Original Research Paper

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Effect of Different Schedules of Knowledge of Performance As Feedback On Skill Acquistion in Adults

Medical Science

KEYWORDS : Knowledge of performance, Knowledge of result, Motor learning.

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ABSTRACT

Background: The acquisition of motor skills is fundamental to human life. Feedback is considered important determinant of motor learning. Deciding what type and frequency of feedback is most effective for teaching a specific motor skill is critical for physical therapy professionals. Previous work done has focused mainly on Knowledge of Result as augmented feedback but our study aims at studying the other form of augmented feedback i.e. Knowledge of performance.
Purpose: The purpose of the study is to study the effect of different schedules of Knowledge of performance as feedback on skill acquisition in adults.
Design: Experimental research design
Methods: 140 young adults (20-30 years) were recruited from Jamia Hamdard, New Delhi, India. Comparison of different schedules of Knowledge of performance as feedback on the basis of mean radial error in dart throwing task.
Outcome Measures: Mean radial error i.e. Average deviation from the centre of target (in cms).
Results: The results show significant difference between performances of different schedules of feedback. 50% KP was found better than 100% KP and 50% KR group during acquisition, retention, and transfer phases. However there was no significant difference between groups during retention phase.
Conclusion: With reduced frequency of Knowledge of performance as extrinsic feedback performance was better during acquisition, retention, and transfer phases. Thus, 50% KP is more efficient and advantageous form of feedback for learning of motor skills.

BACKGROUND

The acquisition of motor skills is fundamental to human life1. Skill is an individual's ability to consistently achieve a goal(s) under a wide variety of conditions. Movements are the means by which motor problems or motor skills are solved. A movement is viewed as a kinematic chain of motion having spatial and temporal coherence relevant to the task. Motor learning has always been concerned mainly with the acquisition of new skills with practice2. The principles of motor learning have been proven very useful in their applications to learning a variety of tasks requiring various types of coordinated physical movement. Skill learning is a continuous and dynamic process without distinct and definite stages. It is widely recognized that task performance improves with practice thus not only the amount of exercise, but also its condition and quality can have an important effect on learning and final performance3.

Numerous variables are considered important determinants of motor learning and one of the most critical is Feedback1,2. Feedback is sensory information that is available during or after the action related to the sensations associated with the movement itself (e.g., feel, sound) as well as information related to the result of the action with respect to the environment goal1. These two sources of feedback have been referred to as intrinsic (inherent to the action and includes kinesthetic, visual, cutaneous, vestibular, and auditory signals) and extrinsic (information provided from an external source)3.

Extrinsic feedback relating to the outcome of an action with respect to the environmental goal is referred to as "knowledge of result" and extrinsic feedback, which provides information about the nature of the movement pattern underlying the goal outcome, is called "knowledge of performance1".Extrinsic, or augmented, feedback can be provided to the performer in various ways. It can be verbal or nonverbal, and it can be provided concurrently, immediately following, or delayed in time with respect to the relevant action1.

It is known for some time that augmented feedback has a substantial effect on learning and performance during training. Numerous studies have examined the predictions of the 'guidance hypothesis' which received its name from the role feedback is thought to play in guiding the performer to the correct movement. Frequent feedback during practice has been argued to result in less stable performance it prompts the performer to adjust even small response errors that may simply represent an inherent variability in the motor system4.

Recent research on augmented feedback has focused on the effects of variations in the form and scheduling of feedback. Several knowledge of result studies have shown that frequent feedback guide a learner's performance during acquisition, it also causes dependence on feedback and prevents the learner from intrinsic feedback processing and error detection that ultimately maintains performance when feedback is withdrawn5.

To better verify the empirical validity of recommendations for the use of knowledge of performance as augmented feedback, more studies are necessary. For this reason present study aims at investigating effect of different schedules of knowledge of performance as feedback on skill acquisition in adults.

METHOD

A total of 140 normal individuals (20-30 yrs) were recruited in the study from Jamia Hamdard campus, New Delhi, India, by Convenience sampling. All the selected subjects were informed in detail about the type, nature and purpose of the study and those who signed informed consent participated in the study.

