Journal of Physical Education and Sport ® (JPES), Vol 19 (Supplement issue 4), Art 208 pp 1435 – 1440, 2019
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Effects of bandwidth knowledge of results by components in learning a sequential motor task

MATHEUS HENRIQUE SANTOS LUCAS[1],MARIA FLÁVIA SOARES PINTO CARVALHO2,HERBERT UGRINOWITSCH[3]
[1,2,3,]School of Physical Education, Physiotherapy and Occupational Therapy, UniversidadeFederal de Minas Gerais, BRAZIL

Published online: July 31, 2019
(Accepted for publication: June 28, 2019)
DOI:10.7752/jpes.2019.s4208

Abstract:
Feedback can have a detrimental effect on motor learning if it is provided too frequently. Based on this,a previous study adopted an assumption that augmented feedback related only about critical elements of skills will avoid its adverse effects and could improve motor learning. The present study aimed to test this assumption. The task consisted of performing a sequence of touches in keypad with absolute and relative time goals. The experiment was divided into acquisition phase and retention test. During acquisition, knowledge of resultsabout all components was provided to a groupwhile another group received this information only for the component whose error was higher than 15% of the goal. The results showed that there was no significant difference between groups in performance measures. Maybe the presentation of quantitative and qualitative information at the same trial caused an overloadin processing information. The possibility that it acts in the same way as the negative guidance properties of feedback was discussed.
KeyWords: Bandwidth Knowledge of Results, Sequential Task, Motor Learning, Motor Skill

Introduction

Knowledge of Results (KR) has received much attention in the last decades KR and is a type of feedback that informs about the movement outcome in terms of environmental goal (Winstein & Schmidt, 1990).During the process of motor skill learning, KR diminishesdiscrepancies between planned and performed action because theKR serves as a reference to errors corrections in subsequent trials leading to improvements in performance throughout practice (Schmidt, 1991). The importance conceived to KR is remarkably noted throughout a lot of studies in Motor Learning (Agethen & Krause, 2016; Miguel-Junqueira et al., 2015; Ugrinowitsch, Coca-Ugrinowitsch, Benda, & Tertuliano, 2010).One of the first studies about KR adopted the assumption that higher frequencies of KR should result in better effects on learning (Bilodeau & Bilodeau, 1958). However, this study did not count with learning tests and it makes impossible to distinguish transient effects of performance from the relatively permanent ones of learning(Salmoni, Schmidt, & Walter, 1984). These authors observed that high KR frequencies conducts the learner to a better performance in acquisition phase not on learning tests when KR is withdrawn (Salmoni et al., 1984). Since then, different ways to reduce the frequency of KR presentation has been investigated, one of them is bandwidth KR.

Bandwidth KR is a way to provide KR that uses a range of error tolerance. In this way, KR is provided if the error is outside of the range previously determined, but if the performance is inside the range previously established, KR is not provided. In this case, the absence of KR means a correct trial and quantitative information is not provide, and it is understood as qualitative information (Sherwood, 1988). Some studies pointed out that qualitative information helps the learner to maintain its performance close to the goal(Cauraugh, Chen, & Radlo, 1993; Lee & Carnahan, 1990).However, the effects of bandwidth KR could be resultant from the lower KR frequency, so further studies compared bandwidth KR with yoked groups (Chen, 2002; Graydon, Paine, Ellis, & Threadgold, 1997; Lee & Carnahan, 1990). In yoked procedure, the participants receive KR in the same trials as their respective peers in bandwidth group, but the subjects in yoked groups were not informed that trials with no KR represented a correct trial. Based on this design, the bandwidth group could interpret trials with no KR as qualitative information but not the yoked group. These studies showed that bandwidth KR leads to a better performance than yoked group, highlighting the importance of qualitative information in motor learning (Badets & Blandin, 2005, 2010a; Cauraugh et al., 1993). The effects of qualitative information present in bandwidth KR is more evident in the reduction of performance variability since qualitative information (no KR) indicates that performance was correct and there is no need of changing in the plan of action adopted in the previous trials(Lee & Carnahan, 1990). In another way, when the performance is outside of range previously determined, KR indicates that corrections in the next trial have to be made to reach the task goal (Lee & Carnahan, 1990). Therefore, bandwidth KR cannot be considered as a way to reduce feedback presentation since after every trial some information is provided (KR - quantitative information or no KR - qualitative information).

