Lab 4

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Psychological experiments

Lab class

This week we are going to start having a closer look at experiments. As explained in detail in Beth's book, by manipulating one or a few variables and by holding constant other variables, experiments allow us to make causal claims. If the experiment has a between-subjects design, random allocation to groups is another key characteristic of experiments.

Experiments are all about explaining an observed effect on the **dependent variable (DV)** as a result of the manipulation of the **independent variable (IV)**. If the observed effect is actually the result of manipulating the IV, the experiment is referred to as **internally valid** (meaning that it appears there are no alternative explanations for the observed effect). Threats to internal validity are a key issue for experiments and are discussed in detail in Chapter 11 in Beth's book.

Our focus in the labs will be on a number of experiments that measure **response times (RTs)**[1] **and accuracy**. RTs and accuracies have a number of advantages that make them suitable for our lab classes: they can be easily acquired using standard keyboards, they are objective and they are sufficiently precise for our purposes.

Simple vs choice RT

RTs and accuracies provide us with information about the cognitive and neuronal mechanisms taking place in your minds and brains. Any processing going on in our brains takes time. And more complicated things take more time (and typically increase error rates)!

Let us take a look at what is perhaps *the* classic example of the idea that adding extra processing demands slows us down: The comparison of **simple and choice reaction time**. The cost of making a simple two-alternative choice is typically in the range of 75 to 200 ms. Given that RTs in a simple reaction time task are typically between 200 and 350 ms, this represents a substantial cost.

The idea of comparing simple and choice reaction time was introduced by Franciscus Donders more than 150 years ago in one of the most influential publications in the history of psychology (Donders, 1969)[2]. In his own words:

[1] The terms response time and reaction time are often used synonymously and refer to the length of time from stimulus onset (e.g., a picture on a screen) to movement offset (e.g., pressing down a key with a finger). Sometimes response time is defined as the sum of reaction time (i.e., time from stimulus onset to movement onset) plus movement time (i.e., time from movement onset to movement offset). Following this definition, in the above example reaction time would be measured from picture onset up to the point when the finger starts moving. Movement time on the other hand would be the length of time from when the finger starts moving to when the key is fully depressed. For simple responses (such as key presses), this distinction doesn't usually matter. For more complex responses (such as, say, pointing responses involving whole arm movements), separating reaction and movement time can be of interest.

[2] This is the 100th anniversary reprint. The original was published in 1869.

> The idea occurred to me to interpose into the process of the physiological time [i.e., simple reaction time, J.D.] some new components of mental action. If I investigated how much this would lengthen the physiological time, this would, I judged, reveal the time required for the interposed term.
>
> F. C. Donders (1869), *On the speed of mental processes*

We have implemented a version of the simple and choice reaction time task for you to try out. It takes about 2 minutes to complete. Once the experiment is complete, you will be automatically forwarded to an interactive app where you can view a leaderboard, the group results and individual results. Note that in this example, **response time is our DV** and **type of task (simple vs choice) is our IV**. Try to be as quick as possible to make it to the top of the leaderboard!

Click on this link to run the experiment. (This link opens in a new browser tab or window.)

Click here to go to the interactive app with the results.

< fa stopwatch > Try it out!

To explore these tasks further, you could:

- Repeat the tasks a few times. How reliable are your RTs/choice costs?
- Repeat the tasks at different times of the day. Do your RTs/choice costs seem to depend on the time of the day?
- Ask others to try it out: Are your flatmates/siblings/parents/grandparents faster or slower than you?

Reference

Interference tasks and cognitive control

Lab class

Next, we are going to have a look at slightly more complicated experimental paradigms that have been used to study interference and cognitive control, the Stroop task and the flanker task. In **interference tasks**, there are at least two sources of information or dimensions presented to the participant; one of these is the **task-relevant dimension** and the other the **task-irrelevant dimension**.

Stroop task

The **Stroop task** (Stroop, 1935) is likely the most well-known interference task. In the interference condition, participants are presented with colour words printed in a colour that does not correspond to the meaning of the colour word and are instructed to indicate the colour of the word (and to ignore its meaning). Thus, **the colour of the word is the relevant dimension, and the meaning of the word the irrelevant dimension** (see Figure 1).