The subjects were selected on the basis of inclusion criteria: were apparently normal healthy individuals; age between 20-30 years; had no prior experience with the experimental task. The subjects were excluded if they had any neurological disorder; musculoskeletal problem of upper limb

that would be used to perform the task or any uncorrected visual deformity.

Measuring tools and Equipments: Wooden dart board (24 cm in diameter), Steel tipped darts, Measuring tape.

Procedure: All procedures were approved by the Institutional Ethics Committee. Subjects meeting inclusion criteria were selected for study. All the participants were informed in detail about the type, nature and purpose of the study and informed consent was taken from each participant. The wooden dart board was mounted on the wall at a height of 1.7 m from ground and target distance was 2.3 m during acquisition and retention phase and during transfer phase target distance was increased to 3m.

Subjects were randomly assigned into four groups: No Feedback, 50% KP, 100% KP and 50% KR group through lottery method. Individuals in No Feedback group were not given any feedback. Individuals in 50% KP group were provided KP as feedback after alternate trails. In 100% KP group feedback was given after every trail. And in 50% KR group another form of feedback i.e. KR was given after alternate trails. Prior to the first (acquisition) phase, the experimenter spent 10 minutes with each participant to explain and demonstrate the basic technique of throwing darts.

Knowledge of performance was provided as information about movement patterns, for e.g., "for dart throwing shoulder should be fixed, force is to be applied through elbow and wrist is to be moved from radial extension to ulnar flexion". Knowledge of result was provided as information about the outcome of the movement, for example, "good if movement was done properly and poor if movement was not done properly." Both types of feedback were verbalized by the investigator.

All participants were given the same general instructions regarding the task goal and the throwing position. General instructions included: The feet, hips, knees, and shoulders should be aimed at the target, feet shoulder-width apart. The back should be arched at the beginning of the throw. The dart should be behind your head at the beginning of the throw. The arms should go over the head during the throw and finish by being aimed at the target. The dart should be released just in front of the head. Feet should remain on the ground.

Each participant came for 2 consecutive days. On the first day, during the acquisition phase, participants had to throw the darts 50 times in 5 trial sets (10 throws per set). At the end of each trial set, the experimenter marked where the dart hit the target, and removed the darts from the target.

One day after the acquisition phase, both retention and transfer phases were conducted. In the retention phase, participants had to throw 20 darts (2 sets of 10 throws each) from the same distance as in the acquisition phase. Several minutes later, the transfer phase was conducted, in which participants had to throw 20 darts (2 sets of 10 throws each) from a farther distance of 1m. No further feedback was given in both retention and transfer phases.

Data was collected on the basis of average deviations of darts from the centre of target (in centimeters).

DATA ANALYSIS

Data was analyzed using SPSS 20 software. Descriptive analysis was done to project the results. Dependent variables were analyzed using one-way and repeated ANOVA and the significance level of 0.05 was kept.

RESULTS

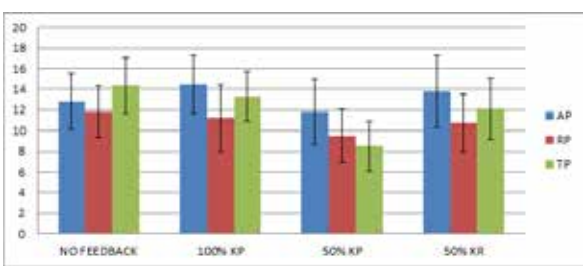
The four independent variables were different feedback conditions i.e. No feedback, 100% KP, 50% KP, 50% KR. The dependent variable was mean radial error, measure of the accuracy of the task. Mean radial error provided an indication of the average deviation of the darts from the centre of the target in centimeters. Lower score indicated a more accurate performance. Mean radial error was analyzed in acquisition, retention and transfer phase of motor learning.

