

A REVIEW OF IMPLICIT AND EXPLICIT LEARNING STRATEGIES IN THE
DEVELOPMENT OF MOTOR SKILLS AND ITS APPLICATION TO TEACHING
INSTRUMENTAL TECHNIQUE

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How Music Pedagogy Traditional Teaches Instrumental Technique

Performing on a musical instrument requires a wide variety of cognitive and physical skills. The performer must coordinate such things as fingering, posture, breathing, and tonguing to a fine degree, on top of the cognitive load of reading musical notation, following a conductor, listening closely to blend and play in tune with other musicians, and playing expressively. With all the multitasking that musical performance demands, teachers and performers have developed a variety of strategies to instruct and practice in order to best develop and retain instrumental technique.

At one end of this spectrum is the approach taught by Arnold Jacobs. An orchestral tubist who performed with groups such as the Pittsburgh Symphony Orchestra and Chicago Symphony Orchestra, Jacobs was highly sought after as a teacher for both his knowledge and understanding of the respiratory process as well as his success as a teacher and clinician. His teaching philosophy, frequently summarized as “song and wind” has been highly influential leading Dale Clevenger to say, “Nearly every brass player in America has studied with Arnold Jacobs, whether they know it or not” (Frederiksen, 1997, p. 88).

According to Jacobs, difficulties with instrumental technique on brass and woodwind instruments could be traced down to two main causes, insufficient breathing and lack of proper mental focus on the musical expression. Using the “song and wind” approach, students are instructed that, “one should stress being an artist, and the body with conditioned responses will take care of the results” (Nelson, 2006, p. 15).

Jacobs's approach is contrasted by the brass pedagogical method of Donald S. Reinhardt, which he termed the Pivot System (Reinhardt, 1973). Where Jacobs stressed taking the student's attention away from the physical actions used to perform on a musical instrument, Reinhardt chose to break down the mechanics of performing on a brass instrument into its component parts and developed personalized practice routines designed to emphasize correct technique. Reinhardt's approach involved analyzing each student's particular physical characteristics in great detail and categorizing the student's embouchure, tonguing, and breathing patterns accordingly, offering specific practice instructions on the precise mechanics.

While both Jacobs's and Reinhardt's pedagogy shares much more in common than these brief summaries would suggest, these two approaches are essentially examples of teaching through implicit instructions or explicit instructions. Implicit learning is goal oriented and non-verbal. Jacobs's instructions to focus primarily on the music and let the technique work itself out is based on the implicit strategy. This contrasts with Reinhardt's explicit instruction, which involved the teaching of facts and rules of how to play.

For the instrumental music teacher these two almost opposite approaches offer a teaching conundrum. Should students be taught the specific mechanical procedures they use when playing their instrument as Reinhardt instructed or should the rather have their attention moved away from technique towards expressive musical communication as Jacobs recommended? Do these two contrasting pedagogies represent a false dichotomy and is a blended approach more effective? If so, what is the proper balance between the two? While most of the published research looking at these questions involves athletic or

non-musical tasks, looking at literature concerning the differences between implicit and explicit learning in motor skill development may offer some practical suggestions for the instrumental music teacher.

Implicit Learning Over Explicit Learning

One of the most prominent authors on the topic of implicit versus explicit motor skill learning has been R. S. W. Masters. In 1992 Masters published the results of a study investigating subjects learning a golf putting skill assessing the differences between subjects instructed to practice with knowledge of rules or without. Masters then subjected these two groups to stressful performance situations to test which method of instruction would provide the best results. The results suggest that performers who learned the golf putting skill implicitly performed better under pressure than those who learned with explicit knowledge (Masters, 1992).