Corresponding Author: HERBERT UGRINOWITSCH, E-mail: herbertu@ufmg.br

Consequently, the positive effects of bandwidth KR can be related to both quantitative KR (guiding the learner to a correct performance) and qualitative information (guiding the learner to maintenance of behavior), and the effects persist even on later retention tests one week later (Cruz; Benda; Carvalho; Lage; Cattuzzo& Ugrinowitsch, 2018).

The positive effects of bandwidth KR in motor skill learning can be explained by the guidance hypothesis (Salmoni et al., 1984). According to this hypothesis, KR provides information about the discrepancies between the planned andperformed action, which is used to correct the plan of action in the subsequent trial and improveperformance during the acquisition phase. However, if KR is frequently provided along practice performanceis deteriorated because the action plan has to be changed on every trial and deteriorates the use of intrinsic information throughout learning phase (Lee & Carnahan, 1990; Cruz et al., 2018).If the ability to use intrinsic information to detect and correct errors is not improved throughout the learning phase, the learner may become dependent on external sources of information.Thus, the bandwidth KR can improve performance on retention and transfer tests, since no KR is provided when performance is inside bandwidth and only the intrinsic KR is available.

When one thinks about learning sequential motor skills, usinga specific bandwidth KR to each component of the motor skill can be a strategy to improve motor learning(Sadowski, Mastalerz, & Niznikowski, 2013). In this way, KR will be provided only for the component whose error is outside the bandwidth and not for all the components. Thus, attention can be focusedonly on the components with higher errorand the harmful guidance properties of KR could be avoided. Although bandwidth KR can improve motor skill and prevent dependency, only one study was found that manipulating a specific bandwidth to each component of the motor skillduring practice (Sadowski et al., 2013). However, the authors did not address the possible negative consequences of bandwidth KR provided to each component of the motor skill. For instance, how can the learner manage quantitative and qualitative KR in the same trial? Can the qualitative KR about one component, added to the quantitative KR related to another,represent some overload of information processing?In this way of thinking, the bandwidth KR can represent an overload and reduce the positive effects of bandwidth KRleading to asimilar performance than no bandwidth KR condition.

The present work aimed to investigatethe effects of bandwidth KR about components on learning a sequential motor skill. The hypothesis was that providing quantitative and qualitative KR about components of the motor skill could suppress beneficial effects of bandwidth KR to the level of no bandwidth KR condition.

Material & methods

Participants

The sample was composed of thirty undergraduate students, self-declared high-handers, with age between 18 and 35 years old (23,5 ± 4,2 years) were volunteers. After reading and sign the consent form that informed the procedures of the study, these volunteers were randomly allocated in one of two groups (n=15): G0% and G15%.The study respected all the standards established by the Nacional Health Council for research with humans, was approved by the ethics committee of the University (nº ETIC/525/07) and followed all ethical guidance of American Psychology Association.

Instruments and Test protocol

A Dell microcomputer model OptiPlex 3010 with a led monitor Dell 21,5 inches (Dell Inc, South Eldorado, RS), a numeric keypad(Multilaser USB model Tc096) were used and a specific software to run the experiment and data collection (Lage et al., 2007), similar to that used by Lai and Shea (1999). The participant entered in a room, sat in a chair and the numeric keypad was positioned in from of the right shoulder.

The task required to press sequentially the keys 2, 8, 6 and 4 of a numeric keyboard with the index finger of the right hand. The goals of the task were to touch the four keys in a total time of 900 milliseconds and distribute this time between components of the task as established: 22,2% from the key 2 to 8, component 1; 44,4% between from the key 8 to 6, i.e., component 2 and 33,3% from the key 6 to 4, i.e., component 3.

Procedure and Design

Before the experiment beginning, verbal instruction and auditive modeling about the total and relative time of the task were provided.The keypads were virtually represented on the screen and then glowed to them and emitted a beep simultaneously to the keypad pressing, according to the temporal goal described before, with one beep for each key. The four beeps corresponding to keypads touches of components 1, 2 and 3 and were presented with an interval of 199.98 ms, 399.96 ms and 299.97between them. The auditive modeling was presented just once before practice starts and it was used as an instructive way like reported in other studies (Lai, Shea, Bruechert, & Little, 2002; Lai, Shea, & Little, 2000; Shea, Wulf, Park, & Gaunt, 2001).

