UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

METASCHEMATA AND WORKING MEMORY: THE EFFECT OF MUSICAL KNOWLEDGE ON THE ACQUISITION OF AURAL SKILLS

A THESIS

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

Degree of

MASTER OF MUSIC

By

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Norman, Oklahoma
2017

METASCHEMATA AND WORKING MEMORY: THE EFFECT OF MUSICAL KNOWLEDGE ON THE ACQUISITION OF AURAL SKILLS

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SCHOOL OF MUSIC

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Acknowledgements

I must start by thanking Dr. Jeffrey Swinkin, who offered his utmost patience, understanding, and philosophical guidance to prod me along as I stumbled through the process of writing. He has been invaluable both to my personal development and to the development of this project. My sincere appreciation also goes to Dr. Charles Ciorba and Dr. Scott Gronlund for their valuable time and astute advice. I owe much of my productivity to Rebecca Little; we held each other accountable to our goals through weekly writing rendezvous, and I am indebted to her for her feedback along the way. I thank my fellow music theory graduate assistants, Sam Backman and Tara Traxler, whose willingness to step in and assist my students and me has played a significant role in the protection of my sanity. I am also grateful to friends for their support, especially Brittni Bilyeu, Blake and Kelsey Randall, Keith Strasbaugh, and Ben Bowder, and to my sister for her loving encouragement. Finally, I thank my mother for her unending willingness to listen, and my God for the opportunities He has provided.

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Abstract

In the undergraduate music theory curriculum, aural skills are often regarded as more physical than cognitive, which I suspect is partially due to a lack of understanding as to which cognitive processes and tools are used when performing aural skills. I aim to assert that musical schemata, formed to recognize and anticipate the tendencies of familiar musical styles, highly influence student acquisition of aural skills. I then consider this assertion in light of recent studies of musical learning and discuss pedagogical applications. My main objectives are to a) assert that schemata evolve autonomously over a lifetime and may be actively helpful or obstructive in the efficient acquisition of aural skills, and b) consider the implications of this assertion for aural skills pedagogy. I conclude that instruction might be more efficient and effective when consciously geared toward building helpful musical schemata rather than when too geared toward the accomplishment of aural skills tasks.

Introduction

Undergraduates tend to find aural skills intimidating, perhaps more so than other skills in the music theory curriculum. Many students believe themselves incapable of sightsinging or taking melodic and harmonic dictation, on the supposed basis that they have a "bad ear."

Self-efficacy, or the belief in one's ability to successfully accomplish a task, plays a role in the student's ability to learn *any* concept or skill. There seems to be, however, a fundamental difference between developing confidence in one's *cognitive* ability and developing confidence in one's *physical* ability. For instance, consider trying to learn to read fifty different languages—a daunting task. However, one can believe it is theoretically possible, given sufficient tutelage, time, and determination. Now consider deciding to outdo the current women's lifting record by squatting more than 854 pounds. Speaking for myself, I cannot believe my 5'6" body would ever be capable of lifting nearly six times its weight, no matter how much desire and assistance I have. Both feats appear truly unrealistic, even outlandish. In both cases, an optimistic adviser might remind me that I am always capable of expanding my abilities and should not preemptively limit my success with a self-defeating mindset. However, for some reason, the physical feat will still appear more difficult to attain. Perhaps there is a reason one hears the phrase "physically impossible" yet seldom if ever hears the phrase "cognitively impossible."

As an aural skills instructor, I often hear students and fellow instructors lament the student's inability to hear an interval, a melodic contour, or a harmonic progression. I myself have thought on more than one occasion, "why can't they hear what is so blatantly obvious to me?" Note that these frustrations focus on the *ability to hear*. "Hearing" in regards to aural skills includes both the physical ability to aurally detect a sound as well as the cognitive ability to discern what the sound means within a given theoretical parameter of a tonal system, whether that is perceiving a specific pitch in relation to a tonic or recognizing the quality of a particular chord. Unfortunately, teachers often conflate these two meanings such that they interpret the inability to accurately perform aural skills as indicating a physical deficiency as much as, if not more than, a cognitive deficiency. When students fail to understand a mathematical concept, they do not bemoan their inability to see the equations and wonder if they have a "bad eye." Yet when they fail to properly notate a melody, they bemoan their inability to hear the melody and believe they have a "bad ear." Precisely for this reason, students often believe themselves physically incapable of successfully accomplishing certain aural skills. Unfortunately, instructors sometimes believe this of students as well.

The belief that some students are "naturally" good at aural skills while others are not inevitably impacts the way in which instructors teach such skills. Instructors often teach aural skills as they would physical skills such as shooting free-throws, playing scales on an instrument, and performing difficult passages in a musical score. To be sure, many instructors believe to some degree that understanding theoretical concepts renders aural skills more achievable. However, despite that, many ultimately still advise that the best way to improve the skill is by repetitive practice.[1] After numerous failed attempts, students decide they are not meant for basketball, they will never be good at

[1] This has been my personal observation, as well as the observation of colleagues and students. Future survey research would help determine whether this claim is generalizable across all instructors.

playing scales, they should pick a less difficult piece for the upcoming recital, they have a bad ear. Even worse, instructors often come to similar conclusions: "He is a talented pianist, but playing scales is just not his thing."

Aural skills require more than mastering the physical task of sensing different pitches—they require the sophisticated cognitive ability to assign specific, relational meaning to those pitches. It is not efficient to simply practice aural skills tasks over and over; we should be able to strengthen the cognitive ability more directly. Unfortunately, we currently do not understand the cognitive processes underlying the skills well enough to know how else to teach them effectively. Previous research in aural skills pedagogy focuses on effective methodologies for accomplishing tasks, and can only offer well-informed suggestions as to which of the current approaches to practicing aural skills will be most successful.[2] My research, by contrast, will focus on understanding the cognitive abilities that inform aural skills by examining schemata, a cognitive tool that I believe has the potential to help or actively hinder the acquisition of aural skills.

