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Original Research Article

Effect of Random, Blocked, and Mixed Practice Order on Upper Extremity Motor Learning in Subjects with Parkinson's Disease

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ABSTRACT

Background: Random practice order has been shown to improve motor learning in normal individuals as well as sports players. The purpose of this study is to investigate which practice order is beneficial in subjects with Parkinson's disease.

Methodology: The total number of Subjects included in this study was 32. Blocked practice order followed by random followed by mixed practice order was given. In between washout period of 1 week was given. Response time during acquisition and retention was assessed. Data were analyzed statistically by using one-way ANOVA.

Results: The mean time taken by the subjects was maximum with Random practice order with (p=0.001, SD= 10.73) during Acquisition and (p=0.003, SD=8.88). The mean time difference was maximum with random (p= 0.001) in both the acquisitions as well as retention phases. On comparing the difference between the 1st and 10th trials of all three practice orders by using Analysis of Variance (ANOVA) post hoc analysis by using Tukey's test, we observed that in subjects with PD Random practice order is more beneficial than mixed and blocked respectively.

Discussion: On comparing all three practice orders we can infer that Upper Extremity motor learning skill was superior with Random practice orders followed by Mixed and blocked practice orders respectively in both the acquisition and retention phases.

KEYWORDS: Parkinson's Disease, Motor Learning, Practice Order, Acquisition, Retention.

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INTRODUCTION

Physiotherapy has an important role in reducing functional limitation and promoting activity participation and independence thus improving the quality of life in subjects with Parkinson's disease.

Parkinson's disease (PD) is a disorder belonging to a group of conditions called motor system disorders, which are caused by the loss of dopamine-producing brain cells [1].

The cardinal motor symptoms of Parkinson's disease are Rigidity, Bradykinesia, Tremors, and Postural instability. PD is also associated with Freezing episodes, Micrographia, Trembling of hands, legs, face, and jaw, Poverty of movement, Hypomimia (masked face), Festinating gait, and Akathisia [2]. Motor learning is defined as, the "study of acquisition or/and modification of movement" [3].

The definition of motor learning reflects four concepts: 1) Learning is the process of acquiring the capability for skilled action; 2) learning results from experience or practice; 3) Learning cannot measure directly; 4) learning results in permanent changes in behavior [3].

Practice order refers to the sequence in which tasks are practiced [4]. Battig (1966) was the first to study the 'contextual variety' instead of 'intra-task interference' (Battig, 1972) [5]. Finally, he developed the term 'contextual interference' (Battig, 1979) [6]. He used this term because 'contextual interference' focuses on the roles of contextual factors that are internal and external to both the task characteristic and the learner characteristics. In other words, the entire practice context, including the task difficulties, the practice schedule, and the processing engaged by the learner, were seen as potential sources of interference that could enhance (or reduce) learning [6].

It has been proved that in blocked practice order, repetition may provide early opportunities for error correction and movement pattern exploration [4]. This helps normal individuals to get a general idea of what needs to be done to reach the action goal, which in turn helps in the retention of the task. (4) Random order practice is more beneficial when transfer from one task to another task is required [4]. Alireza Zamani and colleagues in "world journal of sports sciences proved that mixed order practice had a beneficial effect on the retention of skills and task-switching capacity in beginner of volleyball players [7].

Procedural learning is defined as the ability to learn new perceptual, motor, or cognitive skills [5]. According to Cohen and Squire (1980), it refers to the capacity to progressively acquire new skills because of long and repetitive training [5]. These skills are stored in unconscious reference to previous experience. Because of the preservation of procedural learning abilities in a patient with memory impairment, it is easy to construct new rehabilitation strategies in clinical settings [5]. It will help clinicians to develop more efficient rehabilitation programs. Procedural learning is affected in subjects with Parkinson's disease [5,8]. Our goal is to identify an optimal task practice order for people with Parkinson's disease.

AIM: To find the effect of random, blocked, and mixed practice order on upper extremity motor learning in subjects with Parkinson's disease.

OBJECTIVES

· To assess the effect of blocked practice order on sequential task response time, and Retention in subjects with Parkinson's disease.

