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Effects of summary knowledge of results in motor skills acquisition[1]

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EFFECTS OF SUMMARY KNOWLEDGE OF RESULTS OF MOTOR SKILL ACQUISITION

KEY WORDS: Summary knowledge of results, Practice, Motor skills.

ABSTRACT: The effects of Summary Knowledge of Results (KR) were tested, using 30 volunteers and a positioning task in which a tennis ball had to be transported in 30 trials, following a specific sequence and with a target time of 3000 msec. Ten minutes after the acquisition phase, the transfer test was performed with 10 trials of different sequences and target times. The retention test took place 24 hours later with 10 trials of the same sequence and target time as the acquisition phase. In the transfer and retention tests, KR was not provided. The volunteers were randomly divided into three groups: G5 (KR every five trials); G3 (KR every three trials) and G100 (KR every trial). The results showed that G3 had a smaller absolute error than G100. However, G3 and G5 had a smaller constant error than G100. In general, the effects of G3 and G5 on motor skill acquisition could be caused by the lower KR frequency, which was 33% and 20% respectively.

Knowledge of Results (KR) is a category of extrinsic feedback that consists of verbal or verbalized information, post-answer that informs the volunteer about performance in the environment (Magill, 2010). The KR can be provided in different ways, which has increased the number of studies about it (Godinho and Mendes, 1996; Tani, Freudenheim, Meira Junior and Corrêa, 2004; Young and Schmidt, 1992).

The KR has been considered an important variable in the process of skill acquisition and the researches have tried to understand the effects of different KR arrangements during practice (Chiviacowsky-Clark, 2005; Godinho and Mendes, 1996). The summary KR is adopted to provide information in a specific trial as a summary about a block of trials that has been practiced (Swinnen, 1990; Yao, Fischman and Wang, 1994). The first study that we found about summary KR was from Lavery and Sudon (1962) and the task required hit a ball trying to reach a target. There were three groups: KR every 20 trials, KR every trial and both together. The summary KR (every 20 trials) showed better results than the other groups. Similar results were found by Schmidt, Young, Swinnen and Shapiro (1989), when KR every 15 trials showed better results than KR every trials, KR every five trials and KR every 10 trials. Gable, Shea and Wright (1991) found the summary every eight trials with better results than KR every trial or KR every 16 trials and Schmidt, Lange and Young (1990) found better performance of KR every five trails in relation to KR every trial.

One explanation for these results was that the summary KR diminishes the relative frequency of KR (Sidaway, Moore, Britta and Schoenfelder-Zhodi, 1992). The guidance hypothesis (Salmoni, Schmidt and Walter, 1984) could be another explanation, because the smaller amount of KR during acquisition phase could conducts to the intrinsic feedback analysis resulting in higher capacity error detection system and higher capacity to organize new answers.

Opposite to this proposal, the higher amount of KR favors the use of extrinsic feedback, conducting to a poor mechanism of error detection and correction. This situation impairs the interaction between intrinsic and extrinsic KR and its comparison with a reference pattern. Hence, the use of extrinsic KR as a source of information could lead the learner to a dependence from extrinsic KR (Salmoni et al., 1984).

Another explanation is the consistency hypothesis (Winstein and Schmidt, 1990), in which high KR frequencies conducts to constant corrections, sometimes resultant from intrinsic variability from neuromuscular system. These corrections conduct to high instability during practice, which makes difficult to find a consistent pattern. Following this hypothesis, low frequencies should increase outcome stability caused by the smaller amount of KR during acquisition phase as well as should increase the attention on intrinsic feedback (Godinho and Mendes, 1996).

On the opposite side, Sidaway, Moore, Britta and Schoenfelder-Zhodi (1992) investigated the KR effect providing KR every 15 trials. However, the information was related to the last trial or over the last three, seven or 15 trials from the block of trials. There was no difference between groups, suggesting that the most important variable is the relative frequency of KR instead of the length of summary and similar results were found

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by Guay, Salmoni and Lajoie (1999). This proposal has support from some explanations about summary KR: the difficulty to make connections between provided KR and the amount of information inside the block of summary (Guay, Salmoni and Lajoie, 1999). Based on these points, the aim of this study was to investigate the effect of the extension of the summary KR on motor skill acquisition.