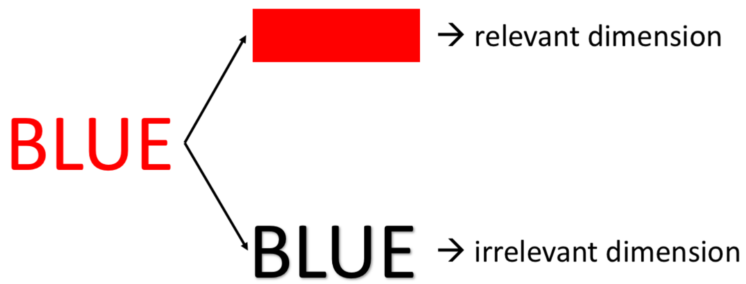


Figure 1: Relevant and irrelevant dimensions in the Stroop task.

A key concept for many experiments is that of **a trial**. Think of a trial as a **stimulus-response cycle** in an experiment. In the Stroop task, a trial begins when a colour word is presented. After a short time, the participant responds (e.g., by pressing a key on a keyboard). After the response, there might be a short break of a few 100 ms before the next stimulus comes up. This completes the trial. Overall, a trial in the Stroop task might take about 1 to 1.5 s.

Clearly, this is very different from the meaning of the word "trial" in the context of a clinical study where "trial" refers to the complete study. Make sure to distinguish these two meanings! [1]

[1] Also, note that "trial" might be auto-corrected to "trail" by some pieces of software. If this does happen, you might want to tell your software that it should not auto-correct "trial".

In a Stroop trial, the two sources of information can be conflicting, in agreement, or they are unrelated. When they conflict, the trial is **incongruent** or incompatible. When they are in agreement, the trial is **congruent** or compatible. And when they are unrelated, the trial is **neutral**. Figure 2 illustrates these three trial types for the Stroop task.

Figure 2: Example incongruent, congruent and neutral trials in the Stroop task.

When a Stroop trial is incongruent, the presence of the irrelevant dimension creates **cognitive conflict** that has to be resolved to give a correct response. Cognitive psychologists assume that we need to exert **cognitive control** (also referred to as executive control, top-down control or attentional control) to resolve this conflict. Resolving this conflict takes time and effort. Therefore, incongruent mean RTs are slower than congruent mean RTs and neutral mean RTs. Also, incongruent trials are associated with higher error rates. Both of these effects are referred to as **interference effects**.

Sometimes, but not as consistently, **facilitation** is observed (i.e., congruent mean RTs can be *faster* than neutral mean RTs).

Flanker task

Another well-known interference task is the **flanker task**. The classic demonstration of the flanker interference effect was reported by B. A. Eriksen & Eriksen (1974). In the visual flanker task (there is also an auditory version), a target is presented in the middle of screen. On both sides of the target are the flankers. The target is relevant, the flankers are irrelevant. One popular version of the flanker task uses letters. In the letter flanker task, you might receive the following set of instructions:

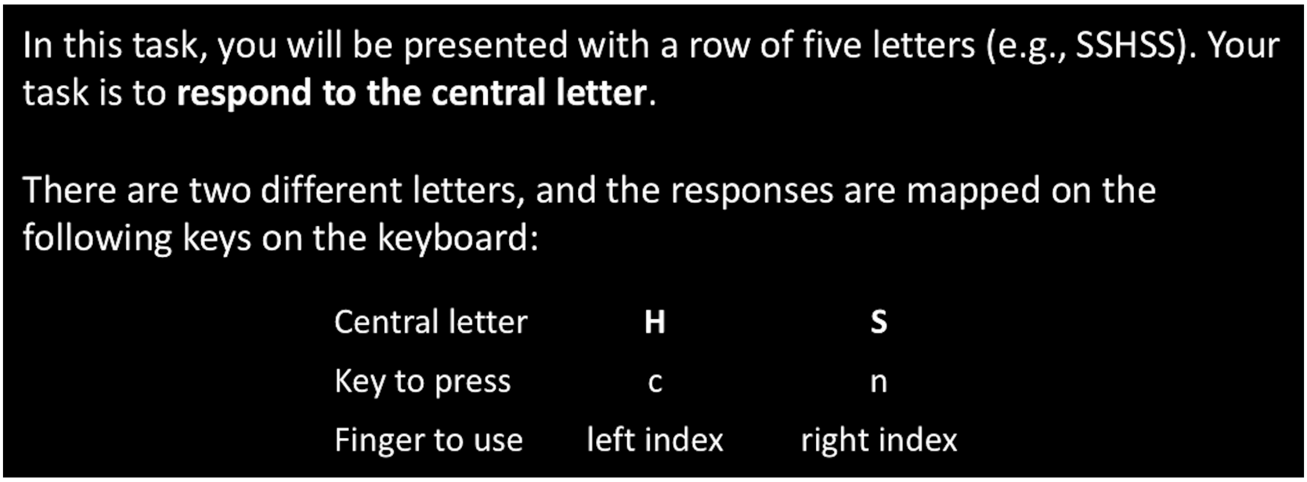


Figure 3: Example instructions for a letter flanker task.

