CPEP

(Cognitive Psychology Experiment Package)

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This resource currently contains the following components:

1. **Objects in motion** – An investigation of participants' understanding of Newton's 1st law.
2. **Tower of London** – An investigation of the factors affected the difficulty of unfamiliar sequential problems.
3. **Phillips Effect** – An investigation of the effect of delay and pattern complexity on memory for abstract visual patterns.

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"Objects in Motion" experiment

Installing, running, and getting the data

The program for this experiment only works under Windows (it has been tested on Windows 98 and XP). Ideally, you should install the *London* program on your PC by running the installer provided. If you do not have access to a machine on which you can install software, then you can try running the *Motion* program directly. This latter option is not guaranteed to work.

Once installed, run the program from the *Start* menu, Give your participant the printed instructions, make sure they understand them, and then leave them to do the experiment.

At the end of the experiment, the participant will be asked to enter a number. Make sure each of your participants enters a different number – if you reuse a number, you will lose data. You will find the data in text files in the root directory of your C drive (open "My Computer", and double click on the drive marked " (C:)"). Each participant produces a separate file, and each file contains 12 lines:

```
0
0
1
0
0
1
1
0
0
C
C
A
```

You can ignore the first nine lines. The remaining three lines record the answers given by your participant to the three problems, in the order listed in the program.

<u>Advanced users note:</u> This is for advanced users only. If you don't understand these instructions, please do not attempt to follow them. Otherwise, read on. If you would like the data to be saved somewhere other than C:, then create a file called "path.txt" and put the full path of where you want the file saved into this text file (e.g. C:\Data). Save the file *path.txt* in the same directory as *london.exe*

Theoretical background

This experiment examines peoples' understanding of Newton's 1st Law of Motion "Objects continue to move in a straight line at a constant speed unless acted upon by some external force". Gravity is the external force.

In the case of car, the cliff provides an exactly opposing force to gravity so the car travels in a straight line. Once the car is over the cliff, gravity is the only major external force and so the car is pulled downwards. The left-to-right motion is maintained because there is no force to stop it (air resistance will provide some opposing force, but this would not be sufficient to stop the left-right motion or reverse it).

The physics of the bomb's motion are identical. The support from the aeroplane provides an upwards force that exactly counters gravity. When that force is removed, the bomb accelerates downwards. The left-to-right motion is maintained because there is no force to stop it. Again, air resistance would not lead to the other two motion options.

Nevertheless, you will probably find that more people get the car question right than the bomb question. McCloskey argues that this is because many people's intuitive theories of motion are impetus-based. The car powers itself along, so it has its own impetus. Therefore it's left-to-right motion is maintained. The bomb, on the other hand, only moves left-to-right because it is carried. The aeroplane has its own impetus but the bomb does not. Therefore, once the bomb is released it falls straight down because it never had any left-right impetus.

The weight: The weight on the string is not travelling in a straight line and so some force must be acting upon it to make it change direction. That force is provided by the string. When the string breaks, it no longer exerts a force and so the only force acting upon the weight is gravity. Seen from above, the weight continues in a straight line in the direction it was travelling at the point the string broke. *People often say the weight travels on a curved path after the string breaks.* This can again be explained by an impetus-based naive theory of physics. The weight is travelling in a circle. This is because of the action of the string, but what the string does is impart a curved impetus to the weight. The weight follows that path after the string breaks, possibly straightening slightly as the effect of the string decays with time.

Impetus theory was the prevailing scientific wisdom prior to Newton.

Eysenck and Keane (1995 / 2000, Chapter 16) provides a good introduction to the psychology of naïve physics.

References

Eysenck, M.W. & Keane M.T. (1995 / 2000). *Cognitive psychology: A student's handbook.* Hove: LEA.

Participants' instructions

In this experiment you'll see three different animations for each of three objects in motion. Your job is to work out which animation is closest to the way the object in question would actually move. Click on the first blue button, and then view all the animations of the car driving off a cliff. Decide which is the correct animation and then click on the "Exit" button. Enter your decision (A, B or C) in the box to the immediate right of the button. Now do the other two objects.

