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Reduced Feedback learning and implicit Process

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ABSTRACT

Current research was done to investigate the effect of reduced feedback on implicit process generation in learning a throwing task. 24 female students werevoluntarily and randomly placed in two groups of without visual feedback and with visual feedback. None of the groups were provided with throwing instructions. The groups exercised for three days, while retention and transfer tests were held on the fourth day. Visual of the participants was continuously checked based onSnellen scale and using Stereo Optical 5000 visualtester. The results of statistical analyses did not revealed a significant difference between the groups during acquisition, pretest, retention, accuracy and speed of counting (P>0.05). However, there was a significant difference in transfer and verbal protocol (P<0.05). It was concluded that the group without visual feedback has acquiredthe skill through implicit and individual process of working memory. In other words, learning has led to implicit process generation in throwing task via reduced feedback.

Keywords: implicit learning, reduced feedback, working memory, throwing task, visual manipulation apparatus

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INTRODUCTION

Skilled athletes have acquired their ability to execute complex motor skills using automatic control mechanisms (1).During learning of Fitts and Posner (1973), learners progress via relatively separate steps when they acquire a skill. The task is implemented rather difficultly such that each component of the skill requires attention (cognition step). The learner will get at motor step later and will thenachieve automatic step by noticeable exercise to execute the skill with the least attention. Numerous characteristics distinguish automatic processes from non-automatic (controlled) processes. The automatic process is described as empty capacity (Pashler, 1994; Shiffrin & Schneider, 1997), quick (Posner & Snyder, 1975), effortless (Logan, 1988; Shiffrin& Snyder, 1977), autonomous or with no need to attention (Kahneman & Treisman, 1984; Logan, 1988, and Pashler 1994)(2). AT the same time and with automation of the skill, various compatibilities might appear along the information which is being processed such that some variations from declarative knowledge to procedural knowledge will occur. Conventional approaches have concentrated on the first step of Fitts and Posner (1973) and use rules and instructions from which the learners are aware for training motor skill(3). However, there is a common technique among coaches behind this traditional method which facilitates quick progress in motor learning and movement control. Implicit motor learning is based on this assumption that the positive results of learning can be obtained by minimizing explicit information in learning processes and thus, minimizing the need to keep information in the working memory. Implicit learning is generally considered as "a process by using which the base of a complex and systematic knowledge is processed and generated independent from awareness" (4).Implicit motor learning was first introduced by Masters (1992) who pointed that the exercise environment could be effective in reliance to procedural knowledge and in reduction ofexplicit control. Implicit motor learning occurs as a reduction in hypothesis testing behavior. In most of the motor learning methods, the learners employ strategies associated to motion and assess the effects of them based on feedback of the result. Explicit knowledge is accumulated as a result of hypothesis testing behavior. Specifically during hypothesis testing, the learners useverbal rules in how they have acquired the skills which will be stored for future implementationif assessed useful and will be abandoned if rated useless (Allen &Reber, 1980). Generally speaking, implicit motor learning leads to reduction in the hypothesis testing behavior during motor acquisition and thus unawareness of the learner from infrastructures acquired (5). The researches have shown that the skill which is learnt implicitly in comparison with the skill which is acquired explicitly is much less exposed to failure and loss under stress (Masters, 1992; Maxwell, Masters & Eves, 2000; Lam, Maxwell & Masters, 2009); needs smaller attentional control (Masters, 1992; Maxwell, Masters & Eves, 2003); is resistant against aerobic and anaerobic fatigue (Poolton, Masters & Maxwell, 2007c, Masters, Poolton& Maxwell, 2009a); and is less susceptible to forgetting (Allen &Reber, 1980; Poolton, Masters & Maxwell, 2007c)(3-10). These observations have been demonstrated using different motor tasks including golf putting (Masters, 1992; Maxwell, Masters & Eves, 2000), forehand top spin on table tennis (Liao& Masters, 2001), equilibrium (Orell, Eves, Masters, 2006) and pass in rugby (Poolton, Masters & Maxwell, 2007c)(3-12). In recent years, some models of implicit learning have been developed which involve reduction in the number of traditional instructions and rules offered during learning (13), loading working memory along with a secondary cognitive task (dual task learning: Masters, 1992; Maxwell, Masters & Eves, 2000; Bright & Fridman, 1998), reduction of execution errors and conscious process (errorless learning: Maxwell, Masters, Karr&Weedon, 2001; Poolton, Masters & Maxwell, 2005), prevention of providing visual and auditoryinformation to the learner (reduced feedback learning: Masters, 2000; Maxwell, Masters & Eves, 2000&2003), providing skill rules by analogy (analogy learning: Lam, Maxwell & Masters, 2009; Law, Masters & Maxwell, 2003; Liao& Masters, 2001), prevention of outcome feedback at marginally perceptible thresholds of awareness perception threshold (subliminal learning, Masters, Maxwell & Eves, 2009)(14-18). However, learning via reduced feedback is insufficiently examined in terms of implicit process advantages and seems to be useful in sports and motor learning fields (8).

