A Course Project Report on

Visuospatial Working Memory: Effect Of Practice and Proactive Interference Effects on performance

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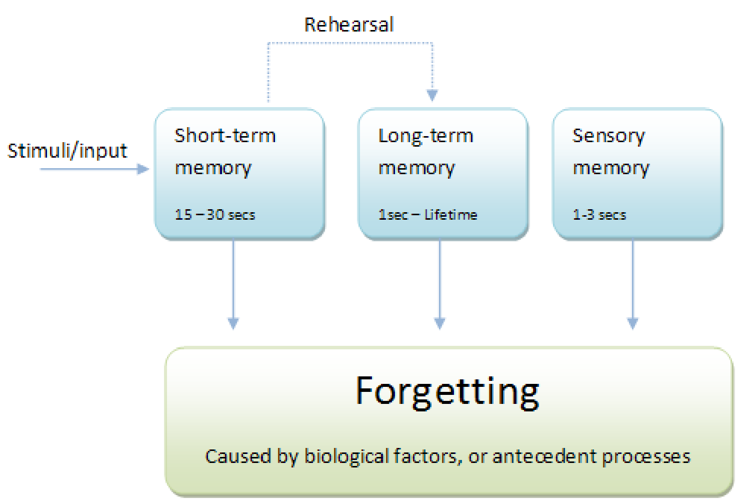
Abstract

In the current study, the effects of practice and proactive interference effects on the performance of visuospatial memory are being studied by conducting certain experiments. Subjects performed a visuospatial working memory span task either under high-PI conditions or low PI conditions (a span task with relaxing stimuli in between). Twelve trials from different length of stimuli (ranging from three to five) were randomly distributed across three blocks. This design was adapted in order to measure practice effects on the recall from working memory. The results obtained were in correspondence with previous studies on the same areas in auditory memory. The recall was lower in high-PI conditions than low PI-conditions and over a period of time practice tends to mask the PI-inhibition and improve recall performance.

Contents

1 Introduction

In cognitive psychology, memory has been defined has the mental framework which encodes, stores and retrieves necessary information whenever required. Classically, memory has been broadly classified in two categories - short term memory and long term memory. The Multistore Model of Memory (Atkinson & Shiffrin, 1968) states that human memory can be classified into three different sub-components namely short term memory (STM), long term memory and sensory memory. Short term memory was supposed to hold information for small durations of time, usually thirty seconds or less. When we look up for a phone number and immediately dial it, STM comes into action. Long term memory allows for retaining of huge amount of information for very long periods of time. For accurately recalling an incident from our childhood, we have to count on our long term memory. Sensory memory provides temporary storage of information perceived by our senses. When we watch someone wave a flashlight in some dark area and see it to be trails of light behind it, we essentially make use of our sensory memory. It was stated that our attention processes are associated with the short term memory and also there have been studies to show that there is a limitation on the storage capacity (chunks of 7) in the short term memory (George Miller, 1956). However, almost no details were available about the information processing mechanism in sensory memory.



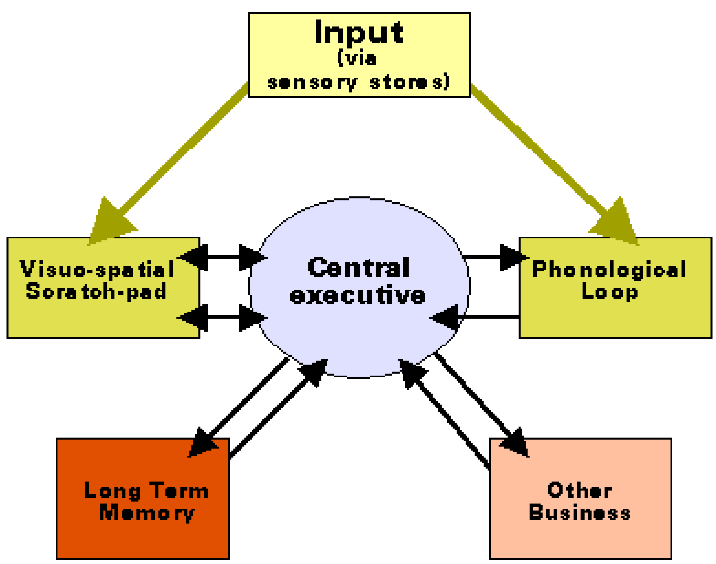
"**Atkinson-Shiffrin Memory Model**" (Source: www.wikipedia.org)

This led to subsequent research and a new model was proposed by Baddeley and Hitch which essentially replaced short term memory and sensory memory with a new phrase-working memory. The new model proposed three major components for the working memory - the central-executive or the Attention controller and the two subsidiary systems - the phonological loop, responsible for verbal and speech acquisition and the visuospatial loop, responsible for storing information related to spatial and visual domain. Thus working memory was now identified as the prime agent responsible for our perceptual cognition and subsequent processing and maintenance of the stimuli around us.