HHSHH	HHHHH	BBSBB
incongruent	**congruent**	**neutral**

Figure 4: Example conditions in a letter flanker task.

Based on these instructions, we can again create incongruent, congruent and neutral trials (see Figure 4).

The **flanker effect** refers to a slowing of RTs in incongruent relative to neutral/congruent trials and/or a decrease in accuracy in incongruent relative to neutral/congruent trials.

Note the following key characteristics of this task:

- The **incongruent condition** is incongruent because the two **letters are mapped onto different responses**. The fact that the target and flanking letters are different is in itself not sufficient (otherwise there could not be a neutral condition…). The key is that they are associated with different responses in the context of the task.
- The **congruent condition** is congruent because the two **letters are mapped onto the same response**. The fact that the target and flanking letters are identical will speed up the response, but is not a requirement for a congruent trial (e.g., you could map two letters onto the same response, present these two letters as target and flankers, respectively, and it would still be a congruent trial).
- The **neutral condition** is neutral because the flanking **letters are not associated with a response** in the context of the task.

Self-study

Explanations for interference effects

Explanations of the interference effect in the Stroop task typically stress that we are highly practised readers. According to one influential model (Cohen et al., 1990), this implies that our "word reading pathways" are therefore stronger than our "colour naming pathways".[2] The function of cognitive control mechanisms is to boost the colour naming pathway (and/or, depending on the researcher's predilections, to inhibit the word reading pathway).

Explanations of the flanker interference effect assume that we are not able to consistently focus our attention solely on the target and that we therefore also tend to process the flankers (C. W. Eriksen & St James, 1986; White et al., 2011). Cognitive control mechanisms are involved in focusing our attention on the target.

[2] "Pathways" should not be understood to imply neuronal pathways specific to word reading and colour naming. Instead, both of these functions will involve a network of brain areas and the neuronal tracts connecting them.

Understanding interference effects in cognitive tasks

To reiterate: **Interference effects** are a measure of the time and effort it takes us to resolve the interference.

They can be expressed as a **slowing down in response time**. For example, we might say that participants were on average 200 ms slower in incongruent Stroop trials as compared to congruent Stroop trials.

On some trials, the interference resolution mechanisms might fail and the participant gives an incorrect response. Thus, an interference effect can also result in **increased error rates**. For example, we might say that the average difference in error rates in incongruent and congruent Stroop trials was 15%.

Relevance of interference effects

Interference effects are relevant for **cognitive psychology** as they reveal how well we are able to focus on relevant information and ignore irrelevant information.

They are also relevant in **applied psychology** (e.g., when designing user interfaces for appliances, machines or software) and **clinical psychology** (e.g., cognitive control is affected in **developmental disorders** such as ADHD (Mullane et al., 2009; Onandia-Hinchado et al., 2021) and psychiatric conditions such as schizophrenia (Lesh et al., 2011; Westerhausen et al., 2011)).

Although interference effects might seem straightforward, they are powerful tools for investigating cognition. They cannot be avoided if participants follow task instructions, making them a reliable window into cognitive processes. These effects reveal fundamental limitations of our cognitive system, such as the difficulty of suppressing irrelevant information.

Beyond this, interference measures can uncover basic mechanisms that underlie higher-order disorders like ADHD, where deficits in attention control are prominent, making them essential for understanding both typical and atypical cognition.

Confirmation

> **!** Important
>
> Please confirm you have worked through this chapter by submitting the corresponding chapter completion form on Moodle.