Table 1:-The scores of four groups in three different phases

Group(s)	AP (Mean±SD)	RP (Mean±SD)	TP (Mean±SD)
No feedback (n=35)	12.8±2.7	11.8±2.5	14.4±2.7
100% KP (n=35)	14.5±2.8	11.2±3.2	13.3±2.4
50% KP (n=35)	11.8±3.2	9.5±2.6	8.5±2.4
50% KR (n=35)	13.8±3.5	10.8±2.8	12.1±3.0

n=number of subjects in each group, AP: Acquisition phase,

RP: Retention phase, TP: Transfer phase



Graph 1: Change in Performance of all four groups.

Between group results

Acquisition phase: Result of analysis for acquisition phase show significant difference between performance of 50% KP group when compared to 100% KP and 50% KR groups.

Retention phase: Result of analysis for retention phase show significant difference between performance of 50 % KP group and no feedback group. Performance in other feedback conditions group has shown no significant differences.

Transfer phase: Result of analysis for transfer phase has shown significant improvement in performance in all feedback conditions but 50% KP group was superior in their performance.

Table 2: Comparison between groups during different phases of motor learning:

Group(s)	AP	RP	TP
p-value** (overall comparison)	0.00*	0.00*	0.00*
No feedback vs. 100% KP	0.11NS	0.99NS	0.40NS

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No feedback vs. 50% KP	**0.99^{NS}**	**0.00***	**0.00***
No feedback vs. 50% KR	**0.88^{NS}**	**0.99^{NS}**	**0.00***
100% KP vs. 50% KP	**0.00***	**0.06^{NS}**	**0.00***
100% KP vs. 50% KR	**0.99^{NS}**	**0.99^{NS}**	**0.40^{NS}**
50% KP vs. 50% KR	**0.04***	**0.26^{NS}**	**0.00***

*: significant at p≤0.05, **: One-way ANOVA used, NS: Non significant

Within group comparison
No feedback group: As the learning progressed from acquisition to retention phase the improvement was significant but as the learning progressed from retention to transfer phase the scores deteriorated and even more than scores of acquisition phase.

100% KP group: As the learning progressed from acquisition to retention phase the improvement was significant but as the learning progressed from retention to transfer phase the scores deteriorated but better than scores of acquisition phase.

50% KP group: As the learning progressed from acquisition to retention phase the improvement was significant and also there was significant improvement while progressing from retention to transfer phase.

50% KR group: As the learning progressed from acquisition to retention phase the improvement was significant but as the learning progressed from retention to transfer phase the scores deteriorated but better than scores of acquisition phase.

Table 3: Comparison within groups during different phases of motor learning:

Group(s)	AP vs. RP	AP vs. TP	RP vs. TP	Overall within group comparison**
No feedback	**<0.01***	**<0.01***	**<0.01***	**<0.01**
100% KP	**<0.01***	**<0.01***	**<0.01***	**<0.01***
50% KP	**<0.01***	**<0.01***	**<0.01***	**<0.01***
50% KR	**<0.01***	**<0.01***	**<0.01***	**<0.01***

** Repeated measure ANOVA used, *: significant at p≤0.05

DISCUSSION

The present study attempts to describe the effects of different schedules of feedback on acquisition, retention, and transfer phases of motor learning.

The key findings that emerged from the study were that 50% KP is more beneficial than other feedback conditions when given as feedback. Major group differences became pronounced during transfer phase when subjects could actually made use of 50% KP as feedback to learn a novel skill. The results of our study support the work done by S. Chiviacowsky et al (2010) which indicated that reducing KR frequency can enhance motor learning in persons with PD6. They compared different frequencies of KR (100% vs. 66%) and concluded that 66% KR group was more accurate and less variable in their performance. It concludes that increase in relative frequency of feedback lead to decrease in motor performance and learning. This result is also supported by "Guidance hypothesis" which says that extrinsic feedback guides the learner to goal behavior. It signifies that extrinsic feedback is an important part of learning process but if it is provided too frequently it can cause a dependency. Frequent extrinsic feedback causes the blocking of processing of intrinsic feedback. This result concludes that reduced frequency of extrinsic feedback is beneficial but previous researches has focused more on KR as augmented feedback and in present study we found that reduced frequency of other form of Augmented feedback i.e. KP is also beneficial.

