Pianistic Action, Analysis and Motor Coordination Interdisciplinary Application in the Practice Organization

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Abstract

This paper presents part of the research conducted within an interdisciplinary framework, drawing particularly on arguments from motor coordination and biomechanics to enhance the efficiency and quality of pianistic performance, and examining technical strategies applied to instrumental practice. Essential conditions for achieving optimal results in instrumental music performance include knowledge of the bodily aspects involved in action, familiarity with the materials being manipulated (such as the score and the piano), and the organization of the process leading to the desired outcomes. The first condition focuses on understanding the performer's characteristics while the second involves grasping the specific content being rehearsed. The third condition, which is organizational, deals with developing and evaluating the repertoire. This topic has been addressed by researchers across various fields, including motor control, cognition, and performance practices, and is relevant to pianistic action and technical strategies. One example of this kind of correlation is the Movement Cycles and SMRD strategies (Simplification of Movement by Distances Reduction), both proposed by Póvoas (1999, 2006). The primary purpose of this research is to explore interdisciplinary concepts in practice and their impact on motivation during training, as well as the optimization of piano performance through continuous analysis of training and performing repertoire in specific performance musical situations, incorporating the planning of practice and the aforementioned strategies. Describing the issues raised, analysing the information, and diagnosing their causes should contribute to establishing criteria for selecting technical resources to address musical situations, leading to the optimization of pianistic action.

Keywords: pianistic movement, motor coordination, piano practicing, practice organization

Introduction

This research examines technical-instrumental strategies through an interdisciplinary approach. The primary goals are to explore how applying interdisciplinary principles to instrumental practice influences motivation during training, to establish connections between the musical material, technical exercises, and sound outputs, while incorporating Movement Cycles and SMRD strategies into practice planning, and finally to assess the impact of interdisciplinary knowledge on (1) motivation during practice and (2) performance optimization in specific musical tasks, based on results obtained from an experimental group. All strategies application depends on the musical components of a composition to be explored for an artistic realization with its detailed context characteristics.

The central hypothesis of this research is that the application of technical strategies informed by principles of motor coordination and biomechanics enhances the efficiency and quality of pianistic performance. Accordingly, the aim is to establish connections between the musical material, the practice of technical resources, and the resulting sound, incorporating them into the practice planning.

Theoretical context

In this section, we present several concepts that supported this research. Regarding the perception of time and space in communicative processes, Pinto (2010, p. 43) stated that, in a collective space, our body acts as a 'centre of action', adding that movement is perceived as a type of individual action in the context of relationships between the self and the environment. There is a mutual exchange, since the body receives and returns movements in this relationship. In addition, Davidson and Correia (2002, p. 239) explain that, because all bodies are involved in musical production, motor programs must be well established. However, they emphasized that the body is much more than a mechanistic source of input and output. They highlight the fact that, just as there is a wide variety of situations for

musical performance, there are also movements and gestures to meet the needs of performance. Referring to Shaffer (1982, 1984), they noted: "[In] his studies on the skilled performances of typists and pianists, Shaffer explored how motor programs are structured."

Addressing the organization of knowledge and its influence on cognitive abilities, in the Brazilian edition of Sloboda's *The Musical Mind: The Cognitive Psychology of Music* (2008, p. 12), it is mentioned that "The 1970s saw the field expand in multiple directions, with growing interest in higher cognitive processes, the control of complex behaviours". Regarding the organization of practice, if considered as a result of conscious mental and physical work of the body, according to Magill and Anderson (2017, p. 444), this combination will probably create conditions to improve learning and facilitate the application of strategies with their more complex characteristics, since it predisposes the execution of body movements with greater efficiency, aiming at optimizing performance.

The movement cycles application can also be considered from the point of view of gesture integration, presented as both technical and strategic resources for recognition and the acquisition of technical control to be used in building the musical interpretation, aiming to enhance its expressiveness (Juslin, 2003).

Piano planning and practice organization

In discussing piano planning and practice organization, certain conditions and steps are essential for achieving optimal results throughout the stages of instrumental development. This involves not only an understanding of the musical construction elements being developed, but also an awareness and perception of the bodily aspects involved in the action: specifically, the role of the body in expressing musical and artistic intention. Merleau-Ponty (1999, p.32) described the body as a "transmitter of messages." For him, "[the] body is the vehicle of being in the world", and he added: "it is as simple as that". These words point to a foundational idea that the body functions as the primary medium through which musical expression is realized. From this perspective, organizing practice also involves planning physical movements to address both technical and musical challenges, movements that are closely linked to the musical elements being developed and the corresponding sound. The process in this context constitutes an essential aspect of development, that depends largely on motivation.

