

Amy Thompson
 Professor Huang
 MUPP 690
 15 April 2017

The Impact of Transposition on the Memorization of Contemporary Scores

As early as the 17th century, European organists were required to transpose written music at sight due to the variance in pitch standards between geographical regions and between the instrumentalists and singers that the organist accompanied.¹ Organists, pianists, and orchestral instrumentalists continued the practice of transposition into the 20th century, mainly for the purpose of accompanying vocal music.² With the dawn of the digital era, however, the instrumentalist's ability to transpose music at sight has become seemingly less useful due to computer programs able to transpose sheet music and electronic keyboards built with controls to manipulate the instrument's pitch.

Despite the relative abundance of pedagogical methodology on developing the skill of instrumental transposition (much of it published in the pre-digital age), little scientific literature exists exploring the skill's cognitive benefits. Many studies investigate the brain's acquisition of other musical skills such as memorization, but few studies explore the impact of transposition on

¹ *Grove Music Online*, s.v. "Pitch," by Bruce Haynes and Peter Cooke, accessed April 13, 2017, <http://oxfordmusiconline.com/>.

² "If the aria is to be accompanied by an orchestra or a band, the conductor simply announces the key in which the aria is desired to be transposed, and the members of the organization are expected to transpose their respective parts at sight. Consequently, it is an absolute necessity for every musician who desires to become an accomplished orchestra or band member, to study transposition at sight as early and as thoroughly as possible." from Henri Kling, *Transposition: A Practical Authoritative Guide for All Instruments* (New York: C. Fischer, 1910), 11.

"It is a common occurrence to have music in the wrong key; or a sudden indisposition on the part of some singer which requires the playing to be in a higher or lower key than the printed pages indicate. . . inability [to transpose] is a virtual confession of partial incompetence." from Rowland W. Dunham, *Practical Transposition: For Pianists and Organists* (New York: J. Fischer & Bro., 1952), v.

the brain (the ones coming closest focus on listeners' ability to *recognize* a transposed melody, rather than instrumentalists' ability to reproduce a melody at a new pitch level).

Yet stories abound detailing the fantastic feats of transposition of piano prodigies and great composers, such as the well-known anecdote about Brahms, who was once forced by a low-pitched piano to transpose at sight the piano part to Beethoven's entire Violin Sonata in C Minor up a half step in public performance when accompanying the violinist Eduard Reményi.³

One scientific study on memory provides some cognitive explanation for stories similar to the Brahms legend by suggesting a possible relationship between transposition and other cognitive skills in the brains of great musicians. Researchers Lehmann and Ericsson "found significant correlations between memorization ability and ability with other musical tasks (i.e., . . . transposing into other keys)" and suggested that "these abilities are mediated by an underlying mental representation that permits encoded information to be reproduced and manipulated accurately."⁴ However, the study addresses only the transposition of material previously memorized and thus cannot fully account for Brahms' accompanying feat, since he was reading music, not playing from a previously formed "underlying mental representation."

This paper explores whether transposition can be used to facilitate the formation of the "underlying mental representation," and if so, whether this can happen in atonal as well as tonal music. By examining the writings of teachers who advocate for transposition from a cognitive

³ Florence May, *The Life of Johannes Brahms* (St. Clair Shores: Scholarly Press, 1977), chap. 4, <http://www.gutenberg.org/files/40643/40643-h/40643-h.htm>.

⁴ This quote, taken from Rita Aiello and Aaron Williamon, "Memory," in *The Science and Psychology of Music Performance: Creative Strategies for Teaching and Learning*, ed. Richard Parncutt and Gary McPherson. (New York: Oxford University Press, 2002), 172, is referencing the following study: A. C. Lehmann & K. A. Ericsson, "Expert pianists' mental representation of memorized music" (poster presented at the thirty-sixth annual meeting for the Psychonomic Society, Los Angeles, California, 1995).

perspective, reviewing what is known about memory formation, and making self-observations, I suggest a possible mechanism by which transposition benefits memory, particularly in an atonal context, and outline several directions for future studies.