A brief history of existing theories of schemata (Chapter 1) provides the context for a discussion of musical schemata and metaschemata (Chapter 2). I then consider implications for aural skills pedagogy (Chapter 3). To conclude, I contend that instruction might be more effective, and more efficient, when consciously geared toward building helpful musical schemata rather than when too focused on the accomplishment of aural skills tasks (Chapter 4).

[2] See Quaglia 2016, Paney et al. 2014, and Pike and Carter 2010.

Chapter 1: Schema Theory

1.1 A Brief History

Schema theory has a relatively short but robust history. Sir Frederic Charles Bartlett is credited with introducing it in 1932 when he discovered that prior knowledge impacts how people remember and interpret stories.[3] In his most famous set of studies, British participants read a Native American folktale which they were later asked to recall and retell. As the time between the initial telling and the participants' retelling increased, the level of distortion present in the participants' retellings also increased, and these distortions occurred in systematic ways: participants omitted information from the original story that did not make sense to them, and they reinterpreted facts in the original story in order to match facts more consistent with their own cultural backgrounds.

Bartlett's findings led him to believe that human beings possess a generic knowledge, organized in unconscious mental structures called schemata (sing: schema) that actively guide the interpretation of new information and events. He contended that, when asked to recall the Native American story, the British participants *reconstructed* their memory of the story rather than passively *replayed* it as if it were a video recording. During this reconstruction, the participants supplemented the original story, filling in gaps by drawing on their schemata in order to create a complete storyline that, to their mind, was logical. It is important to note that this process transpired automatically and subconsciously; when reconstructing these memories, the participants

[3] Although Bartlett is credited with introducing modern-day schema theory, several researchers had presented pioneering ideas that would shape schemata. See Iran-Nejad and Winsler 2000 for a substantial historical account.

did not know which parts of their retelling were true to the original and which were self-created.[4]

Bartlett's work led researchers to further investigate the role of prior knowledge in memory, especially in the encoding of new information as it is stored in memory. I will address some of this research later. Schemata, on the other hand, remained vague constructs until Ulric Niesser 1967 compared the schemata to computer programs, providing a concrete example with which researchers could compare the more abstract notion of a schema. Marvin Minsky furthered the comparison, presenting a case for units of data he named *frames* as a part of his work on artificial intelligence in 1975. In Minsky's own words:

> Here is the essence of the frame theory: When one encounters a new situation (or makes a substantial change in one's view of a problem), one selects from memory a structure called a frame. This is a remembered framework to be adapted to fit reality by changing details as necessary.[5]

Like Bartlett's schemata, Minsky's frames guide the interpretation of new information and events. Attached to each frame are sets of information; some of these sets explain how to use the frame, others predict what might happen next, and others prescribe what to do if the expectations are not met.

An important difference, however, is that whereas Bartlett views schemata as "living, constantly developing, [and] affected by every bit of incoming sensational experience of a given kind,"[6] Minsky sees his frames as inanimate entities that are utilized and altered as needed by a separate, active being. Iran-Nejad and Winsler 2000,

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[4] F.C. Bartlett, "Some Experiments on the Reproduction of Folk–Stories," *Folklore* 31, no. 1 (1920): 30–47, accessed April 25, 2017, http://www.jstor.org/stable/1255009.
[5] Marvin Minsky, "Minsky's Frame System Theory," (FIX)
[6] F. C. Bartlett, *Remembering: A Study in Experimental and Social Psychology* (Cambridge: Cambridge University Press, 1932), 200.

in pointing out that the study of schemata has been somewhat problematic due to its various definitions, suggest a useful division between *functional* schema theories (such as Bartlett's) and *structural* schema theories (such as Neisser's and Minsky's).[7]

1.2 Structural Schemata

As Rumelhart 1980 notes, all structural schema theories view schemata as "fundamental elements upon which all information processing depends."[8] Iran-Nejad and Winsler helpfully further distinguish the various structural schema theories into three main subcategories: a) program-like frames, b) nodes in an associative network, and c) underlying event sequences.[9] The theories of Neisser and Minsky fall under the first subcategory, as they use the computer program analogy. A significant criticism of this type of structural schema theory led to its virtual obsolescence: the theories rely on retrieving schemata from long-term storage as required by certain situations, and thus cannot account for the perception and understanding of information for which a long-term schema is not available.

In the second category, we find the idea that schemata are simply the connecting points, or nodes, of an associative long-term memory network. Schemata are organized in a hierarchical network with the most complex, abstract schemata at the top and the

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[7] Asghar Iran-Nejad and Adam Winsler, "Bartlett's Schema Theory and Modern Accounts of Learning and Remembering," in "Brain, Knowledge, and Self-Regulation," special issue, *The Journal of Mind and Behavior* 21, no. 1/2 (Winter and Spring 2000): 5, accessed April 26, 2017, http://www.jstor.org/stable/43853902.
[8] D.E. Rumelhart, "Schemata: The building blocks of cognition," in *Theoretical issues in reading comprehension: Perspectives from cognitive psychology, linguistics, artificial intelligence, and education*, ed. by R.J. Spiro, B.C. Bruce, and W.F. Brewer (Hillsdale, New Jersey: Erlbaum, 1980): 33.
[9] Asghar Iran-Nejad and Adam Winsler, "Bartlett's Schema Theory," 5.

most simple, sensory schemata at the bottom. The brain searches its network through a retrieval process, the most influential method proposed being *spreading activation* (Collins and Loftus 1975). Through spreading activation, a single concept will trigger various concepts strongly associated with it from within the human memory. For example, thinking of a fire truck might prime the concepts of vehicle and red. We are unlikely to continue down the associative path past red toward, say, cherries, because though the cherries and fire truck are both red, they share little else in common and are therefore not very closely related concepts. We might travel past the concept of vehicle toward ambulance or police car, as they are more closely-related. These theories are also highly criticized today, for their inability to explain how people learn to go beyond what they already know. Bartlett himself argued a schema must be more than a group of associated elements.[10] However, one of the current theories of cognitive modeling is a highly-elaborated form of the association network model: the parallel distributed processing (PDP) model, also known as neural networks or connectionism, popularized by McClelland and Rumelhart in the 1980s.