Regarding motivation, Lehmann, Sloboda, and Woody (2007, p. 44) point out that musicians encounter 'multiple sources' of motivation throughout their lives, distinguishing between intrinsic and extrinsic sources. Although both are important in the preparation of musical-instrumental performances, the strategies applied to this process are considered intrinsic sources and should be considered essential in achieving technical and musical objectivity. The results come from a conscious bodily activity. Therefore, they allow for greater security and satisfaction during performance, which can certainly be experienced.

In general, people make music because of the enjoyment and fulfilment they get from it. However, because acquiring musical skill takes much time and effort, developing musicians also rely on extrinsic motivation, or secondary non-musical rewards that come with musical participation.

Within the context of the present research, assessment is considered from a formative perspective, according to Lebler & Harrison (2017, p. 93). In this way, an evaluation should reflect the result or "standard of the work more holistically than simply presenting correct elements and numbers". Thus, assessments may include both qualitative and quantitative analysis, with data cross-referenced from questionnaires.

The organization of training aims to guide musicians in optimizing and controlling actions (Davidson & Correia, 2002; Kohut, 1992), as well as the steps necessary to achieve the desired results. A system for organizing practice should provide the pianist with greater control over skills, which can be divided into two main categories: cognitive skills and motor skills. Cognitive skills refer to the complex set of mental processes (e.g., memory, perception, logical reasoning). Motor skills are actions, tasks, either simple and basic or complex, that can be performed with varying degrees of success (basic or fundamental, and specific).

It is worth noting that the spatial orientation of movements related to distance planning is also considered an essential technical resource in piano training. This is the reason why performing distant events on the keyboard can be defined as a matter of medium or high complexity.

Method

The organization of a skill refers to the relationship between its components. A skill has a high level of organization when its components are spatially and

temporally interdependent (Magill & Anderson, 2017, p. 432). Schmidt & Wrisberg (2001, p. 21) point out that, during the process of cognitive skills development, it is ideal to focus on strategy, namely, "how and which movement to perform", in order to improve performance know-how. This concept is applied here to musical-instrumental practice. The pianistic action is, in fact, a motor skill that requires voluntary movements of body parts to achieve musical objectives. According to these authors, healthy working conditions and the optimization of practice depend on the systematic organisation of training time through distributed practice sessions (Magill & Anderson, 2017; Schmidt & Lee, 2005; Bangert et al., 2013).

The schematic representation of practice organization, the necessary conditions, means, and materials is shown in Figure 1.

*** Knowledge and perception about:**
- elements of musical construction
- bodily aspects involved in the action

*** Planning of related bodily movements:**
- resolution of technical, musical issues (application of strategies)
- inherent sound qualities

*** Assessment:**
- of the process
- of outcomes

Figure 1. Organization of practice conditions schema

Movement cycle application

To operationalize the practice of this strategy, the direction of the movement of the segments is indicated by the cycle, whose shape and extent guide the movement and displacement of the segments along the X, Y, and Z axes (Póvoas, 2006, p. 666). The length of each line represents the displacement of the pianist's arms and fingers along the X coordinate on the keyboard. The upward or downward orientation of the arrows indicates movement in relation to the Y axis, while the concavity or convexity of the line's design guides movement in the Z axis, corresponding to the extension or depth of the key.

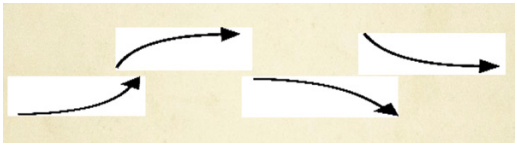

Figure 2. Arrows direction

This explanation is further illustrated by Figures 3, 4, 6, and 7. In Figure 3, we observe the directions of the coordinate axes relative to the keyboard.