The experiment was composed by acquisition phase and retention test. The acquisition phase had 100 trials, when the G15% received KR related to magnitude and direction of the errorof the components in percentage, butonly for the components whose error was higher than the bandwidth of 15%. When the error of some component was inside bandwidth, qualitative KR was provided, indicated by "0". In this case, participants were instructed to interpret such information as a correct trial. In contrast, the G0% had a bandwidth of 0% and received KR about all components after every trial. The KR about total time was also available for both groups after every trial. Twenty-four hours after the acquisition phase, the retention test with 10 trials was performed without KR and with the same total and relative time goals from the acquisition phase.

Data collection and Statistical analysis

All data were organized in blocks of ten trials, resulting in ten blocks fromthe acquisition phase and one block from the retention test. The effects of the bandwidth KR were analyzed through absolute error (average and standard deviation) in milliseconds (ms), total relative error (average and standard deviation), in percentage (%), and relative error by component (average and standard deviation), also in percentage (%). The absolute error indicates accuracy of the total time; total relative error indicates accuracy of the interaction between the three components and relative error by component indicates accuracy of each component. The standard deviations represent the consistency of each measure. The possible differences in acquisition phase were tested through a two-way ANOVA (2 Groups x 10 Blocks). Tukey was adopted for pairwise comparisons, when necessary. The retention test was tested through a Student t-test. The significance level for all analyses was $p \leq .05$. The statistical analyses were conducted through the Statistica 10 for Windows software.

Results

Absolut Error

Figure I-A shows that during acquisition phase, the performance accuracy increased significantly between blocks [F (9, 306) = 2.40, p = .01, η_p^2 = 0.06]. The post hoc test detected that performance accuracy increased from the first to the third and later blocks (p = .01). There was no significant difference between groups [F (1, 34) = 0.26, p = .61, η_p^2 = 0.01]or significant interactions [F (9, 306) = 1.32, p = .22, η_p^2 = 0.04].In retention test, there was no differences between groups onperformance accuracy [t (N = 36) = -0.41, p = .68, Cohen's d = 0.14].

Figure I-B shows that during acquisition phase, the performance consistency increased significantly between blocks [F (9, 306) = 4.19, p = .01, η_p^2 = 0.13]. The post hoc detected that performanceconsistency increased from the first block to the second and later blocks (p= .04). There was no significant difference between groups [F (1, 34) = 0.49, p = .48, η_p^2 = 0.01]or significant interactions [F (9, 306) = 1.41, p = .18, η_p^2 = 0.04].In retention test, there was no differences between groups on performance consistency[t (N = 36) = -0.67, p = .51, Cohen's d = 0.22].

Relative Error

Figure I-C shows that during acquisition phase, the relative error accuracy increased significantly between blocks [F (9, 306) = 4.36, p = .01, η_p^2 = 0.11]. The post hoc test detected that performance accuracy increased from the first block to the fifth block and so on (p= .03). There was no significant difference between groups [F (1, 34) = 0.97, p = .33, η_p^2 = 0.03]or significant interactions [F (9, 306) = 1.09, p = .37, η_p^2 = 0.03].In retention test, there was no difference between groups on relative error accuracy [t (N = 36) =-0.62, p =.54, Cohen's d = 0.21].

Figure I-D shows that during acquisition phase, the relative error consistency increased significantly between blocks [F (9, 306) = 3.94, p = .01, η_p^2 = 0.10]. The post hoc test detected that performance accuracy increased from the first to the third and later blocks (p= .04). There was no significant difference between groups [F (1, 34) = 0.84, p = .37, η_p^2 = 0.02], or significant interactions [F (9, 306) = 0.75, p = .66, η_p^2 = 0.02].In retention test, there was no difference between groups on relative error consistency [t (N = 36) = -0.85, p = .40, Cohen's d = 0.28].