Method

Participants

The sample was composed by thirty undergraduate young typical adults (between 18 and 32 years-old) of both sexes (12 men and 18 women). They were novice in the task, volunteers, with average age M = 23.6 years-old, SD = 2.5 years. The study was approved by Ethical Committee of the University (ETIC 558/09).

Instrument and Task

The instrument was composed by a platform with six recipients with numbers 1 to 6 that was connected to a Box with Five LEDs and when they turn on the volunteer understood that the task could start. Both, platform and box were connected to a computer with software developed to run the experiment and data analysis. (Figure 1). The task consisted of transport one tennis balls from the nearest recipients (4, 5 and 6) to the far ones (1, 2 e 3).

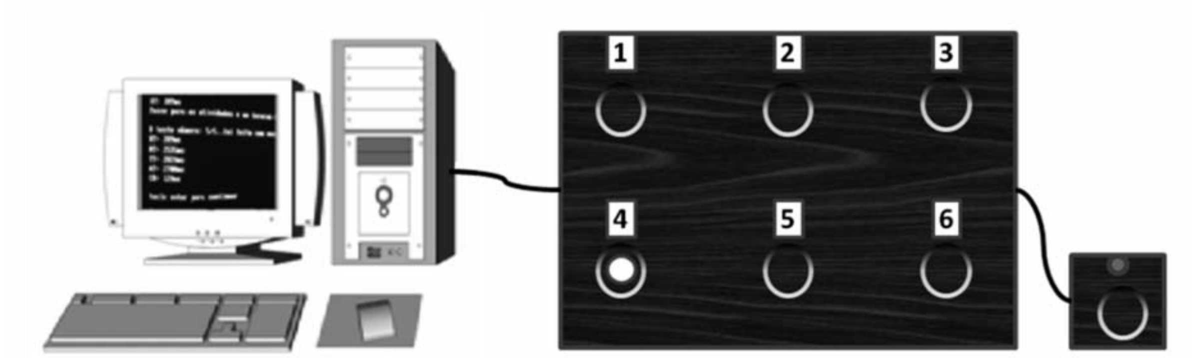

Figure 1. Apparatus diagram.

Experimental Design

The sample was randomly distributed in three groups: G5 (KR provided every five trials); G3 (KR provided every three trials) and G100 (KR every trial). The study was composed of acquisition phase plus retention and transfer tests. The first phase had 30 trials with an established sequence to transport a tennis ball (4 to 2; 5 to 3; 6 to 1) in a target time of 3000 msec. Transfer test was run 10 minutes after acquisition phase with 10 trials in a new sequence (6 to 1; 5 to 3; 4 to 2) in a target time of 4000 msec. and KR was not provided. Twenty four hours after transfer test we run retention test with 10 trials of the same task in the same target time but with no KR. The sequences and target time was stipulated through pilot study.

Procedures

Data collection was performed individually in a specific room. Subject stood up in front of the apparatus and received three verbal instructions and three demonstrations about the task. After the "prepare" signal given by the experimenter, the participant put ball in recipient one, after a visual stimulus (firing of the LEDs) the tennis ball was transported through the recipients. After the trial, KR was provided according to the groups. In transfer test, instructions about new sequence and target time were given while in retention test the same procedures of the acquisition phase were provided. In tests no KR was provided.

Data analyses

Data were organized in block of five trials and absolute error (AE), variable error (VE) and constant error (CE) were the dependent variables analyzed in acquisition phase and tests. Acquisition phase was analyzed by a two way Anova (3 Groups x 6 Blocks). Transfer and retention tests were analyzed by a two way Anova (3 Groups x 2 Blocks) each. Tukey test was adopted for pair comparison and $p < .05$.