Theories in the third category view schemata as internalized event sequences. Iran-Nejad and Winsler propose two types of these underlying patterns. The *story grammar approach*, first proposed by Rumelhart 1975, suggests that all well-formed stories follow a generic design in the same manner that all sentences can be considered to have an internal structure, such as a clear subject and predicate with standard grammatical patterns; therefore, a generic underlying structure must exist in our long-term memory to guide our understanding of such stories. The *script approach* deals

[10] F.C. Bartlett, *Remembering*, 197.

with activities that are so frequently performed in such a consistent fashion that we are able to imagine an expected series of events upon the initial enactment of the activity schema. For example, meeting a new acquaintance for the first time might cause us to retrieve our introduction schema, which might consist of smiling, shaking right hands, saying a pleasantry, and asking about the person's profession or well-being.

While the theories in the three above subcategories contain significant differences, they are not necessarily incompatible and are collectively helpful in understanding various aspects of cognition. The first category illustrates information processing, the second an overall structure of the long-term memory storage, and the third the tendency for human knowledge to exist in concatenations. However, none of these theories serve to explain learning, or specifically, the integration of wholly new concepts into previous comprehensions and the ability to imagine beyond the known. Iran-Nejad and Winsler suggest this oversight might be due to an overreliance upon human beings' active control over their learning.[11] In other words, these theories seem exclusively to rely upon explicit learning for the acquisition of new information; they do not provide an explanation for implicit learning.

1.3 Functional Schemata

In functional schema theories, researchers make less of a distinction between the conscious and unconscious processing of information. Those who favor functional schemata also argue against the notion of a large storehouse of information within which the schemata merely make up categories, patterns, and scripts for our use when

[11] Iran-Nejad and Winsler, "Bartlett's Schema Theory," 16.

needed. Rather, they contend that schemata are more an “organized mass,” within which the individual pieces of information comprising the schema do not preserve their own specific character, but instead combine with the other components in such a way as to create a new identity as a whole. An associative cluster might be compared to a mixture of oil and vinegar; the concoction will consist only of those two physical elements for there is no chemical combination. A schema in the functional sense, by contrast, is a mental combination created like the combining of oxygen and hydrogen; the resulting substance is a new compound entirely, more than the sum of its parts. However, unlike the relatively lasting nature of the chemical combination of water, schemata are continually morphing, transient structures. Bartlett went so far as to sometimes call a schema a “schema-of-the-moment.”[12] Their continual evolution depends upon two types of activity: the influences asserted outside an individual’s active control, and the active efforts of the individual to better know and control the components of each schema. Similar to the reconstruction of memory that Bartlett noticed in his experiment, these reconstructions of schemata are an amalgamation of background knowledge and new knowledge, inseparable through simultaneous, mutual influence, and sometimes altered without conscious intent. In short, structural schemata are passive categorical units that influence the way we perceive new information, whereas functional schemata are active, continually evolving units of knowledge that influence the way we perceive new information *while* the new information influences their composition.

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[12] Bartlett, *Remembering*, 202.

In an effort to explain how we might develop our schemata without conscious effort/awareness, an ability without which we would be sorely confined to only developing schemata for concepts we already fully understood, Iran-Nejad and Winsler propose a *biofunctional* theory. This theory is Bartlettian in nature, as it subscribes to the functional schema theorist's definition of schemata: ever-evolving structures that both influence and are influenced by the process of learning. It also proposes a two-source theory of internal self-regulation: rather than a single executive function—the manifestation of the individual's control within their own cognitive workings—it argues for an additional source of internal self-regulation that is dynamic and has an autonomic nature akin to that of trees. Trees grow naturally without being dependent on humans, though humans can facilitate and control various aspects of their growth. According to the biofunctional theory, schemata are also able to "grow" apart from conscious stimulation, though they are also subject to conscious interference. In other words, schemata are regulated through both a biofunctional sense of autonomy as well as through external directive.

I will adopt the Bartlettian notion of schemata as ever-evolving, active structures of knowledge and assume the biofunctional perspective that schemata evolutions are not constrained by consciousness. Musical schemata, it would follow, develop over time without our explicit awareness. As a result, we harbor musical expectancies of which we are largely unaware, as well as a tendency to prioritize attention to some musical characteristics over others. The participants in Bartlett's study attended the aspects of the folktale that made the most sense according to their schemata; we attend the musical aspects which with we are most acquainted.

Chapter 2: Music-Theoretical Perspectives on Schemata

2.1 A Case for Musical Metaschemata

Because schemata are active entities that apply themselves to sensory data (sights, sounds, smells, and so on) without the need for direction, they are responsible for knowing, in a sense, when they apply. Consider a security officer in a bank: when a robber enters the building with a gun, the officer does not need to wait for the manager to direct her to action—she compares the present situation to her knowledge store of situations, gained through experience, to actively respond appropriately. If she lacks the competency to accurately assess that the situation calls for her involvement, or if something interferes with her becoming involved, she will require direction from another person to become involved or else she will fail to do her job. Similarly, schemata maintain their own set of "trigger conditions," and self-select themselves for application to incoming sensory material. When the sensory material bears a close enough resemblance to previous material for which the schema has self-applied itself before, it "triggers" the activation of the schema. However, the schema must be adequately formed in order to be effective; without the "competency," so to speak, they will fail to apply themselves and the sensory input will require more processing in the working memory than would be necessary had a schema been applied.[13] The working memory is limited in capacity; schemata connect individual pieces of information

[13] Clarke 1993 explores an interesting model that incorporates a short-term phonological store capable of temporarily holding unprocessed auditory "images." While beyond the scope of this thesis, further research might investigate where "unprocessed" sensory information enters into working memory.

together into a single chunk, which occupies less "space" in the working memory, effectively lightening the cognitive load.[14]

As neurological imaging on experts and novices in a variety of fields suggest, experts develop a neural efficiency that allows them to utilize the task-related regions of their brains less, and the information-integration regions of their brains more, than their novice counterparts, while both experts and novices produce equivalent performance levels.[15] In other words, the expert and novice perform at a similar level, but the expert is able to do so more neurologically efficiently. In the same way, a melodic line from within the common-practice tonal system will be minimally processed by a person who has developed a well-formed network of schemata for that era of music.