2 Working Memory

2.1 Model

Baddeley(1981) looked at working memory as consisting of three components. The first is the central executive which is responsible for directing the flow of information, selecting which information to be processed when. The central executive rather than dealing with retrieval and storage of information handles the ways cognitive resources are allocated for these processes. It is thought to attend to information and allow for its processing even in the face of external distraction and disturbance. As aforementioned, the two other components are more concerned with the temporary storage of external stimuli: phonological/auditory loop to carry out sub-vocal practices to hold verbal information, and the visual-spatial component used to assimilate vision related stimulus. The latter is also supposed to coordinate between our visual awareness and our tactile movements and hence the name – visuospatial sketch pad. The central executive regulates the flow of stimuli between these two domains and also allows the people to manipulate information gained from these domains to process and form appropriate strategies.



“**Baddeley's model of working memory**”

(Source: http://ahsmail.uwaterloo.ca/kin356/cexec/cexec.htm)

2.2 Interference

Peterson and Peterson (1959) and Brown (1958) both independently proclaimed through their findings that any piece of information, if left unattended to, is lost from the domain of working memory within 20 students. There have been various debates to explain if the Brown-Peterson task can be explained through the concepts of Interference. Two aspects of this phenomenon called Interference have been looked upon by researchers – Proactive and Retroactive Interference. The former refers to the process in which the material learned first can disrupt the learning of subsequent material. The latter refers to the process in the freshly learned material wipes away the old stored memory. In Proactive Interference (PI), once we start storing some information in our memory, a threshold reaches beyond which the stored memory inhibits with the storage of any additional content. It is striking to note that similarity between new and old pieces of information determines the extent of interference (Wickens et al, 1963). More is the similarity between stimuli; greater is the tendency to forget.

2.3 Practice

While Proactive Interference build over time and causes memory failures, there is another competing factor which is in operation and tends to compete with the PI effect to enhance memory functioning. It has been observed that while processing a puzzle or while storing pieces of information, we usually tend to form some strategies and employ some methods which assist us in our mental task and hence reduce the cognitive load. All such mental strategies have been collectively termed as practice effect in memory tasks. Practice effects are more prominent in complex span task which involve two specific unrelated tasks performed simultaneously. For e.g. you are simultaneously asked to remember a set of words as well as check if another set of statements is grammatically correct or not.

2.4 Previous Research

In order to understand the complex processes of cognition, there have been many research debates in the field of working memory on areas such as differences in the nature of short term and long term memory, exact working of the central executive, binding of representations of different components of the working memory into one coherent form and the role of working memory in controlling action. With reference to cognition, broadly two kinds of memory tasks have been studied - simple span tasks which are restricted to domain specific loops responsible for temporary storage or processing of information and complex span tasks which are essentially controlled by the domain-independent central executive and are related to our higher cognitive functions such as comprehension, reading and language learning. For example, a reading span task would involve determining the truth of the sentence (mental processing) and storing the final word of each sentences (memory maintenance). The working memory storehouse (as measured by a complex span task) is a mental workspace in which the unique differences between individuals reflect "the ability to control attention to maintain information in an active, quickly retrievable state" (Engle, 2002, p.20).

Some interesting observations have puzzled the researchers when it comes to experiments in memory. "When learning lists of words the first list will be relatively easy to recall but subsequent lists become increasingly more difficult to recall because words from previous lists will interfere with the retrieval of current list items" (Kane & Engle, 2000; Keppel & Underwood, 1962). This study brings to surface the concept of proactive interference in which previous information in our memory limits our retrieval and processing abilities. The central executive has been identified as the main controller of PI effects. It has been observed that by increasing the number of trials, practice over a period of time tends to compete with the PI inhibition and thereby improve recall in some cases. In one of the studies, it was suggested that for younger subjects, the effect of practice outscored the effect of PI in determining the WM performance (May et al., 1999, and Lustig et al., 2001). In older adults, however opposite was true because of age-specific retardation in inhibitory control (Rowe, Hasher, & Turcotte, 2009). Lutig and others proposed that in low PI condition, there is no correlation between WM span recall and higher cognitive functions such as fluid intelligence. In high PI condition, when the situation gets taxing individual differences in responses based on fluid intelligence are observed.