Although many pedagogical methods only mention the (diminishing) practical reasons for transposition, certain teachers have observed other benefits for the musician. In his article on commercial music, percussionist Robert Slack says, “A skill that aids sight-reading is transposition. Start with simple musical ideas, such as the first three notes of a major scale, and play through the circle of fourths while adjusting for each new key center. . . . This way, you can sometimes avoid having to read one note at a time by recognizing a transposed pattern.”⁵ Jazz pianist Jean-Michel Pilc compares music to language, pointing out that the brain naturally memorizes (or “assimilates”) phrases in languages that it understands. Being able to play music in any key aids this understanding.⁶ Pianist, composer, and researcher Aaron Berkowitz presents a similar theory in his book on improvisation where he says, “Learning a formula in various keys can foster a stronger representation of the formula’s components and internal relationships.”⁷

The great 20th century French pedagogue Nadia Boulanger required many of her students to transpose entire works at sight. Her student Emile Naoumoff suggests her impetus for this teaching was both cognitive and quasi-spiritual: “. . . the techniques that Mademoiselle Boulanger instilled in me as the building blocks of the complete musician (some of which appear particularly old-fashioned today, thanks to computer prosthetics—such as being able to read in

⁵ Robert Slack, “Sight-Reading in Commercial Music,” *Percussive Notes* 39, no. 6 (2001): 34.

⁶ Jean-Michel Pilc, e-mail message to author, April 4, 2017.

⁷ Aaron L. Berkowitz, *The Improvising Mind: Cognition and Creativity in the Musical Moment* (New York: Oxford University Press, 2010), 46, DOI:10.1093/acprof:oso/9780199590957.003.0003.

all seven clefs or transpose at sight) were not intended to be ends in themselves; rather, they were tools to assist my own overriding thirst for musical creativity.”⁸ Another of Boulanger’s students, Marianne Ploger, explains, “Though I did not fully appreciate the significance of transposition until much later than during my studies with her, I early recognized that it was the best way to ensure that I would *not* learn literature kinesthetically, by rote repetition, but would be compelled to comprehend how notes relate to one another. . . . In music, patterns—whether formed by pitches or rhythms—form a crucial aspect of good communication. Because transposition requires pitch and rhythm pattern recognition, it is a worthwhile cognitive skill to cultivate. . . . The value, then, is in identifying *the pattern* formed between the notes, not just some random smattering of disconnected pitches.”⁹

If transposing causes the brain to recognize patterns, then it appears likely that transposition facilitates memorization, a skill that is dependent on the recognition of patterns. In his now-classic article, George Miller explains how immediate memory is limited by the number of items (what he calls “chunks”), not the amount of information (“bits”). Although short-term memory can only contain around seven chunks, it is possible to increase the amount of information per chunk through “recoding” the input material so that the brain recognizes greater amounts of information as a single item.¹⁰ Miller only describes the recoding of random information via mnemonic devices, but Aiello and Williamon point out that in a musical context, this recoding can be accomplished by learning to recognize existing patterns, such as through

⁸ Emile Naoumoff, *My Chronicles with Nadia Boulanger*, trans. Gregory Martin (2015), 70, https://media.wix.com/ugd/9aaf97_fd97e9af97934dca8e96720cd66e5f08.pdf.

⁹ Marianne Ploger, e-mail message to author, March 8, 2017.

¹⁰ George A. Miller, “The Magical Number Seven, Plus Or Minus Two: Some Limits on Our Capacity for Processing Information,” *The Psychological Review* 63, no. 2 (1956): 81–97.

developing a comprehensive understanding of music theory.¹¹ Berkowitz notes that transposition can accomplish this kind of pattern recognition without conscious knowledge of music theory: “The rehearsal of cadences and other progressions in all keys allow[s] for the implicit learning of the fundamentals of tonal harmony and voice leading.”¹²

However, much musical repertoire of the 20th century challenges the performer’s ability to memorize through recoding via pattern recognition. Beginning with early modernism, continuing through the post-war avant-garde, and persisting in certain contemporary trends such as spectralism or the New Complexity, many schools of composition have abandoned large-scale structural formulae and small-scale harmonic and melodic sequences in favor of other types of organization. The resultant music’s seeming randomness may impede performers’ ability to recognize any kind of pattern. Can transposition still facilitate memory by finding patterns where none would otherwise be discerned, or does 20th century repertoire render transposition useless as a tool for memorization?

To answer this question, I designed and executed an experiment for myself. I chose two 20th century pieces for solo harp, George Rochberg’s *Ukiyo-e* and Elliott Carter’s *Bariolage*, and a tonal “control” piece, Domenico Scarlatti’s Keyboard Sonata in A major, K. 209. I selected four passages from each piece, allowing the length of the passage to vary in order to keep the number of chunks per passage approximately the same. For the atonal but repetitive Rochberg, passages were at least an entire page, for the relatively dense Carter, passages were around four measures, and for Scarlatti, about eight bars.

¹¹ Aiello and Williamon, “Memory,” 171.

¹² Berkowitz, *The Improvising Mind*, 41.

