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# Effects of Implicit Learning on Temporal Image Patterns

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Human beings have an amazing mechanism for acquiring new information. This system can not only handle extremely complex situations but can also operate without in the background of people's lives. Most people usually do not realize that much of what they know – the social rules by which they live, the ever-changing world surrounding them, the numerous people in their lives with myriad types of personalities – silently register in their brains without their conscious knowledge.

So actually how fast and accurate is this type of learning? Does implicit learning exist in the simplest case such as recognizing trivial patterns in the order in which the pictures appear? Through this experiment, the very basis of implicit learning is investigated and the results are carefully analyzed.

## Method

### *Participants*

The participants of this experiment are 104 Carnegie Mellon undergraduate and graduate students whose ages vary from 17 to 28 years old. Half of the participants (52) were females while the other half was males. The participants were randomly selected from all majors and areas of studies. The majors of the participants therefore was not evaluated to be a factor in this study.

### *Apparatus*

All participants completed a 50 minute experiment via E-Prime on a computer. Data were collected by E-Prime and then analyzed with E-Merge, E-DataAid, and a statistic package Jmp.

### *Design & Procedure*

All participants were shown a series of pictures (4 pictures on each screen). From time to time, the word "Now" will appear on the center of the screen. The participant's job was to press the space bar as fast as possible while maintaining accuracy. The experiment was made up of 3 separate phases: Practice, Training, Testing. Practice phase was designed to familiarize the participant with the procedure of the experiment. All variables in the Practice phase were the same as in both Training and Testing phases. The only difference between the

Practice phase and other two was that the speed in which the pictures were shown on the screen was slightly slower in the Practice phase. Training phase marked the learning process of the participant. Training phase composed four (4) blocks of 100 trials (i.e. 100 screens of pictures). Finally, the Testing phase checked whether the participant had implicitly learned to respond to the work "Now" faster. Testing phase contained one block of 100 trials.

Between blocks of 100 trials, there were also "Break" sections. During the break, the participant was asked to recall whether he/she had seen the particular picture in the experiment so far. The question took a “yes” or “no” format. This would mask the real objective of the experiment and would remove the possibility of demand characteristics of the participants. All break sections contained 10 of such questions.

There were a total of 24 pictures used in this experiment. To avoid confound in the experiment, these pictures varied in terms of color, brightness, and content. The sizes of the pictures were manipulated to be same in order for the participants to respond equally to all pictures. These pictures were selected to have comparable levels of visibility (i.e. no one picture would appear particularly flashy to the participant). To decrease the possibility of confound even further, only 15 of these pictures were randomly selected from the picture pool to be used in the experiment at the beginning of each run of the experiment. The rest of the 9 pictures would be used in the break sections to create some variety in the questions. Moreover, two random target pictures were also chosen: one for the Practice phase and the other for the Training and Testing phases. The target picture had a much higher percentage (90 percent chance) of being followed by “Now” than all other pictures (10 percent chance) shown to the participant. If implicit were to exist, then the participant’s reaction time to the word "Now" followed by the target picture will decrease.

*Data Collection*

After the participants completed the 50-minute experiment as described above, the data were automatically collected by E-Prime program. From the data, we would be able to tell the following: 1) reaction times of the participants to each appearance of “Now”, 2) the number of misses, times when the participant failed to respond to “Now”, and 3) the number of misfires, times when the participant responded to a screen that was not “Now”. Data from the Practice phase would not be used. Data from the Training and Testing phases would be collected and compared with a paired t-test.

Since the experiment instructed the participants to respond as quickly as possible while maintaining accuracy, most participants should have rather low number of misfires. We need

to filter through all participants data and discard the ones where the percentage of misfires exceeded 10 percent of total number of "Now" screens.

Finally, we average all reaction times of "Now" that followed the target picture and those that did not follow the target picture for each block of 100 trials.

