An Andragogical Approach for Reducing Cognitive Load within Aural Theory Tasks

By

Dave S. Knowlton
Southern Illinois University Edwardsville

Abstract

This article points to a contradiction between the need for the acquisition of aural theory skills to primarily be internal and a key tenet of learning theory that requires learners to avoid cognitive overload by externally manipulating ideas in order to learn them substantively. The article points to generative learning strategies as one means of alleviating this contradiction. The article describes the application of generative learning theory within a graduate-level aural theory and ear-training course. Implications for both research and pedagogical practice are offered in the last section of the article.

The development of aural theory skills "is made possible by the brain's capacity to create, maintain, and manipulate abstract representations." That is, aural theory tasks are "mediated by inner hearing" (Holahan, Saunders, & Goldberg, 2000, p. 163). DeNardo and Kantorski (1998), in fact, argue that placing "sound before symbol" is a key "axiom that . . . can be traced throughout numerous instructional theories and approaches that have evolved since the inception of the music education profession" (p. 320).

This truism about the basis for developing aural theory competence, though, is opposed by two key tenets of learning. First, there is the principle of cognitive overload. The brain's capacity is very limited and incompetent when dealing with abstract representations. Learners cannot hold large amounts of information in their working memory and focus on that information all at one time. On average, a learner can hold between five and seven items in their memory (Morrison, Ross, & Kemp, 2004). Thus, the internal manipulation of sounds can become a cognitively heavy burden. Second, because the manipulation of ideas within the brain leads to cognitive overload, cognitive learning theorists generally agree that learners may need to manipulate ideas concretely in order to learn. Learners who are overtly active in representing ideas are likely to learn more durably than those who are not overtly representing ideas (Morrison, Ross, & Kemp, 2004). Yet, when learners make ideas concrete, they no longer are dealing with the type of "inner hearing" that has been characterized as an essential component of developing aural theory skills.

These contradictions beg questions of what professors (not to mention learners) of music theory can do to best allow learners to master the content of an aural theory course, which requires inner hearing, while also adhering to empirically-derived principles about the nature of completing learning tasks. Numerous ways of addressing these questions exist, and some are probably based in unique structures to the curriculum. Other ways are probably based in pedagogical practices. This paper looks at andragogical (the corollary to pedagogical) practices by examining one nascent student's generative approach to improving aural skills and developing theoretical understanding. Examining successful andragogical practices is important because such examinations can provide insights into efficient and effective pedagogical practices (McCoy, 1997).

This paper begins with an overview of cognitive load theory and its manifestations for an aural theory student. Next an overview of generative learning as a set of strategies for overcoming cognitive load is provided. Then, one student's use of generative learning strategies in a graduate-level aural theory course is described. The last section offers implications for pedagogy and future research.

Cognitive Load

Cognitive Load Theory is based on the perspective that learners have a limited working memory that can only hold between five and seven pieces of information at one time (Morrison, Ross, & Kemp, 2004). To ask learners—particularly novice learners—to deal with more than this five to seven pieces of information is to risk cognitive overload for the learner (van Gog, Ericsson, Rikers, & Pass, 2005). That is, the individual pieces of information become cognitively burdensome. Once individual pieces of information have been processed, though, the pieces become integrated with previous information and organized into larger schemata. Organized information that has been grouped into cognitive schemata becomes embedded in a learner's long-term memory, which allows learners to automatically use that information by constantly applying it to new learning tasks (Van Merriënboer & Ayers, 2005). Cognitive load theory holds that learners create their own cognitive schemata through deliberate and overt rehearsal techniques (van Gog, Ericsson, Rikers, & Pass, 2005).

This general description of cognitive load has implications for teaching and learning aural theory. After all, if learners can organize aural theory information into schemata and apply those schemata to subsequent aural theory tasks, then their efforts will become more efficient and automatic (Price, 2000). Beckett (1997) notes, however, that cognitive psychologists and music researchers point to a lack of learner-focused attention and the limitations of working memory as two factors that can hinder success in mastering aural theory tasks. Students must learn, Beckett argues, to focus their attention. In her example, she examines whether it is best to have students focus first on rhythm and then on pitch during dictation exercises. The basis of Beckett's point seems to be the dual requirements of dictation tasks—the ability to focus on rhythm *and* pitch, a common practical example of cognitive overload within an aural theory context. She theorizes that focusing on one of these two aspects of an aural theory exercise will improve attention and prevent cognitive overload.