Later research by Masters and others supports his earlier findings. Extending the initial study of golf putting skills, Maxwell, Masters, and Eves (2000) looked at how the performance of implicit and explicit learners compared over a longer period. They found that while the performance of the implicit group remained below the explicit group while still in the learning phase, there were no statistically significant differences found in retention of the skills between groups. Furthermore, the explicit learners were found to show a negative correlation in the number of rules they learned with their performance quality. As subjects learned more rules to follow, their overall putting performance decreased.

Investigating how cognitive effort effects implicit motor skill development Rendell, Masters, Farrow, and Morris (2011) looked at how contextual interference altered the retention of motor learning skills. They note that randomly sequencing practice trials results in poorer performance during the acquisition phase of motor learning compared with repeated practice trials until the particular task is learned. However, when tested on retention and transfer of motor skills, randomized practice with high contextual interference resulted in better long-term performance. Speculating that the mechanism responsible for these results was the increased cognitive activity associated with randomized practice, Rendell and her co-authors designed an experiment to test subjects on their retention of Australian Rules Football kicking and handball tasks. They found that practice with high contextual interference resulted in a more implicit mode of learning, however they only noted this feature on the more complex of the two tested tasks. This suggest adopting a more implicit mode of learning may be more beneficial for more complex motor skill tasks.

Lam, Maxwell, and Masters (2009) investigated the results of analogy learning in a complex motor task and compared subjects using an explicit learning strategy. The authors tested two groups of subjects at a modified basketball shooting task. One group was trained with instruction using analogies while the other was given explicit instruction on correct shooting technique. The authors found that while both groups performed equally well during the learning phase of the study, the analogy group's performance was superior while under pressure. In 2010 the same authors published a paper using similar methodology to look at the effect errors had on the retention and transfer of golf putting

skills on implicit learners. They found that the group that practiced golf putting skills in a manner that was designed to be error free were better able to transfer their skills to performing with an unusual putter, suggesting that reducing errors during initial learning stages encourages implicit learning and therefore lower demand on cognitive resources during transfer (Lam, et al., 2010).

Such differences in the performance between implicit and explicit learners may have a neuropsychological basis. Using an EEG to examine brain wave activity while performing golf putting tasks, researchers found that subjects who preferred to learn through conscious monitoring and controlling their movements displayed more co-activation between brain regions associated with verbal-analytical cognitive processes and motor planning cognitive processes (Zhu, et al., 2011). They also found that the explicit learning group also displayed more co-activation than implicit learners when asked to perform the task under stressful conditions. Other researchers using slightly different methods found similar results. By applying direct current stimulation to particular brain regions associated with implicit motor learning and explicit learning, Kantak, Mummidisetty, and Stinear (2012) found that stimulation of the primary motor cortex, known to be engaged during implicit motor learning, resulted in better performance of motor skill tasks both during and after practice.

Of interest to some researchers is the role that rest can play in the implicit acquisition of motor skills. Janacek and Nemeth (2012) point out that implicit learning does not just occur during the actual practice of a task, but also during the so-called offline periods between practice, particularly during or after sleep. The above noted study

by Katak, et al. (2012) further reinforces the importance of the offline period of rest between practice. When applying current stimulation to the the dorsal premotor cortex, the brain region associated with explicit learning, they found that subjects' offline performance gains were reduced.

As the majority of research to date has used novice performers, rather than high performance subjects, one raised problem is how to relate implicit learning strategies to expert athletes. Gabbett and Masters (2011) attempted to address this issue through describing these challenges to coaches and athletes. They also presented specific training activities and techniques designed to develop implicit learning with rugby athletes, recommending strategies such as errorless learning practice, random practices, and use of appropriate analogies (Gabbett & Masters, 2011). Jackson and Farrow (2005) similarly investigated the use of implicit learning in athletic training and discussed different coaching strategies along with their benefits and drawbacks.

