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Research Paper

Prospective Memory as A Function of Reward Responsiveness and Ongoing Task Difficulty

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ABSTRACT

Prospective Memory is the capability to remember to perform planned actions in the future. The experiment aimed to investigate the event-based Prospective Memory task performance of young adults as function of reward-responsiveness and difficulty in ongoing task. For the present experiment total 120 young adults-76 females and 44 males had been taken on the basis of inclusion and exclusion criteria. Convenience sampling method was used. BIS/BAS scale was administered to find out group of participants with (low, medium and high) reward-responsiveness and they were exposed to two experimental conditions (Prospective memory task embedded in simple and complex ongoing task) to investigate their prospective memory task performance. In Prospective memory task embedded in simple ongoing task total 60 words were presented to them, where each slide contained only one word at the middle. Among those, 18 words were presented as Prospective Memory target word. The target words were any country name with red colour. And the other 42 words were any type of word with any colour. Target and nontarget words were presented randomly. Participants' task was to say 'present' to the target words and find out 'parts of speech' from the rest of the words. In Prospective memory task embedded in complex ongoing task same number of words were presented but additionally there were one-digit numbers, each of which was presented beside each word. Here the participants' task was to say 'present' to the Indian city name written with black colour as this was the Prospective memory target word. Participant's task was to find out 'parts of speech' from the rest of words as well as sum up all the one-digit numbers from beginning to end of stimulus presentation. To investigate the event-based prospective memory signal detection paradigm was used as this method enables to understand the accuracy as well as inaccuracy of performance in terms of both right and wrong response. Right response consists of Hit and correct rejection and wrong response or error can be defined as error of omission (miss) and error of commission (false alarm). The result revealed that there is significant mean difference on the Prospective memory task performance between participants of low and high reward responsiveness group in terms of hit responses and true proportion of correct detection. There is significant mean difference on the Prospective memory task performance between participants of (low-high), (low-medium) and (medium-high) reward responsiveness group in terms of false alarm responses. There is significant effect of ongoing task difficulty on Prospective Memory task performance among

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the participants of (low, medium & high) reward responsiveness group. No significant interaction effect of reward responsiveness and ongoing task difficulty has been found on Prospective Memory task performance.

Keywords: *Prospective memory, Event-based prospective memory, Reward responsiveness, Ongoing task difficulty.*

Prospective memory is a cognitive ability to remember to conduct an intended action at the appropriate moment in the future (Ellis and Kvavilashvili, 2000). Prospective memory task involves task in which planned intensions must be accomplished in the future either after specific circumstances occur (event based Prospective Memory) or at a certain time (time based Prospective Memory).

Event based prospective memory is a process which involves remembering to perform or carry out certain actions when specific events occur. Time based prospective memory involves remembering to carry out an intended action at appropriate moment of time.
Additionally, Event based prospective memory is classified by McDaniel et al. (2004) into immediate- execute task and delayed execute task.

Immediate execute task involves making response as soon as a particular cue is recognized. Whether Delayed execute task involves concisely delaying the performance of the intended action.

Prospective memory tasks are modeled according to several criteria in order to define the nature of real life Prospective Memory situations. It is evident in prospective memory task that there is a criterion that an intended action cannot be accomplished immediately, but need to be ceased until a later point in time. The second criterion is that usually the delay must be filled with some activities to prevent rehearsal of the prospective memory action.

LITERATURE REVIEW

Effect of reward on prospective memory

Reward has an important impact on an organism's function. To examine the effect of reward on Prospective memory, many studies have investigated. First the linkage of motivation with Prospective memory was done by Meacham and Singer (1977). Meacham and Singer (1977) used rewards as a beneficial material for remembering the intention. In their experiment the prospective memory task was to send a letter to the researcher. In experimental condition participants were rewarded with money for returning each letter on time. In the control condition no such assurance was given to them. Results indicated promising reward causes better performance.

Aberle and Kliegel (2007) reported incorporating monetary rewards in order to accelerate motivational level had a marked effect on prospective memory performance in a sample of children.

Peter and Kliegel (2018) worked with the sample of older adults. They reported motivation enhances prospective memory performances in older adults but when the motivation is created through social motive instead of monetary reward.

On contrary Guajrado and Best (2000) investigated the effect of reward on prospective memory performance in the sample of preschoolers. The children were shown some pictures

on a computer screen and they were asked to recall as many pictures as possible. The prospective memory task was to press a key whenever a specific target picture appeared on the screen. No beneficial effect was seen for promising a reward.

Individual differences in reward-sensitivity

Reinforcement sensitivity theory (Corr, 2004; Gray, 1970,1981), describes individual differences in responses to incentive stimuli.

Capa and Bouquet (2018) investigated regarding the topic of reward sensitivity through exploring whether individual difference associated with reward sensitivity, enhances the memory updating.

Effect of ongoing task on Prospective memory

Prospective memory task must be accomplished after a delay. The delay is filled up with ongoing task. Performance of the ongoing task prevents the continuous rehearsal of the intended action throughout the delay period. This is due to ongoing task requires cognitive resources. In the study of (Smith, Horn and Bayen, 2006) with young and older adults, the numbers of per trials were varied to make easier and harder version of ongoing task for each age group in order to manipulate difficulty level of ongoing task. Result indicated easy ongoing task for older adults and hard for younger adults did not eliminate age related differences. Mahy, Moses and Kliegel (2011) explored the impact of age and effect of cue salience on 4 and 5 years old children's performance and also examined the relation between individual differences in working memory and prospective memory, ongoing task and cue salience are predicted to affect the detection of Prospective memory cues.

METHODS

Objectives

- To determine whether reward-responsiveness of the participants can affect event-based prospective memory performance.
- To determine whether difficulty in ongoing task can affect event-based prospective memory performance.
- To determine whether interaction of reward-responsiveness and difficulty in ongoing task can affect event-based prospective memory performance of the participants.