I divided my experiment's timeline into four weeks. Each week I focused on a different three passages, one from each of the three pieces. Every day for six days, I read the passages four times at the piano and four times at the harp. On the seventh day I played the passages from memory to see what I had retained. I also tested memory one, two, and three weeks after the initial testing.

During the second and fourth weeks, I read the passages at written pitch; on the first and third weeks, I transposed the passages at sight. During the first week, I played the passages at every pitch level (including the written pitch level) twice at each instrument over the course of the week. During the third week I played the passages twice at each instrument at every pitch level except for the written pitch (so twice I transposed to two randomly chosen intervals to meet the total of twenty-four times for the week). Each day at each instrument I transposed each passage twice up and twice down, and each day I also made sure two of the intervals were larger than half the octave and two were smaller (six semitones counted as either). My daily plan can be seen in Figure 1, which shows the direction and number of semitones of each transposition.

Figure 1. Daily plan for transposition.

	Week 1			Week 3		
	Rochberg	Carter	Scarlatti	Rochberg	Carter	Scarlatti
Day 1	↑ 3 ↓ 1	0 ↓ 4	↑ 6 ↓ 2	↑ 2 ↓ 5	↑ 4 ↓ 2	↑ 6 ↓ 4
	↑ 10 ↓ 8	↑ 9 ↓ 7	↑ 11 ↓ 9	↑ 9 ↓ 8	↑ 8 ↓ 11	↑ 11 ↓ 9
Day 2	↑ 2 ↓ 4	↑ 5 ↓ 2	0 ↓ 1	↑ 4 ↓ 6	↑ 2 ↓ 4	↑ 1 ↓ 3
	↑ 9 ↓ 7	↑ 8 ↓ 10	↑ 3 ↓ 11	↑ 8 ↓ 7	↑ 10 ↓ 9	↑ 7 ↓ 10
Day 3	0 ↑ 1	↑ 4 ↓ 6	↑ 2 ↓ 3	↑ 6 ↓ 3	↑ 3 ↓ 1	↑ 5 ↓ 2
	↓ 10 ↑ 6	↑ 11 ↓ 9	↑ 8 ↓ 7	↑ 7 ↓ 11	↑ 9 ↓ 6	↑ 8 ↓ 9
Day 4	↑ 5 ↓ 2	0 ↑ 2	↑ 4 ↓ 5	↑ 5 ↓ 1	↑ 1 ↓ 5	↑ 2 ↓ 6
	↑ 11 ↓ 6	↓ 3 ↑ 7	↑ 10 ↓ 6	↑ 6 ↓ 9	↑ 11 ↓ 7	↑ 7 ↓ 8
Day 5	0 ↓ 5	↑ 3 ↓ 1	↑ 1 ↓ 4	↑ 1 ↓ 2	↑ 5 ↓ 3	↑ 3 ↓ 1
	↑ 8 ↓ 9	↑ 6 ↓ 11	↑ 7 ↓ 8	↑ 11 ↓ 10	↑ 6 ↓ 11	↑ 10 ↓ 7
Day 6	↓ 3 ↑ 4	↑ 1 ↓ 5	0 ↑ 5	↑ 3 ↓ 4	↑ 6 ↓ 3	↑ 4 ↓ 5
	↓ 11 ↑ 7	↑ 10 ↓ 8	↓ 10 ↑ 9	↑ 11 ↓ 8	↑ 7 ↓ 10	↑ 9 ↓ 11

Musicians typically acquire the skill of transposition through practicing one or more of four major methods. One may transpose by “sighting” (visualizing the transposed notes written on the appropriate line or space on the staff at a fixed distance from the written notes), by “interval” (thinking up or down a certain interval from each written), by “tonal function” (recognizing the scale degrees of the written pitches and playing the same scale degrees in a different key), or by “clef substitution” (imagining a different clef to effect the transposition).¹³ My method of transposition was to observe the intervallic distances between the notes and, beginning at the appropriate interval away from the original, play notes related by the same intervallic distances. I found the “interval” method to be too slow, and only when finding the initial pitches did I think about the interval by which I was transposing. If I lost my place, I would necessarily recall the interval in order to resume, but I found that I often had completely forgotten which interval I was transposing by. I decided against clef transposition because the abundance of accidentals in atonal music would hinder fluent transposition even more greatly than in tonal music. However, I also employed the “tonal function” method when playing the Scarlatti, simultaneously noticing scale degrees as well as intervallic distances. Although there was no tonal center in the Rochberg, sections tended to employ a single non-symmetrical collection of seven pitches that allowed me to use a method somewhat like “tonal function,” as I was always aware of the position of the note I was playing relative to the whole collection.