Holahan, Saunders, and Goldberg (2000) discovered that even minor variations in a musical phrase, specifically a one-tone change in a three-tone pattern, could create a high cognitive load for some adults. McCoy's (1997) study seems to support this perspective, as too much aural stimuli was more detrimental than it was useful to college students who were trying to complete aural tasks. In this particular case, the addition of played musical chords increased the cognitive load that students were experiencing, even though the played chords were congruent with their assigned tasks.

Generative Strategies as a Means of Overcoming Cognitive Load

Generative learning is based on the ideas of Wittrock (1974, 1990, 1992; Wittrock & Alesandrini, 1990). Originally, Wittrock proposed generative learning as a tool to promote stronger reading comprehension, but others (e.g., Jonassen, 1998) have refined ideas associated with generative learning for broader applications (Grabowski, 1996). Proponents of generative learning argue that students, rather than professors, should be engaged in actively pursuing an understanding of course content (Sharp, Knowlton, & Weiss, 2005). Furthermore, students must represent their new understanding by creating concrete "artifacts." Through this activity of artifact creation, learners are likely to be learning more durably than when they simply are thinking about content that is provided to them by professors (Knowlton, Eschmann, Fish, Heffren, & Voss, 2004).

Jonassen (1988) identified four categories of generative strategies—those that promote (a) recall, (b) organization, (c) integration, and (d) elaboration. These four are consistently effective in fostering learning (Grabowski, 1996). See Table 1 for an overview of these strategies.

Strategy	Purpose	Examples
Recall	Memorizing information	Mnemonics Rhymes Songs
Organization	Imposing an order on content	Outlines Summaries Concept Maps
Integration	Making connections between new content and prior knowledge structures	Paraphrase Metaphors
Elaboration	Making connections between new content and real-world contexts	Identifying examples Predicting results and implications

Table 1. Overview of generative strategies and their purposes.

Recall

Recall generative strategies are designed to help students remember information. Commonly, recall generative strategies include simplistic rehearsal devices like mnemonics, rhymes, or songs. Consider the use of the mnemonic for recalling the order of musical notes on a treble clef staff: "*E*very *G*ood *B*ird *D*oes *F*ly." Students can recall the rehearsal device more easily than they can recall actual bits of content because the rehearsal device already has been organized into an information group (i.e., a schema). Rehearsal devices that fall into the category of recall generative strategies are particularly useful when the learners create the device, rather than using a device handed down from teachers. When learners create their own recall generative strategy, it becomes "theirs" and is thus more meaningful and easy to remember.

Organization

More substantively than simply memorizing, learners should be involved in organizing course content. The idea of an organizational generative strategy implies more than students mimicking an already-existing organization from a textbook, lecture, or other educational experience. Students should be encouraged to impose an organization on content that makes sense to them. By imposing their own organization on content, students are more likely to learn from their own organizations because they are—in essence—rehearsing the information as they organize (Sharp, Knowlton, & Weiss, 2005).

Organizational generative strategies can come in the form of a piece of writing, such as requiring students to create an outline of, say, a chapter in a music history text or writing a summary of the key points of a lecture. Organizational generative strategies can also come in the form of graphics, such as a flow chart that shows the form (e.g., A-B-A form) and various signs (e.g., a new key signature) or signals (e.g., unstable passages) of a musical composition. As students complete such writings and graphics, they, in one respect, simply are reporting the key points of a source; but, in another respect, they actively are organizing—and thus rehearsing—the content presented in that source.

Integration

Integration is the process of connecting new knowledge with already-existing knowledge—connecting the unknown with the known. As learners integrate new knowledge into their existing knowledge structures, they are building a personal understanding of course content. Writing paraphrases and developing metaphors are two examples of integration generative strategies that are particularly powerful. Initially, writing paraphrases may seem no different than summarizing, which was described earlier as an organization generative strategy. There are, however, key differences. Summarizing emphasizes the *structure* of broad content; when students paraphrase, on the other hand, they are maintaining the integrity of the content by articulating that content in their own words. In using their own words, students are integrating the content with their own natural use of language. In short, a student's "own words" is indicative of a student's "own knowledge."