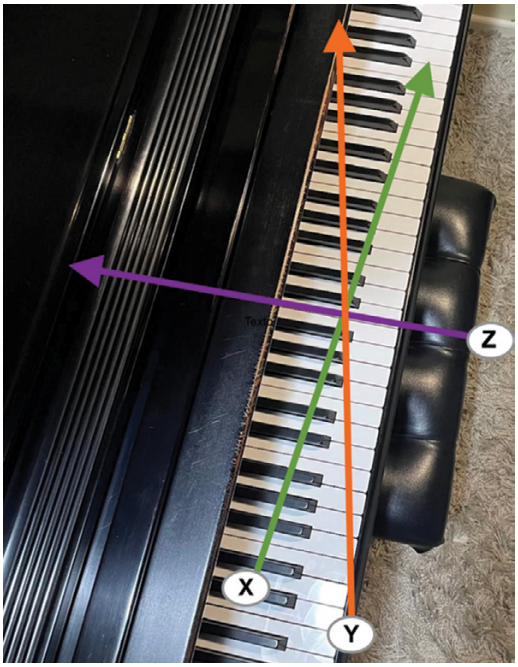

Figure 3. Axes

Figure 4 shows the *Dança Negra* excerpt that pianists played during the experimental procedure.

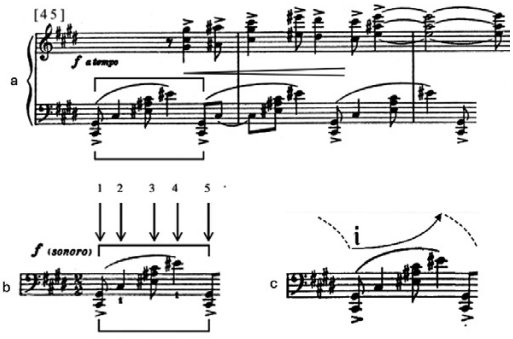

Figure 4. Excerpts from Guarneri's *Dança Negra*, mm. 45-47

The first part of this example shows the musical material used for the pianist's practice. The second part (b) shows the five musical events, while the third part (c), to the right of the figure, represents the musical ostinato selected for the kinematic analysis. The analysis and evaluation were based on this musical material, which is repeated 43 times throughout *Black Dance*. Each note or group of notes (chords or clusters) written vertically in the score was considered a musical event.

Data acquisition

Data were acquired at the Biomechanics Laboratory of CEFID – UDESC**.** On the occasion, each pianist participant played the excerpt in Figure 4a three times. For the analysis, the portion related to the left hand (Figure 4c) was extracted from the performed excerpt**.**

As part of the experimental procedure, images were captured for analysis at a rate of 180 frames per second. Following this step, the software generated an average of more than 200 graphs, of_which 40 were analysed. Two examples are presented in Figures 5a and 5b.

Experimental design

Since this research is both theoretical and exploratory, as well as experimental, the methodological procedures are largely practical and hands-on. They involve continuous feedback on the application of strategies in pianistic training and performance (qualitative analysis), as well as quantitative analysis through biomechanical experiments.

In the context of our research, bodily movement is understood as both a means of operationalizing instrumental action and an element of communication with the objective and perceived world, according to Merleau-Ponty (1999, pp. 23-37). In instrumental practice, the projection of the musical text depends on coordinated movements that result from the development of motor skills. These topics are also explored by researchers across various fields, including motor control (Magill & Anderson, 2017), cognition (Pinto, 2010), and performance practices related to pianistic action and technical strategies such as Movement Cycles and SMRD.

Within the scope of motor coordination, practicing the cited orientations aimed at task optimisation requires skill acquisition, which occurs through a combination of physical and mental practice, according to Magill & Anderson (2017). This context refers to the importance of practice organization, which is intrinsic to instrumental activity.

To assess and validate the effectiveness and applicability_of the Movement Cycles strategy, a biomechanical experiment was conducted. Twelve pianists of varying skill levels were invited to participate in the experiment (kinematic analysis) at the Biomechanics Laboratory of the Physical Education Centre, CEFID-UDESC, Brazil.

Table 1 includes the following participant information: gender, age, level of education (*currently in progress), total study time (TST), and average daily practice time (ADPT). In some cases, ADPT was not provided.