· To assess the effect of random practice order on sequential task response time, and their Retention in subject with Parkinson's disease.

· To assess the effect of mixed practice order on sequential task response time, and Retention in subject with Parkinson's disease.

· To compare the effect of blocked, random and mixed practice order on sequential task response time and Retention in subjects with Parkinson's disease.

MATERIALS AND METHODOLOGY

It was a crossover observational study, with a sampling size of 32. From previous study by, "Chien-Ho (Janice), Lin, Katherine J Sullivan, Allan D Wu, Shailesh Kantak, Carolee J Winstein" [16], we found that the Effect size for change in reaction time in blocked pattern is 0.54. for estimation of sample size , $\alpha = 0.05$, power $(1-\beta) = 80\%$ based on these values using formula for sample size estimation for two co-related means following same author we estimated sample size b using "STATA VERSION 13.1" , our sample size is 29. In the same study author also reported, "The effect size for random to be 0.83" we also estimated sample size as in previous case with $\alpha = 0.05$, $(1-\beta) = 80\%$ we used same formula for estimating sample size and sample size to be estimated 15.

We choose larger no. to be our final sample, thus our estimated sample size is 29. Accounting for 10% data loss we inflated sample size by 3 thus our final sample is 32.

A conventional sampling method was used. OPD of tertiary health care center was used as a study setting. The duration of the study was 18 months. Subjects with Parkinson's disease classified according to Hoehn and Yahr stages 1 to 3, Age group above 40 years, and Subjects with MoCA score e” 26 (normal cognition) were included in this study. Subjects with a neurological condition other than Parkinson’s disease, acute musculoskeletal disorder, cardiovascular disorder, Uncorrected visual disorder, Uncontrolled Diabetes mellitus, Hypertension, or any psychological condition were excluded from the study.

Ethical clearance was obtained from the institute’s ethical committee. Subjects willing to participate in the study were recruited from a Physiotherapy OPD of a tertiary care center and written informed consent in a language best understood by the subject (English/Hindi/ Marathi) was obtained. Subjects were enrolled according to inclusion and exclusion criteria, then the detailed procedure and importance of this study were explained to the patient. The dominant hand was used to perform practice orders. A sequential upper extremity learning task was given to the subjects.

One container full of different colored blocks was kept on the table, and a chart depicting the sequence of practice order: blocked (e.g.-R-R-R-R, G-G-G-G-G etc.), Random (e.g.-B-G-Y-W, W-R-G-B-Y, etc.), Mixed (e.g.-R-R-R-R, R-B-G-Y-W etc.) as shown in the pictures were given to the subjects on day1 (acquisition phase). Subjects were asked to choose blocks from the container and placed it on a given practice order chart. Subjects performed 10 repetitions of sequences in each type of practice order. Time taken to complete each task was considered as response time.10 such response times were measured for each practice order. Total 5 blocks×10 repetitions that is total 50 trials were given to the subjects.

The above procedure was repeated on the next day in order to assess retention. Errors were defined as the selection of the wrong color and/or sequencing of blocks on that particular block on the chart. Errors in the performance were reflected as an increase in the sequential task time. When the number of errors increased, the time taken to complete the sequential task also increased.

The difference between the 1st response time and the 10th response time in each practice order gave an idea about motor learning during acquisition and retention.

Practice trials were given to the subjects. During the acquisition phase, the methodology was explained to the subjects and 3 repetitions of each practice order were given before the actual trials. By following the principles of the Challenge Point Framework, practice trials’ knowledge of results in the form of Feedback on the time taken to complete the previous trial and errors was given to the subjects.

This was a cross-over study, hence a washout period of one week was given in between the different practice order trials. All subjects performed blocked order trials (acquisition and retention) in the first week. Random practice order trials (acquisition and retention) were performed in the second week followed by Mixed practice order (acquisition and retention) in the third week. Outcome measures used was Response time in seconds during acquisition phase (day1) (time taken by subjects to complete sequential task), Response time in seconds during retention phase (day2) (time taken by subjects to complete sequential task) Data was analyzed using appropriate statistical test.