Results

Absolute Error (AE)

Figure 2 shows that in acquisition phase Anova found significant difference between groups [$F(2, 27) = 4.94$, $p = .02$]. Tukey test detected that G5 had worst performance than G100 ($p = .013$). Anova registered significant difference between blocks [$F(5, 14) = 15.11$, $p < .0001$] and post-hoc test de Tukey detected that the first block had worst performance than the other ones ($p < .05$). There was no significant main interaction [$F(10, 14) = 1.5$, $p < .13$].

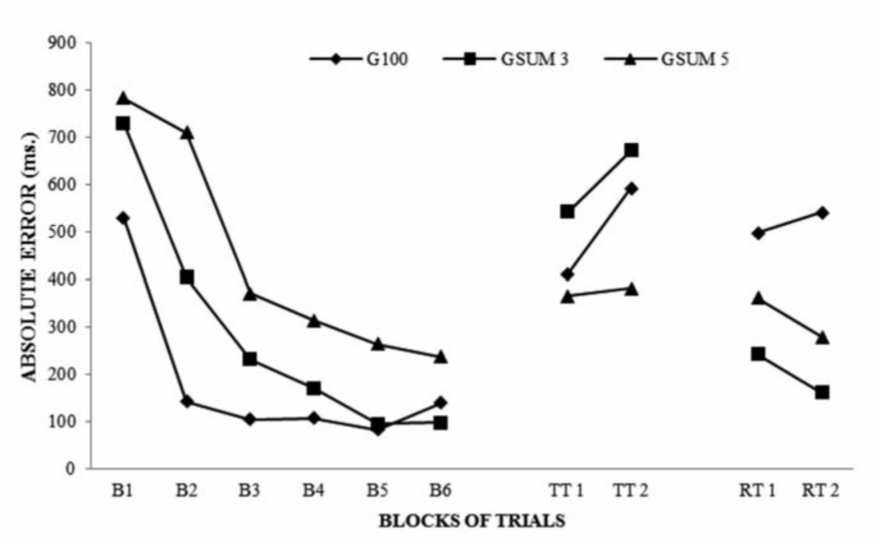

Figure 2. Absolute error average in blocks of five trials.

Figure 2 also shows that in transfer test there was no significant difference between groups, [$F(2, 27) = 2.51$, $p = .1$], blocks [$F(1, 27) = 3.67$, $p = .07$] or main interaction [$F(2. 27) = .75$, $p = .5$]. Moreover, in retention test it was found significant difference between groups [$F(2, 27) = 6.97$, $p = .004$]. Tukey test detected that G3 had better performance than G100 ($p = .003$). There was no significant difference between groups [$F(1, 27) = 2.36$, $p = .13$] nor main interaction [$F(2, 27) = 2.63$, $p = .10$].

Variable Error (VE)

Figure 3 shows that in acquisition phase Anova did not find significant difference between groups [$F(2, 27) = 1.25$, $p = .31$] nor significant main interaction [$F(10. 14) = 1.12$, $p = .36$]. However, it was found significant difference between blocks [$F(5. 14) = 6.76$, $p = .01$]. Tukey test detected that the first block had higher variability than the others ($p < .05$).