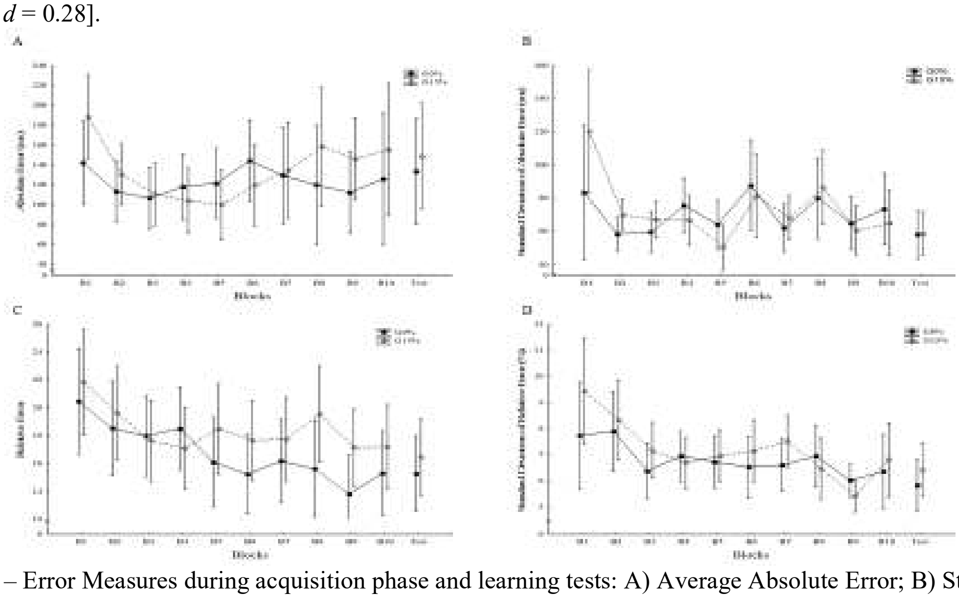

Figure 1 – Error Measures during acquisition phase and learning tests: A) Average Absolute Error; B) Standard Deviation of Absolute Error; C) Average Relative Error; D) Standard Deviation of Relative Error.

Relative Error (Component 1)

Figure II-A shows that during acquisition phase, component 1 relative error accuracy increased significantly between blocks [F (9, 306) = 10.34, p = .01, η_p^2 = 0.23]. The post hoc testdetected that relative error accuracy increased from thefirst block to the third block and so on (p= .04). There was no significant difference between groups [F (1, 34) = 0.11, p = .74, η_p^2 = 0.01] or significant interactions [F (9, 306) = 0.51, p = .86, η_p^2 = 0.01].In retention test, there was no difference between groups on component 1 relative erroraccuracy [t (N = 36) = 0.31, p =.76,Cohen's d = 0.10].

Figure II-B shows that during acquisition phase, component 1 relative error consistency had significant interactions between groups and blocks [F (9, 306) = 3.56, p = .01, η_p^2 = 0.09]. The post hoc detected that the second block of the G15% was more variable than G0% (p = .04). The relative error consistency increased significantly between blocks [F (9, 306) = 7.93, p = .01, η_p^2 = 0.19].The post hoc detected that the relative error consistency improved from the first block to fifth block and so on (p= .01). There was no significant difference between groups [F (1, 34) = 1.07, p = .31, η_p^2 = 0.03]. In retention test, there was no difference between groups [t (N = 36) = 0.45, p = .65, Cohen's d = 0.15].

Relative Error (Component 2)

Figure II-C shows that during acquisition phase, component 2 relative error accuracy increased significantly [F (9, 306) = 4.09, p = .01, η_p^2 = 0.11]. The post hoc test detected that relative error accuracy increased from first block to sixth block and so on (p= .04). There was no difference between groups [F (1, 34) = 0.59, p = .45, η_p^2 = 0.02] or significant interactions [F (9, 306) = 1.51, p = .14, η_p^2 = 0.04]. In retention test, there was no difference between groups [t (N = 36) =0.20, p =.84, Cohen's d = 0.07].

Figure II-D shows that during acquisition phase, relative error consistency increased significantly [F (9, 306) = 3.47, p = .01, η_p^2 = 0.09]. The post hoc detected that relative error consistency increased from the first block and second blocks to ninth and tenth blocks (p= .04). There was no difference between groups [F (1, 34) = 0.71, p = .40, η_p^2 = 0.02] or significant interactions [F (9, 306) = 0.83, p = .58, η_p^2 = 0.02]. In retention test, there was no difference betweengroups[t (N = 36) =1.26, p =.22, Cohen's d = 0.42].

Relative Error (Component 3)

Figure II-E shows that during acquisition phase, component 3 relative error accuracy had no difference between blocks[F (9, 306) = 0.82, p = .59, η_p^2 = 0.02], groups [F (1, 34) = 2.81, p = .10, η_p^2 = 0.08] or significant interactions [F (9, 306) = 1.03, p = .42, η_p^2 = 0.03]. In retention test, there wasno difference between groups [t (N = 36) =-0.58, p =.56, Cohen's d = 0.19].