Students also can integrate new information into their existing knowledge structures by creating metaphors. As Lakoff and Johnson (1980) note, metaphors are so pervasive in human thinking that we often do not even realize that we are thinking metaphorically. To make this point, consider that we describe bass lines as "walking" or rhythms as "driving." Students can be asked to create metaphors as a means of integrating aural content so that the content becomes more personal and concrete.

Elaboration

Whereas integration generative strategies allow students to make connections between new content and prior knowledge, elaboration strategies help students connect content with extended information—often coming in the form of real-world events or examples. When provided with opportunities to elaborate on information, students can go beyond information given in a text or revealed through a lecture. This extended information provided by students may be more personally relevant and interesting to that student. Elaborated information typically is learned and remembered more easily than nonelaborated information (Anderson, 1990). Strategies for promoting elaboration include the following: (a) identifying novel examples of course content; (b) predicting results and implications; (c) synthesizing discipline-specific content with content from other disciplines; and (d) inferring causes for outcomes.

Application of Generative Strategies Toward Developing Aural Theory Skills

So far, this paper has addressed the limitations of a learner's working memory and offered examples from research in music to illustrate such limitations. This paper has provided an overview of generative strategies and suggested that the use of generative strategies can help overcome the limitations of working memory. In the current section of this paper, I offer applied examples from my experiences as a student in a graduate-level aural theory and ear-training course.

I serve as a very relevant example for examining a generative approach to learning aural theory because of the combination of my novice status as a music theory student and my expertise in cognitive approaches to learning. As a rudimental drummer, I had virtually no experiences in completing aural theory tasks that involve issues of pitch, tonality, chord character, and other music qualities that transcend rhythmic awareness. Adding to my novice status, this theory course was the first music theory course that I had ever taken. Van Gog, Ericsson, Rikers, and Pass (2005) suggest that content-area novices deal with issues of cognitive load in ways different from learners who are more advanced. In what follows, I offer two examples of my application of generative strategies within the aural theory course.

Example #1:

Early in the semester, the professor of the theory course introduced solfège as a system for completing aural tasks. One of the early assignments in the course was to use solfege to sing each of the modes, though they were explained to the class as "white note scales." For example, the Ionian mode was simply singing solfege from Do to Do. Dorian began on Re and went to Re, and so forth. For me, as a novice aural theory student, cognitive overload quickly set in. A listing of the items that a novice learner had to hold in working memory shows a list that extends far beyond the "magical number" of seven items that can be held in working memory. Consider that as a novice learner, I was focusing on (a) the correct solfège syllable, (b) which two syllables indicated a whole step versus a half step, (c) the relative distance between whole steps and half steps, (d) the mechanics of manipulating my own voice to make audible my understanding, and (e) when practicing using a keyboard for support, what note corresponds with what syllable. Because of this already taxing cognitive load, I would sometimes even lose sight of which scale I was practicing while in the middle of singing that scale. It was not uncommon, for example, as I was practicing a scale to lose sight of whether I started on the syllable of "Sol" or "La."

The use of generative strategies as described earlier in this paper served as a process for helping me overcome the limitations of working memory and thus "free up" thinking space to focus on the key aural task at hand (i.e., singing the correct scale). Most superficially, I learned the words to "Do, Re, Me" from *The Sound of Music*. The song simply served as a recall generative strategy to help me recall the syllables (and order of those syllables) that constitute solfege. Next, I created a review sheet for myself that listed the syllables for each mode and showed the location of half steps with a bracket. Part of this review sheet is shown in table 2. This review sheet is an example of an organizational generative strategy; it made the structure of each scale more concrete, thereby reducing cognitive load. Notice even that each scale represented in the table is meant to be read starting at the bottom. That is, as I ascended the scale, I ascended the table starting with the bottom syllable; descending the scale corresponded with reading the table from top to bottom. Structuring the table in this order further reduced cognitive load.