Hypotheses

Null Hypotheses

[H0 (1)]: There is no significant main effect of reward responsiveness on prospective memory task performance of the participants with (low, medium and high) reward responsiveness group in terms of their hit responses [H0 (1.1)], in terms of their false alarm responses [H0 (1.2)], in terms of true proportion of correct detection [H0 (1.3)].

[H0 (2)]: There is no significant main effect of ongoing task difficulty on prospective memory task performance of the participants with (low, medium and high) reward responsiveness group in terms of their hit responses [H0 (2.1)], in terms of their false alarm responses [H0 (2.2)], in terms of true proportion of correct detection [H0 (2.3)].

[H0 (3)]: There is no significant interaction effect of reward responsiveness and ongoing task difficulty on prospective memory task performance of the participants with (low, medium and high) reward responsiveness group in terms of their hit responses [H0 (3.1)], in

terms of their false alarm responses [H0 (3.2)], in terms of true proportion of correct detection [H0 (3.3)].

[H0 (4)]: There is no significant mean difference between the prospective memory task performance of the participants with (low and medium) reward responsiveness group in terms of their hit responses [H0 (4.1)], in terms of their false alarm responses [H0 (4.2)], in terms of true proportion of correct detection [H0 (4.3)].

[H0 (5)]: There is no significant mean difference between the prospective memory task performance of the participants with (low and high) reward responsiveness group in terms of their hit responses [H0 (5.1)], in terms of their false alarm responses [H0 (5.2)], in terms of true proportion of correct detection [H0 (5.3)].

[H0 (6)]: There is no significant mean difference between the prospective memory task performance of the participants with (medium and high) reward responsiveness group in terms of their hit responses [H0 (6.1)], in terms of their false alarm responses [H0 (6.2)], in terms of true proportion of correct detection [H0 (6.3)].

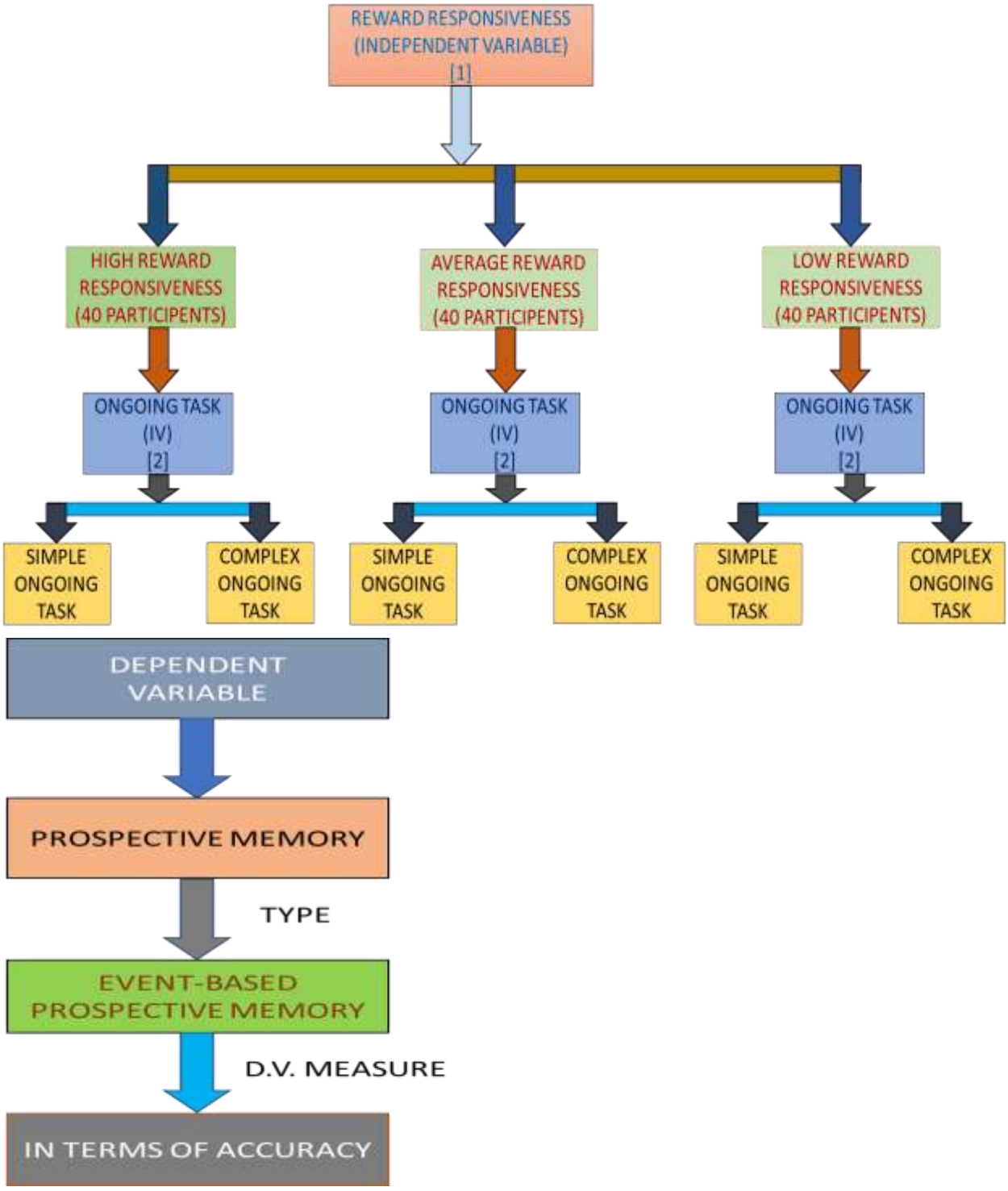
Participants

In the present experiment total 120 participants participated, where number of females were 76 and number of males were 44. All participants were within the age range of 18-23 years, with mean age of 21 years. Participants were from urban residence. They had at least standard 12 passed educational qualifications and learned English as either 1st language or 2nd at their school level. Participants who had any source of self- income were excluded. Participants who had any learning disorder, speech disorder or difficulty, visual impairment and any psychiatric illness were also excluded. *Appropriate relevant safeguards in relation to the protection of subjects had been undertaken and reviewed by an ethical review committee at the University for the Current Research. At first the subjects were approached and informed about the purpose of experiment. It was conducted following general guidelines in Psychology. This was followed by obtaining written consent from all the participants.*

Design of the work

Figure 1:

The figure depicts entire design of the current research work through a flowchart presentation which reflects number of independent variables along with their levels, allocation of participants in each experimental condition. Number of dependent variables extracted.