Evidence Supporting Inclusion of Explicit Learning

While most of the published literature looking at the differences between implicit and explicit learning for motor skill development generally favor the implicit approach as superior, there are a number of researchers who have found some conflicting results. Much of the literature already discussed focuses on completely separating implicit and explicit learning. However, some authors point out that such a differentiation is neither practical in real world applications nor feasible to truly isolate. Researchers using transcranial magnetic stimulation to map brain regions demonstrated that implicit practice showed gradual activity in areas in the brain associated with explicit learning as well,

until subjects achieved explicit knowledge of the task when brain activity returned to its base line (Pascual-Leone, et al., 1994). Similarly, Willingham and Goedert-Eschmann (1999) point out that while functional MRI studies indicate that motor skill development may be purely implicitly or explicitly developed, their experimental study showed that when presented with a random task, subjects in the explicit group demonstrated similar sequential knowledge to those in the implicit group. The authors are careful to qualify that further research is needed, but they suggest that consciously acquired motor skills are successfully learned at the beginning of the learning stages until a more implicit awareness is sufficiently developed at which point the explicit representation is no longer needed or used.

Looking at how implicit and explicit development interacts while learning a catching task, Lagarde, et al., (2002) found measurable differences between groups that were instructed using either implicit learning methods or explicit methods. Specifically, they noted a difference in performance between groups that received explicit instructions given prior to practice compared to the middle of practice. Instructions given before practice resulted in more errors than explicit instructions given in the middle of practice. The control group, who practiced using an implicit learning method only, showed motor skill development limited to visuo-motor processes. The authors conclude that these results show a much more complex interaction of motor learning between implicit and explicit approaches than previously demonstrated (Lagarde, et al., 2002).

Other research suggests that a combination of implicit and explicit learning may make for the most effective method for motor skill development. Lola, Tzetzis, and Zetou

(2012) conducted a study comparing four groups' abilities to make important decisions while serving a volleyball. Their analysis showed that all groups improved over time, excepting the control group who simply performed the assessments. The implicit group outperformed the explicit group, however the group that was instructed through a combination of the two was faster and more accurate than both. Mazzoni and Wexler (2009) investigated a similar research question and also found that subjects who engaged in both implicit and explicit motor control during assessments performed without degradation compared to groups that used explicit or implicit control alone.

Other research explored the limitations of implicit practice for longer term retention of skills. Willingham and Dumas (1997) noted that while older research showed that implicit learning is effective for retention of motor skills, subjects who had been trained implicitly in a button pushing task did no better after a year compared to participants who had no training at all.

Some research calls into question the methodology for assessing the differences between implicit learning and explicit learning. While investigating how explicit learners acquire motor sequence knowledge, Knee, et al. (2007) found that subjects instructed to practice a button pushing task through explicit methods learned the skill based on the locations of the the provided stimulus. This contrasts with subjects using implicit learning strategies, which was found to be mentally represented as response locations, independent of the stimuli. When the stimuli was changed for the explicit learners their performance suffered compared to the implicit learners (Knee, et al., 2007).

Another study (Lemieux & Penhune, 2010) suggests that subjects who were assigned to a group using random practice performed better on visual motor sequence skills compared to learning with an explicit learning method. Conversely, massed practice was more effective for learning skills involving sensorimotor integration and timing. These studies suggest that some of the differences in performance between implicit and explicit learners may be related to the type of task being assessed and the whether the subjects are instructed in massed or random practice.

In spite of these criticisms, improved methodology continues to support implicit learning's benefits under most situations. In one of Masters's studies (1992), implicit learners were required to perform an articulatory suppression task while initially practicing golf putting tasks. Other authors have pointed out that the final assessment of these learners did not require the subjects to continue to perform this suppression task, suggesting that improvement may be related to the subjects performing an easier task, albeit under stressful conditions. Hardy, Mullen, and Jones (1996) replicated this study controlling for this factor. The results showed that implicit learners still continued to improve when subjected to stressful situations, while the explicit learners did not. Mullen, Hardy, and Oldham further addressed issues in their methodology later in 2007 and found that implicit practice was superior to explicit learning when subjects were later asked to perform golf putting tasks under situations designed to induce anxiety.

