BJMB
Brazilian Journal of Motor Behavior

Special issue:
The role of practice in motor skill acquisition

Editorial: The Role of Practice in Motor Skill Acquisition: New Issues, the Same Question

MATHEUS M. PACHECO[1]

[1] CIFI2D, Faculty of Sport, University of Porto, Portugal.

Correspondence to: Matheus M. Pacheco.
email: matheusp@fade.up.pt
https://doi.org/10.20338/bjmb.v16i2.314

ABBREVIATIONS

PUBLICATION DATA
Received 23 05 2022
Accepted 30 05 2022
Published 01 06 2022

ABSTRACT
Practice is necessary but not sufficient for learning. Why is that the case? In this editorial, I invite the readers to consider what is the role of practice in motor skill acquisition and to read the contributions of well-known researchers in the area to this special issue. Through a summary of the diverse offered opinions, I provide a potential heuristic view that demonstrate what are the new venues on the theme. As it seems, the question remains unanswered and challenges to answer it abound. This special issue sets the starting point for a needed research agenda on the theme.

KEYWORDS: Motor learning | Theory development | Methodology | Motor performance

INTRODUCTION

"Practice makes perfect" is an adage commonly heard in many walks of life, and in none more so than the sporting world. Although few performers would deny the necessity of practice for the learning and performance of motor skills, by the same token, few would wholeheartedly uphold this familiar saying by arguing that practice is a sufficient condition in itself" (p. 195) [1].

Interestingly, the "agreement" found by Prof. Karl Newell in the 70s can be easily replicated in the present years. Despite no data on the issue, current discussions in the area demonstrate that, indeed, practice is a necessary, but not sufficient, condition for one to get "perfect." Indeed, the forecited statement comes from a text discussing how, when and how much knowledge of results *should* be provided to *optimize* or *induce* practice effects in motor learning – a discussion that has reoccurred over the years [2,3].

More interesting, maybe, is the disagreement that we can find when asking why Newell's statement is true: why practice is necessary but not sufficient? The answer lies in the theoretical understanding of the role of practice in motor learning. This has been the "correlated" question of my line of research: I study how individuals change over time considering their own *history* of practice (i.e., motor repertoire; tendencies in perception and action) and their current interaction with task and environment *during* practice. What makes learners go to one or another "route" of change, how instances or manipulations of practice favor or repels given solutions, and all related aspects [4].

It was thinking in this interest and the potential disagreement that the question raises[a] that the editors of Brazilian Journal of Motor Behavior invited me to be the guest editor of this special issue. Lucky or not, I asked several specialists in the area to share

[a] I am assuming that the interest is related to me and the disagreement to the literature, but it can clearly be the opposite.

their views, ideas, experiments – in any of the many levels of analysis that motor learning touches – with the following intentions. First, it is always good to remember us that the issue of practice is still an open question – one of the most basic in the area of motor learning. Having a special issue highlights that. Second, the special issue will shed light on the diversity in opinions and approaches to the problem of practice. In fact, the diversity highlights the difficulty in answering the question. Third, and final, it might be that only through this diversity that a potential solution can be found.

FROM BASIC CONCEPTS TO CANDIDATE VIEWS

To my surprise, the expected diversity was surpassed by far. While I thought that two to three views would be introduced through different papers, the authors (and their different views) showed that the question of practice might not even be the question to be answered at the moment. Ranganathan, Lee and Krishnan [5] point out that motor learning as a phenomenon is key to many academic disciplines which, despite increased effort in understanding the phenomenon, leads to variety of approaches to the same problem. Such diversity might threaten common understanding as different methods, concepts and definitions lead to a babelic situation.

To remediate the situation, Ranganathan, Lee and Krishnan [5] provide a set of guidelines that would help researchers to solve the problem and raise awareness to the incompatibility of "approaches" to motor learning. These guidelines range from methodological decisions (e.g., task selection, measurement decisions) to open science directions (e.g., pre-registration, code availability). It is of primary importance that the *first* step (or "stage 0") is "Defining what motor learning is", in the sense that not even *this* has been solved. Would be intuitive to say, therefore, that the question "what is the role of practice in motor learning?" should await further agreement in the motor learning area first.

A second approach to my invitation was to postulate new views on the process of motor learning – which might solve the aforementioned issues and provide an answer to the role of practice. A first view was the hierarchical system's view to motor learning, discussed by Corrêa et al. [6]. Under this view, motor learning relates to formation of an invariant macrostructure – directed to consistency and order – which constrains a variant and flexible microstructure. According to the authors, the consideration of these two levels allows for a hybrid view with representation and emergence (see [7] for a thorough treatment of the issue). The authors list several insights that result from applying such approach on the question of practice schedules.