Materials

- Behavioral inhibition and Behavioral activation scale (BIS/BAS) scale [Carver, C.S and White, T.L, 1994]
- Hardware-Laptop (HP 10TH Gen, 15.6 inch)
- Software- Power Point presentation (Windows version -2013)

Stimuli

- Stimulus presentation was done by power point presentation.

- PowerPoint presentation-
- Power point windows version (2013) was used. Font size was kept at (60)
- Two sets of Power Point presentation (PPT) were made.

i) There were total 60 words, where each slide contained only one word at the middle. Among those, 18 words were presented as Prospective Memory target word. The target words were name of any country with red colour. Other 42 words were any type of word with any colour. Those words were used for ongoing task. Target and non target words were presented randomly. The PPT was made for prospective memory task embedded within simple ongoing task.

ii) There were also total 60 words, where each slide contained only one word at the middle. Among those, 18 words were presented as target words. Here the target words were name of any Indian city with black colour and, the other 42 words were any type of word with any colour. Additionally, there were one-digit numbers. Each of which was presented beside each word individually. The PPT was made for Prospective Memory task embedded within complex ongoing task.

In both conditions, duration of presentation of each slide along with each stimulus was 4 seconds. And for both conditions the target words and the other words used for ongoing task were arranged using 'Random Sequence Generator Software'.

Procedure

Method of data collection

To conduct the experiment, permission was sought from different college authorities.

A total of 120 college students were participated from different colleges. At first principals of those colleges were requested to permit to conduct the experiment for research purpose. 4 colleges were selected by requesting the authorities who permitted to do the experiment on their students.

After getting permission from the colleges, all the students of permitted classes were given two papers.
i) One paper consisted of various country names (a list of 25 country names).
ii) Another paper consisted of various Indian city names (a list of 25 Indian city names).

The students were asked to put a tick mark beside the name of countries and cities which were known to him / her. Among all those known marked name of countries and cities 18 countries and 18 cities were selected as target words. And all of those selections of target words were done before two weeks of experimentation. The procedure of target word selection was done in this manner because if any one of the city or country name is not known to them, will not be perceived as target word.

Experiment was conducted by selecting quiet room of selected college campuses. They were provided the information schedule at first and then asked to fill up all the personal details that were asked to report on this paper. They were assured that all the details will be kept confidential.

After completion of this task entire BIS/BAS scale was administered. Thereafter participants were instructed to concentrate on the questionnaire and indicate how much they agree or disagree with what the item says.

The participants took more or less 5-7 minutes to complete the questionnaire. Questionnaires were collected from them and scores of subscale (BAS- Reward Responsiveness) was calculated. On the basis of this score participants with high, medium and low reward responsiveness trait were separated into 3 groups and assigned to two experimental conditions. That is, one condition with prospective memory task embedded within simple ongoing task and another condition with prospective memory task embedded within complex ongoing task. For both of these conditions those 3 groups of participants with low reward-responsiveness trait, medium or average reward-responsiveness trait and high reward-responsiveness trait were assured a reward as a result of 100% correct responses to the entire task that have to be performed by them.

After administration of the BIS/BAS scale the participants were given a paper which contains a small list of rewards of same monetary value. The list contained 3 items, Such as: 1. A pen, 2. A chocolate, 3. A channel file. The participants were asked to put tick beside the object name; they would like to get as reward after providing 100% correct response. More than 95% of the participants selected chocolate as reward. So chocolate was provided as reward.

These allocations of the participants into two experimental conditions were counterbalanced. After assigning each participant to a particular experimental condition 10 minutes rest was given to them before assigning them to the next experimental condition.

Tasks

Prospective memory task-

- Prospective memory task when embedded within simple ongoing task- The task was to say the word "Present", whenever a country name with red colour will appear on the screen among many other words in different colours along with country name, written with different colours other than red.
- Prospective memory task when embedded within complex ongoing task- The task was to say the word "Present" whenever a Indian city name with black colour will appear on the screen among many other words in different colours along with city name, written with different colours other than black.

Ongoing task-

- **Simple ongoing task-** The ongoing task was to find out parts of speech' from words. That means finding out and to inform verbally whether the word is noun, pronoun, verb, adverb, adjective, preposition, conjunction or interjection.
- **Complex ongoing task –** Here the ongoing task was to find out and to inform verbally 'parts of speech' from the words and simultaneously their task was to add one digit numbers. Each of which was presented separately besides each word.

Participants received instructions twice for specific version of Prospective Memory task embedded within simple and complex ongoing task.

Measurement of Dependent variable-

In this experiment the Prospective Memory task performance was measured in terms of *accuracy.*

The valid retrieval time for the event-based Prospective Memory task was considered to be the duration of presentation of target word (i.e., 4 seconds). In case of delayed retrieval (i.e., when the next word was shown instead of the previous target word in front of the participants on the laptop screen) response was not considered as correct.

The accuracy of Prospective Memory task was measured through the *signal detection paradigm.*

According to the Signal Detection Theory the most important general feature of the theory is that it enables the independent assessment of the observer as a sensor and as a decision maker. (Coombs, Dawes and Tversky,1970).

The theory was initially adopted for use in regard to perceptual problems by Tanner and Swets (1954).

According to the signal detection paradigm the observer's or participant's decision of detection on any trial can result in four possible outcomes:

- Hit- It indicates a signal or target is reported when it was present.
- False alarm- It indicates a signal or target is reported when no signal or target was present.
- Correct rejection- It indicates no signal or target is reported when no signal or target was present.
- Miss- It indicates signal or target is not reported when a target or signal was presented.