Figure II-F shows that during acquisition phase, component 3 relative error consistency had no difference between blocks [F (9, 306) = 1.70, p = .09, η_p^2 = 0.05], groups [F (1, 34) = 0.09, p = .77, η_p^2 = 0.01] or significant interactions [F (9, 306) = 1.43, p = .17, η_p^2 = 0.04]. In retention test, there was no difference between groups[t (N = 36) = 1.61, p =.11, Cohen's d = 0.54].

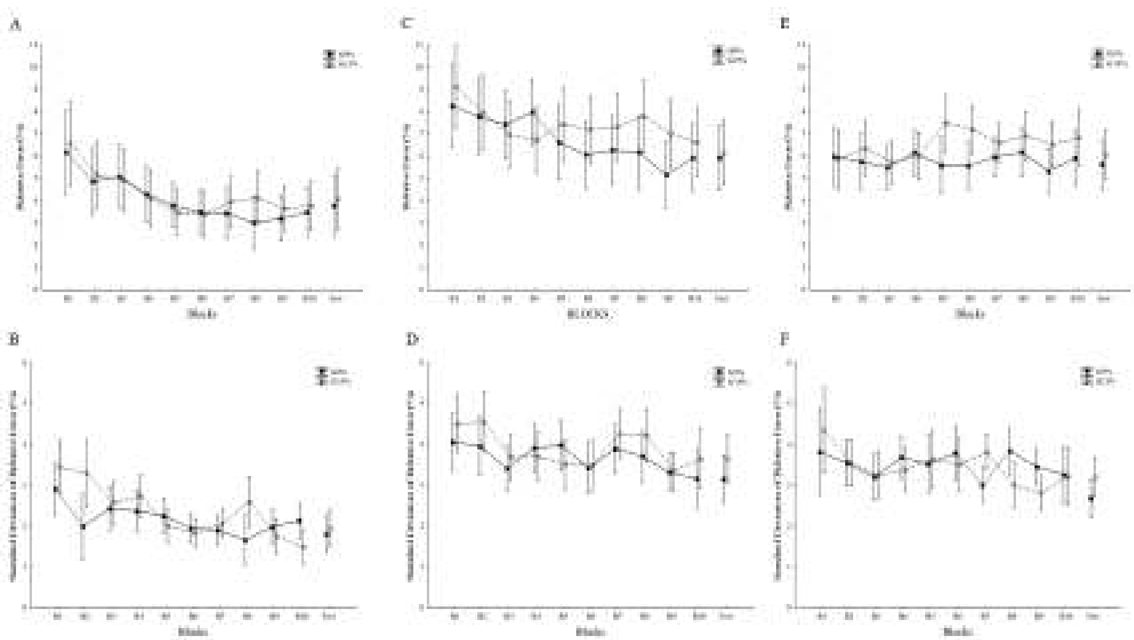

Figure 2 – Relative Error separated by task components during acquisition phase and learning tests: A) Average Relative Error of Component 1; B) Standard Deviation of Relative Error of Component 1; C) Average Relative Error of Component 2; D) Standard Deviation of Relative Error of component 2; E) Average Relative Error of Component 3; F) Standard Deviation of Relative Error of Component 3.

Discussion

The present study investigated the effects of bandwidth KR about skill components in learning of a sequentialtask. The hypothesis was that different types of information (i.e., KR and qualitative information) at the same trial could be lead to an overload of informationprocessingwhich would diminish the positive effects of bandwidth KR on motor learning.The results of this experiment showed increment in performance of both bandwidth conditions, confirming the hypothesis.

The bandwidth KR providing qualitative information,i.e., no KR meaning right trial, maintains the behavior or makessomething close to it because there is no need to change the plan of action adopted in the previous trial. That is, the qualitative information could be considered like essential to increase behavior consistency (Lee & Carnahan, 1990), results observed on previous studies (Coca-Ugrinowitsch, Cruz, & Ugrinowitsch, 2018; Lee, White, & Carnahan, 1990; Sherwood, 1988; Ugrinowitsch et al., 2010). On the other hand, the quantitative KR,e.g., "you performed 300 milliseconds later",gives direction to adjustments of the plan of action and consequent performance improvement.The present study adopted a sequential motor skill, specified temporal goals for each component and adopted a bandwidth of error for each of them. During the acquisition phase, one component could have a good performance but not another, and qualitative KR was provided for the former and quantitative KR for the later. The combination of the two types of information may have caused a bias or an overload of information processing since the necessary change in one component requires a change in another because the total time was kept constant.