Each animation has an "action replay" feature. This slows down the action so you can inspect the path taken by the object in more detail. Use this feature if you are unsure about which animation to choose.

Tower of London experiment

Installing, running, and getting the data

The program for this experiment only works under Windows (it has been tested on Windows 98 and XP). Ideally, you should install the *London* program on your PC by running the installer provided. If you do not have access to a machine on which you can install software, then you can try running the *London* program directly. This latter option is not guaranteed to work.

Once installed, run the program from the *Start* menu, Give your participant the printed instructions, make sure they understand them, and then leave them to do the experiment.

At the end of the experiment, the participant will be asked to enter a number. Make sure each of your participants enters a different number – if you reuse a number, you will lose data. You will find the data in text files in the root directory of your C drive (open "My Computer", and double click on the drive marked " (C:)"). Each participant produces a separate file, and each file contains 18 lines. Here's what each of the lines means:

```
0        - Error on  3-move problem (1 = error; 0 = correct)
1        - Error on  7-move problem (1 = error; 0 = correct)
0        - Error on  9-move problem (1 = error; 0 = correct)
0        - Error on 13-move problem (1 = error; 0 = correct)
3        - Planning time (sec) on 3-move problem
         - Planning time (sec) on 7-move problem
6        - Planning time (sec) on 9-move problem
2        - Planning time (sec) on 13-move problem
5        - Time to execute solution on 3-move problem.
         - Time to execute solution on 7-move problem.
14       - Time to execute solution on 9-move problem.
19       - Time to execute solution on 13-move problem.
0        - Probability of an error on 5-move (zero sub-goal moves) problems
0        - Probability of an error on 5-move (two sub-goal moves) problems
3        -  Mean planning time (sec) on 5-move (zero sub-goal moves) problems
3.5      -  Mean planning time (sec) on 5-move (two sub-goal moves) problems
6        -  Mean time to execute  (sec) on 5-move (zero sub-goal moves) problems
7        -  Mean time to execute  (sec) on 5-move (twi sub-goal moves) problems
```

It is likely that one or more of the lines containing times will be blank (because, if no correct answer is given, then mean reaction time for correct trials would be undefined, and so the computer leaves a blank line). "Error" in this context means that the participant did not complete the problem in the minimum possible number of moves.

Advanced users note: This is for advanced users only. If you don't understand these instructions, please do not attempt to follow them. Otherwise, read on. If you would like the data to be saved somewhere other than C:, then create a file called "path.txt" and put the full path of where you want the file saved into this text file (e.g. C:\Data). Save the file *path.txt* in the same directory as *london.exe*

Methodological details

There are 3 practice problems followed by eight problems for which data is recorded. The non-practice problems comprise problems that vary in the minimum number of steps required for solution. There is one 3-move, four 5-move, one 7-move, one 9-move, and one 13-move problem. Amongst the 5-move problems there are two which do not require sub-goal moves, and two which each require two sub-goal moves. A sub-goal move involves moving a ball from its starting position to somewhere other than its goal position. The non-practice problems are presented in random order. The "too slow" sign flashes if any move takes more than two seconds to execute. Times are recorded to the nearest second.

Theoretical background

This experiment is modelled on Ward and Allport (1997), and is an investigation of the factors that affect the difficult of finding a solution to an unfamiliar problem. The *Tower of London* task employed is often used in the testing of neuropsychological patients, and is a development of the classic *Tower of Hanoi* problem. A good introduction to this kind of sequential problem-solving task is given by Eysenck & Keane (1995 / 2000, Chapter 15).

One would obviously expect that more complex problems would be more difficult, but what exactly do we mean by complexity? This experiment investigates two factors:

Number of steps from start to goal. If people solve novel problems by rehearsing various solutions in a step-by-step manner, then increasing the number of steps needed should increase the difficulty. Difficulty is assessed here by errors (using more than the optimum number of moves), and planning time. Execution time is included for completeness.