Ionian (Major)	**Dorian**	**Phrygian**	**Lydian (Major with # 4th)**	**Mixolydian (Major, flat 7th)**	**Aeolian (Minor)**	**Locrian**
•Do	• Re	• Mi	• Fa	• Sol	• La	• Ti
• Ti	• Do	•Re	• Mi	• Fa	• Sol	• La
• La	• Ti	•Do	• Re	• Mi	• Fa	• Sol
• Sol	• La	• Ti	• Do	• Re	• Mi	• Fa
• Fa	• Sol	• La	• Ti	• Do	• Re	• Mi
• Mi	• Fa	• Sol	• La	• Ti	• Do	• Re
• Re	• Mi	• Fa	• Sol	• La	• Ti	• Do
• Do	• Re	• Mi	• Fa	• Sol	• La	• Ti

Table 2. Organizational generative strategy of the modes (i.e., white note scales)

When practicing the modes, I would put one hand on the keyboard to check each syllable after I sang it and with the other hand would point at the corresponding syllable on the table, moving my finger upwards as I sang each syllable. Using the table as a rehearsal device while practicing these scales meant that the table allowed me to create integration. I was integrating new knowledge, as represented on the table, with the process of practicing a musical idea through repetition, which was something more familiar to me.

What of an elaboration generative strategy? Organizing the modes through the generative activity of creating a table did provide a concrete representation of the modes upon which I could elaborate. For example, in examining the table, I recognized the familiar pattern in the steps of an Aeolian mode—whole, half, whole, whole, half, whole, whole. I saw that the Aeolian mode was a natural minor scale. While certainly to professors of music theory and to advanced students the fact that the Aeolian mode is a minor scale is a statement of the obvious, for a novice student without formal theory training, this discovery was educationally constructive.

Also, through trying to identify patterns among the modes as represented in the table, I was able to elaborate on the commonalities between the Locrian and Phrygian modes, noting that each began with a half step. I also was able to identify that the Mixolydian mode was a Major Scale with a flat seventh. These certainly are all facts that the professor could have "told" a novice student; the point is, however, that because I elaborated on my own organizational generative strategy, I discovered these facts for myself and thus those facts are likely to be more durable.

Example #2:

The course progressed by focusing on various intervals and singing them as a means of developing student facility with intervals. For example, facility exercises were assigned that required students in the course to use solfège to sing major and minor seconds, thirds, fourths, and so on. The assignment of these exercises again led me to engage in generative strategies as a means of reducing cognitive load while mastering the aural theory tasks. An example of triads with the third in the bass will be used to illustrate this point. The course professor gave students figure 1. The instructions were to be prepared to audibly articulate this figure as written in major but also in natural minor and harmonic minor.

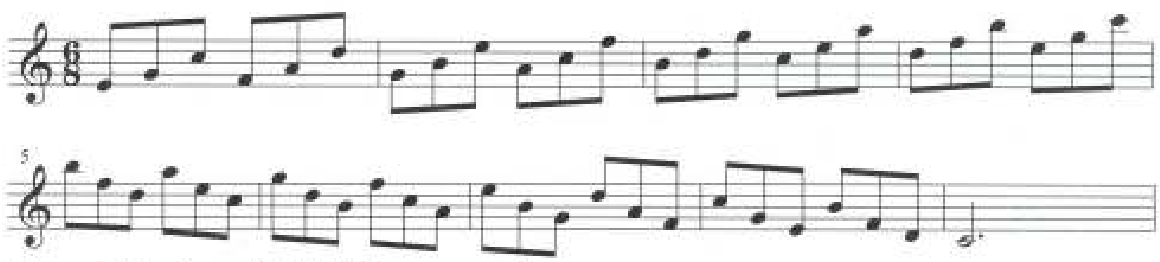

Figure 1. Exercise as distributed by course professor

Numerous factors here created a heavy cognitive load for me. For example, solfege and tonality, which were the emphasis of this course, were not solidified in my mind; thus, I had to concentrate heavily on those. Furthermore, though, using the one figure, written in major, to sing the minor added additional cognitive load. For example, figure 1 is written in the Key of C Major, but the parallel minor of three flats meant that I now had to mentally add the three flats while practicing. Furthermore, while in major the starting “E” is “Mi,” in minor the starting “E” was “Do.” In addition, to execute this exercise, I had to find a “comfortable” place to change octaves both ascending and descending. For a student formally trained in theory, these issues may be commonplace and “automatic,” thus not resulting in a heavy cognitive burden. I, however, was dealing with these issues as a novice music theory student; the cognitive load was debilitating.