UoN interference examples

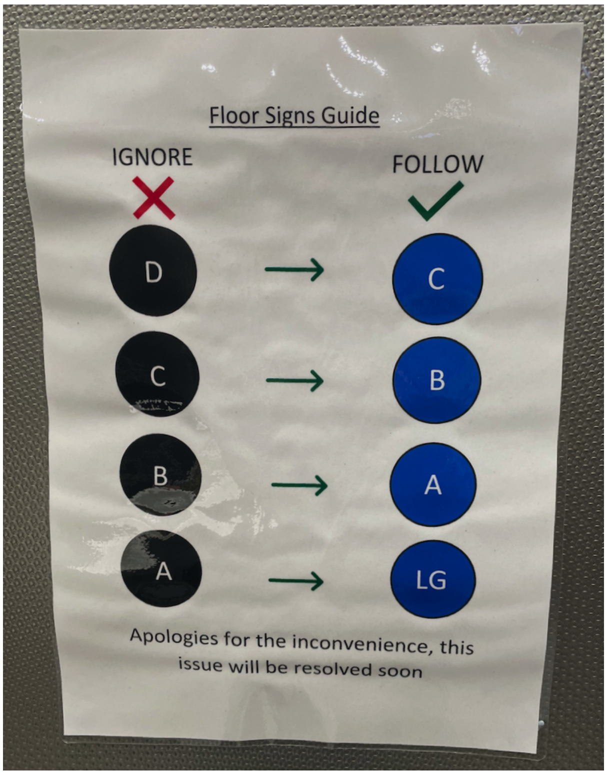
Self-study

The School of Psychology lift

The floors in the Psychology building are labelled LG (lower ground), A, B and C. Confusingly, for a while the labels in the lift were A, B, C and D:

So, in the lift, the LG floor is the A floor, the A floor is the B floor, and so on. If you would like to go to, say, the C floor, you need to press D in the lift:

That this is confusing did not go unnoticed and someone decided to print a guide in an attempt to make things less confusing:

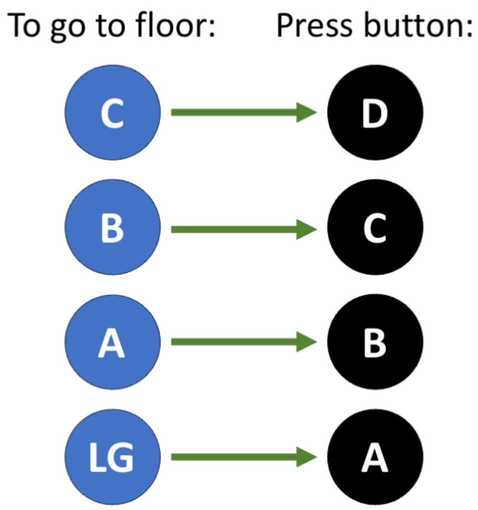


< fa lightbulb > Food for thought

What do you think about this design? Do you think you can design a better version? What would your version look like?

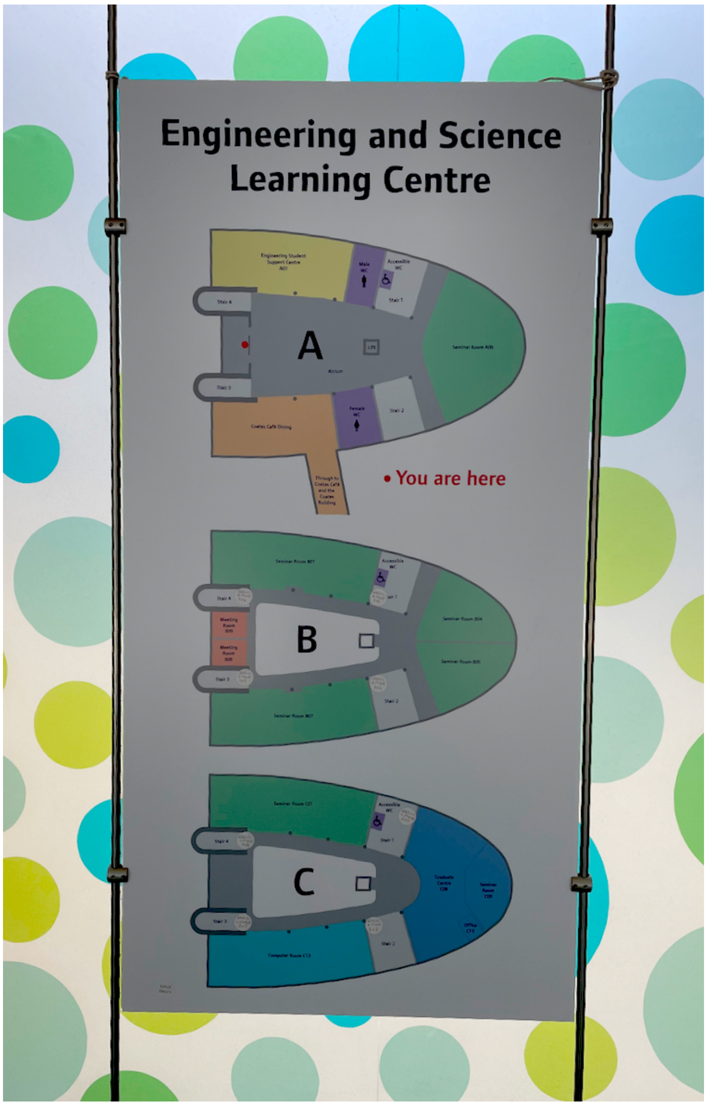
Think about this, then click here to view my answer