Although memorization is more difficult in the absence of patterns, the same isn't necessarily true for transposition. Transposition at sight is hindered by a lack of patterns only as much as the transposer's sight-reading is hindered: a mediocre sight-reader will find repetitious

¹³ Karpinski, Gary S., *Manual for Ear Training and Sight Singing* (New York: W.W. Norton & Company, 2007), 209–212.

music with easily discernible patterns easier to read (either at pitch or transposed) because the pattern behaves as a “crutch,” allowing the fingers to play on “autopilot” for a few moments while the brain begins deciphering the next bit of music after the pattern changes, and so the brain is not forced to read in real time. Yet nothing about the specific act of transposing each note is made more difficult by a lack of larger patterns. That said, I found that the contemporary score still challenges transposition in a number of other ways.

My brain was often initially overwhelmed in the presence of complex rhythms (as in the Carter) or by a plethora of expressive markings (as in the Rochberg). In both pieces, non-intuitive spellings and passages of large leaps slowed my ability to calculate intervallic distances between the written notes, forcing me to resort temporarily to the slower “interval” method.

I observed that in all the transposed passages, my brain recoded the meaning of the visual cues on the page over the course of the week. At the week’s beginning, the dots on the staff represented what they always have: specific notes. If all went well, by the week’s end, the markings on the page recalled to my mind only particular distances. Seeing only distances is useful for increasing the amount of information per chunk, because for a given pair of notes, there are 144 possible combinations of two pitches but only twelve basic intervallic relationships.

In the atonal scores, this recoding process was challenged mainly by the lack of relationship between the notes in a passage and a single tonic pitch. The most difficult passage was the Carter on the first week (Example 1); I could only transpose it very slowly, and when tested, my memory retained no more than a few chords. Thus, I was surprised when the easiest transposition and best memory of any passage in the entire experiment turned out to be the Carter on the third week (Example 2). Despite the passage’s chromaticism and changing accidentals, my brain easily recoded the passage because it contained a repeated pitch throughout, making the

other notes' relationships to a center even more obvious than in Scarlatti (which contains a tonic but isn't always sounding). The recoding process in the Rochberg was only somewhat more difficult than that in the Scarlatti, but not nearly as difficult as that in the initial week of Carter, due to the fact that, as mentioned, I could locate each note within a defined collection, even though it had no center (such as in the first page, shown in Example 3). Although the typical lack of both a central pitch and a limited pitch collection in atonal music does make transposition in most contemporary scores less easy (and thus a rather laborious way of improving memory), I believe that in the future, I could partially rectify the issue by imposing a drone on atonal passages, either by singing, playing, or simply imagining a repeated pitch.

Example 1. Elliott Carter, *Bariolage*, mm. 89–93.¹⁴

¹⁴ Elliott Carter, *Bariolage* (London: Boosey & Hawkes, 1992).

Transposition also helped me find intervallic patterns over large spans of music, which is especially helpful for atonal scores, as they “tend to be based on patterns and sonorities that are unique to the piece itself more so than tonal composition.”¹⁷ Although transposing at sight didn’t allow me to master the memorization of the first week’s passage by Carter, I believe that I would have observed different results if that same passage had been on the third week, because many of his non-functional harmonies that seemed random the first time would have been recognizable.

I was surprised by the degree to which transposition sharpened my aural memory. I’ve long been aware that my ear’s ability to memorize sounds is faster than my conscious mind’s ability to memorize notes on a page, but since I have only an intermediate level of relative pitch, my aural memory tends not to help me since I don’t know what I’m hearing in my memory. My method of transposition enabled me to play the next notes only when I was aware of their relationship to the previous and simultaneous ones, and thus I was always associating a conscious awareness of the interval with its sound. While testing my memory of the transposed weeks, sometimes my conscious memory muddled momentarily, and I was thrilled to observe my fingers naturally following my ear to the correct notes without conscious direction.

Although transposition helped strengthen my pitch collection memory by creating what felt like a spatial network of intervals, I conversely found that transposition had no effect on my memorization of rhythm and order. Example 4 shows a portion of a passage in the Rochberg consisting of slightly varied repetitions of a basic idea. When testing my memory, I could remember the basic idea and the variations, but not the order of the variations.

¹⁷ Aiello and Williamon, “Memory,” 175.