The entire data collection procedure was done one by one.

Afterwards the number of hits, misses, false alarms and correct rejections were calculated.
True proportions of correct detections were calculated by using the formula:
= ($Proportion\ of\ Hits$) – ($proportion\ of\ false\ alarm$)/(1 – $Proportion\ of\ false\ alarm$)

RESULT

The data obtained from the participants were arranged and tabulated with respect to each variable chosen for the experiment. The data are then analyzed statistically with the help of suitable statistical analysis. The processed data have been represented in the different tables as follows:

Table 1: Means and Standard Deviation for Hits, False alarm & True proportion of correct detection presented by the participants of (LOW, MEDIUM and HIGH) Reward-Responsiveness (R-R) group in Prospective memory task embedded within simple ongoing task and complex ongoing task

	Simple O.T						**Complex O.T**					
	Hit		**False alarm**		**True proportion of correct detection**		**Hit**		**False alarm**		**True proportion of correct detection**	
	Mean	***SD***	***Mean***	***SD***	***Mean***	***SD***	***Mean***	***SD***	***Mean***	***SD***	***Mean***	**SD**
LOW R-R	15.83	2.541	0.4	1.033	0.878	0.14	14.72	3.602	1.08	1.9	0.8125	0.2038
MEDIUM R-R	17.27	1.176	1.92	3.198	0.9578	0,069	15.22	3.926	3.58	4.414	0.836	0.2237
HIGH R-R	17.6	0.955	1.72	3.08	0.9753	0.588	15.68	3.165	2.62	3.417	0.862	0.1796

O.T= Ongoing Task; SD= Standard Deviation; R-R= Reward-Responsiveness

It was seen from the above table -1: participants have scored greater when they were exposed to prospective memory task embedded within simple ongoing task than when they were exposed to complex ongoing task in terms of number of HIT responses. The participants of high reward responsiveness group have scored highest in terms of HIT responses in both Prospective Memory task embedded within simple and complex ongoing task. The participants with medium reward responsiveness group have scored higher than the participants with low reward responsiveness group in terms of HIT responses in both Prospective Memory task embedded within simple and complex ongoing task. And the participants with low reward responsiveness group have scored lowest in terms of HIT responses in both Prospective Memory task embedded within simple and complex ongoing task.

Mean of False Alarms of the participants of (Low, Medium and High) reward responsiveness group is greater when participants were exposed to Prospective Memory task embedded within complex ongoing task than the situation when they were exposed to the Prospective Memory task embedded within simple ongoing task.

It was seen from the above table participants of medium reward responsiveness group have scored highest in terms of FALSE ALARM responses in both Prospective Memory task embedded within simple and complex ongoing task. Participants of low reward responsiveness group have scored lowest in terms FALSE ALARM responses in both Prospective Memory task embedded within simple and complex ongoing task. Participants of high reward responsiveness group have scored higher than the participants of low reward responsiveness group in terms of FALSE ALARM responses in both Prospective Memory task embedded within simple and complex ongoing task.

It was seen from the above table participants have scored greater when they were exposed to prospective memory task embedded within simple ongoing task than when they were exposed to complex ongoing task. That indicates participants' proportion of correct detection in Prospective Memory task was better when they were engaged in simple Ongoing Task.

The participants of high reward responsiveness group have scored highest in terms of TRUE PROPORTION OF CORRECT DETECTION in both Prospective Memory task embedded within simple and complex ongoing task. Medium reward responsiveness group has scored higher than low reward responsiveness group in terms of TRUE PROPORTION OF CORRECT DETECTIONS in case of both Prospective Memory task embedded within simple ongoing task and complex ongoing task. Low reward responsiveness group has scored lowest in terms TRUE PROPORTION OF CORRECT DETECTION in Prospective Memory task embedded within simple and complex ongoing task.

Table 2: F ratios (at df = [1, 117] and [2,117]) for the main effects of reward responsiveness and difficulty in ongoing task and their interaction effects on Prospective memory task performance in terms of HIT, FALSE ALARM & TRUE PROPORTION OF CORRECT DETECTION responses given by the participants of (Low, Medium, High) reward responsiveness group

Table-2:

	Main effects		**Interaction effects**
	Reward-responsiveness (R-R)	Difficulty in ongoing task	R-R* Difficulty in ongoing task
Hits presented by participants	3.874*	30.996**	0.962
False alarm given by participants	7.787**	9.274**	0.697
True proportion of correct detection	3.506*	33.160**	1.009

(*) mean difference is significant at 0.05 level.
(**) mean difference is significant at 0.01 level.

From table 2, it can be seen the F values obtained from the mixed ANOVA. It was seen there is significant main effect of reward responsiveness in terms of hit responses given by the participants to the Prospective Memory task [(F ratio at df (2,117) =3.874, $P < 0.05$]. Therefore, the null hypothesis [H0 (1.1)] was rejected.

There is significant main effect of difficulty in ongoing task on Prospective Memory task performance of participants in terms of hits [(F ratio at df (1,117) =30.996, $P < 0.01$]. Therefore, the null hypothesis [H0 (2.1)] was rejected.

There is no significant interaction effect of reward responsiveness and difficulty level of ongoing task on Prospective Memory task performance in terms of hit responses given by participants. Therefore, the null hypothesis [H0 (3.1)] was accepted.

There is significant main effect of reward responsiveness in terms of false alarm given by the participants to the Prospective Memory task [(F ratio at df (2,117) =7.787, $P < 0.01$]. Therefore, null hypothesis [H0 (1.2)] was rejected.

There is significant main effect of difficulty in ongoing task in terms of false alarm responses given by the participants to the Prospective Memory task [(F ratio at df (1,117) =9.274, $P < 0.01$]. Therefore, null hypothesis [H0 (2.2)] was rejected.

It was also seen there is significant main effect of reward responsiveness in terms of true proportion of correct detections done by the participants to the Prospective Memory task [(F ratio at df (2,117) =3.506, P < 0.05]. Therefore, null hypothesis [H0 (1.3)] was rejected.