Here is my suggestion. I would argue that you can't really "ignore" the existing buttons as the design above suggests. In my view, a sign like this would have been clearer:



The ESLC floor plan map

Then again, what the lift sign did get right is the spatial relationship of the floors. For example, Floor C is located above Floor B, and this spatial relationship is reflected on the sign. Makes intuitive sense, right? Because of this, one should think that this principle is adhered to everywhere. Well, not in our ESLC building. In this building, the A floor is the ground floor, the B floor is one floor up and the C floor is the top floor. On the building's floor plan map, however, the A floor is on top and the C floor is at the bottom:



This creates a **spatial incongruency** that could have been avoided by having the floors on the map reflect the real-world physical arrangement of the floors.

Confirmation

> ❗ Important
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> Please confirm you have worked through this chapter by submitting the corresponding chapter completion form on Moodle.

A little bit of history

Self-study

Experimental psychology evolved in 19th century Germany. Figure 1 shows three of the key scholars involved.

Figure 1: Gustav Fechner, Hermann von Helmholtz and Wilhelm Wundt.

< fa comments > Food for thought

Why were they all men?

Think about this, then read this answer

Women were simply not allowed to study! In Germany, women were only allowed to matriculate at universities starting between 1900 and 1909 (depending on the *Bundesland*). A notable, but also singular, exception was Dorothea Erxleben.
In England, the first degrees for women were awarded by the University of London in 1878 (although Oxford only followed suit in 1920 and Cambridge in 1948!). Beatrice Edgell was the first female psychology professor in the UK. She was appointed in 1927 by the University of London.

Before the advent of experimental psychology, psychological theorising had been the purview of philosophers. Unfortunately, while coming up with some ideas highly relevant to psychology (see, e.g., John Locke, David Hume and John Stuart Mill), they were not interested in testing their ideas empirically.

In 19th century Germany, the physiologists mentioned above[1], among others, took a different approach and started to **perform experiments to empirically test ideas** relevant to the nascent field of psychology.

Among his many other contributions to science, in 1849 von Helmholtz measured **neuronal conduction speeds** and showed that, while neuronal conduction was fast (about 25 to 40 m/s in frog neurons), it was not so fast that it could not be measured.[2] This insight opened the door to **investigating the human mind by measuring the time it took to complete certain tasks**.

Fechner on the other hand, building on the work of Ernst Heinrich Weber, established the field of **psychophysics**.

And, in 1879, Wundt founded the **first psychological institute** in the world at the University of Leipzig. According to Boring (1950), he should be considered **the first psychologist**.

Confirmation

! Important

Please confirm you have worked through this chapter by submitting the corresponding chapter completion form on Moodle.

[1] Notably, Fechner, von Helmholtz and Wundt had all studied medicine, not philosophy. That said, they were not just physiologists or psychologists. Boring (1950) notes that Fechner "was for seven years a physiologist (1817-1824); for fifteen a physicist (1824-1839); for a dozen years an invalid (1839 to about 1851); for fourteen years a psychophysicist (1851-1865); for eleven years an experimental estheticist (1865-1876); (…) recurrently and persistently a philosopher (1836-1879); and finally, during his last eleven years, an old man whose attention had been brought back (…) to psychophysics (1876-1887)" (p. 283). Von Helmholtz was also an eminent physicist. And Wundt was also a philosopher.

[2] Even Johannes Müller, one of the most eminent physiologists of the time, was of the opinion that neuronal conduction speeds must be so fast they cannot be measured (Cobb, 2020).

Quiz 2

Quiz details

- Available from **Thursday, 23 October at 3pm** in the **Quizzes and assignments** section on Moodle.
- **Deadline: Thursday, 6 November at 3pm.**
- The quiz consists of 40 questions covering Chapters 10, 11, and 14 of Beth's book.
- The quiz is time-limited: Once you start, you have 40 minutes to complete it. Make sure to read the chapters before attempting the quiz.
- All other details (including AI use) are the same as for Quiz 1.