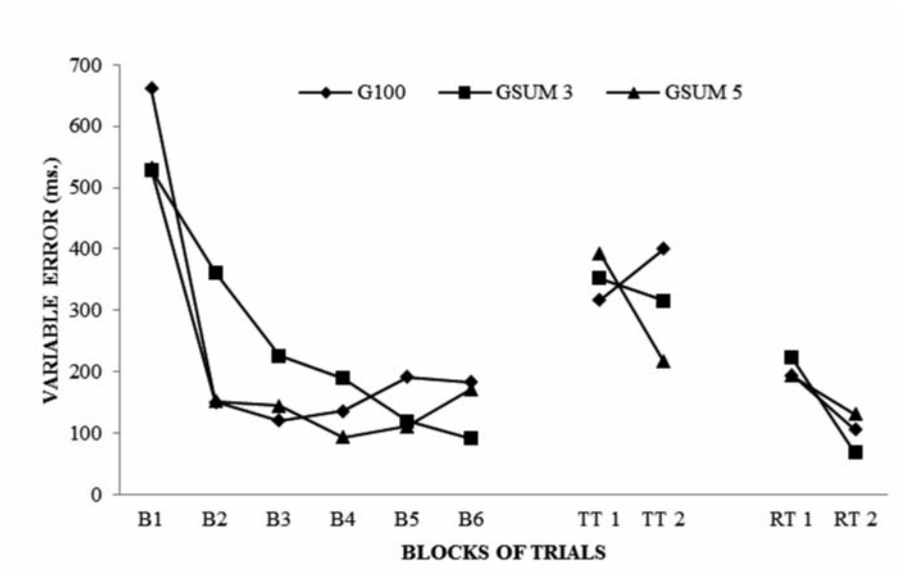

Figure 3. Variable error average in blocks of five trials.

Figure 3 also shows that in transfer test there was no significant difference between groups [*F*(2, 27) = .104, *p* = .90], blocks [*F*(1, 27) = .23, *p* = .64] and significant main interaction [*F*(2, 27) = .68, *p* = .52]. Moreover, in retention test there was no significant difference between groups [*F*(2, 27) = .08, *p* = .93] nor main interaction [*F*(10, 135) = 1.12, *p* = .35]. However, it was detected significant difference between blocks [*F*(1, 27) = 10.68, *p* < .001]. Tukey test detected that the first block had higher variability than the second (*p* = 1.01).

Constant Error (CE)

Figure 4 shows that in acquisition phase there was no significant difference between groups [*F*(2, 27) = .5, *p* = .62] nor main interaction [*F*(10, 16) = .3, *p* = .98]. However, there was significant difference between blocks [*F*(5, 16) = 2.65, *p* = .03]. Tukey test detected that the first block had higher error than the other ones (*p* = .01).

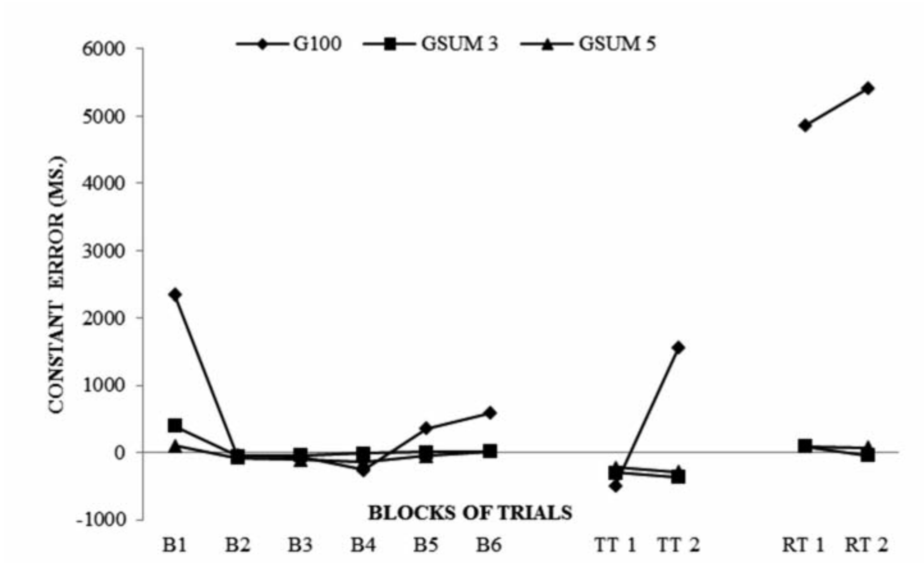

Figure 4. Constant error average in blocks of five trials.