Fig. 1: Blocked Practice Order (Subject performing with Blocked Practice Order)

Fig. 2: Random Practice Order (Subject performing with Random Practice Order)

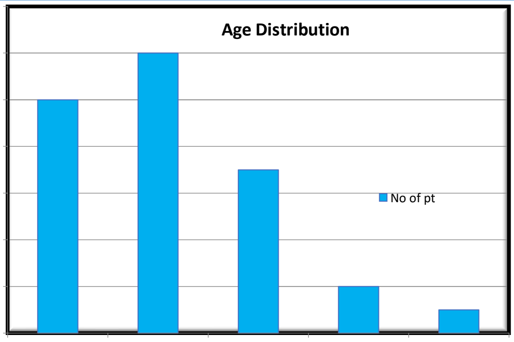
Fig. 3: Mixed Practice Order (Subject performing with Mixed Practice Order)

RESULTS

All the data were analyzed using STATA version 13. Statistical significance was defined by p-value $\leq$ 0.05. We calculated the means and standard deviation for linear variables by using paired t-test. The mean across three groups was compared using Analysis of Variance with a post hoc test using Tukey's correction.

Table 1: Age distribution of subjects with PD who are included in this study.

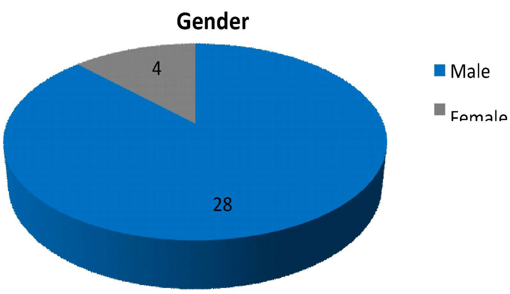
variables	obs	mean	Std dev	Min Age	Max age
age	32	68.63	5.42	60	82



Graph1: Age distribution of Parkinson's disease Population. (Table 1)

Table 2. Gender distribution 32 subjects were included in the study of which 87.5% (n=28) were males and 12.5% (n=4) were females.

Male	28
Female	4
Total	32



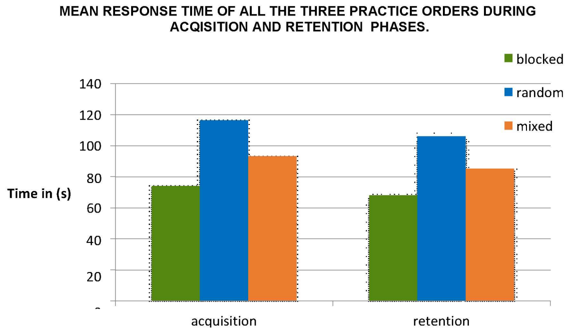
Graph 2: Gender distribution of subjects with Parkinson's disease included in this study. (Table 2)

Inference: This Pie chart concluded that there were 28 males, and 4 females were included in this study.

Table 3: mean response time during all three practice orders on day1(acquisition) and day2 (retention)

ACQUISITION	Variables	Mean 't'	SD	95%conf interval		p value
blocked	32	70.94	9.27	67.59	74.28	
Random	32	110.73	10.73	107.06	114.8	<0.001
Mixed	32	88.88	7.83	86.05	91.7	
RETENTION						
blocked	32	62.48	7.19	59.88	65.08	
Random	32	106.69	8,88	103.49	109.86	<0.003
Mixed	32	84.76	7.89	81.92	87.61	

The p value of all three practice orders is less than 0.001 for acquisition and 0.003 for retention is statistically significant.