Results also indicated significant difference between 50% KP and 50% KR. Among reduced frequency of both forms of extrinsic feedback KP was found beneficial. Explanation to this result can be provided on the basis of work done by Newell and Walter (1987)7. In previous researches KR was proved to be appropriate for scaling of a single degree of freedom movement. As KR specifies all the information that is required to learn the positioning or timing of single dimension response, KP is found to be effective for multiple degree of freedom tasks. As in multiple degree of freedom tasks appropriate outcome depends on interaction among movement segments, so the information provided in form of movement kinematics or kinetics i.e. KP is more important than providing information regarding the end results of movement i.e. KR. Present study aimed at a task which included multiple degrees of freedom so information in form of movement kinematics was found to be beneficial.

The fundamental assumption is that learning is a problem solving process and that the information available during and after each attempt to solve the problem is remembered and forms the basis of learning8. The present study demonstrated that type of information delivered via verbal instructions regarding the kinematics of motion can significantly influence the subsequent movement production rather than providing the information regarding the end result of movements.

Between group discussion
Learning is defined as process that results in a relatively permanent change in behavior brought about by experience9. Present study includes three phases of learning: Acquisition, Retention, Transfer phases.

Acquisition phase
Acquisition is active process of attempting to perform a task. It is one of the factors that affect motor learning10. 50 trials were performed by subjects in 5 trial sets. It is said that when brain performs a movement and observes the consequences, it learns from resulting errors11.

Present study showed significant difference between acquisition phases scores of 50% KP compared with 100% KP and 50% KR group. This indicates learning improved with practice and feedback given in form of KP after alternate trials as it produced baseline differences during acquisition phase. This result is supported by the work done by G. Tzetius et al in 199912. They assessed the effects of implementing different instructions strategies (a) Knowledge of Performance, (b) Knowledge of Performance + Knowledge of Result + Goal Setting, (c) Knowledge of Result + Goal Setting on acquisition and retention of technique for dribbling and shooting skill in basketball. Results revealed that KP is beneficial to learning of motor skills which require specific forms for optimal performance. Task complexity and task criterion specifies the type of information feedback which is needed for skill learning. The information provided through feedback must match the end results required and the constraints imposed upon the response.

Retention phase
Retention refers to performance level after completion of

practice phase13. The most common means of assessing learning is by a retention test. The purpose of retention test is to determine the degree of persistence of the performance level achieved during practice. In present study fewer practice trials were used with no feedback given to subjects to test performance. Retention test used to determine the presence of motor learning was performed after 24 hours. It is seen that passage of time is essential for maximum benefit of practice to be gained as the time delay may allow for consolidation of learning14.

According to result there occurred a significant difference between the scores of retention phase of 50% KP group when compared to no feedback condition and 100% KP group. This implies that when information was provide in form of KP, reduced frequency of feedback showed better result during retention phase. This result is supported by the work done by P. M.V. Vliet et al (2006)15. They assessed the effect of extrinsic feedback for motor learning after stroke. They found that there were no significant differences between feedback frequency groups in retention test, although both reduced frequency groups tended to be more accurate than the 100% condition. When feedback is provided too frequently, learners become dependent on it. Feedback were given through acquisition phase became a part of practice so sudden removal of feedback during retention phase resulted in movement instability as by this time dependency on feedback has occurred.

Also a Meta analysis done by F. Marschall16 concludes that frequent augmented feedback degrades learning. Results confirm the presence of "Reversal Effect". It concludes that the groups which practice at reduced frequency of augmented feedback show a lower performance level at the end of acquisition but during retention phase trend reverses. During retention phase group which was provided with reduced augmented feedback showed better performance so they tend to be superior learners.

Other results from retention test showed no significant difference between No feedback condition when compared to other feedback condition i.e. 100% KP and 50% KR group and also when 50% KP group was compared to 100% KP and 50% KR group. Schmidt (1992)10 gave some possible reasons for this non significant difference between groups in Retention phase. One possibility could be explained by fact that there was absence of feedback in RP. Also the feedback given in acquisition phase, to acquire the capability to produce effective performance could block information processing activities in retention phase. Another possibility can be that the feedback made the performance too variable preventing the learning of stabilized representation which is necessary to sustain performance on retention phase.