Figure 4 also shows that in transfer test there was no significant difference between groups [*F*(2, 27) = 2.86, *p* = .08], blocks [*F*(1, 27) = .1, *p* = .76] or main interaction [*F*(2, 27) = 1,44, *p* = .3]. Moreover, in retention test there was significant difference between groups [*F*(2, 27) = 10.5, *p* = .001]. Tukey test detected that G100 had higher CE than G3 (*p* = .001) and G5 (*p* = .003). There was no significant difference between blocks [*F*(1, 27) = 1.01, *p* = .32] nor main interaction [*F*(2, 27) = 3.2, *p* = .06].

Discussion

The present study investigated the effects of different summary KR extensions in motor skill acquisition. The results from AE showed that G3 had higher performance than G100, and CE results showed that G3 and G5 had better performance than G100, both in retention test. These results are in accordance to previous studies that investigated distinct extensions of summary KR in blocks from five to 20 trials with 100% de KR (Lavery and Sudon, 1962; Schmidt, Young, Swinnen and Shapiro, 1989; Schmidt, Lange and Young, 1990; Gable, Shea and Wright, 1991).

One possible explanation of these findings would be the effect of reduced frequency of KR. Relative reduced frequency of KR would present a better performance in tests because of guidance hypothesis (Salmoni et al., 1984). This better performance of low relative frequency than high relative frequency (100%) has been explained by guidance hypothesis, as the learner would process intrinsic feedback in those trials which knowledge of results is not provided. High relative frequency of KR promotes a dependency of extrinsic information what drives learners to a worse performance. The results of the present study showed better performance of G3 than G100 in AE and better performance of G3 and G5 than G100 in CE. It is important to highlight that G3 had a relative frequency of 66% and G5 a relative frequency of 20%. Then, these groups presented a lower relative frequency than G100, what is in accordance to guidance hypothesis.

Another interpretation of our results is that relative frequency should not be so low, because learner must have some reference of the correct pattern. This interpretation explains the same performance of G5 and G100 in AE. Thus, KR frequency should be lower than 100%, but it would not be so low, maybe close to an intermediary level, between 50 and 75%.

A second hypothesis that explains the benefits of lower KR relative frequency is consistency hypothesis (Winstein and Schmidt, 1990). In this hypothesis G100 would be more variable in acquisition phase than groups of reduced relative frequency because learner would change the pattern in each trial, in order to correct the errors pointed out by KR. In a lower relative frequency, the pattern would be kept in trials without KR. Then, a consistent performance would help to enhance motor skills. However, our results did not confirm this hypothesis, because G100 was not more variable in acquisition phase. In this case, consistency hypothesis is not adequate to explain our findings.

The summary KR can also help to keep high level of motivation in the task (Bilodeau, 1966). However, when high frequency of KR is provided, intrinsic feedback cannot be used hindering the formation of a mechanism of detection and correction of errors. The high frequency inhibits the associative function of KR and intrinsic feedback is not analyzed and compared to a reference pattern to identify differences between the expected and performed pattern.

On the other hand, low frequency of KR should help the learner to correct errors as well as to form a correct the pattern of reference (Adams, 1971). It happens because in no-KR trials one should process intrinsic feedback because there is no KR. This small probability of KR dependence related to no-KR trials inducts the learner to evaluate their performance through intrinsic feedback (Salmoni et al., 1984; Ugrinowitsch et al., 2010).

The similar results of G3 and G5 give support to the proposal that summary KR does not disturb the association between KR and a specific error in a group of trials. Other researchers (Guay, Salmoni and Lajoie, 1999; Sidaway, Moore, Britta and Schoenfelder- Zhodi, 1992) proposed that uncertainty caused by a KR in relation to a group of trials should interfere in the comparison between KR and performance, and inhibit the process of error detection and correction.