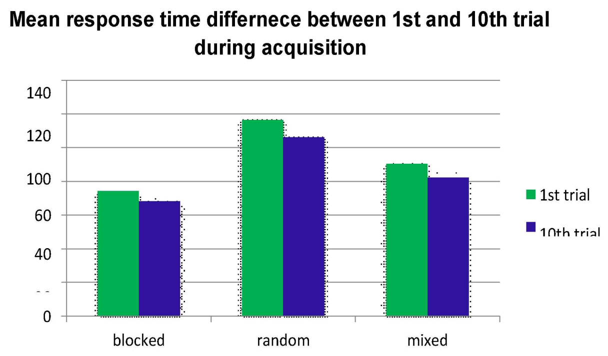
Graph 3: Mean response time during all three practice orders on Day 1 Acquisition and Day 2 Retention. (Table 3)

Inference: We compared mean time of 10 trails to complete a sequential task during acquisition (Day1) and retention phase (Day2). As shown in the table 1, the P value is less than 0.01 for the Acquisition phase and 0.03 for the Retention phase which is statically significant. We infer that mean time taken to complete the sequential task was maximum with Random followed by mixed and blocked practice order respectively.

Table 4: mean response time difference between 1st and 10th trials in all three practice orders during Acquisition(day1).

Variables (response time)	Obs	Mean	Std dev	95% conf interval		p value
BLOCKED				lower	Upper	
1st trial	32	74..28	9.5	70.85	77.71	<0.001
10th trial	32	68.13	9.33	64.76	71.48	
Diff		6.16	2.59	5.22	7.09	
RANDOM						
1ST trial	32	116.5	11.39	112.39	120.61	<0.001
10th trial	32	106.25	10.33	102.45	110.05	
Diff		10.25	3.03	9.16	11.34	
MIXED						
1ST trial	32	93.28	7.58	90.45	95.92	<0.001
10th trial	32	85.18	8.44	82.14	88.23	
Diff		8	1.92	7.31	8.69	

The p value of all three practice orders is less than 0.001 is statistically significant.



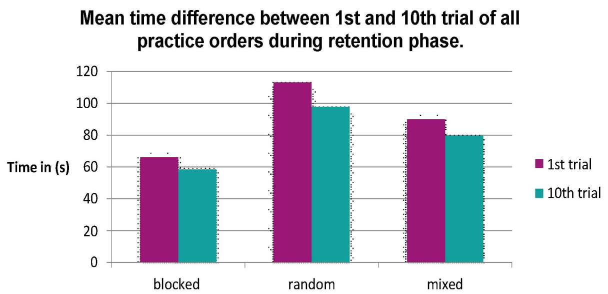
Graph 4: Mean response time difference between 1st and 10th trials in all three practice orders during Acquisition (Day1). (Table 4).

Inference: Time taken in all the three practice orders to complete a sequential task during acquisition phase was significantly less in 10th trial than time taken to complete the first trial. Paired t test was used to compare two variables which showed P value is less than 0.001 for all the three practice orders.

Table 5: showing time difference between 1st and 10th trial of all the three practices order during retention phase.

BLOCKED	Obs	Mean	Std dev	95% conf interval		p value
1st trial	32	66.16	7.79	63.35	68.97	
10th trial	32	58.44	7.75	55.64	61.23	<0.001
Diff		7.72	1.84	7.06	8.38	
RANDOM						
1ST trial	32	113.31	9.8	109.78	116.85	
10th trial	32	97.81	9.98	94.21	101.41	<0.001
Diff		15.5	6.73	13.07	17.93	
MIXED						
1ST trial	32	90.22	7.97	87.34	93.09	<0.001
10th trial	32	79.63	8.47	82.14	82.67	
Diff		10.59	2.89	9.55	11.64	

P value of all the three practice orders is 0.001 is statistically significant.



Graph 5: Time difference between the 1st and 10th trials of all three practices order during retention phase. (Table 5).

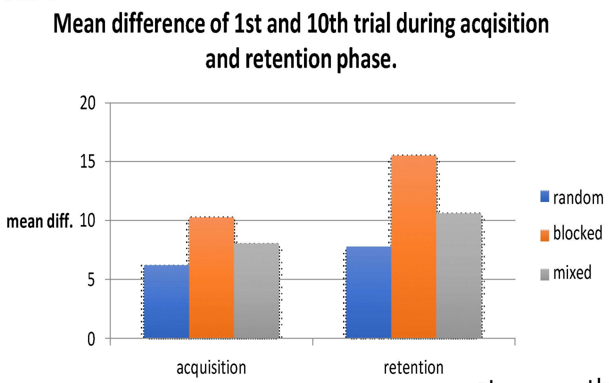
Inference: Time taken in all three practice orders to complete a sequential task during the retention phase was significantly less in the 10th trial as compared to the time taken to complete the first trial. Paired t test was used to compare two variables which showed P value is less than 0.001 for all the three practice orders.