Reduced feedback learning is based on a similar assumption to errorless learning, especially implicit learning due to decreased reliance on the working memory as it does not study hypothetical rules about results of execution (8). Since there is no error in the errorless learning and since the least possible senses identifies errors in reduced feedback learning, the learner has just small information about errors of execution results or he/she has totally no information on this field. Then, the learner will use animplicit control model without further need to a working memory for hypothesis testing. Maxwell et al. (2003) explained reduced feedback learning in a set of three tests. All participants should have hit golf balls by either one of the two methods or without feedback about execution result. It was expected that the feedback access could have encouraged participants to be involved in the hypothesis testing behavior (thus explicit learning) and thereby, minimize feedback of the hypothesis testing behavior (thus cause implicit learning). In the first study, the results revealed no considerable difference between test conditions. This suggests that the reduced feedback group might have been involved in some explicit processes during learning. In the second study, all participants were asked to execute a visual search task during learning effort which prohibited the learners of reduced feedback group from using the working memory for processing sensory and proprioceptive feedback. The obtained results uncovered that the visual search task has prevented creation of explicit knowledge in the reduced feedback group which supports the hypothesis of reduced feedback. The third study extended the first two studies in two ways: first, it utilized a control group which executed an irrelevant motor task; and second, it measured acceleration of the golf club using an accelerometer during the shot as a dependent variable of learning. The final results emphasized that the learning is occurs upon reduced feedback conditions.

As mentioned before, the assumption test leads to accumulation of verbal knowledge related to the skill in working memory of the learner. The feedback from motion, especially visual feedback, is a tool utilized by the learner for evaluation of both skill and hypothesis testing in order to modify its performance error. The information is manipulated in the working memory and thus the learner becomes dependent on the working memory. However, using the working memory is decreased in reduced feedback based on the model of reduced feedback learning. Therefore, whenever the learners are asked to execute the skill under secondary task conditions, the group which has not received the feedback must outperform the group which receives it as dependent on the working memory (8). Thus, current work aims to investigate the effect of reduced feedback model on implicit process generation by elimination of the resultant visual feedback. Meanwhile, it has tried to study the effect of this model on learning a throwing task. In other words, the current research will try to answer this question whether reduced feedback affects implicit process generation in learning a throwing task.

MATERIALS AND METHODS

2.1. Participants

Some 24 female students with average ages of 22±2 years from Shahid Beheshti University participated in this survey voluntarily. All of them were right-handed with healthy visual and motor abilities. The participants had no previous experience in the task under study. They were randomly divided into 2 groups of 12 participants: with and without visual feedback.

2.2. Apparatus and Tasks

The tools utilized in this research included researcher-made task, visual manipulation apparatus made by sport institute of PadidarOmidFarda (Iran), visual accuracy assessment scale of Snellen and Stereo Optical 5000 visual test apparatus made in USA for ensuring healthy visual of the participants. The task used had two targets with the second target being made for the task was comprised of 10 concentric circles 3 cm far from each other. Each circle had a specific score: the smallest circle has 10 scores with the rest 9 larger circles being rated from 9 to 1, respectively. The first target was the area of hitting the ball to the ground. This area was located at a distance from the first target parallel with the second target. The ball must have first hit this area and then the second target. Scoring system for this task was such that if the ball did not hit the ground inside this area, zero point was given. If the ball hit inside the area but did not hit the second target, zero point was considered. If the ball hit inside the area and then hit the second target, a point relevant to the hit circle was gained.

2.3. Procedure

The participants were pretested using a 10 tasks block with 5 chances of experimental tasks before them (19). Afterwards, the acquisition step including 3 days of exercise was held with 5 blocks of 25 tasks in each. Participants rested for 50 seconds between each block. None of the groups were given instructions on how to throw the ball. Both groups exercised from distance of 3 m to the target. Both groups had Visual manipulation apparatus on eyes though these apparatus were activated only for the group of without visual feedback. The visual manipulation apparatus were remotely blinded by the tester apparatus in this group immediately after hitting the first target, such that the participant was unable to see his/her score. The visual manipulation apparatus was properly designed to solve the problems in the apparatus used by the research of Maxwell, Masters & Eves (2003). One major disadvantage of the apparatus utilized by Maxwell, Masters & Eves (2003) was using translucent technology, Plato System. Application of translucent technology widens pupil of eyes when the glasses is dimmed, and closes it when the glasses is cleared. As a result of these two, visual of the eyes is constantly changed which will make eyes tired, and reduce visual and thus accuracy of task execution. But the recently developed visual manipulation apparatus was operated by opening and closing of a semi-opaque diaphragm which obscured the visual without interrupting the visual. When this apparatus was wore, it provided a completely normal visual being remotely controlled once needed. Both groups were unaware that they were going to write after verbal protocol test. Each test was comprised of one block of 10 tasks. The participants attempted throws from 3 m distance in the retention test. The participants should have subtracted 3 values from 1000 along with throwing each time from the retention distance. They were also informed that both their accuracy and speed of counting were important and they must execute the two tasks as proper as possible. At the end of experiments, the participants were asked to write down the all rules and techniques used during execution with as much detail as possible.