3 Proposed Hypothesis

The above mentioned research has been primarily conducted on auditory stimuli based complex span tasks without much focus to the visual and spatial domain. One attempt to probe into the visual domain was made by Rowe, Hasher, and Turcotte (2008). However the task involved was only a simple task. A recent study which is one of it's own kind breaks the shackles and looks at these issues using a complex visuospatial span tasks. The paper is by Blalock and McCabe published in 2011. The aim of the authors was to validate the above findings in the visuo spatial domain and by administering a complex span task which includes both mental processing and memory maintenance component. The current study aims at replicating the efforts of Blalock *et.al* with some minor changes incorporated in the scoring key. The proposed hypothesis for the set of experiments conducted is similar to the one subscribed by the aforementioned authors and can be summarized as follows:

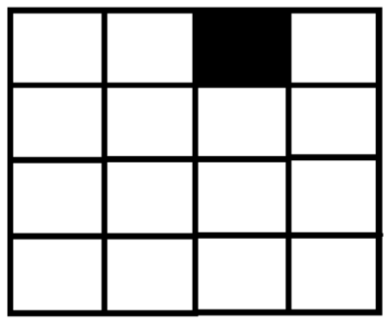
a. The recall of stimuli should be better in case of low PI condition than in high PI condition as similar set of stimuli tend to cause a more a more cognitive load an impair the memory.
b. With increasing exposure to the span task, practice should assist improving the performance after a certain number of trials.
c. Amongst Practice and PI effects, the former should influence working memory performance more.

4 Experimental Design

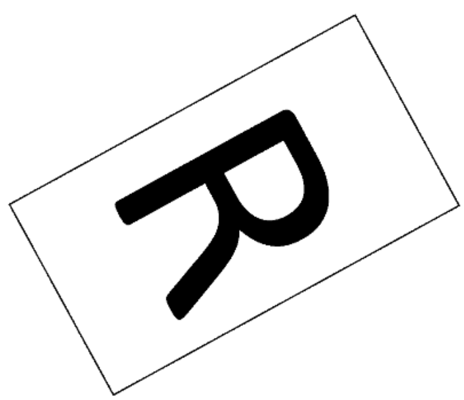
4.1 Materials

The set of stimuli used for performing the desired experiment are as follows:

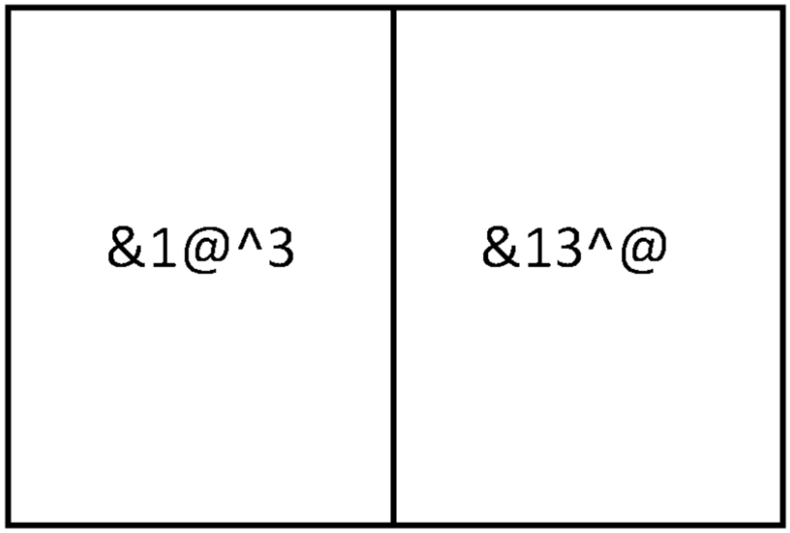
- Memory Maintenance Task - 4*4 matrices with one of their squares blackened.



- Mental Processing Task - Alphabets/Alphanumeric characters presented in rotated format either normally or mirror-reversed.