ANOVA Post hoc analysis of blocked, Random, and mixed Practice order in subjects with Parkinson's disease:

Table 6: Mean difference between 1st and 10th trials of all three-practice order during acquisition and retention phase.

ACQUISITION PHASE	Standard Error	Mean diff	p	T	95% confidence interval	
Random vs Blocked	0.482667 5	4.25	0	8.81	3.1	5.399
Mixed vs blocked	0.482667 5	2.378	0	4.92	1.225	3.524
Mixed vs Random	0.482667 5	-1.875	0.001	-3.88	-3.024	-0.752
RETENTION PHASE						
Random vs blocked	0.496755 3	6.937	0	13.97	5.754	8.121
Mixed vs Random	0.496755 3	2.531	0	5.1	1.348	3.714
Mixed vs Random	0.496755 3	-4.4	0	-8.87	-5.589	-3.223

Difference between response time of 1st and 10th trial of all three practice orders during acquisition and retention were compared using Analysis of variance (ANOVA). Post hoc analysis test was done by using Tukey Kramer's test.



Graph 6. Mean difference between the 1st and 10th trials of all three practice orders during the acquisition and retention phase. (Table 6)

Inference: The difference between the response time of the 1st and 10th trial of all three practice orders during acquisition and retention were compared using Analysis of variance (ANOVA). A post hoc analysis test was done by using Tukey Kramer's test.

DISCUSSION

Our study showed that the mean time of 10 trials taken to complete a sequential task during the acquisition phase as well as retention was maximum with Random followed by mixed and blocked practice orders respectively. The time taken to complete the sequential task was maximum in the random practice order because the random schedule is characterized by superior cognitive demands compared to the other two practice orders. The reconstruction mechanism takes place in random practice order which requires more effortful processing to construct a new plan for the generation and execution of a particular process or movement [5]. A study done by Shea and his colleagues suggested that in Random practice order, the action to be learned undergoes a more elaborative and distinctive process as compared to blocked practice order [9]. In the Random group the presence of more than one action in working memory facilitates elaborative and distinctive processing both across the action and within the action, because of the time taken to complete the sequential task was maximum with random practice order [9,10].

According to Immink and Wright (1998), random scheduled subjects may need more time to complete their preparation of upcoming movements than their blocked practice schedule. (11) To test this prediction, they allowed participants to choose how long they viewed stimulus material to plan a forthcoming movement. In the blocked schedule, subjects practiced all the trials corresponding to one of the sequences before practicing another sequence, whereas in the random schedule, the practice trials for each sequence were randomly distributed among all the practice trials [11]. As predicted by the reconstruction hypothesis, the study time decreased faster and reached a lower limit during blocked practice than during random practice [4], hence the mean time would have been lesser with blocked practice as compared to random practice.

Keller, Li, Weiss, and Relyea (2006) consider that response selection, task comparison, and the effortful processes involved in the reconstruction of an action plan have an important role in top-down executive control processes. Random practice forces the learner to become more actively engaged in the learning process by preventing simple repetitions of actions [12].

Because of the construction-comparison-reconstruction of the action plan, the sequential task takes more time with Random practice orders than the other two practice orders.

Our study also showed that in all the three-practice order time taken to complete the sequential task for acquisition as well as retention phase was significantly less in the 10th trial than in the 1st trial, which suggests that upper extremity motor learning has occurred in all the three-practice orders.