2.4. Statistical Analysis

Descriptive statistics used for data ordering, and the Kolmogorov-Smirnov test used for normal distribution data. Levine's test was used for homogeneity of variance; variance analysis (3days×2groups) was used to analyze accuracy of throwing at the acquisition period; while independent T-test was utilized for comparing the groups during experiments, secondary task execution (speed and accuracy of counting), analysis of the number of rules reported in the verbal protocol. SPSS 18 software was employed to analyze the information, while the selected level for showing significant statistical difference was considered as $P<0.05$.

RESULTS

3.1. Acquisition period

The results of mixed analysis of variance demonstrated that the main effect of exercise groups and the main effect of exercise days were significant ($P<0.05$). The results of The Bonferroni post hoc test showed that there is no significant difference between the groups ($P=0.665$).

Table1. Statistical description of throwing accuracy variable during days of exercise (acquisition period) with and without visual feedback

Group	First Day M±SD	Second Day M±SD	Third Day M±SD
with visual feedback	143.75±3.25	162.6±10.44	171.16±9.34
without visual feedback	141.9±86	155.83±8.45	165.083±10.49
total	1423.37±3.30	159.12±9.88	168.12±10.19

Table2.Summary of results obtained from mixed analysis of variance (2groups×3days) for studying the effect of exercise days with and without visual feedback on accuracy of throwing

Source of Variation/Variable	sum of squares	degree of freedom	mean sum of squares	F	Significance	η^2
group	475.347	1	2415.544	6.617	0.017	0.231
days of exercise	8197	2	4098	64.801	0.0001	0.747
group × days of exercise	52.111	2	26.056	0.412	0.665	0.18

3.2. The test phase

The obtained results demonstrated that there is no significant difference between the groups during pretest, retention, as well as accuracy and speed of counting (P>0.05). Although, there is a significant different between transfer test and the number of reported rules (P=0.0001).

Table3. Statistical description of throwing accuracy variable during days of exercise (acquisition step) with and without visual feedback

Test/Group	Without Visual Feedback M±SD	With Visual Feedback M±SD
pretest	29.5833±7.92531	28±7.29882
retention	37.8333±5.85947	35.3333±4.84924
transfer	48.6667±5.98989	31.9167±5.83809
accuracy of counting	0.08253±0.14834	0.7918±0.1634
speed of counting	11.2506±3.51172	10.4059±4.99291
number of reported verbal rules	4.1667±1.11464	8.0833±1.5054

Table4. Results of T-test for studying the performance of throwing accuracy with and without visual feedback in pretest, retention, transfer, number of reported verbal rules, accuracy and speed of counting

Test/ Group	Average	Standard Deviation Error	Degree of Freedom	Significance	T-value
pretest	-1.58333	3.11024	22	0.616	-0.509
retention	-2.5	2.19561	22	0.267	-1.139
transfer	-16.75	2.414558	22	0.0001	-6.937
accuracy of counting	-0.3342	0.6369	22	0.605	-0.525
speed of counting	-0.84467	1.76213	22	0.636	-0.479
number of reported verbal rules	3.91667	0.54065	22	0.0001	7.244