Previous studies providing bandwidth KR about the total relative error of the components, instead of relative error about each component, related positive effects of bandwidth KR on skill acquisition(Badets & Blandin, 2005, 2010b; Cruz, 2012; Lai & Shea, 1999; Miguel-Junqueira et al., 2015). Providing KR about total relative error, the higher error of one component could be compensated for the lower error in another, resulting in a total relative error inside the bandwidth and qualitative KR was provided. When quantitative KR about the total relative error was provided, the next trial should be plannedchanging the relation between the components but with the constraint of the total time of 900ms (Cruz et al., 2018; Lai & Shea, 1999; Lai, Shea, Wulf, & Wright, 2000; Miguel-Junqueira et al., 2015) Following the previous procedure, each trial resulted only in one quantitative or qualitative KR. The present study manipulated the bandwidth KR about each component and all the trials resulted in quantitative KR about one component, even with qualitative KR about another component. The combination of these two types of information may have resulted in the overload of processing information not observed in the previous studies.

The results showed increment in absolute error and relative error of components 1 and 2, but not component 3. Probably the plan of action tried to diminish relative error in the order the components were organized and executed (Lashley, 1951) but there was not competence for managing the information about the total error and relative error about each component. In general, the results indicate the necessity of controlling the total and type of information provided on KR.

Although onecould argue that auditive modeling has contributed to present results, it was not an independent variable (since both groups received it). Beyond that,the bandwidth KR related to specific components of motor skill has lead to improvements in learning even withmodeling beingpresented (Sadowski et al., 2013). The interaction between modeling and bandwidth KR on motor learning can be investigated in future studies. Although the findings of the present study still should be tested with complex motor skills (Wulf & Shea, 2002), similar to that run by Sadowski et al. (2013), our results indicate the necessity of control the amount and type of KR information provided while learning a motor skill.

Conclusions

The present findings suggest that bandwidth KR effects are not the same that presented in current literature when it is manipulation isspecific toeach component of motor skill. The present work supports the view that providing quantitative and qualitative KR simultaneously about all the components can be detrimental to motor learning due to an overload of informationprocessing.

Conflicts of interest: The authors declare that there are no conflicts of interest.

Acknowledgements: The authors would like to thank the National Council for Scientific and Technological Development (CNPq) for granting scholarship for the first author during this research.

References:

Agethen, M., & Krause, D. (2016). Effects of bandwidth feedback on the automatization of an arm movement sequence. *Human Movement Science, 45*, 71-83.

Badets, A., & Blandin, Y. (2005). Observational learning: Effects of bandwidth knowledge of results. *Journal of Motor Behavior, 37*(3), 211-216.

Badets, A., & Blandin, Y. (2010a). Feedback Schedules for Motor-Skill Learning: The Similarities and Differences between Physical and Observational Practice. *Journal of Motor Behavior, 42*(4), 257-268.

Badets, A., & Blandin, Y. (2010b). Feedback schedules for motor-skill learning: the similarities and differences between physical and observational practice. *Journal of Motor Behavior, 42*(4), 257-268.

Bilodeau, E. A., & Bilodeau, I. M. (1958). Variable frequency of knowledge of results and the learning of a simple skill. *Journal of Experimental Psychology, 55*(4), 379-383.

Cauraugh, J. H., Chen, D., & Radlo, S. J. (1993). Effects of traditional and reversed bandwidth knowledge of results on motor learning. *Research Quarterly for Exercise and Sport, 64*(4), 413-417.

Chen, D. D. (2002). Catching the learner doing right versus doing wrong: Effects of bandwidth knowledge of results orientations and tolerance range sizes. *Journal of Human Movement Studies, 42*(2), 141-154.

Coca-Ugrinowitsch, A. A., Cruz, M. P., & Ugrinowitsch, H. (2018). Faixa de amplitude de feedback aumenta a consistência do desempenho de habilidades motoras. *ConScientiae Saúde, 17*(2), 155-163.