Similar findings were observed in a study done by Lee, Wishart, Cunningham, and Carnahan's (1997) compared three groups in their study: random practice blocked practice, and a random-blocked practice group for which a model was provided prior to each trial. Lee et al. (1997) showed that providing a template for the next trial should prevent forgetting and the consequent need for action-plan reconstruction processing [35] Their results showed that the random group performed similarly to the blocked group on both the acquisition and retention tests [13]. On comparing means by Analysis of Variance (ANOVA) we can comment that Random practice order (with mean=10.03, SD=2.16) is more effective than mixed (with mean=8.16, SD=1.78) followed by blocked (with mean=5.78, SD=1.83) practice order during the acquisition phase, in subjects with Parkinson's disease. Our study also showed that Random practice order (with mean=15.28, SD=1.81) is more effective than mixed (with mean=10.88, SD=1.81) followed by blocked (with mean=8.34, SD=1.81) practice order during the retention phase, to improve upper extremity motor learning skills in subjects with Parkinson's disease.

Sideway et al., in their study on older adults and subjects with PD, showed that the Random practice order group performed superior to the blocked practice order by older adults as well as subjects with PD. This study suggested that the benefits of Random practice order for older adults and subjects with PD not only improves the implementation and execution of a new set of sequential behaviors but also the quality of knowledge contained in new memory. Hence retention is better with h Random practice order schedule [14].

According to the elaboration hypothesis, new skill learning can be sustained by two different kinds of processes: intra-task and inter-task. Intra-task processing involves the analysis of an individual task, without knowing any information directly related either to another task being acquired or other extant knowledge. In contrast, inter-task processing aims to highlight, through between-task analyses, the similarities and differences between the tasks being acquired. A blocked schedule requires only intra-task processing, whereas a random schedule calls for both intra-task and inter-task processing. In the blocked schedule, only one task is present in working memory at a time, which explains the requirement for intra-task processing. On the other hand, in the random schedule, several tasks are present simultaneously in working memory. Increasing cognitive demands during random practice by the addition of extra processing appears to create an overload phenomenon [15]. Random condition is characterized by superior cognitive demands. They also observed retention performance is better with random practice order [4].

The above studies support our findings that Random practice order is more beneficial during the acquisition as well as Retention Phases. Our study is a cross-over study that is subjects are under their control in subjects with normal cognition (MOCA>26) with Hoehn and Yahr scale grade 1- 3 included. Our study showed Random practice order is more beneficial to upper extremity motor learning skills since the subjects had normal cognition and therefore were able to cope with cognitive demands imposed by Random practice order. Thus, we can comment that in subjects with PD, incorporating a Random order of therapeutic exercise while planning an exercise program may be beneficial in motor learning and improving anticipatory and reactive postural control, thereby reducing the risks of falls.

CONCLUSION

This study concludes that upper extremity motor learning occurred in all three practice orders in Subjects with Parkinson's disease. Random practice order is most beneficial followed by mixed practice order and by blocked practice order respectively for enhancing upper extremity motor learning skills during Acquisition and retention phases in subjects with Parkinson's disease.

Limitations: The limitation of the study is the effect of Counterbalancing of all three practice orders was not studied.

Clinical implications: Our study showed Random practice order is more beneficial to upper extremity motor learning skills since the subjects had normal cognition and hence, they were able to cope up with cognitive demands forced by Random practice order. Thus, we can plan a therapeutic exercise program by using Random practice order to improve anticipatory and reactive postural control, thereby decreasing the risk of falls. It will help to improve the quality of life in subjects with Parkinson's Disease.

Scope for further research: Further studies can be done on subjects with PD who are cognitively impaired.

Authors Contribution

Lakshmiprabha Rangarajan: Helped in the selection of topic, Research Process, Review of Literature, Discussion, and Statistical Research Analysis. **Sneha V Kini:** Idea of research, Data Collection, Research Design, Research Process, Discussion, Editing, and Manuscript Drafting. **Prajakta Naik:** Research process, Discussion of Review of Literature, Data analysis, Discussion of Results.

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Ethical Approval and Patient Consent: .

The study was approved by the "institutional Ethics Committee" of Seth G.S Medical College and KEM Hospital, Mumbai which is affiliated with the Maharashtra University of Health Sciences. The Author explained the study procedure to be given to the participants and had taken the participant's consent prior to the study from every participant.

ABBREVIATIONS

PD- Parkinson's Disease

MOCA-Montre=al Cognitive assessment

Conflicts of interest: None

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