Transfer Phase

Transfer phase is used as distinguishing test to show that learning has taken place10. Transfer phase of learning deals with transferring ones knowledge and skill from one problem solving situation to another10. Transfer phase was conducted by increasing the distance of throw by one meter. No feedback was given to test the transfer phase.

Results from transfer test show significant difference between groups. All feedback conditions had shown better performance than no feedback conditions during transfer phase. This result is supported by the work done by Amir Dana et al in 20113. They assessed the effect of period of feedback training on learning shooting skill and concluded that feedback had a positive effect on learning and performance. Novice performers simply lack experience in controlling their movement while learning a skill and they need experience to remedy skill deficits. Feedback plays an important role in providing information regarding movements which helps in improving performance in novice. Thus feedback conditions had shown better performance than no feedback condition.

Results also revealed that there was significant improvement in performance in 50 % KP group during transfer phase when compared to other feedback conditions i.e. 100% KP and 50% KR groups. It signifies that less frequency of KP is more beneficial. Previous work done on information feedback concluded that KR was more effective for the open skill and KP was the more effective training method for closed skill. In present study task was performed in closed environment with no involvement from external environment. As the task was performed in a closed room so KP was found effective.

Within Group Discussion

Within group differences in 50%KP group showed more significant improvement occurring. It suggests that as one progressed from acquisition to transfer phase, decrease in mean radial error occurred which showed increased accuracy. Thus, this type of feedback condition had relatively stronger and immediate effects on performance. This improvement in 50% KP group during transfer phase captures the idea that better learning can only occur when learner is challenged. In present study learner is challenged by increasing the task difficulty.

For 100% KP and 50% KR group, within group differences showed that learning improved while progressing from acquisition to retention phase, but, then deteriorated while progressing from retention to transfer phase. Our results are consistent with the predictions of the Challenge Point Framework17, which suggests that task demands, learner characteristics, and practice conditions interact to influence the level of challenge posed to the learner during practice. There is a point of optimal challenge at which the benefits of practice for learning are maximum. At this optimum level the learner uses appropriate levels of cognitive efforts. So while progressing from acquisition to retention phase optimal challenged point was reached which result in improved performances. But if the level of challenge exceeds this optimal challenge point, the resulting cognitive effort work beyond the information-processing capability of the learner; thereby interfering with learning benefits.

Relevance to Clinical Practice

From a clinical perspective, this study indicates that motor learning is a fundamental process and feedback has an impact on motor learning. In almost every training situation where motor skills are to be learned, performers are given feedback about correct movement pattern or technique. Since the results of present study revealed that reduced frequency of Knowledge of Performance is more beneficial than other form of feedback so it should be incorporated as a part of rehabilitation protocols for treatment of neurological disorders.

During rehabilitation of patient with neurologic disorder focus should to be kept on correct movement pattern rather than achieving the goal so KP play an important role in determining correct movement patterns.

Future research

Future research can be done including the task performed in variable environmental set-ups such as open environ-

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ment, so that it can be applied to real life situations.

Other schedules of feedback such as 33% or 25% can be studied in future research.

Studies can be done comparing the effect of reduced frequency and self controlled feedback conditions.

Future research can focus on different types of feedback like visual or video.

Limitations

Present study was conducted on a restricted age group.

Present study included less number of practice trials.

Present study aimed at a less complex task.

CONCLUSION

The findings of present study support the experimental hypothesis that there will be an effect of different schedules of Knowledge of Performance as feedback on skill acquisition in adults. The results of our study suggested that performance was better when Knowledge of performance was provided as feedback in reduced frequency as the subjects progressed from acquisition to transfer phase. So in our study experimental hypothesis holds true. Thus, reduced frequency of Knowledge of Performance can be used for rehabilitation of motor skill in patients with neurologic disorders.

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