If you have a support plan:

- The time limit can be adjusted in accordance with your support plan. **If you have already asked for extra time for Quiz 1, I will apply the same percentage of extra time to Quiz 2.** If you have not contacted me about extra time for the first quiz, but you would like to have extra time for your second quiz, please contact me by email well before the deadline.
- If on the other hand you need a deadline extension, please fill in the coursework extension form for students with support plans.

Quiz FAQs

Q: How difficult will this quiz be?

A: The main purpose of the quiz is to ensure that you have read the relevant book chapters and have understood the key concepts. To give you an idea of the quiz difficulty, over the past few years, the average quiz mark has ranged between 74 and 80%, and the percentage of fail marks (i.e., marks below 40%) for this quiz has ranged between 0 and 1%.

Explore, apply, reflect

Lab class

Article reading exercise

For this activity, you will need to **read parts of an empirical journal article**. It's important to start reading primary research literature[1] early in your course. As discussed in Chapter 2 of Beth's book, empirical journal articles are the main way new findings are communicated in psychology.

Remember that **30% of your overall module mark** will come from a lab report you write next semester. **Every primary research article is essentially a lab report.** So, if you want to understand how lab reports should be written, regularly reading journal articles is a great idea.

Before starting, you might want to revisit the section "Reading the Research" in Chapter 2 of Beth's book. I agree with everything Beth says, but I want to **champion the method section**, which I think is the most under-appreciated part of an article. If you really want to understand what happened in a study, read the method section. It often provides the deepest insights into what the researchers actually did.

The article you are about to read (Avital-Cohen & Tsal, 2016) examines the flanker interference effect. There's a twist: the flankers are either letters or numbers, and some are ambiguous (e.g., O could be the number 0 or the letter O). Avital-Cohen and Tsal show that these ambiguous stimuli only elicit interference if participants interpret them as letters.

This finding is interesting because interference effects are often thought to be automatic (not under voluntary control) or driven by **bottom-up processing** (determined by the stimulus rather than your goals or instructions). In contrast, Avital-Cohen and Tsal's results show that **top-down processing** does influence interference in the letter flanker task. This article is also a great example of how classic tasks can still yield new insights!

Your task

For Experiment 1 in the article, please identify:

1. The design (i.e., between-subjects or within-subjects).
    - If between-subjects, posttest-only or pretest/posttest?
    - If within-subjects, was there any counterbalancing employed? If yes, how was this done?

[1] Primary research literature reports original data collected by the authors, whereas meta-analyses aggregate and analyse data from multiple existing studies rather than collecting new raw data.

2. The IV(s), and the levels of the IV(s) (see hint below if you get stuck)
3. The DV(s).
4. Examples of constants.

Optional questions:

1. How many trials did the experiment consist of overall?
2. Can you think of a follow-up experiment to further investigate the effect?

Please work on this activity in pairs and use Copilot to clarify any terms you don't know. Make sure you agree on one answer per question and write it down.

Before you start reading the article:

- Think about which sections of the article (i.e., introduction, method, results, discussion) might be most relevant to answering the questions below, and focus on these sections.
- Please note that to make it easier for you to identify the relevant parts of the article we have removed information pertaining to Experiment 2 from the article.

Click here to download the article.

Show/hide hint for Question 1 (between vs within)

In a between-subjects design, different participants are exposed to different levels of the IV. In a within-subjects design, all participants are exposed to all levels of the IV.

Show/hide hint for Question 1 (pretest/posttest vs counterbalancing)

In a posttest-only design, groups of participants are randomly assigned to levels of the IV and are tested on the DV of interest only once. In a pretest/posttest design, they are tested on the DV twice, once before and once after exposure to the IV. Counterbalancing aims to control order effects in within-subjects designs. This can be achieved by full counterbalancing. E.g., if there were three different conditions (A, B and C) in an experiment, full counterbalancing would require six different orders:

```
A B C
A C B
B A C
B C A
C A B
C B A
```

Note that while the order of conditions would differ across participants, this is still a within-subjects design as all participants are exposed to all conditions.

Show/hide hint for Question 2

Note that there are *two* IVs in this experiment.

The following document with the answers to the above questions is password-protected. We will tell you the password in the lab class.

Click here to download the file with the answers.

Reference

References

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