Example 4. George Rochberg, *Ukiyo-e*, p. 6 system 3.¹⁸

The image shows a musical score for George Rochberg's *Ukiyo-e*, system 3. The score is written for piano and consists of two staves. The upper staff features a series of chords and melodic fragments, often with accents and dynamic markings. The lower staff provides a harmonic accompaniment. Key markings include 'rit.', 'mp', 'pp', 'quasi f. animato', and 'ma dolce'. The score is divided into sections by 'Table' markings and includes a triplet of eighth notes.

Admittedly, my experiment has several issues requiring amendment and leaves many unanswered questions. My experiment needs replication across a larger sample of musicians and instruments to test the usefulness of this method for others and would need to employ a more quantifiable way to rate memorization accuracy. I would also like to replicate my experiment controlling for the amount of time spent transposing vs. reading at pitch: perhaps the increased memory I observed for the material I transposed over that which I read at pitch was due not to the transposition but rather to the greater amount of time I spent with the transposed material since (especially the first week) my transposition abilities were approximately two to three times as slow as my reading abilities. In the future, either the amount of time spent could be held equal (letting the number of repetitions vary) or all passages could be played with a metronome to ensure that the at-pitch material is played as slowly as the transposed material.

Transposition should be compared to other ways of increasing intervallic awareness (such as singing the score or observing the intervals more consciously away from the instrument) in order to determine its relative efficiency as a tool for memorization. Perhaps more important than finding out if transposition is the fastest method for reaching initial memorization is determining

¹⁸ Rochberg, *Ukiyo-e*.

how transposition compares to other methods when measuring the length of time the material stays memorized relative to the length of time spent on the initial memorization.

I would also like to repeat the experiment, this time playing each passage as many times as necessary until the transposition becomes fluent. I observed that the rate at which I reached fluency varied between the pieces. Repeating the experiment in this manner would help determine whether transposition would eventually have accomplished memorization for the passage of Carter on the first week.

Finally, I would like to determine whether some intervals are more effective than others at causing memorization. I noticed that when transposing by small intervals, my brain didn't have to think about relative melodic and harmonic distances nearly as much as when transposing by a sixth.

Despite these unanswered questions, I believe substantial evidence exists in support of using transposition as a tool for memorization. On average, transposition was correlated with better memory in both atonal and tonal contexts in my experiment. This is likely due to the way transposition facilitates the brain's recoding of information into fewer stimuli through pattern recognition. Perhaps transposition's biggest flaw as a memorization technique is its lack of help with the memorization of rhythm and order, and for this reason I conclude that transposition cannot be a complete substitute for other forms of more conscious memorization. However, I am excited to have discovered a new method providing practical benefit for myself, and I look forward to continuing integrating transposition into my practice and pedagogy.

Bibliography

- Aaron L. Berkowitz. *The Improvising Mind: Cognition and Creativity in the Musical Moment*. New York: Oxford University Press, 2010. DOI:10.1093/acprof:oso/9780199590957.003.0003.
- Aiello, Rita and Aaron Williamon. "Memory." In *The Science and Psychology of Music Performance: Creative Strategies for Teaching and Learning*, edited by Richard Parncutt and Gary McPherson, 172. New York: Oxford University Press, 2002.
- Carter, Elliott. *Bariolage*. London: Boosey & Hawkes, 1992.
- Haynes, Bruce and Peter Cooke. "Pitch." In *Grove Music Online*. Oxford Music Online. Accessed April 13, 2017. <http://www.oxfordmusiconline.com.proxy3.library.mcgill.ca/subscriber/article/grove/music/40883>.
- Karpinski, Gary S. *Manual for Ear Training and Sight Singing*. New York: W.W. Norton & Company, 2007.
- Lehmann, A. C., & K. A. Ericsson. "Expert pianists' mental representation of memorized music." Poster presented at the thirty-sixth annual meeting for the Psychonomic Society, Los Angeles, California, 1995.
- Miller, George A. "The Magical Number Seven, Plus Or Minus Two: Some Limits on Our Capacity for Processing Information." *The Psychological Review* 63, no. 2 (1956): 81–97.
- Naoumoff, Emile. *My Chronicles with Nadia Boulanger*. Translated by Gregory Martin. 2015. https://media.wix.com/ugd/9aaf97_fd97e9af97934dca8e96720cd66e5f08.pdf.
- Rochberg, George. *Ukiyo-e: Pictures of the Floating World*. Bryn Mawr: Theodore Presser Co.,

1976.

Scarlatti, Domenico. *Sonata in A Major, K. 208*. Paris: Alphonse Leduc, 1974.

Slack, Robert. "Sight-Reading in Commercial Music." *Percussive Notes* 39, no. 6 (2001): 34–35.