Number of sub-goals. Some problems can be solved by simply moving discs to their goal pegs in the correct order. Others require moving a disc "out of the way" to a non-goal peg so that other discs can be moved. This effectively introduces a sub-goal in to the solution, and this might be expected to increase complexity. In the experiment, the participant performs a number of different five-move problems. Half of those problems don't require any sub-goal moves, the other half required two sub-goal moves. We'd expect the two sub-goal move problems to create more errors, and produce higher planning times. If it affects execution time then subjects cannot be totally formulating their plan before they start, which is interesting in itself.

References

Eysenck, M.W. & Keane M.T. (1995 / 2000). *Cognitive psychology: A student's handbook.* Hove: LEA.

Ward, G. & Allport, A. (1997). Planning and problem-solving using the five-disc Tower of London task. *Quarterly Journal of Experimental Psychology, 50A,* 1, 49-78

## *Participants' instructions*

This is an experiment about problem-solving. When you click on the "BEGIN" button, five discs are placed on the three pegs in the window marked "Start". Your task is to move the discs within the "Start" window so their arrangement matches that of the discs in the "Goal" window.

Rules of the game

- A disc cannot be moved if it has another disc on top of it.
- You can only move one disc at a time.

How to move discs

1. Click on the peg from which you want to remove a disc.
2. Click on the peg to which you wish to add that disc.
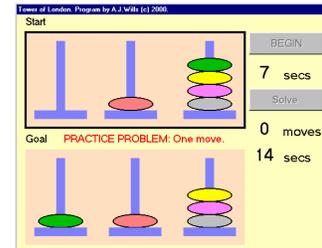
Importance of planning

In this experiment, you must work out exactly how you are going to solve the problem before starting to move any discs. The maximum number of moves you are allowed to make for any particular problem is shown in red on the screen. Work out a plan that takes no more than the number of moves stated. Once you have your plan, click on the "Solve" button and implement it in one smooth sequence of moves. **DO NOT START UNTIL YOU HAVE A COMPLETE PLAN.**

Time pressure

The amount of time you take to formulate and execute your plan is measured. You should take as long as you need to formulate a plan. Once you click the "solve" button, you have just 2 seconds to execute each move. If you take too long, the computer will flash a warning message at you. Try to avoid this happening.
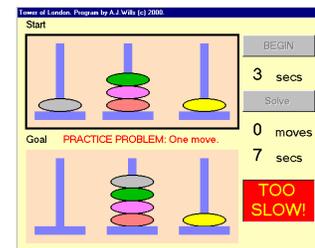
Multiple problems

There are 11 problems to be solved. The first three are simple practice problems to give you a chance to get used to the program.

Phillips' Effect Experiment

Installing, running, and getting the data

The program for this experiment only works under Windows (it has been tested on Windows 98 and XP). Ideally, you should install the *Phillips* program on your PC by running the installer provided. If you do not have access to a machine on which you can install software, then you can try running the *Phillips* program directly. This latter option is not guaranteed to work.

Once installed, run the program from the *Start* menu and enter the number of blocks the experiment should run for (six blocks is assumed in the participant instructions provided). Give your participant the printed instructions, make sure they understand them, and then leave them to do the experiment.

At the end of the experiment, the participant will be asked to enter a number. Make sure each of your participants enters a different number – if you reuse a number, you will lose data. You will find the data in text files in the root directory of your C drive (open "My Computer", and double click on the drive marked " (C:)"). Each participant produces a separate file, and each file contains 8 lines. Here's what each of the lines means:

33.3333333333333   - Percentage error rate for 4 by 4 patterns with a 20ms delay
33.3333333333333   - Percentage error rate for 8 by 8 patterns with a 20ms delay
50   - Percentage error rate for 4 by 4 patterns with a 1000ms delay
50   - Percentage error rate for 8 by 8 patterns with a 1000ms delay
375   - Mean reaction time (ms) for trials for which the correct answer was given (4by4,20ms)
500   - Mean reaction time (ms) for trials for which the correct answer was given (8by8,20ms)
375   - Mean reaction time (ms) for trials for which the correct answer was given (4by4,1000ms)
468.75   - Mean reaction time (ms) for trials for which the correct answer was given (8by8,1000ms)

There is a slight chance that one or more of the last four lines will be blank (if no correct answers are given, then mean reaction time for correct trials would be undefined, and so the computer leaves a blank line).