Another point to be considered is the overload of information every time KR is provided, which should interfere in the memory capacity. The difficulty in recovering should be a consequence of trace deterioration that results from high extension of items in KR as well as from high demand of information processing (Atkinson and Shiffrin, 1971). During information process, stimuli are presented in series (Marteniuk, 1976) and each one is processed while there is enough capability and the last items can be forgotten. This limit in the memory capacity should conduct to degeneration of trace of memory that can interfere in error detection and correction. Consequently, the access to KR information in memory should get uncertainty, which decreases the efficiency of recovery mechanisms (Atkinson and Shiffrin, 1971). The results from G5 do not support this explanation because its performance was very similar to G3. Maybe we would find these effects if the number of trials in each group would have a bigger difference (e.g., summary of 3 trials versus summary of 10 trials).

At last, the complexity of the motor skill can also have effect of summary KR. More complex skills should need smaller blocks of KR because the demand on information process is higher than to the simplest ones. Whether each part of the motor skill is a component to be stored in memory, complex motor skill should need small blocks (e.g., summary of 2 trials).

In sum, summary KR was more effective than higher frequency of KR as 100% group, because intrinsic feedback could be processed while both groups tested did not present a large extension of summary KR. In order to investigate if memory could be affect and disturb the learning process, new studies could be conduct with bigger extensions of summary KR as 10 or 15 trials.

EFECTOS DEL CONOCIMIENTO DE LOS RESULTADOS RESUMEN DE LA ADQUISICIÓN DE LAS HABILIDADES MOTORAS

PALABRAS CLAVE: Conocimiento de los resultados resumen, Práctica, Habilidad Motora.

RESUMEN: El efecto del conocimiento de los resultados (KR) resumen ha sido probado por 30 voluntarios en tarea de posicionamiento que requiere el transporte de una pelota de tenis en una secuencia específica con el tiempo objetivo de 3000 ms. en 30 ensayos. Diez minutos después de la fase de adquisición se jugó el test de transferencia con 10 ensayos con diferente secuencia y tempo objetivo. La retención se realizó la prueba 24 horas más tarde con la misma secuencia y tiempo objetivo fase de adquisición. En los testes de transferencia y retención de la CR no fue suministrado. Los voluntarios fueron divididos aleatoriamente en tres grupos: G5 (CR después de 5 ensayos); G3 (CR después de 3 ensayos) y G100 (CR en todos los ensayos). El resultado mostró que G3 tuvieron menor error absoluto que G100. Sin embargo, G3 y G5 se han registrado menor error constante que G100. En general, los efectos de G3 y G5 en la adquisición de las habilidades motoras pueden ser causados por la disminución de frecuencias CR, que fueron 33% y 20 %, respectivamente.

EFEITOS DO CONHECIMENTO DE RESULTADOS SUMÁRIO NA AQUISIÇÃO DE HABILIDADES MOTORAS

PALAVRAS-CHAVE: Conhecimento de resultados sumário, Prática, Habilidade motora.

RESUMO: O efeito do conhecimento de resultados (CR) sumário foi testado por 30 voluntários em uma tarefa de posicionamento a qual exigia o transporte de uma bola de tênis em uma sequência específica com tempo alvo de 3000 mseg. durante 30 tentativas. Dez minutos após a fase de aquisição foi desempenhado o teste de transferência com 10 tentativas com sequência e tempo alvo diferente. O teste de retenção foi realizado 24 horas mais tarde com a mesma sequência e tempo alvo da fase de aquisição. Nos testes de transferência e retenção o CR não foi fornecido. Os voluntários foram aleatoriamente divididos em três grupos: G5 (CR depois de 5 tentativas); G3 (CR depois de 3 tentativas) e G100 (CR em todas tentativas). O resultado mostrou que G3 apresentou menor erro absoluto que G100. Entretanto, G3 e G5 registraram menor erro constante que G100. Em geral, os efeitos de G3 e G5 sobre a aquisição de habilidades motoras podem ser causados pelas frequências reduzidas de CR, que foram de 33% e 20%, respectivamente.

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