## Results

If implicit learning were to exist in response to the image ordering patterns, then the following would be true: 1) the reaction time to the word "Now" that followed the target picture would be faster during the Testing phase than during the beginning of the Training phase, 2) the reaction time to the word "Now" that followed the target picture during the Testing phase would be faster than those that followed non-target pictures, and 3) the reaction time to the word "Now" at the beginning of the Training phase would be the same for those that followed the target picture and those that did not.

In Figure 1 and Table 1, you will see the average reaction times to the word "Now" that followed the target picture during both the Training and Testing phases (in response to claim 1). A paired t-test was run on the first block of 100 trials during the Training phase and the 100 trials during the Testing phase to find out whether there was statistical significance of implicit learning throughout the Training phase. The paired t-test showed the reaction time for the testing phase is less than that of the first Training phase with the p-value being greater than 0.005.

This first analysis shows that there is indeed a significant decrease in reaction time to the word "Now" that followed the target picture. However, how much of that decrease in reaction time was due to implicit learning alone? The next analysis will show that it was not simply the participants' increasing familiarity to the task that caused the decrease in reaction time. Rather, the effects of implicit learning of the ordering to picture patterns were still significant.

| Phase | Block | Mean RT (ms) | RT Std. Dev. |
|---|---|---|---|
| Training | 1 | 442 | 45 |
| Training | 2 | 422 | 37 |
| Training | 3 | 418 | 25 |
| Training | 4 | 405 | 32 |
| Testing | 5 | 388 | 35 |

Table 1

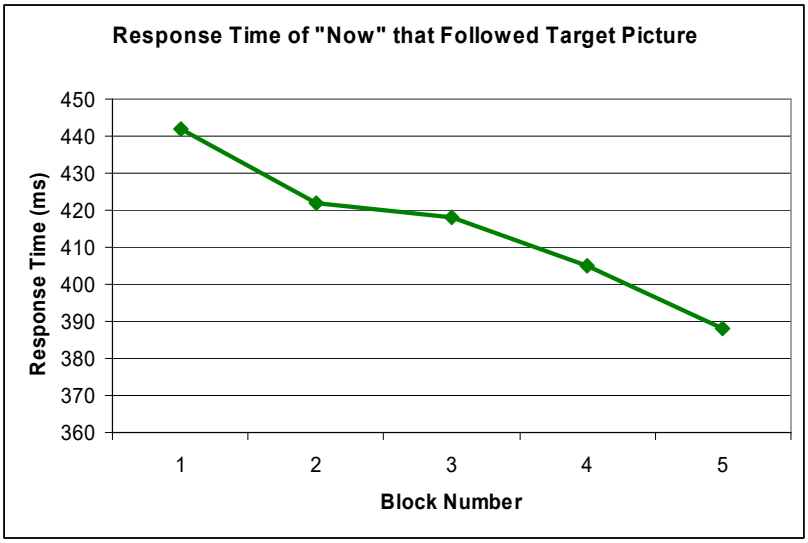


Figure 1

In Figure 2 and Table 2, you will see the average reaction times to the word "Now" that followed the target picture compared to those that did not follow the target picture during the final Testing phase (in response to claim 2 and 3). Another paired t-test between the two types of reaction times revealed that there was also significant difference between reaction time to the word "Now" that followed target picture and those that did not. The t-test had an p-value of greater than 0.005 as well.

| Follow Target Picture | Mean RT (ms) | RT Std. Dev. |
|---|---|---|
| Yes | 388 | 35 |
| No | 418 | 27 |

Table 2

As you can see from Figure 2, both types of reaction times were the same at the beginning of the Training phase. However, as training continued, the reaction time to "Now" the followed the target picture became increasingly faster. Although the reaction time to "Now" that did not follow target picture decrease as well, the drop was mainly due to increasing familiarity to the task.

