

Showing the positive influence of subliminal cues on learner's performance and intuition: an ERP study

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Abstract. This paper presents results from an empirical study conducted with a novel subliminal teaching technique aimed at enhancing learners performance in an ITS. We replicated previous findings with the same technique but in a 2D environment. Non intrusive physiological sensors were used to record affective and cerebral responses. A brain analysis technique called Event-Related Potential (ERP), known to describe and confirm cognitive functions in the brain, provided strong evidence that subliminal cues and miscues were cognitively processed even though reported as not seen. The obtained results showed that only subliminal cues, not miscues, could significantly increase learner performance and intuition in a logic-based problem solving task.

Keywords: unconscious cognition, subliminal priming, ERP, intelligent tutoring systems, intuition.

1 Introduction

The aim of intelligent Tutoring Systems (ITS) has been to properly adapt learning material to the learner. However, a major component of learning and decision making when solving problems has been neglected: human intuition. In fact, a large body of work in neuroscience and other fields has put forth compelling evidence that learning simple to complex information can be done without perception or complete awareness to the task at hand [1, 2]. The existence of perceptual learning without perception has not only been proven [3], but replicated in a recent study two years ago [4]. In the present study, we hope to prove the usefulness of our novel subliminal learning technique by (1) replicating our previous findings, (2) presenting data to assess the presence of cerebral *endogenous* processing, that is processing *inside* the brain when subliminal stimuli is projected and (3) showing that positive subliminal cues can enhance the learner's intuition in decision making without his conscious perception.

2 Experiment and results

The focus of the experiment is to visually teach the construction of an odd magic square of any order without using mathematical operations (see [4] for complete details). EEG data and misdirection cues were added in this experiment with regards

to the last study [4]. The experiment was divided in 5 steps and 3 groups as follows: in **step 1**, a series of neuropsychological tests were administered. Learners then proceeded to **step 2** where the three required tricks to complete a magic square were taught by using either no subliminal cues (control group), subliminal positive cues (answer group) or subliminal misdirection (miscue group). Each stimulus was preceded by a 50 ms pre-mask of random geometrical figures, a 33.33 ms prime (2 frames of a 60Hz SVGA screen) and a 50 ms post-mask of random geometrical figures. We decided to show the learners multiple examples of each trick without explaining how the trick works. It was up to them to *deduce* the inter-workings of each trick. Learners reported how they deduced each trick by choosing between multiple-choice answers (intuition, logic or a mix of both). When all the three tricks were deduced, learners were instructed, in **step 3**, to respond to a series of 13 questions. The first 10 questions, Q1 to Q10 tested their knowledge of each learned trick. The last 3 questions however tested their knowledge of all three tricks combined. Learners reported how they answered each question by choosing between multiple-choice answers (guess, intuition, logical deduction, mainly by intuition or mainly by logical deduction). After answering all the questions, a series of post-tests were administered in **step 4** to test for prime awareness and overall system evaluation. Lastly, **step 5** displayed learner's performance (completion time and mistakes). A total of 46 healthy volunteers, 23 men and 23 women, took part of the experiment. The mean age was 27 (SD = 3.51). Each received a 10\$ CAN as compensation.

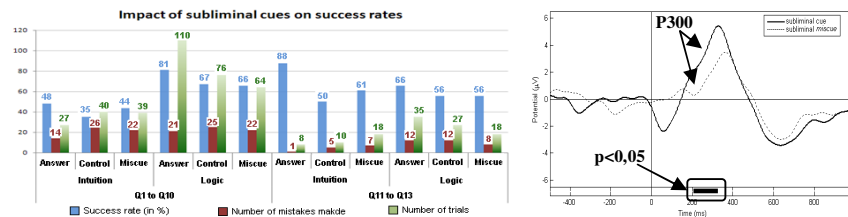


Fig. 1. Subliminal cues can enhance learner's intuition and evoke a P300.

Subliminal cues enhance performance based on intuitive decision making. At first glance, the numbers in fig. 1 seem to indicate a higher success rate for the answer group across all questions. However, a more fine grained analysis revealed a strong significant difference (one way ANOVA, $p=0.007$, $\alpha=0.05$) for the answer group when solving questions based on their intuition. This difference is much more pronounced for the last three questions where the knowledge of all the three tricks was required to answer properly. These questions are supposed to have a 50% success rate if one chooses to answer randomly. We can indeed observe that the success rate for the miscue and control group is approximately 55% whereas the answer group has an astounding rate of 88%. It is also important to note that perception of subliminal cues was assessed at the end of the experiment and none of the participants indicated seeing or noticing anything peculiar about the experiment. Furthermore, a P300 component was found for the subliminal groups (cue and miscue). The P300 component has been of specific interest for cognitive science since it has recently been involved in tasks where decision making is involved [5]. The results indicate

that a P300 component is elicited by subliminal priming. This finding suggests that mental allocation is taking place after the perception of the stimulus, thus the cues taken into consideration at an unconscious level. Since both amplitude and latency differences in P300 components in the past have been linked to reward valence and decision making [6], we can assume that both primes (answers and miscues) are perceived but only the positive cues (answers) carry more 'salience' and eventually more 'pertinent' information to the learner.

4 Conclusion

We have discussed in this paper the use of subliminal priming for learning. We have showed that our learning technique can be used in different learning environments and that it can lead to very encouraging and promising results. The use of ERP in the analysis of the impact of subliminal primes has revealed that both cues and miscues have been registered by the attention centers of the brain and elicit in the process a P300 component. We have demonstrated that subliminal cues can have an important impact on learning but more specifically on decision making when using one's intuition. These results seem to indicate that positive subliminal cues can enhance learner's performance with regards to intuitive decision making when answering questions in a learning session. Further in depth analysis is required in order to examine other sources of information such as response time and emotional manifestations to help establish the optimal cerebral conditions for subliminal learning to occur.

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