In a similar vein, Profeta and Ugrinowitsch [8] compare the Adaptive Process approach [9] and Specificity of Practice hypothesis [10] on the question of extensive practice. Note that while extending practice would be a source of increased adaptability for the former, the latter predicts a decreased capability to deal with new contexts (changed informational resources) as there is an increase in specificity. Following the idea of hierarchically organized open systems, they provide that studies under the Adaptive Process approach have challenged the original results explained by the Specificity of Practice. Under this, they consider how methodological aspects differ and how the *same aspect* in practice (extensive practice) can result in different outcomes when using different perspectives.

Another view, now from an ecological standpoint (ecological dynamics [11]),

Renshaw, Davids and O'Sullivan [12] challenge the cognitivist view on performance and learning. The authors pose interesting questions on the current tests of learning (i.e., retention and transfer tests) and the issue of "variables that *only* affect performance". Indeed, why one would like to dissociate what is done *during* practice to a later performance? Why not always enhance performance in *all* situations? Renshaw and colleagues [12], therefore, demonstrate how a shift in perspective might be fruitful for both practitioners and researchers view of practice, performance, and learning.

The third approach – in line to the applications of Corrêa et al. [6] and Profeta and Ugrinowitsch [8] – was to discuss important aspects of practice. That is, how practice can be manipulated to favor or hinder changes in the learner's movement possibilities. Ilha et al. [13], for instance, showed that modification of the task demands/ increase of task difficulty results in increased variability in the system – which was considered as a measure of exploration. This was demonstrated through increased variability in the center of pressure of a standing individual induced by an increase in reaching distance.

Luz, Santos and Bonuzzi [14] considered a traditional topic in the literature of motor learning: how one should organize practice sessions and its intervals over time? The issue is of primary relevance as during practice a number of processes are influencing the observed performance (e.g., physical/cognitive fatigue, motivational variability, memory encoding/consolidation [15]) and, maybe, the potential learning outcomes of such practice. These processes have their own time scale and are also largely influenced by the spread of trials over time (e.g., minutes, days, weeks). In fact, these influences were demonstrated by Luz, Santos and Bonuzzi [14].

Anderson and Steel [16] nicely capture another dimension of practice that has escaped the large bulk of motor learning literature and, more important, add to the diversity of the present issue. In a provocative title, they state: "it's not the type of practice that matters, it's the attitude"; and argue that, from contemporary literature, it seems that a playful attitude towards practice seems to be more beneficial for the whole spectrum of skill acquisition (any age, or stage of learning). Playful practice would enhance exploration, elicit mindfulness, allow diversity in solutions, and increase generalization.

As observed, we reached the *range* of issues in practice required for a discussion about the topic. From initial concepts, specifics of practice to broad reconceptualization, the invited authors demonstrated the status of the area at the moment and highlighted a whole set of directions that researchers in the area must consider. In the next section, I take the chance to provide (what I think it is) a potential integration of views[b]. Thus, if you did not read the whole issue, then stop your reading here and take a look on all the amazing contributions that we had for the present issue. But, if you did read, consider my humble commentary on them.

ON THE ROLE OF PRACTICE IN MOTOR LEARNING

After all, what is the role of practice in motor learning? Practice per se can be considered just to perform repeatedly – and in the case of learning, with the goal of improving performance (in relatively permanent way [17])[c]. This "dictionary" definition does

[b] Trying to disagree the least that I can from all of them.
[c] See https://www.etymonline.com/word/practice#etymonline_v_18600 and

not tell us much how such repeated practice works or helps in learning. Following the submitted papers to the current issue, those who dared to provide what is happening in this repeated performance (e.g., Correa et al. [6] and Anderson and Steel [16]) brought Bersntein's ideas to the table in the form of "repetition without repetition". Such view is close to the heart as, in my work, I took seriously the *search* part of the description: "The process of practice towards the achievement of new motor habits *essentially consists in the gradual success of a search for optimal motor solutions to the appropriate problems*" [18] (p. 362, my emphasis).

This search view is intuitive as learning "naturally" encompasses the idea of finding a new solution – a movement that the individual is able to perform provided the current constraints. Thus, one needs to "search" (find) the solution. The search view is also interesting as an initial heuristic view of learning provided the idea of practice as a search process is suitable for (almost) all current approaches to motor learning (also development and control). I say this as search can be conceptualized to occur at any level of analyses (see [19]), be it at the "machine" optimizing motor policies (through reinforcement or any other computational process [20,21], or through direct perception of the task and perceptual-motor workspace gradients [4,22].

Despite some development on the process of search and solution finding (see [4,23]), *just* finding a solution is not *sufficient* for learning – which takes us back to Newell's initial statement. There are two points here. First, the issue that improving during practice does not naturally leads to better performance later (disregarding, for now, the issue of few trials in retention and transfer tests as argued by Ranganathan, Lee and Krishnan [5]). Second, some "amount" of retention or transfer is not the same as being the *maximum* amount that could be retained and transferred.