To reduce cognitive load, I created figure 2 as a means of organizing the natural minor version of this facility exercise. I created a similar figure to make concrete a representation of the harmonic minor version, as well. Notice that figure 2 actually shows—organizes concretely—the elements that were creating a high cognitive load. Notice that it was not enough of a reduction in cognitive load for me to simply write the key signature for c minor. The altered notes were included as accidentals. Figure 2 even shows the place where I regularly changed octaves in order to stay in my comfortable vocal range. Creation of the graphic "organized" the task at hand. Consider that using the computer software to select and type each note's syllable was a generative strategy that reinforced an understanding of the order of the syllables in a triad with the third in the bass. As I practiced the scales in minor, I integrated this physical representation with practice.

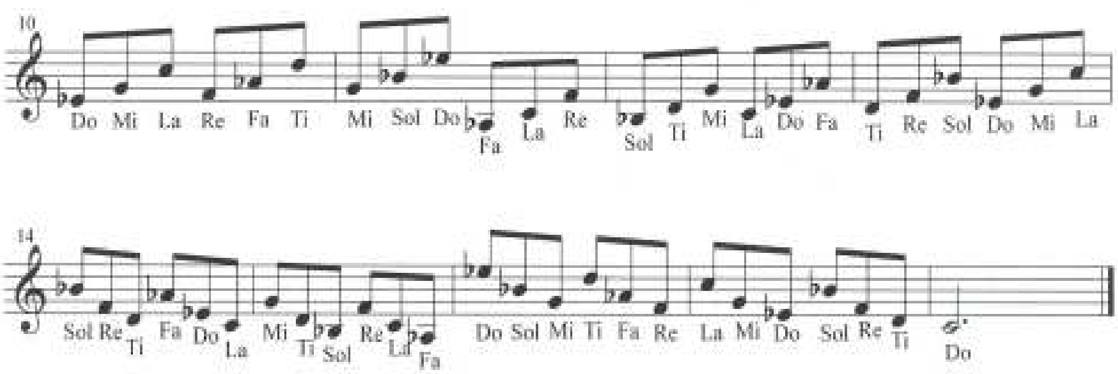

Figure 2. Exercise as generated by author of the paper

Implications

This paper has mainly been geared toward a generative perspective of andragogy within aural music theory tasks. The primary implications of this paper, then, relate to issues surrounding teaching and learning in the music theory classroom. Prior to a discussion of these issues, brief implications for research will be offered.

Research

Beckett (1997) discovered that the order of attention to an aural theory task (e.g., whether to focus on rhythm before pitch) can influence learner success in completing aural theory tasks. Within this paper, the generative process has not been addressed as one of order. Rather, it has only been addressed as a process for simplifying content such that aural tasks do not require such a heavy cognitive load. Researchers should examine the differences, if any, among the order in which generative strategies may be applied to the types of aural tasks that have been described in this paper. For example, if the goal is more sustained student learning, must an elaboration generative strategy be based on a previously-completed organizational generative strategy?

This paper has only presented the experiences of one novice music theory student. Obviously, a narrow focus on one learner is limiting in terms of drawing larger conclusions. Researchers need to examine broader applications of generative strategies within the music theory classroom. Perhaps one area of consideration would be to consider a point of diminishing returns: At what point do generative strategies simply become activity for the sake of activity, as opposed to activity that result in more substantive learning? Another area of consideration might be to examine types of generative strategies: From this paper, it might be inferred that each of the four categories of generative strategies are equally useful. Is that really the case? Can empiricism show quantitative differences in learning among the different types of strategies within the music theory classroom?

Teaching and Learning

This paper began by addressing a tension between the idea of aural theory tasks requiring a covert type of “inner hearing” while cognitive notions of learning require overt manipulation of concepts, principles, and ideas. This paper has addressed this issue to some extent, but music educators need to engage in broader dialogues about this tension. How should the pedagogy of a music theory teacher address this tension?