When multiple schemata work together for a common purpose in such a network, I will call the group a *metaschema*. This term, to my knowledge, has been used by one other individual for a similar purpose to mine. Ole Kühl, in *Musical Semantics*, draws on the ideas of *conceptual blending* as presented by Fauconnier and Turner 2002 and schemata as defined by Bregman 1990 to present a case for the comprehension of music through a semantic experience. In a conceptual blend, concepts from various domains combine to create a new meaning; likewise, a metaschema consists of multiple schemata that, in working together, become more than the sum of their parts. One example Kühl presents of a metaschema is narrativity, which he

[14] See Sweller 1988.
[15] See Milton et al. 2007.

contends may comprise schemata such as the source-path-goal schema, the balance schema, the cycle schema, and the container schema.[16]

Kühl asserts that musical meaning involves an integrative approach that involves the transformation of musical precepts (sensory data) into musical proto-concepts (similar to schemata), though the proto-concepts may extend to concepts not typically considered "musical." He illustrates the process:

> The auditory stream presents humanly structured sound to the human ear, which is not yet music. Auditory scene analysis and schema based perception leads to an extraction of musical elements from the sound stream, like for instance rhythm, melodic phrase and micro pitch… Some of these elements are selected subjectively as being of special interest, evoking cognitive responses that are mapped to the elements: motor pattern to rhythm; gesture to melodic phrase; and affective responses to micro pitch. Through cognitive processing, involving functions like categorization and integration among others, responses are developed and bundled in an emerging musical experience.[17]

2.2 Previous Research of Musical Schemata

In studies involving musical schemata, researchers have almost exclusively adopted the structural definition of schemata. Much of the research involving schemata in the field of music theory focuses on a particular harmonic or melodic schema and the ways in which it is instantiated across years, genres, or individual pieces. Other studies instead consider the role that non-musical schemata, such as gravity and magnetism, play in our interpretation of musical events. Few studies have investigated the role of schemata in the aural skills classroom, but those that do refer to them as patterns.

[16] For a thorough investigation of these schemata and more, see Mandler and Cánovas 2014.
[17] Ole Kühl, *Musical Semantics*, vol. 7, *European Semiotics: Language, Cognition and Culture* (Bern, Germany: Peter Lang, 2008): 150–151.

Nonetheless, the findings are compatible with musical schemata under the biofunctional definition.

Robert Gjerdingen fairly credits Leonard B. Meyer with one of the first studies of schemata in music, which Meyer calls *archetypes.*[18] Gjerdingen continued Meyer's study of these schemata by tracking the "classlike patterns" through the repertoire.[19] In one study, he applied Roger C. Schank's and Robert P. Abelson's distinction between plans and scripts to particular musical conventions.[20] While a script lays out a particular series of events expected to unfold with reasonable consistency, a plan presents a more general series of events that lack the script's specificity and consistency of realization; a plan is to a script as an outline is to an essay. Gjerdingen adopts these terms, categorizing musical patterns that unfold specifically and consistently as script-like schemata, while less restrictive musical patterns fell into the category of plan-like schemata. He asserted that script-like musical schemata naturally transformed into plan-like musical schemata over time. He traced this transformation with respect to a particular melodic schema, the "1–7…4–3," over the eighteenth century.[21] Figure 1 shows an example of this melodic schema. The music schemata here are clearly

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[18] Leonard B. Meyer, "Exploiting Limits: Creation, Archetypes, and Style Change," *Daedalus* 109, no. 2 (1980): 180–181.
Robert Gjerdingen, "The Very Model," *Music Perception: An Interdisciplinary Journal* 25, no. 5, 2008: 481–482.

[19] See Gjerdingen, *A Classic Turn of Phrase* and *Music in the Galant Style*. Meyer eventually continued with Gjerdingen's use of the word *schema* in place of his *archetype*.

[20] Roger C. Schank and Robert P. Abelson, *Scripts, Plans, Goals, Understanding*, Hillsdale, New Jersey: Erlbaum, 1977.

[21] Robert Gjerdingen, *A Classic Turn of Phrase: Music and the Psychology of Convention* (Philadelphia: University of Pennsylvania Press, 1988).

inanimate entities; in this case, they fall under the third category of structural schema theories, which includes underlying event sequences.

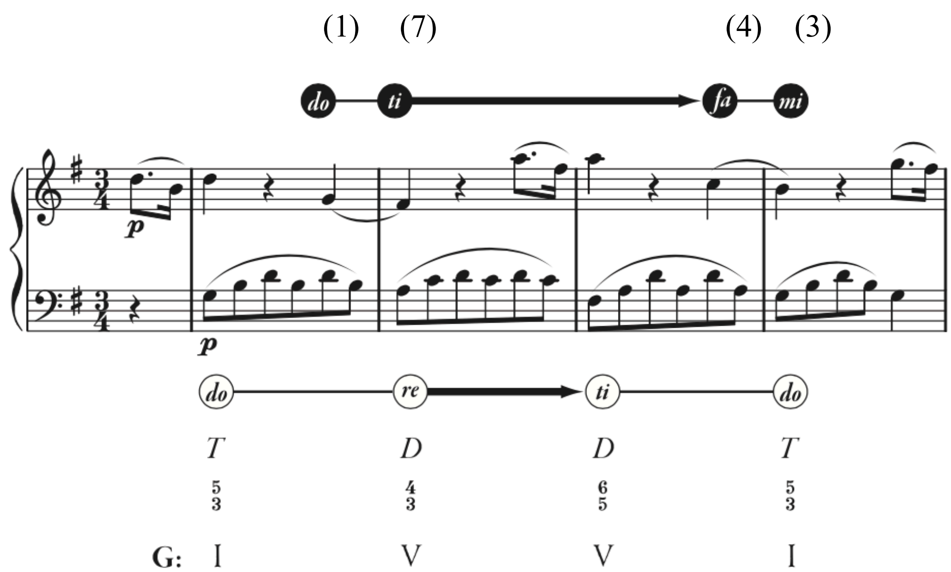

Figure 1 The 1-7-4-3 schema, shown in Mozart, K. 283, I, mm. 1–4.[22]

There is evidence supporting the notion that these underlying sequential events are meaningful to listeners. Rosner and Meyer 1982 suggested that listeners are able to understand the more specific script-like schemata more quickly than the more general plan-like schemata, and they found that their subjects applied the former to unfamiliar phrases before resorting to using the latter. The participants were taught to recognize the script through repeated listenings, without being explicitly informed of the specific components of the script. Later, they listened to musical excerpts and attempted to place them in groups according to similarity. They were able to perform this task with more ease and accuracy when the excerpts were similar due to following the same musical

[22] Vasili Byros, "Meyer's Anvil: Revisiting the Schema Concept," *Music Analysis* 31, no. 3 (October 2012): 276.

script, rather than the more loosely-connected excerpts merely following the same broader plan.