Thus, in line to all the submissions to the current issue, we are still far from understanding the search process (*practice*) that would induce better retention and transfer. Actually, Renshaw, Davids and O'Sullivan [12] nicely discussed what is to expect, manipulate, and even consider in terms of transfer and retention if we are considering, for instance, competitive scenarios. Another interesting point was made by Profeta and Ugrinowitsch [8] in that potential theoretical disputes on what can be transferred comes from the differences from the old to the new situation. Luz, Santos and Bonuzzi [14], Ilha et al. [13], and Anderson and Steel [16] provided interesting directions on how to optimize the process of search to, *first*, approximate the solution found during practice to the "maximum" potential performance referred above and, *second,* how to maximize retention and transfer. In this vein, ideas from Correa et al. [6] (see also Profeta and Ugrinowitsch [8]) on hierarchical systems might provide the theoretical support to understand how (and why) the discussed practice aspects (e.g., attitude, difficulty, distribution, practice schedules) when manipulated can provide better gains in motor learning.

NEW STEPS ON PRACTICE

To conclude, what have we gained in the present special issue? As it seems,

https://www.merriam-webster.com/dictionary/practice

despite the largely positive view (that I promoted) on the special issue, we are still understanding practice and its role for motor learning – as if we were in 1976, when Prof. Karl Newell made the starting statement of this editorial. Truly, we now understand many more effects in motor learning (e.g., guidance effect of knowledge of results [2], task dependence of the guidance effect [3], limits of variability of practice/contextual interference [24-26], focus of attention [27] and others). However, it is clear that all the work discussed here – which, for me, exemplifies the current literature – is still considering the basics of the area. It might be that issues raised by Ranganathan, Lee and Krishnan [5] are more general than what they intended ("early-career researchers who are new to the field") and the guidelines should be followed by all.

Interestingly enough, Ranganathan, Lee and Krishnan [5] speak at a level of practice that is "above" the special issue: the "researcher's practice". Reinforcing that search is related to "any" practice, I believe that the next steps to understand the role of practice entails constraining *our* search space (maybe in line to Ranganathan, Lee and Krishnan [5] guidelines) to better understand the constraints of the learner's search in practice. This might be the path for finally grasping what is *in practice* that is necessary for learning and how to constrain it to be sufficient for the best outcome. Or it could be that, as I postulated earlier, "it might be that only through this diversity that a potential solution can be found". This is an issue that only practice will help us solving it.

REFERENCES

1. Newell KM. Knowledge of results and motor learning. In: Keogh J, Sutton RS, editors. *Exercise and sport sciences reviews*. Santa Barbara, CA: Journal Publishing Affiliates; 1976. p. 195–228.
2. Salmoni AW, Schmidt RA, Walter CB. Knowledge of results and motor learning: A review and critical reappraisal. *Psychol Bull*. 1984; 95(3):355–86. https://doi.org/10.1037/0033-2909.95.3.355
3. Wulf G, Shea C. Principles derived form the studies of simple motor skills do not generalize to complex skill learning. *Psychon Bull Rev*. 2002; 9(2):185–211. https://doi.org/10.3758/BF03196276
4. Pacheco MM, Lafe CW, Newell KM. Search strategies in the perceptual-motor workspace and the acquisition of coordination, control, and skill. *Front Psychol*. 2019; 10:1–24. https://doi.org/10.3389/fpsyg.2019.01874
5. Ranganathan R, Lee M-H, Krishnan C. Ten guidelines for designing motor learning studies. *Braz J Mot Behav.* 2022;16(2):112-133.
6. Corrêa UC, Okada UA, Ugrinowitsch H, Benda RN. Insights on the Practice Schedule Role on Performance under a Hierarchical System View. *Braz J Mot Behav.* 2022; 16(2):194-205. https://doi.org/10.20338/bjmb.v16i2.274
7. Meijer OG, Roth K, editors. *Complex Movement Behavior: "The" motor -action controversy*. North-Holland: Elsevier Science Publishers; 1988.
8. Profeta VLS, Ugrinowitsch H. Extensive practice in motor learning: an overview and future directions. *Braz J Mot Behav.* 2022;16(2):134-142. https://doi.org/10.20338/bjmb.v16i2.279