Other studies show conflicting results to those of Hardy and others. Bright and Freedman (1998) found that controlling for factors in differences between learning and testing conditions resulted in no support for Hardy's 1996 study demonstrate implicit and

explicit learning of motor skills are differentially affected by anxiety. Conflicting results such as these show that further research using improved methodology is needed.

Francesconi (2011) argues that while most physical actions are best done unconsciously during common, recurring activities, at other times an explicit awareness of motor skill performance can have benefit. Arguing for a blend of implicit and explicit approaches, he wrote:

“At the same time, the sense of agency, self perception or proprioception, the consciousness of an action, is at the base of the sense of self, the recognition of being separated from others but embedded in the environment and being the ‘who’ of the action. Moreover, being conscious of our own movements is an essential component in the constitution of the bodily self, which leads to the meaning and sense attribution of our actions through narrative and metacognitive points-of-view. (Francesconi, 2011, p. 6)

Motor Skill Research in Musical Performance and Pedagogy

The majority of research on motor skill training has been done using subjects that are assessed in tasks that either are athletic in nature (i.e., golf putting, volleyball serving, basketball shooting) or artificial tasks specifically designed to test how motor skills are developed. Comparatively little research has been done directly looking at how subjects develop the motor skills necessary for musical performance. Even less published research looks objectively and specifically at instrumental technique development in relation to implicit and explicit instructions. Still, there has been some recent research that directly investigated the development of motor skills using musical tasks.

Cash (2009) found that subjects instructed in keyboard playing not only acquired instrumental technique better when told to rest for short periods during a practice session, but also retained their skills better than control groups overnight. This research replicates that by Janacsek and Nemeth (2012) and Kantak, Mummidisetty, and Stinear (2012) suggesting the importance rest intervals has on improved retention on motor skill practice.

Another study on musical motor skill development (Trimarchi and Luzzatti, 2010) showed that trained pianists developed associations between pitch range and activities involving the use of either their right hand or left hand. This suggests that pianists develop an interaction between their auditory cognitive process and motor control of their hands. When presented with tasks that conflicted with their association with pitch range and one hand or the other the trained pianists were found to have more interference than other groups.

Rosenthal (1984) conducted research looking at the effects modeling and verbal instructions had on expert musician's abilities to perform a challenging passage. She found that the group given a model only outperformed groups given only verbal instructions, both a model and verbal instructions, or practice only. Rosenthal's research would appear to support above mentioned studies that find implicit learning to be superior to explicit learning. However, Rosenthal's results conflict with other research showing the combination of both may provide the better results than an implicit or explicit approach alone (Mazzoni and Wexler, 2009 and Lola, Tzetzis, & Zetou, 2011).

Kennell (1989) devised an experiment that used a similar approach to Rosenthal's yet found slightly different results. Using three different experimental treatments, his results suggested that the effectiveness of a teaching strategy may be related to the context of the situation. He hypothesized that instruction marking critical features would be best for reminding students of skills they have already learned, demonstration would be more beneficial for learning new concepts, and task manipulation best for building new skills (Kennell, 2002, p. 249).

There have been some published papers that attempt to put much of the research related to motor skill development into a music pedagogy context. Wilson and Roehmann (1992) reviewed literature related to the development of music performance skills, including the development of instrumental technique. Kennell (2002) discussed research in studio music instruction, comparing and contrasting different models of private studio instruction for the *New Handbook of Research on Music Teaching and Learning*. Sanders (2004) reviewed research on motor skill development and offered suggestions for its application to music pedagogy. While most of the research discussed in both these reviews do not directly related to comparisons of implicit or explicit learning in music performance they all take a research based approach to teaching music.