- Relaxing stimuli to induce PI condition - Sequence of alphanumeric characters



- Interface for presentation of stimuli – Evaluation of E-Prime Software
- A Laptop
- Score Sheet
- Isolated and peaceful environment (a closed room)
- **Sample** – In total 34 male participants of the age group 19-21 were a part of the experiment, 17 for each of the two PI condition. The experiment required almost 15 min for each subject.

4.2 Method

In the experiment there were three Blocks of four trials each. Each trial randomly consisted of three to five set of stimuli. Each trial was followed by either a low-PI or high-PI condition. In each trial the mental rotation task and the memory maintenance task were presented sequentially one after the other. “Stimuli were presented electronically using the E-Prime 2.0 evaluation version software (Psychological Software Tools Inc., Schneider et al., 2002)”. In the mental rotation task the subjects had to identify if the character was mirror reversed or normal in orientation. The response time was recorded at this stage. Next the four by four matrix with one of its sixteen squares blackened was presented for some period of time (1200 milliseconds). At the end of one trial (consisting of 3-5 length), the subjects were asked to sequentially point out the locations on the score sheet. Then in the low PI condition, after the participants responded on the score sheet (after every trial), a relaxing period of 15-20 seconds gap was provided. In this time the participants were distracted by giving them a third visual task which was based on mental processing. Arbitrary set of symbols will be presented on either side of the center line of the screen and the subjects were asked to respond if the order of characters is same. This process was repeated for 6-8 times after each trial. In the high-PI condition the participants would automatically start the next trial without any break. No priming stimuli were presented after the end of each round. Participants were specifically asked to remember the position of the filled squares and also maintain the accuracy of response in the mental processing task.

4.3 Observations

Here are some of the observations which were noted down while conducting the experiments and communicating the subjects before and after the procedure:

- Primacy and Recency Effects were observed in the beginning of the experiment as the participants could recall only the first or the last position.
- The subjects were found to be excessively compensating the time for mental processing task in order to recall previously shown positions on the matrix.
- The subjects reported more taxing state of mind after the High PI condition after being loaded with similar kind of information one after the other.
- The subjects instantly also reported of a situation similar to Retroactive Interference where the subsequent stimuli led to forgetting of initially learnt stimuli. Since, the participants were asked to immediately mark the positions of the blackened squares on the score sheet after each trial, old memory had really no significance in the design. However, still retroactive interference was discounted by adapting a weighted scoring key for the matrix task.

4.4 Variables

Between-subject variable (different subjects) – PI condition (high or low)

Within-subject variables (same subject**)** – Block, Rotation task score, Response time

The PI condition was essentially the independently variable in the design whereas the score and time recorded were the dependent measures. Also the variations of scores over the three blocks reflect the effect of Practice. Hence, the block has been referred to as a random factor.

In order to negate any effects of Retroactive Interference (RI), a weighted scoring key was used for the memory maintenance task. Since in RI, the initial positions are vulnerable to being lost from memory, they were given more weight age. For e.g. a scoring key of 0.4, 0.3, 0.2 and 0.1 was used for calculation in a trial comprising four set of images. For a trial consisting of 5 images the scoring order was 0.30, 0.25, 0.20, 0.15 and 0.10. This means that if in a sequence of 5 images the subject remembers 3rd and 4th position, he will be awarded 0.20+0.15 = 0.35 marks.

All the data generated after the experiment by E-Prime was recorded in a *.edat2 file. The Response time and position of matrices were extracted in text format using a Ruby Code. A sample text file of the data generated and the program code have been attached along with the Project Report. To assess the individual and combined effects of PI and Practice on the scores, mixed analysis of variance (MANOVA) was employed by using a software SPSS (Statistical Predictor Of Social Sciences)

MANOVA Design – 2 (low, high PI) * 3 (Block 1, 2, 3)