In his exploration of the psychology of expectation, David Huron notes, "auditory learning is dominated by statistical exposure."[23] He argues that musical expectations are highly influenced by the rate of occurrence at which listeners hear different auditory events. This research subscribes to the notion of schemata as underlying sequential events; the more often one hears particular musical tendencies, the more likely one will have increased expectations for how the musical sequences will play out.

The more we listen to music that follows a particular set of tendencies, and the more strictly and consistently those tendencies unfold, the more we are capable of accurately anticipating how a melody or harmonic sequence will unfold in that genre of music. While the evidence convincingly suggests a sequential events schema may be in use, I believe it also suggests that the schema is self-maturing as it processes an increased amount of consistent data.

To elaborate, let us recall the difference between structural schemata and the biofunctional schemata to which I subscribe. The 1–7–4–3 schema, under the structural definition, is a musical pattern of melodic-contrapuntal events that unfolds specifically and consistently, making it a script schema. Under the biofunctional definition, it is an evolving body of musical data that applies itself to incoming sensory information and

[23] David Huron, *Sweet Anticipation: Music and the Psychology of Expectation*, Cambridge: Massachusetts Institute of Technology, 2006: 72.

continuously learns how to better do so with each application, having been influenced by the information gained with each interaction. I find it likely that it works within a metaschema in collaboration with related schemata, such as the gap-and-fill melodic schema or the tonal functional progression schema, found in Figures 2 and 3. Each individual schema does its part in working toward the goal of efficiently processing incoming sensory data, but in working as a whole, in a metaschema, the schemata are more effective. While the individual schemata are only able to maintain their own sets of experientially gained knowledge, when working in a metaschema they are able to communicate with other schemata. This allows access to a broader set of knowledge, which ultimately allows better schematic inferences to be made.

Figure 2 The gap-and-fill melodic schema.[24]

Tonic → Predominant → Dominant → Tonic

Figure 3 The typical functional progression in common practice tonality.

Larson 2012 and Brower 2000 consider the application of learned schemata from other domains to the comprehension of music, proposing that physical forces and language largely influence the way in which we talk about and perceive musical ideas.

[24] Leonard B. Meyer, *Explaining Music: Essays and Explanations*, (Chicago: University of Chicago Press, 1978), 146.

In this case, a structural schema theorist might understand the influence through an associative model; the schemata for gravity appear closely related to the schemata for melodic motion, and the understanding of the former assists in the understanding of the latter.

The biofunctional perspective presents a different, though not entirely separate, idea for consideration. In the formative stages of the development of our metaschema for how music works, where schemata begin to collaborate to account for musical sensory data, we are unlikely to consciously know that sound waves, vibrating x times per second, determine pitches. Middle C, for example, is produced by sound waves vibrating 256 times per second. Thinking of pitches in terms of invisible sound waves vibrating the air particles at faster or slower speeds requires a much more sophisticated knowledge of physics than we are conscious of having when first attempting to discuss musical passages. The concept of high versus low, on the other hand, is comparatively less complex. As we interpret a melody, the less complicated, and more thoroughly formed, schema for height applies itself while the more complicated, and less complete, schema for pitch frequency will not have the necessary refinement to know it should apply itself. We will therefore visualize a melody as points higher or lower on a plane rather than visualizing frequencies of vibrations hitting our eardrums. Note that this does not necessarily mean we do not have an implicit understanding of the true nature of pitch frequency, only that we do not have an effective manner of conveying it. Interestingly, it is more likely that a melody composed of lower-frequency pitches will be composed in a slower tempo as compared to a faster tempo;[25] perhaps this tendency could be thought of as influenced by an implicit understanding of pitch frequency.

Leman 1995 developed a tone-center perception model that could transform musical signals into virtual pitch patterns that would organize themselves into schemata. The model was most effective when it was programmed to compare incoming data to past data and *also* update its schemata store after each additional piece of data. Over long-term learning, new information gradually altered the model's perception of tone center through schemata-driven contemplation, through the application of organized information to the understanding of the relationships between pitches. The schemata were influential in the perceiving of new information, but the new information also influenced the schemata themselves.

Matsunaga, Hartono, and Abe 2015 were able to build a connectionist model—the Learning Network for Tonal Schema (LeNTS)—to mimic the learning of culture-bound schemata through musical experience and training. They found that the process of acquiring a tonal schema entailed small and incremental changes over time and a higher dependence on exposure to musical excerpts than on practice time. Further, the process of internalizing schemata could be culturally invariant, meaning that regardless of the culture to which the model was bound, the model had no trouble creating schemata. Both of the above studies provide support for biofunctional schemata, as well as examples of how they may be working in musical understanding.

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[25] Yuri Broze and David Huron, "Is Higher Music Faster? Pitch–Speed Relationships in Western Compositions," *Music Perception* 31, no. 1 (2013): 19-31.

Vuvan, Podolak, and Schmuckler 2014 found that tonal expectancies impacted the formation of false memories when participants listened to melodies. In a stable, tonal setting, listeners hold high expectations for melodic tendencies whereas in a less stable, atonal setting, listeners hold comparatively low expectations for melodic tendencies. In their study, they were able to trick participants into believing that a particular note sounded by playing into the expectations set by typical melodic tendencies. This experiment bears a resemblance to Bartlett's experiment with the Native American folktales, and exemplifies the influential aspect of schemata on sensory information.