Advanced users note: This is for advanced users only. If you don't understand these instructions, please do not attempt to follow them. Otherwise, read on. If you would like the data to be saved somewhere other than C:, then create a file called "path.txt" and put the full path of where you want the file saved into this text file (e.g. C:\Data). Save the file *path.txt* in the same directory as *phillips.exe*

Methodological details

Each stimulus is created randomly. 8 by 8 patterns are randomly black and white across the whole array; 4 by 4 patterns only use the central 4 by 4 area. The delay between the first and the second pattern is either approximately 20ms (millisecond accuracy is not guaranteed; you will need to use a program like *E-prime* if you need this – this program basically uses as short a delay as the system you are running on can manage with the relatively slow environment [Visual Basic 6] being used here) or 1000ms. The two patterns on a trial are either identical, or differ by exactly one square.

Each block consists of 24 trials – six occurrences of each combination of pattern size and delay. Order of presentation is randomized within each block

Theoretical background

This is a spoiler - you should not read it before trying the experiment, and neither should your participants.

This experiment is based on the work of Phillips (1974). . Chequerboard patterns are chosen because they are very difficult to name.The expected result is that participants will be near-perfect at both large and small patterns at the short delay, but that they will be substantially better at the smaller patterns when the delay is increased. This interaction of delay and pattern complexity can be explained by reference to the

Atkinson and Shiffrin (1968) *modal model* of memory that posits multiple stores – sensory registers, a short-term store, and a long-term store. The long-term store is not needed to explain these results and is not discussed here. The sensory registers are very high capacity (near photographic in the case of the visual sensory register – *iconic* memory) but very limited in duration. Short-term store is somewhat more persistent, but very limited in capacity. At the very short delay, the participant can rely on iconic memory and hence pattern complexity is not a problem. At slightly longer delays, the participant must rely on the short-term store. As this store is limited in capacity, pattern complexity should now be a factor – will simple 4 by 4 patterns being easier to recall than complex 8 by 8 patterns.

A good general introduction to the psychology of human memory is provided by Baddeley (1990 / 1997).

References

Atkinson, R.C. & Shiffrin, R.M. (1968). Human memory: A proposed system and its control processes. In K.W. Spence (Ed.). *The psychology of learning and motivation: advances in research and theory Vol. 2*(pp. 89-195). New York: Academic Press

Baddeley, A. (1990 / 1997). *Human memory: Theory and practice.* London: Lawrence Erlbaum Associates.

Phillips, W.A. (1974). On the distinction between sensory storage and short-term visual memory. *Perception and Psychophysics, 16,* 283-290.

Participants' instructions

This experiment is a test of memory. Patterns like the one below will appear on the screen:
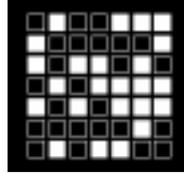
        The pattern represents the array of lights. A filled square represents a light that is turned on. An unfilled light represents a light that is turned off.

        Patterns are presented in pairs. The first pattern in the pair will be shown for one second and will then disappear. It will then be replaced by another pattern. The second pattern will either be IDENTICAL to the first, or it will differ by ONE square. This is where the memory aspect comes in.

        When the word "Respond" appears in big red letters, you need to make a decision:

If you think the second pattern is identical to the first pattern:
- You should press the > key (with your right index finger, no need to use the SHIFT key).

If you think the second pattern is different to the first pattern:
- You should press the X key (with your left index finger, no need to use SHIFT key).

    PLEASE RESPOND AS QUICKLY AS POSSIBLE WHILST AVOIDING ERRORS.

Sometimes the delay between the first and second patterns in a pair will be a few seconds. Other times, the delay will be so short that you will perceive no delay at all. If the first and second patterns are the same, it can look like only one pattern has been shown. However, you will always know when both patterns have been shown because the word "Respond" appears.

        Many pairs of patterns will be presented in this experiment. The computer signals that it is about to show the next pattern by presenting a small '+' in the centre of the screen. The experiment consists of 144 decisions. These are divided into 6 blocks of 24 decisions. You can rest for a few seconds at the end of each block.

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