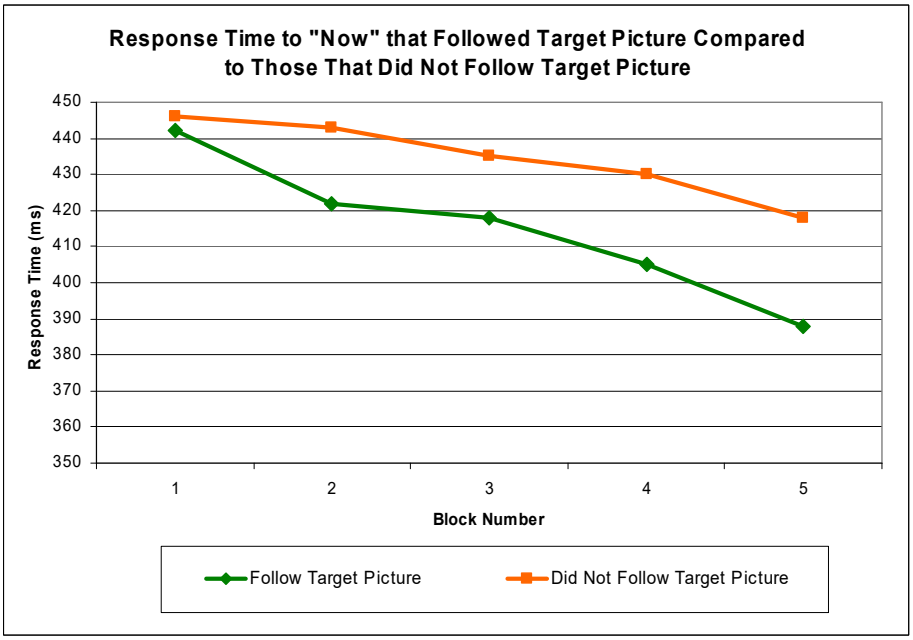


Figure 2

## Discussion

Psychologist, Arthur S. Reber first used the term "implicit learning". He designed an experiment to find out whether people would implicit learn an artificial grammar system. He instructed the participants to memorize strings of letters that used the artificial grammar system without revealing the existence of such grammar system. Later, after the training period, when the participant was asked to determine whether a string of letters was "grammatically correct", they performed much better than chance. Yet when they were asked whether they noticed any underlying structure to the letters, all of them said "no". (Berry, 1997) This result suggested that some learning processes, such as the artificial grammar structure described above occurred implicitly or unconsciously without knowledge of the learner.

Kotovsky, Hayes, and Simon from Carnegie Mellon University confirmed the above claim while studying people's problem solving methods. Participants of their experiments were asked to solve a puzzle that was similar to Towers of Hanoi, where the objective was to reach a certain goal state of the puzzle board given the starting state while obeying specific rules of the puzzle. For the first 10 to 15 tries, the participants mostly used a brute force method to solve the puzzle, which took more than few hundreds of moves to solve the puzzle. However, soon afterwards, the participants seemed to have learned the "trick" of the puzzle and were eventually be able to solve the puzzle in 23 moves. When they were asked

about whether they noticed any changes in their strategies of solving the puzzle, almost all of them denied and claimed that they had no idea how they solved the puzzle at the end. This study showed that implicit learning existed in the process of problem solving as well. People were able to learn the solution to a problem implicitly. (Kotovsky, 1985)

The experiment conducted in this study was a simple implementation to test the existence of implicit learning in recognizing temporal visual patterns. The underlying visual pattern in this experiment was the probabilistic relationship between the target picture and the appearance of the word "Now". As described earlier, the word "Now" had an extremely high probability of following the target picture. According to the results of the experiment, people did implicitly learn to expect the word "Now" after seeing the target picture. This was proven by the fact that the reaction time to the word "Now" that followed the target picture was significant shorter than those that followed non-target pictures at the end of the experiment. Therefore, there was clearly an indication of implicit learning of temporal visual patterns.

## Reference

Berry, D.C. *How Implicit Is Implicit Learning?* (1997) New York, NY: Oxford University Press.

Kotovsky, K., Hayes, J.R., & Simon, H.A. (1985) Why Are Some Problems Hard? Evidence From Tower of Hanoi. *Cognitive Psychology*, 17, 248-294.