Benjamin Anderson discussed musical schemata in a novel way, considering two main categories: *a priori* schemata and *ad hoc* schemata. He differentiated them in this way: *a priori* schemata "influence the understanding of musical styles and cultures [originating] from *ad hoc* schemas that are necessary to understand a novel musical work."[26] His research provides evidence that after a few hearings of a piece of music, a listener will categorize musical units based upon their timbre, texture, loudness, and/or articulation, which he defines as secondary parameters (after Meyer). After hearing the musical units repeatedly, the listener will begin to categorize based on what he calls primary parameters, such as melody and harmony. He explains: "while sometimes simple familiarity is enough for listeners to take this step, other times listeners need to be primed by being told what to listen for [in order] to begin to group based on the

[26] Benjamin Matthew. Anderson, "Understanding Music Through Mental Representations: An Investigation of A Priori and Ad Hoc Schemas," PhD diss., Northwestern University, 2012: 24.

content of the melody or harmony."[27] In my interpretation, this finding reads as follows: while the repetitive listening of a musical unit will eventually build a strong musical schema for that unit, explicit instruction will expedite the maturation of the schema as well as direct its immediate use in the following listening task.

2.3 Future Research

Oura 1991 demonstrates that a *reduced-pitch-pattern model* best accounts for expert musicians' success in melodic memorization. Though it used different terminology, the model proposes that experienced listeners parse a melody into segments, derive a reduced pitch pattern from each of those segments, and then attempt to match each reduced pitch pattern to a musical schema. The study does not account, however, for why some novice aural skills students appear to be able to use the same process and achieve similar success. I contend that early student success in aural skills is largely influenced by the student's pre-formed musical metaschemata. Perhaps some students, though inexperienced in aural skills tasks, are very experienced listeners in regards to music of the common-practice period, and therefore benefit from a musical metaschema they've implicitly learned to apply in much the same way that experts in aural skills tasks have learned to do. To test this hypothesis, a survey of incoming students would collect information to determine the level of experience each student has with the music of the common-practice period, inquiring about what type of music the student listens to most, the instrument she plays, the type of music she performs, and so

[27] Ibid., 144-145.

on. Then, an assessment would seek to determine each student's ability to recognize the basic tonal tendencies of that musical period.

For an example of such a task, consider the line of quarter notes in Figure 4. An expert should notice the melody, for a lack of a better term, features a string of basic tonal patterns commonly present in the music of the common-practice period. The first four notes form a tonic arpeggiation in the key of C, for instance. The assessment might ask the students to section this melody into six smaller chunks; I would analyze the beginning students' responses in comparison to responses of expert students. While the beginning student may not yet know the terminology to describe each melodic pattern, she may have an implicit understanding that would allow her to successfully parse the melody as compared to an expert student.

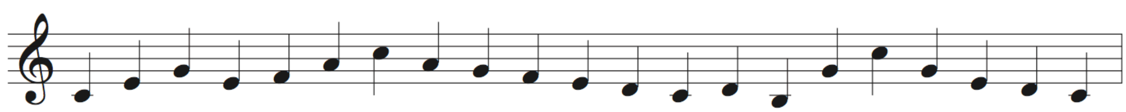

Figure 4 A melodic line featuring basic tonal patterns.

Another task may be to have the students indicate, via a Likert-scale response, the extent to which they would expect the second of two aurally presented chords to follow the first within music of the common-practice period. Multidimensional scaling analysis could then provide support, or make null, the hypothesis that beginning students who have more experience with the musical period would be more likely to perform similarly to expert students on various aural skills tasks.

Researching metaschemata in the context of musical learning opens the field of music to other interdisciplinary exploits. Deschenes 1998, for example, argues for an anthropological study of music, asserting that when we listen to unfamiliar music, we also become acquainted with that music's underlying cultural context. What might cause music to be so culturally emblematic? Could a unique cultural metaschema—perhaps an amalgamation of schemata involving language, social rules, country values, and so on—influence the way in which the people of that culture create and enjoy music?[28] Further research will need to provide evidence for my proposed metaschematic influence; should the model prove useful, then metaschemata may be an interesting and fruitful lens through which researchers can continue to investigate human cognition. Alas, this document will merely set the stage for continued research, beginning with considerations for the pedagogy of aural skills.

[28] See Morrison and Demorest 2009 for an exploration into the role of enculturation in music perception and cognition.

Chapter 3: Applications for Music Theory Pedagogy

3.1 Why Learn Aural Skills?

A question at least one student will inevitably ask is: why is this important? When will I ever use this? In the case of aural skills, Michael Rogers asserts that dictation and sight-singing are "different avenues to the single goal of developing internal musical perception—the ability to hear musical relationships accurately and with understanding… to produce a certain kind of listener who can hear sound as meaningful patterns."[29] Dictations are not meant to teach students to accurately transcribe notes and rhythms like a stenographer transcribes court proceedings, nor are sight-singing exercises intended to produce expert vocalists. What makes aural skills valuable "is the working out of the solution—the analytical act itself."[30] In other words, the cognitive process undertaken for the aural skills task is crucial, not the end result.

The relationship between aural skills and analytical skills can be analogized to that between a chemistry lecture and its lab: in each case, the two components are meant to augment one another—the second component trains the mind through a more hands-on application of the knowledge gained in the former. The theory lecture, which teaches cognitive skills, and the aural skills lab, which applies those skills, enrich each other and are mutually dependent; they are in a sense inseparable. As Rogers states, "the more thinking that takes place, the more there is to hear; the more listening that takes place, the more there is to ponder."[31] Furthermore, aural skills tasks engage the student

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[29] Michael R. Rogers, *Teaching Approaches in Music Theory: An Overview of Pedagogical Philosophies*, second edition (Carbondale: Southern Illinois University Press, 2004), 100.
[30] Ibid., 110.
[31] Ibid., 8.

actively, so that the student learns the material by *doing*. Engaging with the material physically, visually, *and* aurally leads to better recall of the material in the future.[32]