5 Analysis

5.1 Results

- **Memory maintenance task**

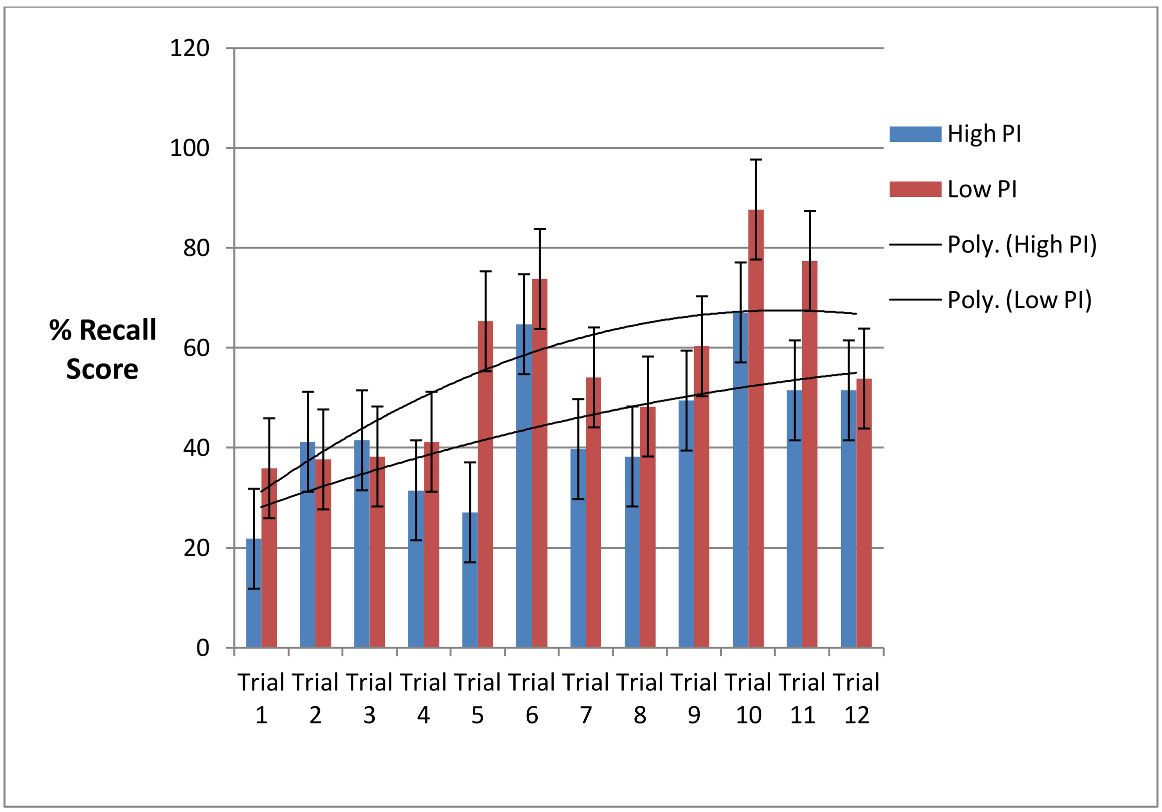


Figure.1 % Recall over increasing trials for both PI conditions

In fig.1 it is evident that the % recall score is more in the low PI condition than high PI condition for every trial. The trend lines in fig.2 indicate improvement of performance with time for the two cases. The trend line is curvilinear for the low PI condition and linear for the high PI condition. This indicates that practice brings about a greater improvement in performance in low PI condition than in high PI condition. In fig.2 for the first four trials (Block 1), the scores do not vary much in the two PI cases. However, there is a sudden increase in the low PI scores from Block 1 to Block 2.

Submitting to MANOVA also results in similar observations. A minimum level of $p=0.05$ was set for all observations. A significant effect for Block and PI effects was observed. For the block case, $F(2, 34) = 144.176$, $p<0.05$. For the PI case, $F(2,34) = 64.633$, $p<.05$. Overall these results reflect that while recall increased across blocks, the difference was more in low PI case.