9. Tani G, Corrêa UC, Basso L, Benda RN, Ugrinowitsch H. An adaptive process model of motor learning: Insights for the teaching of motor skills. *Nonlinear Dyn Psychol Life Sci*. 2014.
10. Proteau L, Marteniuk RG, Lévesque L. A Sensorimotor Basis for Motor Learning: Evidence Indicating Specificity of Practice. *Q J Exp Psychol Sect A*. 1992; 44(3):557–75. https://doi.org/10.1080/14640749208401298
11. Araújo D, Davids K, Hristovski R. The ecological dynamics of decision making in sport. *Psychol Sport Exerc*. 2006; 7(6):653–76. https://doi.org/10.1016/j.psychsport.2006.07.002
12. Renshaw I, Davids K, O'Sullivan M. Learning and performing: What can theory offer high performance sports practitioners?. *Braz J Mot Behav.* 2022;16(2):162-178. https://doi.org/10.20338/bjmb.v16i2.280
13. Ilha J, Récchia MB, Santo CCE, Pereira MP, Pereira ND. The influence of goal-directed reaching distance on standing postural control variability in non-disabled individuals. *Braz J Mot Behav.* 2022;16(2):143-152. https://doi.org/10.20338/bjmb.v16i2.272
14. Luz JEM, Santos HD, Bonuzzi GMG. (2022). Effects of the different distributed practice regimes on the learning of three-ball cascade juggling task. *Braz J Mot Behav.* 2022;16(2):153-161. https://doi.org/10.20338/bjmb.v16i2.268
15. Verhoeven FM, Newell KM. Unifying practice schedules in the timescales of motor learning and performance. *Hum Mov Sci*. 2018; 59:153–69. https://doi.org/10.1016/j.humov.2018.04.004.
16. Anderson DI, Steel KA. It's not the type of practice that matters, it's the attitude: The impact of playful practice on motor skill learning. *Braz J Mot Behav.* 2022;16(2):179-193. https://doi.org/10.20338/bjmb.v16i2.278
17. Schmidt RA, Lee T. Motor control and learning: A behavioral emphasis. Champaign, IL: Human Kinetics; 2005. 592 p.
18. Bernstein NA. The co-ordination and regulation of movements. New York, NY: Pergamon; 1967.
19. Hills TT, Todd PM, Lazer D, Redish AD, Couzin ID, Group CSR. Exploration versus exploitation in space, mind, and society. *Trends Cogn Sci*. 2015;19(1):46–54. https://doi.org/10.1016/j.tics.2014.10.004
20. Sutton RS, Barto AG. Reinforcement learning: An introduction. Cambridge, England: MIT Press; 2018. 552 p.
21. Shadmehr R, Smith MA, Krakauer JW. Error correction, sensory prediction, and adaptation in motor control. *Annu Rev Neurosci*. 2010; 33:89–108. https://doi.org/10.1146/annurev-neuro-060909-153135
22. Jacobs DM, Michaels CF. Direct Learning. *Ecol Psychol*. 2007;19(4):321–49. https://doi.org/10.1080/10407410701432337
23. Komar J, Ong CYY, Choo CZY, Chow JY. Perceptual-motor skill transfer: Multidimensionality and specificity of both general and specific transfers. *Acta Psychol (Amst)*. 2021; 217:103321. https://doi.org/10.1016/j.actpsy.2021.103321

24. Brady F. A theoretical and empirical review of the contextual interference effect and the learning of motor skills. *Quest*. 1998; 50(3):266–93. https://doi.org/10.1080/00336297.1998.10484285
25. van Rossum JHA. Schmidt's Schema Theory: The empitical base of the variability of practice hypothesis - A critical analysis. *Hum Mov Sci*. 1990; 9:387–435. https://doi.org/10.1016/0167-9457(90)90010-B
26. Newell KM. Schema theory (1975): Retrospectives and prospectives. *Res Q Exerc Sport*. 2003; 74(4):383–8. https://doi.org/10.1080/02701367.2003.10609108
27. Wulf G, Chiviacowsky S, Schiller E, Ávila LTG. Frequent external-focus feedback enhances motor learning. *Front Psychol*. 2010; 1:1–7. https//doi.org/10.3389/fpsyg.2010.00190

Citation: Pacheco MM. (2022). Editorial: The Role of Practice in Motor Skill Acquisition: New Issues, the Same Question. *Brazilian Journal of Motor Behavior,* 16(2):105-111.
Editors: Dr Fabio Augusto Barbieri - São Paulo State University (UNESP), Bauru, SP, Brazil; Dr José Angelo Barela - São Paulo State University (UNESP), Rio Claro, SP, Brazil; Dr Natalia Madalena Rinaldi - Federal University of Espírito Santo (UFES), Vitória, ES, Brazil.
Guest Editors: Dr Matheus Maia Pacheco, CIFI2D, Faculty of Sport, University of Porto, Portugal.
Copyright:© 2022 Pacheco and BJMB. This is an open-access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
Competing interests: The authors have declared that no competing interests exist.
DOI: https://doi.org/10.20338/bjmb.v16i2.314