There is significant main effect of difficulty in ongoing task in terms of true proportion of correct detection done by the participants to the Prospective Memory task [(F ratio at df (1,117) =33.160, P < 0.01]. Therefore, null hypothesis [H0 (2.3)] was rejected.

There is no significant interaction effect of reward responsiveness and difficulty level of ongoing task have been found on Prospective Memory task performance in terms of true proportion of correct detection done by participants. Therefore, null hypothesis [H0 (3.3)] was accepted.

There is no significant interaction effect of reward responsiveness and difficulty level of ongoing task have been found on Prospective Memory task performance in terms of false alarm given by participants. Therefore, null hypothesis [H0 (3.2)] was accepted.

Table 3: Tukey test for the difference between the means in terms of HIT FALSE ALARM & TRUE PROPORTION OF CORRECT DETECTION responses given by the participants of (Low, Medium, High) reward responsiveness group

Hits			
	LOW REWARD RESPONSIVENESS	MEDIUM REWARD RESPONSIVENESS	HIGH REWARD RESPONSIVENESS
LOW REWARD RESPONSIVENESS	0	0.98	1.36*
MEDIUM REWARD RESPONSIVENESS	0.98	0	0.39
HIGH REWARD RESPONSIVENESS	1.36 *	0.39	0
False alarm			
LOW REWARD RESPONSIVENESS	0	2.01 **	1.44*
MEDIUM REWARD RESPONSIVENESS	2.01 **	0	0.58
HIGH REWARD RESPONSIVENESS	1.44 *	0.58	0
True proportion of correct detection			
LOW REWARD RESPONSIVENESS	0	0.0516	0.0736*
MEDIUM REWARD RESPONSIVENESS	0.0516	0	0.022
HIGH REWARD RESPONSIVENESS	0.0736 *	0.022	0

(*) mean difference is significant at 0.05 level.
(**) mean difference is significant at 0.01 level.

From the above table of Post Hoc analysis (Tukey test), it was seen there is a significant mean difference between the participants of low reward responsiveness group and high reward responsiveness group at 0.05 level in terms of hit responses given by them to the Prospective Memory task. Therefore, null hypothesis [H0 (5.1)] was rejected.

No significant mean difference was found between the participants of low reward responsiveness group and medium reward responsiveness group in terms of hit responses. Therefore, null hypothesis [H0 (4.1)] was accepted.

Obtained Mean difference between the participants of medium reward responsiveness and high reward responsiveness in terms of hit responses is not significant also. Therefore, null hypothesis [H0 (6.1)] was accepted.

It was seen there is a significant mean difference between the participants of low reward responsiveness group and high reward responsiveness group at 0.05 levels in terms of false alarms given by them to the Prospective Memory task. Therefore, null hypothesis [H0 (5.2)] was rejected.
Significant mean difference was found between the participants of low reward responsiveness group and medium reward responsiveness group at 0.01 level in terms of false alarm given by them. Therefore, null hypothesis [H0 (4.2)] was rejected.

No significant Mean difference was found between the participants of medium reward responsiveness and high reward responsiveness group in terms of false alarm given by them. Therefore, null hypothesis [H0 (6.2)] was accepted.

It was also seen there is a significant mean difference between the participants of low reward responsiveness group and high reward responsiveness group at 0.05 level in terms of true proportion of correct detection done by them to the prospective memory task. Therefore, null hypothesis [H0 (5.3)] was rejected.

No significant difference was found between the participants of low reward responsiveness and medium reward responsiveness group in terms of true proportion of correct detection. Therefore, null hypothesis [H0 (4.3)] was accepted.

Obtained mean difference between the participants of medium reward responsiveness and high reward responsiveness group in terms of true proportion of correct detection was not significant also. Therefore, null hypothesis [H0 (6.3)] was accepted.

Table 4: Observational Finding

Table-4.1: Nature of False Alarm given by the number of participants in terms of percentage to the Prospective memory task embedded in simple ongoing task

GROUPS	Respond to all country name, written with any colour	Respond to all words written with red colour
LOW REWARD RESPONSIVENESS	**2.5%**	**0%**
MEDIUM REWARD RESPONSIVENESS	**7.5%**	**5%**
HIGH REWARD RESPONSIVENESS	**10%**	**10%**

In the above table on the basis of nature of false alarms given by the participants in the experimental condition (PROOSPECTIVE MEMORY TASK EMBEDDED IN SIMPLE ONGOING TASK) responses of the respondents are classified into two types: respond to all country name, written with any colour and respond to all words written with red colour.

It was found from the table, 2.5% of the participants with low reward-responsiveness group respond to all country name, written with any colour and none has respond to all words, written with red colour. 7.5% of the participants with medium/ average reward-responsiveness group respond to all country name, written with any colour and 5% of the participants have respond to all words written with red colour. 10% of the participants with high reward-responsiveness group respond to all country name, written with any colour and 10% of the participants have respond to all words written with red colour.

Table-4.2: Nature of False Alarm given by the number of participants in terms of percentage to the Prospective memory task embedded in complex ongoing task

GROUPS	Respond to all city name, written with any colour	Respond to all words written with black colour
LOW REWARD RESPONSIVENESS	**5%**	**0%**
MEDIUM REWARD RESPONSIVENESS	**18%**	**10%**
HIGH REWARD RESPONSIVENESS	**10%**	**15%**

In this table, on the basis of nature of false alarms given by the participants in the experimental condition (Prospective memory embedded in complex ongoing task) responses of the respondents are classified into two types: respond to all Indian city name, written with any colour and respond to all words written with black colour.

It was found from the table, 5% of the participants with low reward-responsiveness group respond to all city name, written with any colour and none has respond to all words, written with black colour. 17.5% of the participants with medium/ average reward-responsiveness group respond to all city name, written with any colour and 10% of the participants have respond to all words written with black colour. 10% of the participants with high reward-responsiveness group respond to all city name, written with any colour and 10% of the participants have respond to all words written with black colour.