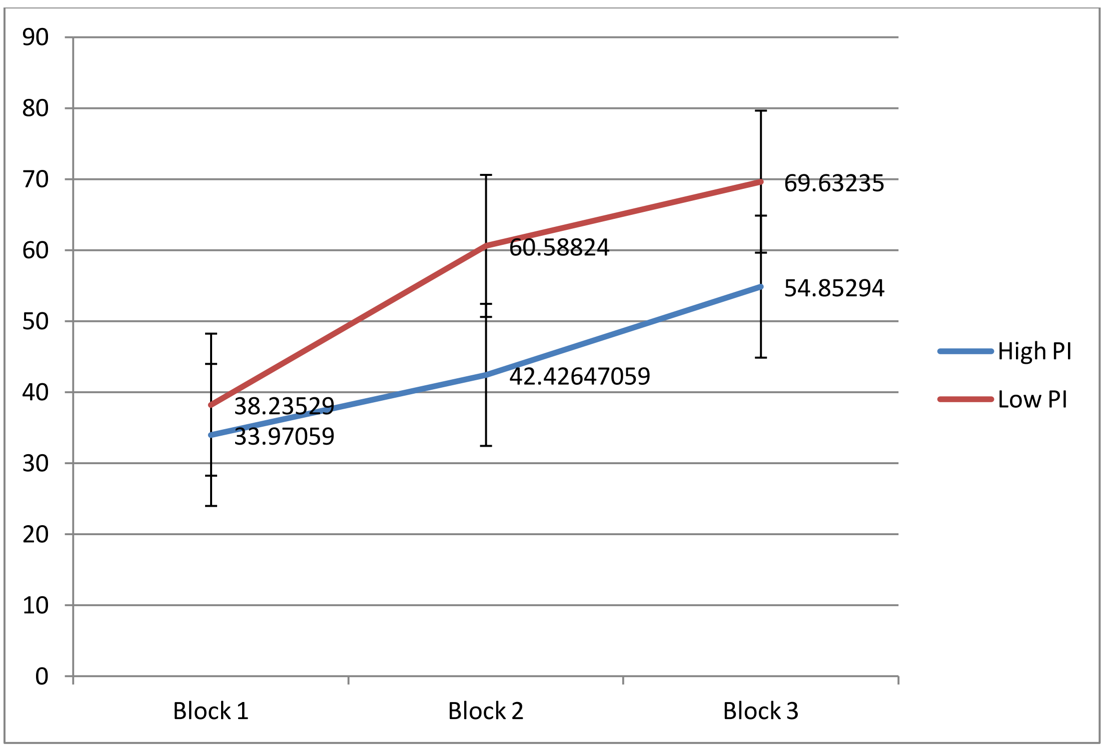


Figure.2 % score in three blocks for the two PI conditions

- **Mental rotation task**

In fig.3, it can be seen that for almost every trial, low PI condition required lesser time for processing than the high PI condition. However the difference in the two processing times is very nominal. The trend lines indicate a non linear decrease in response time for both PI conditions.

The standard deviations are pretty high for both the cases in each block. Block 1 and low PI case , Mean time = 2105.17 ms, SD = 564.999 ms and Block 1and low PI case, Mean time = 2250.2 ms, SD = 852.1 ms. Unlike the recall scores, the difference between response time for two PI conditions remains almost same across three blocks.

Submitting the data to MANOVA further validates the aforementioned observations. A significant main effect is observed for the Block and the effects of PI and Block*PI turn out to be non significant. For Block, $F(2,34) = 12.557$, $p<.05$. This indicates that only practice and not PI tends to influence the speed of processing in mental rotation tasks.