Consider that to not address this tension may, in fact, be an abdication of a key pedagogical responsibility. To not address the tension places professors of music theory in the position of simply being purveyors of music theory knowledge, leaving learners to grapple on their own with questions about how to absorb and process that knowledge. Might it be useful for professors of music to help music students come to “learn how they learn” as a means of better mastering aural theory tasks? Lin (2001) has suggested that there are two broad useful approaches for assisting students with thinking about their own learning (i.e., thinking metacognitively). One approach is to train students in particular strategies for promoting learning, like the use of generative strategies. The other approach is to create an environment that is conducive to student collaboration and sharing ideas as a mean of promoting better learning. Perhaps professors of aural theory would do well to build into their pedagogical approach various collaborative activities that allow students to share their practice regimens. Such collaboration would—at least in Lin’s view—further students’ abilities to think about their own acquisition of aural theory skills.

References

Anderson, J. R. (1990). *Cognitive psychology and its implications* (3rd ed.). New York: W. H. Freeman.

Beckett, C. A. (1997). Directing student attention during two-part dictation. *Journal of Research in Music Education, 45*(4), 613-625.

DeNardo, G. F. & Kantorski, V. J. (1998). A comparison of listeners' musical cognition using a continuous response assessment. *Journal of Research in Music Education, 46*(2), 320-331

Grabowski, B.L. (1996). Generative learning: Past, present, and future. In D. H. Jonassen (Ed.), *Handbook of Research for Educational Communications and Technology*, (pp. 897-918). New York: Simon & Schuster Macmillian.

Holahan, J. M., Suanders, T. C., & Goldberg, M. D. (2000). Tonal cognition in pattern discrimination: Evidence from three populations. *Journal of Research in Music Education, 48*(2), 162-177.

Jonassen, D. H. (1988). Learning strategies in courseware. In David H. Jonassen (Ed.), *Instructional designs for microcomputer courseware*, (pp. 151-181). Hillsdale:NJ. Lawrence Erlbaum Associates, Publishers.

Knowlton, D. S., Eschmann, A., Fish, N., Heffren, B., & Voss, H. (2004). Processes and impact of journal writing in a graduate-level theory course: Students' experiences and reflections. *Teaching & Learning: The Journal of Natural Inquiry and Reflective Practice, 18*(2), 40-53. Retrieved May 26, 2004, from http://www.und.nodak.edu/dept/ehd/journal/.

Lakoff, G. & Johnson, M. (1980). *Metaphors we live by.* Chicago: University of Chicago Press.

Lin, X. (2001). Designing metacognitive activities. *Educational Technology Research and Development*, *49*(2), 23-40.

McCoy, C. W. (1997). Factors relating to pitch-matching skills of elementary education majors. *Journal of Research in Music Education, 45*(3), 356-366.

Morrison, G. R., Ross, S. M., & Kemp, J. E. (2004). *Designing effective instruction* (4th Ed.), New York, NY: John Wiley.

Price, H. E. (2000). Interval matching by undergraduate nonmusic majors. *Journal of Research in Music Education, 48*(4), 360-372.

Sharp, D. C., Knowlton, D. S., & Weiss, R. E. (2005). Applications of generative learning for the survey of international economics course. *Journal of Economic Education, 36*(4), 345-357.

Van Gog, T., Ericsson, K. A., Rikers, R. M. J. P., & Paas, F. (2005). Instructional design for advanced learners: Establishing connections between the theoretical frameworks of cognitive load and deliberate practice. *Educational Technology Research & Development, 53*(3), 73-81.

Van Merriënboer, J. J. G. & Ayers, P. (2005). Research on cognitive load theory and its design implications for e-learning. *Educational Technology Research & Development, 53*(3), 5-13.

Wittrock, M. C. (1974). Learning as a generative process. *Educational Psychologist, 11*(2), 87-95Wittrock, M. C. (1990). Generative processes of comprehension. *Educational Psychologist, 24*(4), 345-376.

Wittrock, M.C. (1992). Generative learning process of the brain. *Educational Psychologist* 27(4), 531-541.

Wittrock, M. C. & Alesandrini, K. (1990). Generation of summaries and analogies and analytic and holistic abilities. *American Educational Research Journal, 27*(3), 489-502.