Table 1. Participant information

Participant	Gender	Age	Education	TST	ADPT
1	M	22	B*	08	5h
2	M	36	B*	20	2h
3	M	22	B	10	3h
4	F	30	B*	24	1h
5	M	23	B*	16	3h
6	F	57	B	50	1h 30m
7	F	38	B	31	**
8	M	40	M	30	**
9	M	29	B	23	**
10	M	22	B*	07	2h 30m
11	M	25	M*	14	1h
12	F	50	D*	43	2h
Average	na	31	na	24	3h 33m

Six participants were assigned to the experimental group (EG), and the remaining six to the control group (CG). All participants practiced an excerpt from *Dança Negra* by Brazilian composer Camargo Guarnieri (measures 45–47). The EG received guidance during three training sessions, while the CG worked independently without instruction. Arrows or curved lines were placed above the musical events that constitute movement cycles as illustrated in the last (c) section of the example in Figure 4. The kinematic procedure enabled detailed analysis of movement trajectories, providing quantitative evidence regarding the efficiency gains associated with the application of the movement cycle approach.

Results

Figure 5a presents a Type-A graph showing the X-coordinate curves for each participant, represented by different colours, with unnormalized

time. In Figure 5b, a Type-B graph displays the same data on the X coordinate, with participants represented by colour and time normalized.

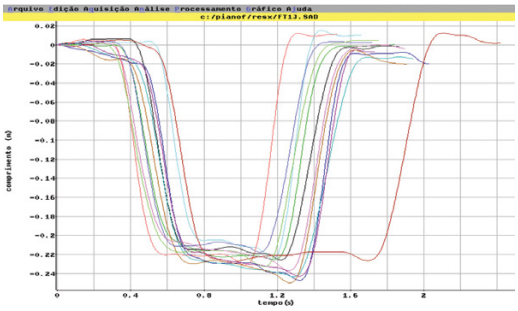

Figure 5a: Type-a curve on X coordinate.

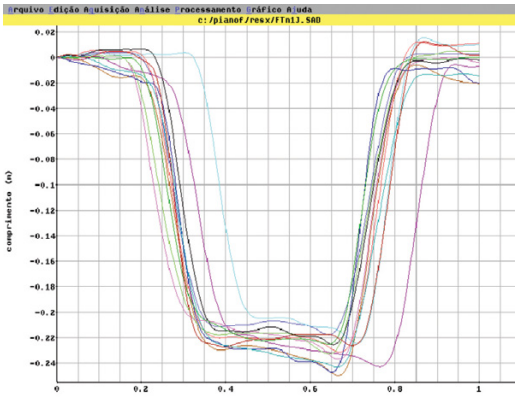

Figure 5b: Type-b curve on X coordinate.

Table 2 shows the trajectory measurements for each participant and group in the X, Y, and Z coordinates, along with individual and group averages. The results demonstrated that the EG's average trajectory was shorter, as was the case for most individual participants in the group. Given that the ostinato is repeated 43 times in the performance of *Dança Negra*, it is possible to infer a significant economy in body movement trajectories.

It can be observed that the CG group showed lower averages on both the X and Z coordinates. As the ostinato presented in Figure 4 (c) was repeated 43 times, the economy of movement was significative. An average difference of 0.9 decimetres between the groups, in favour of the CG group, greatly shortens the distance to be covered during the training and performance of the *Dança Negra*, because of the 43 repetitions of the ostinato.

The basis of the Movement Cycles concept (Póvoas, 1999, 2006) is the direction of musical segments, indicated by arrows or lines placed on the musical events that form a cycle.

It is essential to observe aspects such as preparation for playing distant events and body sensation during the movement execution on the piano. Those actions, combined with kinaesthetic control, may enhance performance. Such conditions allow one to realize more agile movements, for example, allowing for a greater awareness because of the relationship between the movement and the sound results. The data demonstrate that strategies for movement organization may help for a better physical domain when contextually integrated into performance preparation.

To optimize performance learning, it is crucial to apply strategic procedures tailored explicitly to pianistic performance and the demands of motor coordination. However, a lack of clear criteria

Table 2: Trajectory by Participant (TS) and By Group (TG) on X, Y and Z coordinates, Results by Participant (TRS) and Average per Group (AG).

Group	Participant	TP X	TP Y	TP Z	TRP	AG
CG	1	.477	.250	.180	.631	.630
	7	.527	.336	.105	.699	
	8	.455	.178	.109	.540	
	9	.486	.291	.183	.641	
	10	.478	.271	.226	.639	
	11	.483	.275	.143	.628	
AG	---	.484	.267	.158		
EG	2	.503	.189	.132	.629	.621
	3	.457	.108	.135	.511	
	4	.480	.279	.218	.655	
	5	.511	.202	.158	.610	
	6	.516	.529	.210	.684	
AG	---	.494	.264	.165		

in selecting technical procedures aligned with musical construction and sound goals may lead to misunderstandings.