DISCUSSION

The experiment is primarily focused to determine whether there is an effect of reward-responsiveness trait of the college students on the Prospective Memory task performance, when they were provided the reward of same value. It was also determined whether there is an effect of ongoing task difficulty on the Prospective Memory task performance. And finally, interaction effect of reward-responsiveness and ongoing task difficulty has also been determined.

The responses from the participants were taken by using ‘signal detection paradigm’.
The hit rate is considered as the conditional probability of saying yes when a signal or target has been presented. The miss rate is the complementary probability. As there are only two possible responses on signal trials, yes or no, (i.e. that is responding correctly to the target or not responding to the non-target) can be done. The two conditional response probabilities are mutually exclusive and must sum to a probability of 1.0, because the hit and miss rate sum to 1.0. So, the hit rate is sufficient to describe what has happened on target trials. Similarly, the false alarm rate is the conditional probability of responding to it when target has not been

presented and the correct rejection rate is the complementary probability. So, the false alarm rate is enough to gain information about the responses to the non-target trials.

So, for this present experiment the score of hits and false alarms and their corresponding true proportion of correct detection were considered for entire result and discussion.

The mean score of hit responses given by the participants of (low, medium and high) reward – responsiveness group, reveals highest mean is observed for the participants of high reward – responsiveness group for both the experimental conditions, Prospective memory task embedded within simple ongoing task and Prospective memory task embedded within complex ongoing task. The mean score gradually decreases from high to medium & from medium to low.

From theoretical perspective it can be believed that rewards and punishments change any person's motivational value over the life span **(Mather and Carstensen., 2005). (Costa et al., 2015)** reported increment of individual's motivation level leads to active allocation of additional resources to a specific task as well as tends to improve their performance on this task.

Other studies have demonstrated goal directed behaviors need adequate resource allocation of cognitive control process, like the ability to prioritize more relevant information over less relevant in working memory **(Thurm, Zink et al., 2018).** Most of the previous studies have suggested that motivation enhances prospective memory performance in adults. The fact that rewards play strong role as incentive properties, consequently directs people to pay attention to the task with spontaneous engagement.

When gaining or anticipating reward enhances task performances as a whole, from the present findings of prospective memory task performance it was found, all 3 groups of participants (high, medium/average and low) reward- responsiveness performed the prospective memory task but the group with high reward-responsiveness trait provided highest hit responses to the target and there is a significant effect of reward- responsiveness on the prospective memory task performance in terms of hit responses.

From Post Hoc analysis (Tukey test) it was found there is a significant difference between the low reward-responsiveness group and high reward- responsiveness group in terms of hit responses to the prospective memory task. No significant differences exist between low and medium reward-responsiveness group. No significant difference also exists between high and medium reward responsiveness group.

The reward –responsiveness subscale reflects the degree of experiences of positive responses to rewards **(Carver and White, 1994).** Adaptive function is solely predicted by this subscale. Reward-responsiveness is one's self capacity to experience pleasure in the estimation of reward- related stimuli. It claims approach motivation for activities that provide a sense of pleasure **(Corr, 2008).** From the present result it can be said the participants of high reward-responsiveness group experience pleasure in the anticipation of reward as a result they provided maximum hit responses (i.e., respond to stimulus when the target is present).

Previous findings suggested that participants, highly sensitive to rewards are encouraged to show high task engagement when possibility of earning rewards may be secured (**Boksem M.A.S., Tops M., Kostermans E. et al., 2008).**

It implies individual differences in reward and punishment sensitivity plays central role to the better performance of the tasks, though same level and same value of reward were assured to all 3 groups of participants**. (Costumero V. et al., 2013)** also reported brain activity during reactivity is positively correlated with one's reward sensitivity score.

From the mean and standard deviation of false alarms given by the participants of (low, medium/average and high) reward-responsiveness group to the two experimental conditions: Prospective memory task embedded in simple ongoing task and prospective memory task embedded in complex ongoing task, highest mean of false alarm score was observed for participants with medium reward- responsiveness group in both of those experimental conditions. It was also seen from both of these experimental conditions the false alarm scores of participants of low reward –responsiveness group was lowest and the false alarm scores of the participants of high reward –responsiveness group is higher than the participants of low reward-responsiveness group.

Mixed ANOVA shows there is a statistically significant main effect of reward-responsiveness on prospective memory task in terms of false alarm responses given by the participants. False alarm indicates one type of error in detection of target. In case of the present experiment this is error in detection of prospective memory target. The result indicates the participants of medium reward –responsiveness group had done more error (false alarm) than both the participants of (low and high) reward-responsiveness group.

The participants of medium reward-responsiveness group have more reward sensitivity or they have higher reward responsiveness than the participants of low reward-responsiveness group. The participants were assured that they will get a reward of their choice as a result of 100% correct response to the given task. More reward –responsiveness or more sensitivity to reward results more engagement towards the given task and more motivation to earn reward. This motivation to earn reward results loss aversion.

Loss aversion refers to people's propensity to prefer avoiding losses to acquire analogous gains. So, it can be said, to prevent the loss and to gain the reward they tried to respond to all the stimuli with greater motivation. Studies have demonstrated there is greater association of false alarm with higher 'loss aversion' **(Viswanathan, V., Sheppard, J. et al., 2017).** According to **(Taylor et al., 2004),** alteration in reward schedules influence the gains and losses sustained for correct responses. The false alarm cause subjects to minutely regulate response biases for accessing reward on the task.

The mean of false alarm, given by the participants with high reward-responsiveness group is lower than the participants of medium reward-responsiveness group but higher than the participants of low reward responsiveness group. So, it can be said from the result the participants of high reward-responsiveness group perceived the situation as the stringent criteria, as they were instructed, they will earn a reward of their choice for 100% correct response to the given task. Any error may prevent them to earn it. So, the false alarm of this group is lesser than the medium reward-responsiveness group, but higher sensitivity to reward or higher reward responsiveness of this group enhances loss aversion and causes higher false alarm rate than the participants of low reward-responsiveness group.