DISCUSSION AND CONCLUSION

Current research was conducted to investigate the effect of reduced feedback on implicit process generation in learning a throwing task. At acquisition period, the results were indicative of an improved execution from the first session till the last session of exercise irrespective of their groups. Meanwhile, no difference was observed between the groups at retention test. These results were in agreement with those obtained by Maxwell, Master & Eves (2003,study3), Poolton, Masters & Maxwell (2007a), Lam, Masters & Maxwell (2009a&2010b), Masters, Poolton& Maxwell (2008a), Asgari (2010) all of which incorporated nodifferenceamong the groups during acquisition step and retention conditions. During transfer test, the group without visual feedback outperformed the group with visual feedback, such that performance of the latter was decreased for retention test while performance of the former was increased in this test. These results were in agreement with those addressed by Maxwell, Masters, Karr&Weeden (2001), Maxwell, Masters & Eves (2003,study3), Poolton, Masters & Maxwell (2005&2007c), Lam, Masters & Maxwell (2009b, 2010). Although, the results obtained here in this work were rather different with those reported by Maxwell, Masters & Eves (2003,study1), whichshowed that the group without visual feedback had a worse performance for transfer test while no difference was noticed between the groups in Maxwell, Masters & Eves (2003,study2) for the same test. It can be inferred from the resultsof this study that the group without visual feedback has acquired the skill upon implicit process with the implicit motor process being resistant against stress by performance of the secondary task. The results of executing cognitive secondary task showed that the groups have no significant difference in speed and accuracy of counting which implies the similar attention of both groups to the cognitive secondary task. These results were in agreement with those of Lam, Masters & Maxwell (2009a), Maxwell, Masters & Eves (2003,study3). The results also indicate that the groups do not process much information during execution of the skill. However, they are not in agreement with those of Maxwell, Masters & Eves (2003,studies1&2) who addressed a worse execution for the reduced feedback group. Another factor which is considered as a sign of operating the implicit process by Liao& Masters (2001) is the report of counting the verbal rules in relation with skill execution rules. On the other hand the number of verbal rules indicates independency of execution to verbal rules and thus keeping empty the working memory from processing explicit rules during execution of the skill. The results of the current study showed that the group without visual feedback incorporates fewer rules in the verbal protocol as compared to the group with visual feedback. This finding is in agreement with researches conducted by McMahon & Masters (2002), Maxwell & Eves (2003,studies2&3), Poolton, Masters & Maxwell (2007c), Masters, Poolton& Maxwell (2008a), Lam, Masters & Maxwell (2009a). But Maxwell, Masters, Karr&Weedon (2001), and Maxwell, Masters & Eves (2003,study1) did not addressed a significant difference in the report of verbal rules. On the other hand, one of the reasons of lower performance of the group with visual feedback could probably be creation of an added cognitive load on the attentional resources of participants in this group. Learning via reduced feedback might provide a more appropriate environment for making schema and self-analysis of the skill due to reduction of hypothesis testing and error correction and thus, cleaning up the working memory. For confirming this explanation, Berry & Bradbent (1988) argue that application of declarative knowledge needs the working memory to be accessible, whereas it is not the case for application of procedural knowledge. An appropriate working memory for making executive decisions is based on declarative executive rules, which is inappropriate for processing the information of procedural knowledge. Procedural knowledge is typically processed automatically except interrupted by involvement of a controlled process which is executed by the working memory. Therefore, two parallel and independent processes are available for execution of the skill. The declarative knowledge processing which is dependent on the working memory, and procedural knowledge processing which is executed automatically ad independent of the working memory. Storing, manipulation and reloading the explicit knowledge occur in the working memory. Thus, the working memory contributes to awareness execution of verbal instruction and hypothesis testing as well as trial and error behavior. However, the implicit process is independent of the working memory. Maxwell, Masters & Eves (2003) showed that the decreased performance of the explicit learning group indicates dependency of the participants to the verbal knowledge. Furthermore, the results of the study conducted by Masters, Poolton& Maxwell (2008a) showed that the implicit learning of a skill protects the learner against decreased performance under complicated decision making conditions. Lam, Masters & Maxwell (2009a) proposed almost similar discussions for the superiority of the implicit group in execution of the transfer test. They argued that the groups might have applied an intentional control in a different range towards each other on the skill. Based on constrained action hypothesis (McNevin, Shea&Wulf, 2003; Wulf, McNevin& Shea, 2001), concentration on personal motions (i.e. selection of internal focus)causes an intentional interference in the controlling processes which can also damage automatic control processes, while concentration on consequence of motion (i.e. selection of external focus) causes a kind of automatic control which can dominate unintentional processes and allow the participant to control the motions in a broader range thus improvehis/her execution and learning (Wulf, 2007). If it is assumed that the learner without visual feedback concentrates on a sign whereas the learner with visual feedback concentrates on several (internal) signs, then one can state that there is a positive direction in comparison of groups withvisual feedback and without visual feedback in favor of the latter. Because,the attentional load with less processing error is clearly smaller than the cognitive load with more processing error.

Therefore, taking into account the results of current work it seems that the group without visual feedback has acquired the skill through implicit process which is independent from the working memory. In other words, the learning via reduced feedback leads to animplicit process in the throwing task. Moreover, it can be discussed that the method used for withholding the visual feedback acts independent from the working memory here with no need to perform other simultaneous tasks for feedback reduction. Although generalization of the proposed method requires further studies, it can still be recommended to teachers and coaches for using the learning method through reduced feedback whenever applicable in instruction and control of the motor skills.

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