Why learn aural skills? Practically speaking, they provide a more engaging medium through which to learn music–analytic skills, which should serve to strengthen student comprehension of musical analysis. But even more importantly, in my opinion, aural skills connect written theory to performed music—the vast majority of students studying aural skills are musicians, after all. As Rogers again says it best:

> Music should not be performed or heard as if it were a foreign language. To develop "native speakers," the difference between *getting the notes* and *grasping their sense* must be understood by the teacher and then conveyed to the student… True hearing success is probably best observed in sensitivity of interpretation through some performance medium. To nurture and cultivate such expressive values is a goal toward which valid ear training can contribute but which finally overflows far outside the confines of music theory classes.[33]

3.2 Schemata in Aural Skills

I suspect that one significant impact on a student's use of the cognitive processes available to her is the sophistication of the student's musical metaschema for understanding music in the common practice period. Again, while many consider schemata to be constructs akin to frameworks or scripts, I prefer the biofunctional definition proposed by Iran-Nejad and Winsler. Using this metaphorical model for schemata, I assert that musical schemata develop autonomously and without supervision, and that they actively influence the strategies that students use when

[32] Michael Callahan, "Teaching and Learning Undergraduate Music Theory at the Keyboard: Challenges, Solutions, and Impacts," *Music Theory Online* 21, no. 3 (September 2015), accessed April 27, 2016, http://www.mtosmt.org/issues/mto.15.21.3/mto.15.21.3.callahan.html.
[33] Ibid., 112.

accomplishing aural skills tasks. Schemata evolve over time through a combination of self-alterations (implicit learning) and conscious alterations (explicit learning). When a schema fails to recognize the relevance of new information to its constitution, I consider it to lack the ability to alter itself efficiently; in other words, unsophisticated schemata may fail to progress in a manner that is helpful in the long-term, or fail to progress entirely, without explicit instruction. Similar to evolutionary mutations, a schema develops incrementally and without the proper foresight to know how to evolve efficiently for a future use. However, it is equally possible that a schema will develop in a helpful manner, especially when explicit learning aids the progress along the way.

Consider a self-taught pianist; she watches YouTube tutorials and googles chord progressions; perhaps she reads about proper stature and studies performers as they play. In time, she gains the ability to play the piano with a decent knowledge of chord configurations and the mechanics of tone production. Five years into playing, she seeks out a piano teacher for private lessons. Her teacher finds that she has been playing with horrid posture, one that prevents her from using the larger muscles in her arms, and finds tension in her wrist and a lack of curvature in her fingers, which hinders her ability to play scalar passages in a fluid manner. Without supervision, the beginning pianist learned to perform the task successfully, but with inefficient methods. The poor habits actively inhibited adept performance, and would need to be unlearned before the pianist could effectively advance her technique and skills. She was also incapable of noticing that she acquired her understanding of playing the piano in a disadvantageous way; in striving for her goal to become a better pianist, she gathered individual skills incrementally and without the benefit of the bigger picture.

In this metaphor, the pianist represents a metaschema, maturing over time without supervision; her “bad habits” might represent ill-formed schemata. The self-taught learning represents implicit learning, and the piano lesson represents explicit learning; the teacher, like the conscious self, intervenes in the pianist’s education with a more informed perspective, allowing for the more efficient connecting of concepts and simpler schemata to one another. As the metaphor illustrates, schemata are capable of becoming more advanced regardless of the conscious self’s awareness or instruction; they function on their own, and sometimes that leads to the development of inhibitory pieces of understanding about the concept it is attempting to organize. As a result, a person’s comprehension may not simply be wrong; it may also interfere with more accurate comprehension.

I contend that when some students arrive in the aural skills classroom, they bring with them an unsophisticated metaschema for music in the common practice period, as well as musical schemata that obstruct the efficient acquisition of aural skills. Recognizing and addressing the problematic schemata would allow the aural skills instructor to teach more effectively, as she would be addressing the root cause instead of merely the symptoms.

For example, the piano teacher in the above metaphor could simply notice that the pianist was not playing the keys with enough force, and he might instruct her to play with more strength as a result; however, noticing that the lack of strength stems from not sitting in such a way that allows her to engage her arm muscles when playing allows him to address the cause of the tenuous performances instead. The latter scenario leads to the student’s awareness of the root problem as well, advancing her understanding of piano skills but also paving the way for her to notice how the stem problem might also be causing another symptom.

3.3 Pedagogical Applications

Basic Tonal Patterns

A few years ago, I tutored a flutist who struggled to sight-sing melodies. I noticed that she focused on the intervals between pairs of adjacent notes, one at a time, instead of seeing the individual notes as part of a single coherent whole, related to one another within a tonal system. As many instructors know, this strategy provides multiple opportunities for error: the student must identify the interval (both quality and quantity), identify which solfege syllable to use, and sing the pitch. To address this issue, we discussed how the melody fit into the tonal system and how to recognize basic tonal patterns within that system. We then practiced skimming various melodies to find their basic tonal patterns throughout, forming a single coherent picture by connecting pitches to one another through tonal relationships. An example of a sightsinging melody, with identified basic tonal patterns, can be found in Figure 5.

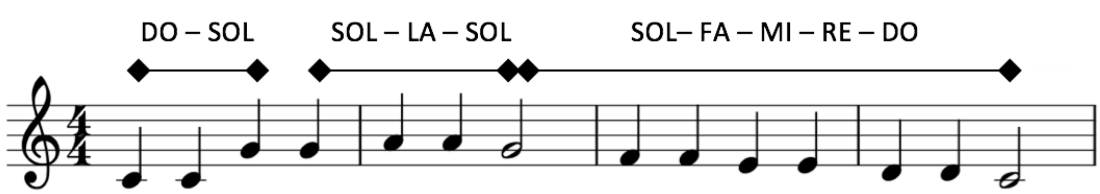

Figure 5 The beginning of "Twinkle Twinkle Little Star," partitioned by basic tonal patterns.

