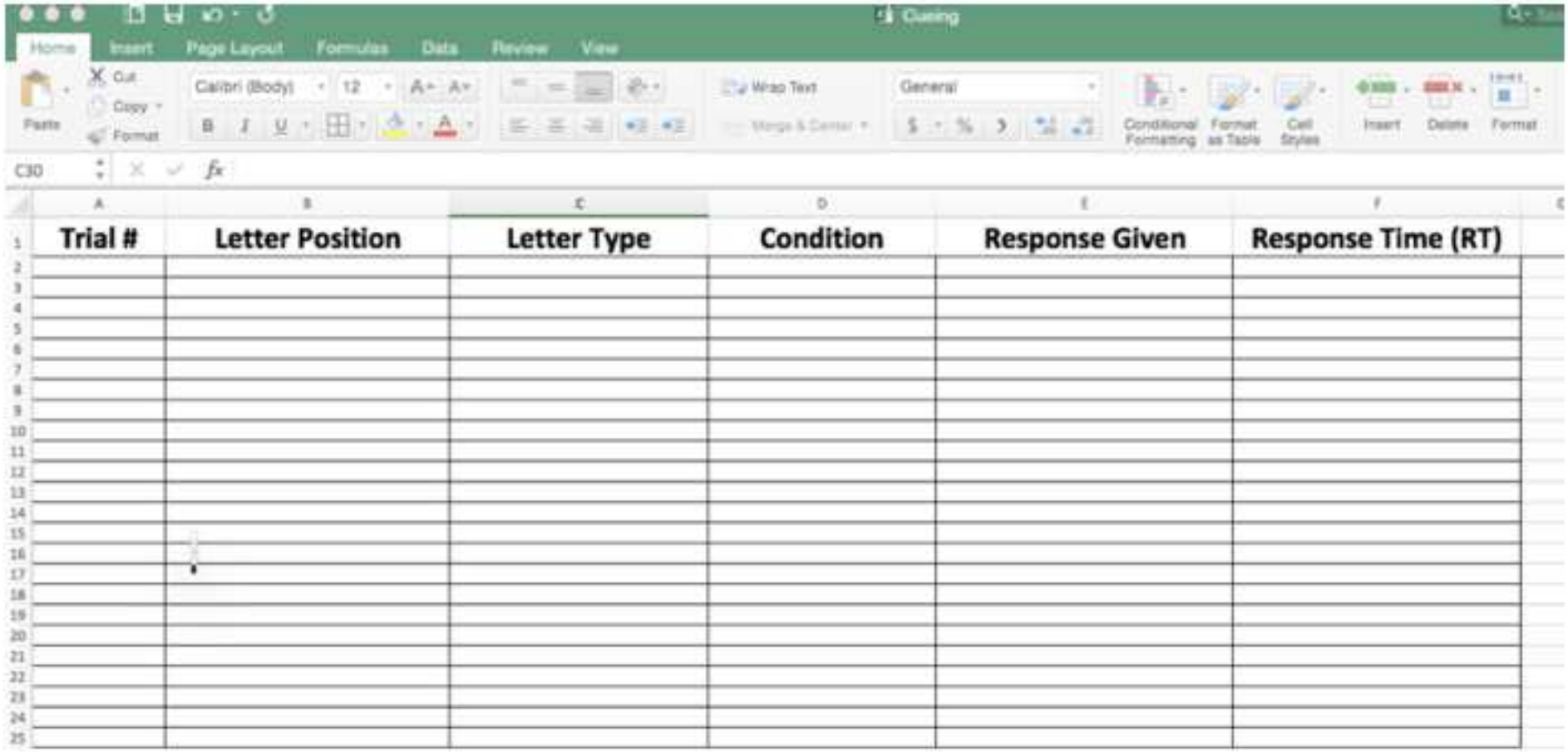
Table for Data Output, Spatial Cueing



Trial #	Letter Position	Letter Type	Condition	Response Given	Response Time (RT)

Photo or Graphic File
Click here to download Photo or Graphic File: Flombaum_spatial_cue_fig3.png

Spatial Cueing Data

	A	B	C	D	E	F	G
1	Trial #	Letter Position	Letter Type	Condition	Response Given	Response Time (RT)	Accuracy
2	1	L	L	C	L	581	1
3	2	L	L	C	L	58	1
4	3	L	T	C	T	130	1
5	4	L	T	C	T	534	1
6	5	R	T	I	T	643	1
7	6	L	T	C	T	139	1
8	7	R	T	C	T	586	1
9	8	L	L	C	L	122	1
10	9	R	L	C	L	457	1
11	10	R	T	C	T	443	1
12	11	R	L	C	T	312	0
13	12	L	T	C	T	461	1
14	13	R	T	C	T	313	1
15	14	R	T	I	T	620	1
16	15	R	L	I	L	732	1
17	16	R	T	C	T	552	1
18	17	R	T	I	T	711	1
19	18	L	L	C	L	308	1
20	19	L	L	C	L	210	1
21	20	L	L	C	L	180	1
22	21	R	T	C	T	384	1
23	22	L	L	C	L	470	1
24	23	L	T	C	T	499	1
25	24	R	T	C	T	96	1
26	25	L	L	C	L	690	1