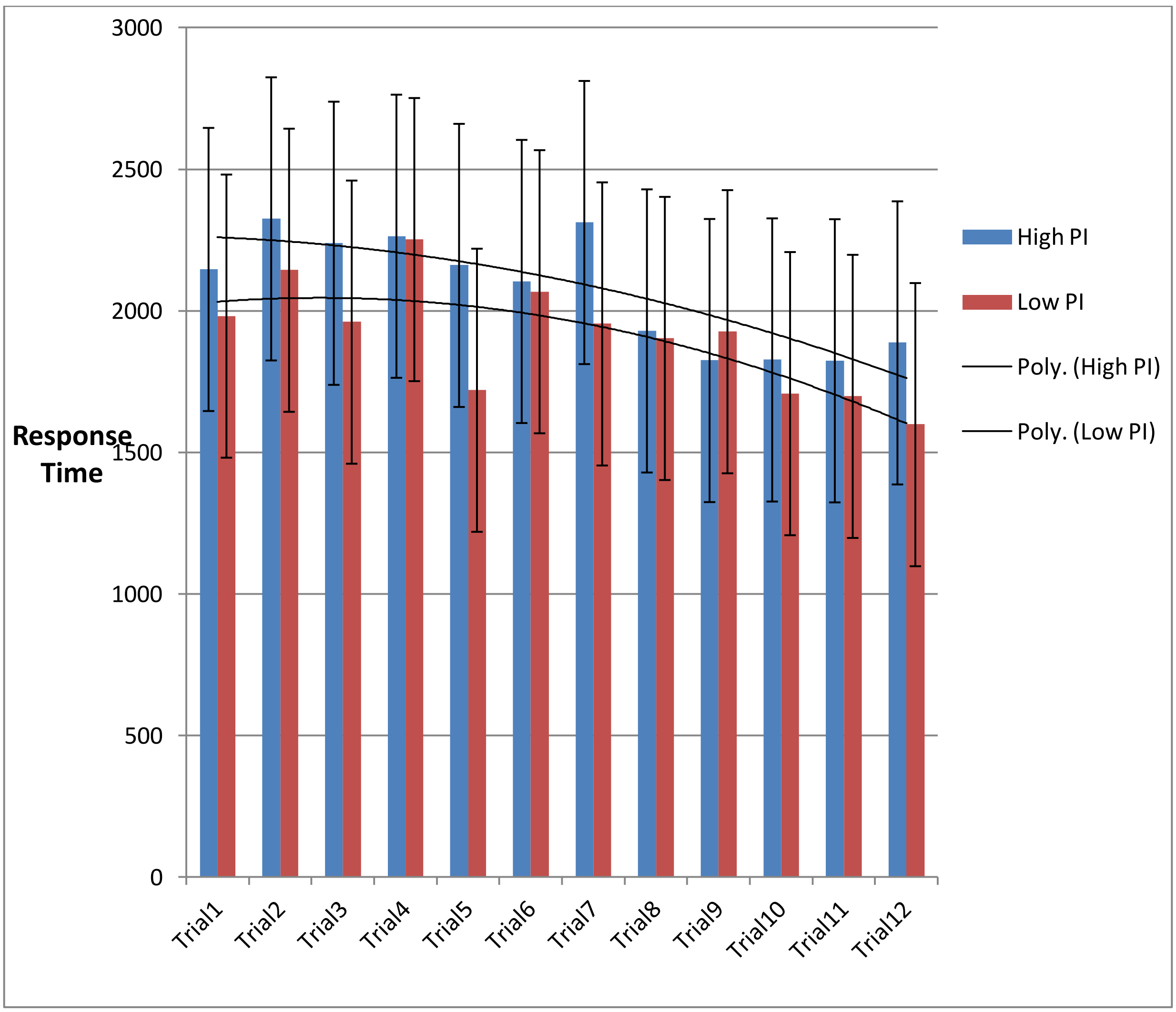


Figure.3 Time scores over increasing trials in different PI conditions.