Conclusions and Recommendations

Making specific recommendations for music pedagogy based on the currently available research is challenging for a variety of reasons. The first issue that must be taken into account is that most of the available research explores either tasks associated with sports or tasks specifically designed to measure motor control. It is likely that the

results of most of these studies will also apply to the motor skill development needed for musical technique, however the lack of research that specifically looks at musical skills makes it difficult to be certain that this is the case. Much of the research relied on visual stimulation, rather than aural stimulation, and it is possible that this change in feedback can alter the benefits or drawbacks to teaching strategies.

While implicit learning has the consensus supporting its benefits over explicit learning, it should be noted that a lot of the recent publications have been done by a limited number of researchers, specifically Masters (8 publications cited in this paper) and Maxwell (5 cited publications). Additionally, replication of their research produced inconsistent results, in spite of later studies by Maxwell, et al. that attempt to correct for methodological issues and replicate their original work. Before these results can be accepted with widespread authority they will need to withstand more peer review and replication by other researchers.

Other areas of caution in applying this research to music instruction involve the ability levels of test subjects, the length of retention, and the specific nature of improvement on a motor skill. The majority of research comparing implicit and explicit learning uses novices as test subjects, yet much music education deals with students who have been studying their instrument for years or even decades. Some of the literature indicates that the type of instruction most effective depends on the particular stage of development a subject is in (Pascual-Leone, et al., 1994 and Willingham & Goedert-Eschmann, 1999) or the specific task being practiced (Lagarde, et al., 2002 and Kennell, 1989). These findings imply that musical instruction related to motor skill development

needs to take the student's current stage of development into account, as well as the specific skill being learned.

Finally, very little research has been done investigating the longevity of motor skills beyond a single year, particularly in relation to expert performance. Wilson, and Roehmann (1992) do make note of research regarding injuries and disorders with expert musicians, such as focal task dystonia. Furthermore, it has been noted that issues such as embouchure dystonia typically manifest between the ages of 35 and 45 (Frucht, 2001 and Frucht, et al., 2009) Many individuals suffering from dystonic-like symptoms tend to be players who favor an implicit learning style (Kagarice, 2005). While implicit learning may show better short term effectiveness, prevention of injury or other related issues may be best done through the inclusion of explicit instruction in correct instrumental mechanics.

In spite of the difficulties applying this research to music pedagogy, there are two statements that can be made with some confidence. First, it is clear that implicit learning strategies make for a powerful tool and music educators must be aware of how to make effective use of it. Instructing through analogies and goal-oriented processes are already widely used in music instruction and is exemplified through the "song and wind" approach advocated by Arnold Jacobs. Secondly, evidence suggests that implicit and explicit learning work in conjunction and parallel with each other, as suggested by Donald Reinhardt's "Pivot System" approach. Music educators should become familiar with the situations where explicit instructions have the most potential benefit and learn how to use it effectively. This will not only ensure that students progress quickly and

perform well under the pressure of a concert or audition situation, but can also have potential benefits for long term health and technique maintenance among professional musicians.

Lastly, it would be beneficial for the field of music education for more emphasis on research methodology and to encourage high level research specifically in the area of the development of musical technique. In part due to the over reliance on teaching implicitly through analogy and emphasizing expression over technique, many teachers have a weaker background in the explicit understanding of how they actually play their instrument. Furthermore, the very people who can most benefit from an improved understanding of the development of musical technique through the balance of implicit and explicit teaching strategies are the ones who will need to lead the way if greater understanding of these findings can be effectively applied to music pedagogy. Speaking on this very issue, Wilson and Roehmann wrote:

Most Ed.D. And D.M.A. Candidates will never engage in experimental research; they will teach and perform and teach others to teach and perform. Because they are in a unique position to observe student performers at all levels of ability and all stages of life, they can make an enormous contribution to clinical research. . . . Although not every teacher-performer would be inclined to take on such an arduous task, and fewer still might commit themselves to it for the long haul, some would - and the effort would make a difference. (Wilson & Roehmann, 1992, p. 520-521)

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