Post Hoc analysis (Tukey test) implies significant difference exists between the low and medium reward- responsiveness group, medium and high reward-responsiveness group and low and high reward-responsiveness group.

Different rates of false alarm reflect varying degrees of bias in the observer's willingness to guess the presence of a target. Thus, in order to obtain the true proportion, it is necessary to correct the bias by calculating the true proportion of correct detection.

In case of true proportion of correct detection, the highest mean is observed for the participants of high reward-responsiveness group.
From mixed ANOVA it was shown there is a significant main effect of reward-responsiveness in terms of true proportion of correct detection.

So, it can be said as the sensitivity to reward is high of the participants of high reward-responsiveness group that enables them to be engaged with the task more and encourages them to perform better.

From the **Table** of Post Hoc analysis (Tukey test) it was found statistically significant difference exist only between the participants of low and high reward-responsiveness group. No significant difference exists between the participants of low and medium reward-responsiveness group as well as between the high and medium reward-responsiveness group.

Thus, it can be said that the participants with high reward-responsiveness group was highly motivated to obtain reward and therefore show higher task engagement that enables them to perform better than any other groups. **(Franken and Muris, 2005**) indicated in their study that reward-responsiveness is associated between better decision making on the IOWA Gambling task. Significant main effect of reward-responsiveness in this present experiment indicates high reward sensitivity, which enhances allocation of the available resources to the task.

In a Prospective Memory task, the delay period between the intention formation and the appropriate time to act is filled with ongoing activity. In this present experiment the hit rate (i.e, responding to target stimulus got decreased when the difficulty of ongoing task got increased.

Many studies revealed performance of the ongoing task prevents continuous and conscious rehearsal process of the intention over the entire delay period. This is typically because the ongoing activity absorbs heavy cognitive resources. Accuracy decline in Prospective Memory task is accompanied by a decline in monitoring (as measured by Prospective Memory cost to the ongoing task in the trials immediately before the Prospective Memory cue was presented.

Result indicates the mean score of hit responses got decreased when participants were exposed to Prospective Memory task embedded within complex ongoing task.

Table of Mixed design ANOVA) shows there is statistically significant main effect of difficulty level of ongoing task in the Prospective Memory task, in terms of hit responses. That implies there is significant mean difference between the two experimental conditions from simple ongoing task to complex ongoing task.

Prior Studies revealed that Prospective Memory retrieval noticeably brought about through a variety of cognitive processes. These processes range from resource-intensive, self-initiated retrieval process or automatic retrieval processes activated by environmental cues connected with intended action **(Gil Gonen-Yaacovi, & Paul W. Burgess., 2012).**

On the basis of previous theories, the present result can be explained.
From the perspective of Preparatory attentional and memory processes theory (PAM), **Smith and Bayen., (2004**) stated Prospective Memory retrieval occurs through the capacity seeking attention processes. According to the PAM theory (Smith, 2003), capacity demanding preparatory processes are needed for event-based prospective memory to be successful. The preparatory processes are engaged in monitoring of the environment for the occurrence of the Prospective Memory target events. As the preparatory processes are not automatic it requires allocation of some of the limited cognitive resources away from the ongoing activity and towards preparation for the Prospective Memory task. According to this theory, preparatory attentional processes include nonautomatic monitoring of the environment for the Prospective Memory cue, so that when Prospective Memory task is embedded in an ongoing task, it is expected to have a deficit in available resources for the ongoing task, even when Prospective Memory is not present.

According to Multiprocess theory (**McDaniel & Einstein, 2000),** the demand or resources required by the ongoing activity is another essential factor that influences the dominance of either monitoring or spontaneous retrieval process. More specifically, it states that a decrease in resources available for monitoring should interfere with Prospective Memory performance.

Studies of **(McDaniel, Robinson-Reigler and Einstein, 1998),** revealed that divided attention decreased Prospective Memory performance**. (Marsh & Hicks., 2002)** also reported divided-attention tasks that increased the demand for executive control, decreased Prospective Memory performance.

In the present experiment, the Prospective Memory task embedded in complex ongoing task, the participants were asked to find out parts of speech from the words as well as they were asked to sum up the one-digit numbers each of which were placed beside each word. It has increased workload and it causes decrement in hit rate. **(Stone M, et al., 2001)** reported high workload increased Prospective Memory errors, because it prevented verbal rehearsal of the Prospective instructions.

From the perspective of resource allocation, it is known when two tasks are combined resources must be allocated between two tasks. More or less resources can be allocated to one or other tasks, on the basis of priority. There will be a complementary relationship between the two tasks, if the two tasks are resource limited. Performance on one task will improve along with decline in performance on other task. In this present experiment when participants were exposed to Prospective Memory task embedded in simple ongoing task their task was to find out 'parts of speech' from the words presented on the screen and simultaneously their task was to say the word '*present***'** when there is any country name with red colour (target) was presented on the screen among other words (non target). But when the participants were exposed to Prospective Memory task embedded in complex ongoing task, their ongoing task was to find 'parts of speech' as well as summing up one digit numbers, both of these tasks were competing to each other. Whereas their Prospective Memory task was to say the word *'present'* when any Indian city name with black colour

was presented on the screen. The present result indicated poorer performance on the Prospective Memory task embedded in complex ongoing task. Previous finding has been found in support of this present result. **Norman and Bobrow (1975)** believed each kind of resource would have to be investigated separately to determine whether or not two tasks were competing for them.

If the two tasks interfere, they are said to be competing for the same resources, of they don't interfere they were using separate resources.
From the mean and standard deviation of false alarm given by the participants it can be seen mean of false alarm is greater when participants were exposed to Prospective Memory task embedded in complex ongoing task.

Mixed ANOVA of false alarm scores indicates there was a statistically significant main effect of difficulty level of ongoing task, in terms of false alarm responses given by the participants to the Prospective Memory task performance.