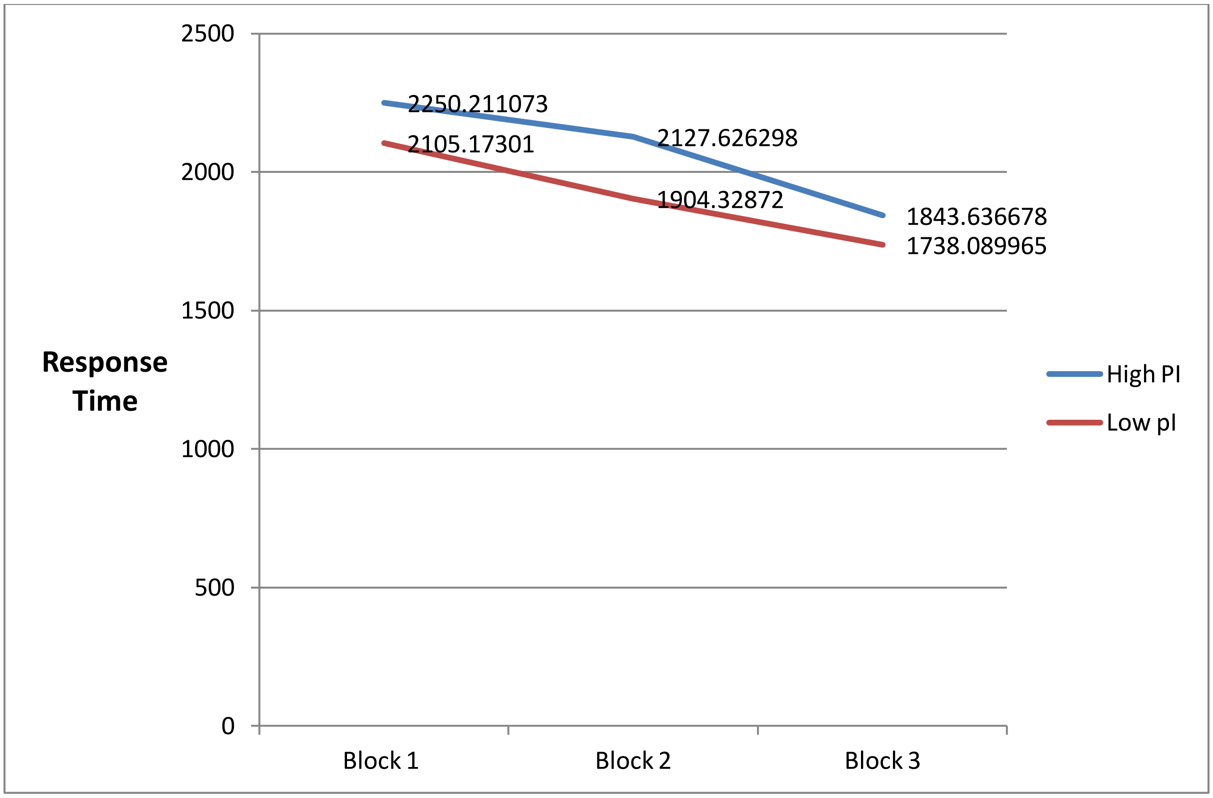


Figure.4 Response time scores over three blocks in different PI conditions

5.2 Discussion

- The two main inferences that can be drawn from the present experimental design. First, for low PI cases both recall and speed of processing is better. Second, practices tends to improve performance, however the effect of practice is more in low PI condition. Also, in processing tasks, PI condition does not play any significant role in determining performance. These results in harmony with the results by Blalock and McCabe (2011) whose paper was referenced for the present study. Also the observations are in congruence with the findings of experiments on auditory memory.

- The above observations can also be substantiated by a lot of theoretical evidence. It is in perfect harmony with Kane and Engle's view which states that unique differences in working memory are regulated by the central executive which regulates focus on relevant stimuli and mitigates PI build up (Engle & Kane, 2004; Kane & Engle, 2000,2003). The fact that with practice our cognitive system tends to resist any interference growth can be corroborated by a recently proposed Inhibition Deficit theory. It proposed three main functions for the central executive – (1) controlling access to the focus of attention, (2) suppressing strong though irrelevant stimuli and responses and (3) removing unnecessary information from our storage (Lustig, Hasher & Jacks,2007). Ackerman stated in 1987 that practice result in automation of the cognitive process thereby resulting in independence from higher level cognitive system. However, higher levels of PI inhibit this automaticity.

- Looking at the mental rotation response time, practice enhanced the processing; however PI did not have much effect. The two factor theory (Engle & Kane,2004) which states that PI has primarily its effect on recall of data and not its processing.

- Initially since the participants found it difficult to memorize any position, only those positions which made some impact were easily recalled. Hence, the so-called Primacy-Recency effect was shown during the early stages of the experiment.

- The standard deviations of the response time and the recall scores are comparatively higher than what they should be because of the individual differences in working memory capacity. Some subjects scored relatively higher than the others because of these variations.

- The purpose of the study is to look at effects of PI and practice. In experiments of memory, Retroactive Interference also takes place in which old data is forgotten because of current data. To discount effects of RI, a weighted scoring key was used which gave more weight age to previous data. The results using such a key have been more accurate than the referenced paper by Blalock. While applying MANOVA over recall scores, no significant effect of PI was observed which is slightly ambiguous. However, in present study a healthy effect of PI on recall scores has been observed.

- The drastic increase in recall scores from Block1 to Block 2 remains unexplained convincingly even in the referenced paper (Blalock, 2010). This needs to be probed in though further research.

- A small sample study was done to check that if particular position has been previously learned then it amounts to higher probability of recalling the position in its next occurrence. No significant relation was observed. The possible explanation for this that subjects do not learn any concrete information such a number or word, rather they just try to spatially figure out the positions.

6 Future Scope

It is possible to look at the same issues taking into account some more factors such as age and gender. The finding that the scores are highest in Block 2 for low PI case also deserves some explanation through some further research. Various combinations of complex span tasks could be used to corroborate the findings.

Example – a verbal memory maintenance stimuli and a visuospatial processing task

7 Acknowledgements

I would like to take this opportunity to thank Dr. Amitabha Mukherjee for guiding and mentoring me throughout the project. Without his regular feedbacks and guidance, it would have been impossible to successfully complete the project.

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