Essentially, I attempted to help build her metaschema for the way melodies tend to act in the common practice era, since her schema was ill-equipped to provide assistance in sight-singing, causing her to fall back on her more strongly formed schema for identifying and singing intervals. Instead, I might have easily set multiple sight-singing melodies in front of her, citing the adage “practice makes perfect”; in fact, I am sure I have done just that before, and even recently I have heard instructors tell their struggling sight-singing students to simply practice singing every day and they will improve. I do still believe that practice and repetition will lead to improved abilities, as an increased amount of time spent engaging in a particular activity will lend more opportunities for the relevant schemata to develop. However, implicitly learning basic tonal patterns through repeated sightsinging exercises will take a significant amount of time, especially as compared to explicitly learning the musical patterns. Direction or guidance along the way will certainly expedite the schema acquisition process, as well as help ensure that schemata develop in an efficient and helpful manner.

Invoking Existing Schemata

Unfortunately, as a tutor who met with the student only once a week, I did not know her well enough to discover if she had previously formed a problematic musical schema. As a result, I was unable to address any concepts she needed to unlearn before building. Perhaps this contributed to the fact that she did improve her sight-singing skills but remained behind in class. Interestingly, the next strategy I taught her had a much more immediate and substantial impact on her ability, noticeable in her performance of the very next sight-singing excerpt she attempted: I asked her to first imagine playing the entire melody on the flute, her primary instrument, before attempting to sing it aloud.

I would speculate that she had explicitly tapped into a metaschema that developed to facilitate her abilities as a flutist, which included a multiplex network of implicitly and explicitly learned skills and expectations for music. Within this metaschema was the schema for audiating pitches upon seeing them on the treble clef staff. Before the “flutist” metaschema was explicitly invoked by the conscious self, the metaschema failed to apply itself to the incoming sensory material or the student directed the use of other, less helpful schemata, or perhaps a measure of both were involved. In any case, from the moment she applied the more constructive metaschema to the sightsinging melody, it learned to apply itself to aural skills class tasks. Updating a longstanding schema took much less effort, and therefore much less time, than building a new one; thinking of the melody in terms of her intricate knowledge of flute-related information proved more immediately helpful than building a metaschema for common practice music from scratch. Of course, future instruction would do well to continue encouraging building and connecting both schemata in order to develop an even more robust metaschema.

Obstructive Musical Schemata

A skilled jazz pianist once told me he had never been able to hear the dominant seventh chord as an unstable harmony needing to resolve to its tonic. Having only ever studied jazz piano, he considered the dominant seventh chord to be a stable harmonic unit; in fact, many pieces finish on dominant sevenths or extended tertian versions of them. He explained that his professor would often play the chord on the piano and knowingly smile at his class, exclaiming “don’t you hear the tension, the need to resolve?” Every time, he would try but fail to hear the cogent relationship that others heard between the two chords.

In this case, the jazz pianist had developed an accomplished metaschema for how music works in which dominant seventh chords were just another harmony, devoid of a tendency to resolve to the major or minor chord built on the pitch a fifth below it. When learning to aurally comprehend the music of a different era, he applied his previously developed schemata and it actively prevented him from recognizing a new set of musical tendencies.

Of course, it is nearly impossible for the music theory pedagogue to discover each of her students’ problematic schemata in a time-effective manner. However, the simple awareness that a student’s inability to understand the material might not stem from a physical deficit or from lack of effort will encourage the instructor to look for more helpful suggestions for improvement than repetition. This awareness will also benefit the student; knowing the problem is due to a cognitive gap rather than a physical limitation may give the student more optimism about her ability to improve, thus increasing her motivation to do so. At the very least, the awareness would help eradicate the damaging use of phrases and beliefs such as “she doesn’t have a good ear.”

Often, simply asking why a student is struggling with a concept or requesting that she explain her approach to the concept will reveal the misstep(s) she is making. After identifying the issue, the instructor should consider whether it is symptomatic of an obstructive or underdeveloped musical schema. If an obstructive musical schema is at play, it will need to be addressed; either the instructor should explicitly clarify that it does not apply to music of the era presently being taught, or the instructor should help the student unlearn the schema in order to be able to progress in the right direction without continued missteps, such as in the example with the self-taught pianist and her bad habits. If an incomplete musical schema is the root issue, the instructor can work to build that schema. In both cases, the instructor attends to the root cause of the misunderstanding instead of the manifestation of that cause.

Chapter 4: Conclusion

Students and instructors alike would benefit from a better understanding of the cognitive skills behind the acquisition of music theory aural skills. Lacking this understanding, both groups problematically tend to treat aural skills like physical skills, decreasing the self-efficacy of the students and causing the instructors to fail to recognize the causes of the symptoms.

According to the biofunctional definition, schemata influence the interpretation of new sensory data as they are simultaneously influenced by that data. They apply themselves to the sensory data as the latter enter working memory, and their level of sophistication will determine how readily they apply themselves without direction from the conscious self. When a schema determines that it applies to a set of sensory data that does not exactly match sets of sensory data to which it applied in the past, the schema will update itself to incorporate the new information, without supervision.

Musical schemata, formed to recognize and anticipate the tendencies of familiar musical styles, sometimes interfere with the expeditious learning of schemata that would prove more useful to less familiar musical styles. I contend that some students enter the aural skills classroom with well-formed schemata for the tonal system of the common-practice period, while others have well-formed schemata for other musical styles; as a result, the former students may bring with them a proclivity for acquiring aural skills in the traditional undergraduate beginning courses, while the latter may find the skills more difficult to learn. The acquisition of aural skills can be helped along or hindered by previously formed musical schemata.

When the aural skills instructor recognizes and addresses the problematic musical schemata behind a student's struggle to perform an aural skills task, she can confront the root misconception causing the struggle. Teachers should work to actively build musical schemata for the aural comprehension of music of the common practice period through the explicit connecting of newer concepts to previously learned concepts, as well as through the illumination of basic tonal patterns and tonal resolution tendencies in the aural skills classroom. The alternative—presenting the information without explaining their relation to recently learned concepts or merely repeating dictation or sight-singing practice—leaves the schema construction in the hands of the students. Without supervision, the schemata are more likely to develop in problematic ways. In short, instruction might be more effective, and more efficient, when consciously geared toward building helpful musical schemata rather than being too focused on the accomplishment of aural skills tasks.

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