From the result it can be said as the difficulty level of ongoing task gets increased, the tendency of doing error or false alarm also gets increased. Studies revealed the delay period between encoding the intention and the actual act is filled with cognitive activity that prevents active and conscious rehearsal, which differentiates Prospective Memory from working memory or vigilance **(Reynolds et al., 2009; Burgess et al., 2011).** This prevention of rehearsal of future intention causes more tendency of doing error. That means participants were not aware of preparing remembered responses.

Mean and standard deviation of true proportion of correct detection indicates, true proportion of correct detection is higher when the 3 groups of participants were exposed to Prospective Memory task embedded in simple ongoing task than Prospective Memory task embedded in complex ongoing task.

The present result reveals there was a statistically significant main effect of ongoing task difficulty to the Prospective Memory task in terms of true proportion of correct detection done by the participants.

Prospective Memory involves remembering to perform intended action in the future. It also measures the discrimination ability of an individual to differentiate between target and non-target events **(RE Smith, 2012).** According to the **Preparatory Attentional and Memory Process theory**, retrospective memories are also involved in Prospective Memory performance. Retrospective processes are needed for discrimination between Prospective Memory target and non-target events, as well as for the recollection of the intended action, processes that are likely to absorb attentional resources when the target is present.

Only hit rate and false alarm rate can't explain the discrimination ability of participants, so it is necessary to consider the true proportion of correct detection by correcting the bias of error.

From the present result, indicating true proportion of correct detection, it was seen, with the increment of ongoing task difficulty the proportion of correct detection got decreased, which indicates complexity of ongoing task reduces the ability of participants to discriminate between target and non-target events. As a result, true proportion of correct detection which was obtained by correcting the response bias, got affected.

Prior Studies revealed, while an individual is simultaneously committed in a competing activity, namely an ongoing task with Prospective Memory task, ongoing task may compete for attentional resources with the Prospective Memory task, leading to a decrease in Prospective Memory performance. According to the attentional resource allocation theory (**Chen and Zhang, 2003**), an individual's attentional resources can be assigned to different tasks simultaneously, when an ongoing task seeks excessive attentional resources, the resources assigned to the prospective memory decrease, adversely affecting Prospective Memory performance. **(Mahy et al**., **2015**) also reported when an ongoing task is more difficult, it occupies more attentional resources assigned to the Prospective and as a result the resources assigned to the prospective memory task being reduced and affects an individual's performance.

Substantial evidence has revealed that the objective characteristics (e.g., difficulty) of an ongoing task can affect an individual's Prospective Memory performance. Attention management theory of (**Norman and Shallice, 1986**) posits, completing Prospective Memory task requires attentional resources and that the difficulty of an ongoing task directly influences Prospective Memory performance. **(Khan et al., 2008)** similarly explored the role of cognitive load in prospective memory performance. The low cognitive load condition involved minimal information processing, whereas the high cognitive load condition required deep processing. The result revealed same from this study that the ongoing task and prospective memory tasks compete for attentional resources, causes diminishment in Prospective Memory performances.

(Bisiacchi et al., 2009) found that increased ongoing task difficulty could adversely affect prospective memory performance, regardless of age.

Hence it can be said ongoing task difficulty reduces the true proportion of correct detection by reducing hit responses to the target and enhancing false alarm responses to the non-target events.

Present result implied there are no significant interaction effect of reward- responsiveness and difficulty level of ongoing task on the Prospective Memory task. It denotes impact of reward-responsiveness does not depend on the level of ongoing task difficulty, and vice versa.

Table of observational finding represents about the nature of false alarms given by the participants of (low, medium/average & high) reward responsive group on the Prospective memory task embedded in simple and complex ongoing task. The false alarm can be defined as error of commission. Error of commission implies mistake that consists of doing something wrong. And the table represents maximum of the participants respond to city name written with any colour and country name written with any colour and forgot to discriminate another property (physical property) of target word that is specific colour. But comparatively lesser percentage of participants respond to all word written with black colour in complex ongoing task and red colour in simple ongoing task and this percentage of participant forgot to respond to the (semantic property) of target word. So, it can be said the participants who were respond to semantic properties of target more, engaged with the task intensely.

Previous research revealed observer can build attentional set on the basis of higher level of semantic categorization, which enables one's attentiveness to prioritizing semantic content

over others stimulus parameters, such as shape, size, colour, luminance, location and motion regulate the occurrence of Inattentional blindnesss **(Yaning Guo, Ying Li., 2016). Mack & Rock (1998)**.

CONCLUSION

On the basis of the results reported earlier and discussion as stated, the following conclusions may be drawn.

i. There is significant mean difference in the event-based Prospective Memory task performance in terms of hit responses between the low and high reward-responsiveness group.
ii. There is significant mean difference in the event-based Prospective Memory task performance in terms of false alarm responses between the participants with (low-medium) and (low-high) reward-responsiveness group.
iii. There is significant mean difference in the event-based Prospective Memory task performance in terms of true proportion of correct detection between the group of (low and high) reward-responsiveness trait.
iv. There is significant effect of ongoing task difficulty on the event-based Prospective Memory task performance in terms of hit responses given by the participants.
v. There is significant effect of ongoing task difficulty on the Prospective Memory task performance in terms of false alarm responses given by the participants.
vi. There is significant effect of ongoing task difficulty on the event-based Prospective Memory task performance in terms of true proportion of correct detection done by the participants.
vii. There is significant difference between event-based Prospective Memory task performance in terms of hit responses and true proportion of correct detection between the participants of low and high reward-responsiveness group.
viii. There is significant mean difference on event-based Prospective Memory task performance in terms of false alarm responses between the participants of (low - high), (low - medium) & (medium - high) reward-responsiveness group.

Thus, on the basis of the present experiment it can be concluded that individual differences in reward-responsiveness, may make variation in prospective memory task performance even when reward of same value is provided to all. Person with high reward responsiveness trait can be motivated more with a reward which may not be sufficient for a person with low reward-responsiveness trait. Ongoing task difficulty adversely affects performance across all groups of participants with (low, medium & high) reward-responsiveness group. Participants not only forget to carry out intended action but also make errors by not remembering one property of target stimulus due to emphasizing another property more.

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Conflict of Interest

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