Simplification of movement by reduced distance (SMRD)

Building on previous results, we present SMRD, Simplification of Movement by Reduced Distance, an interdisciplinary approach to planning and guiding medium- and long-distance movements in piano practice. It proposes movement reduction as a strategy to establish clear reference points on the keyboard, integrating with the concept of Movement Cycles.

The application of SMRD is demonstrated in measures 342-345 of Franz Liszt's *Dante Sonata.* Initially, the passage may be practiced using only the first and second fingers, with octaves suppressed, to enhance awareness of the optimal proximity between musical events. This case study is still in development. Figure 6 displays a reduction of this excerpt for right hand realization, where only notes played with the thumb and double notes should be executed. The passage should be approached with elliptical movements, performed as naturally and flexibly as possible during training.

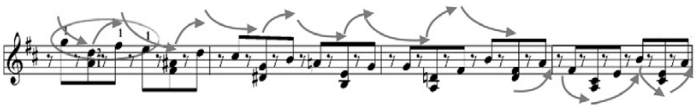

Figure 6: SMRD, Liszt: *Dante Sonata*, mm. 342-345

The same excerpt presented in Figure 5, now arranged for both hands and incorporating the Movement Cycles. It is recommended to play the musical text, performing the events with elliptical movements in the most organic and flexible way.

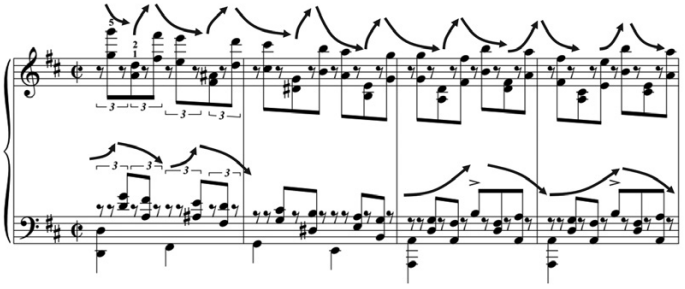

Figure 7: SMRD strategy. Liszt: *Dante Sonata*, mm. 342-345

A conscious approach to manipulating different musical parameters may be note suppression or even an octave displacement. Thus, it "proves to be a valuable tool for adaptation and improvement of motor efficiency", as Ardigo observes (2024: 68). Adding to this strategy, we may create references on the keyboard. Notably, the cycles for the right hand in measures 344 and 345 were adjusted to meet the musical design demands for the right hand.

Conclusion

Within the analytical framework of bodily and musical interactions, it is suggested that, as an integral part of the process, relationships be established between recurring patterns, such as similarities in musical configurations, articulations, and their corresponding body movements during the conditioning process and technical musical mastery. Additionally, there is an association between previously experienced technical-musical situations and those present during performance practice. These actions can enhance the efficiency of training by optimizing both time and energy. Such relational strategies may also support increased focus, greater objectivity in movement planning and execution, and improved neuromuscular performance, thereby positively influencing the aesthetic and sonic quality of performance. This paper presents only the results of cycle strategy analysis. The investigation into SMRD is still in development.

The proposal to simplify complex movements was initially implemented in pianistic practice and pedagogical contexts through the application of two strategies: Simplification of Movement by Reduced Distance (SMRD) and Movement Cycles. These strategies are currently being employed in targeted musical excerpts to examine their practical relevance and pedagogical value. We still intend to conduct evaluations through biomechanical studies, involving motion capture of performances by groups of pianists. While the kinematic method provides quantitative data on movement trajectories along the X, Y, and Z axes, a complementary qualitative analysis will be necessary to evaluate the musical results and the motivational dimension of training with the proposed strategies. A thorough understanding of these issues, along with a detailed analysis of relevant

data and identification of underlying causes, may help establish more precise criteria for selecting technical resources. This process is expected to support the development of more effective piano strategies focused on the musician's health, ultimately leading to performance optimization. Based on the obtained results, it can be concluded that all work depends on the pianist's understanding and engagement with the practice of strategies in an organized manner, focusing on technical and musical demands. In this way, the musician could achieve greater progress and optimize their performance.

The kinematic data collected during the participants' execution of the selected excerpt allowed a detailed analysis of the movement trajectories, providing quantitative evidence regarding the efficiency gains associated with the application of the movement cycle approach.

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