Cruz, M. P. (2012). *Efeitos temporário e permanente da faixa de amplitude de conhecimento de resultados na aprendizagem de habilidades motoras.* (Master's Thesis), Universidade Federal de Minas Gerais.

Cruz, M. P., Benda, R. N., Carvalho, M. F. S. P., Lage, G. M., Cattuzzo, M. T., & Ugrinowitsch, H. (2018). Bandwidth knowledge of results persists on motor skillsacquisition. *Motricidade, 14*(2-3), 107-114.

Graydon, J., Paine, L., Ellis, C., & Threadgold, R. (1997). Comparison of bandwidth knowledge of results and the relative frequency effect in learning a discrete motor skill. *Journal of Human Movement Studies, 32*(1), 15-28.

Lage, G. M., Alves, M. A. F., Oliveira, F. S., Palhares, L. R., Ugrinowitsch, H., & Benda, R. N. (2007). The combination of practice schedules: effects on relative and absolute dimensions of the task. *Journal of Human Movement Studies, 52*, 21-35.

Lai, Q., & Shea, C. H. (1999). Bandwidth knowledge of results enhances generalized motor program learning. *Research Quarterly for Exercise and Sport, 70*(1), 79-83.

Lai, Q., Shea, C. H., Bruechert, L., & Little, M. (2002). Auditory model enhances relative-timing learning. *J Mot Behav, 34*(3), 299-307.

Lai, Q., Shea, C. H., & Little, M. (2000). Effects of modeled auditory information on a sequential timing task. *Research Quarterly for Exercise and Sport, 71*(4), 349-356.

Lai, Q., Shea, C. H., Wulf, G., & Wright, D. L. (2000). Optimizing generalized motor program and parameter learning. *Research Quarterly for Exercise and Sport, 71*(1), 10-24.

Lashley, K. S. (1951). The problem of serial order in behavior. In L. A. Jeffress (Ed.), *Cerebral mechanisms in behavior; the Hixon Symposium* (112-146). Oxford, England: Wiley.

Lee, T. D., & Carnahan, H. (1990). Bandwidth knowledge of results and motor learning: More than just a relative frequency effect. *Quarterly Journal of Experimental Psychology Section a-Human Experimental Psychology, 42*(4), 777-789.

Lee, T. D., White, M. A., & Carnahan, H. (1990). On the role of knowledge of results in motor learning: Exploring the guidance hypothesis. *Journal of Motor Behavior, 22*(2), 191-208.

Miguel-Junqueira, A. H., Benda, R. N., Santos, S. P., Lage, G. M., Vieira, M. M., Carvalho, M. F. S. P., & Ugrinowitsch, H. (2015). Thin bandwidth knowledge of results (KR) improves performance consistency on motor skill acquisition. *American Journal of Sports Science, 3*(6), 115-119.

Sadowski, J., Mastalerz, A., & Niznikowski, T. (2013). Benefits of bandwidth feedback in learning a complex gymnastic skill. *Journal of Human Kinetics, 37*(Section III - Sport Training), 183-193.

Salmoni, A. W., Schmidt, R. A., & Walter, C. B. (1984). Knowledge of results and motor learning: A review and critical reappraisal. *Psychological Bulletin, 95*(3), 355-386.

Schmidt, R. A. (1991). Frequent augmented feedback can degrade learning: Evidence and interpretations In J. Requin & G. E. Stelmach (Eds.), *Tutorials in Motor Neuroscience* (pp. 59-75). Kluwer Academic Publishers.

Shea, C. H., Wulf, G., Park, J. H., & Gaunt, B. (2001). Effects of an auditory model on the learning of relative and absolute timing. *Journal of Motor Behavior, 33*(2), 127-138.

Sherwood, D. E. (1988). Effect of bandwidth knowledge of results on movement consistency. *Perceptual and Motor Skills, 66*(2), 535-542.

Ugrinowitsch, H., Coca-Ugrinowitsch, A. A., Benda, R. N., & Tertuliano, I. W. (2010). Effect of bandwidth knowledge of results on the learning of a grip force control task. *Perceptual and Motor Skills, 111*(3), 643-652.

Winstein, C. J., & Schmidt, R. A. (1990). Reduced frequency of knowledge of results enhances motor skill learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*(4), 677-691.

Wulf, G., & Shea, C. H. (2002). Principles derived from the study of simple skills do not generalize to complex skill learning. *Psychonomic Bulletin & Review, 9*(2), 185-211.