EMBODIED EFFECTS ON MUSICIANS' MEMORY OF HIGHLY POLISHED PERFORMANCES

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ABSTRACT

A professional pianist's and a professional soprano's ability to begin playing from the middle of a previously memorized piece was tested using a modified cued recall task. Stimuli tested the musicians' ability to begin playing from different types of *performance cues (PCs)* – retrieval cues to which they attend as they perform the piece from memory – as well as the effect that movement had on their ability to utilize PCs. For the vocalist we also tested how the order in which the stimuli were presented (either the same order as they occur in the piece or random order) influenced her response times.

The pianist was faster to respond to *expressive cues* (locations where he intended to convey a new musical meaning) than to *basic cues* (locations where he needed to attend to a technical element). His response times were also faster when he was able to move as stimuli were presented, compared to when he remained still. For the vocalist, response times were fastest in the no movement-sequential condition and movement-random condition.

The pianist's results replicate previous findings implying that instrumentalists would be likely to use expressive cues to recover from a memory failure, and suggest that movement might benefit overall performance. The vocalist's results imply that she would be likely use a strategy different from that of the pianist to recover from memory failure and that movement is only beneficial in certain circumstances.

1. INTRODUCTION

Professional musicians are often expected to give note-perfect performances from memory when performing for a live audience. Previous studies have demonstrated that these musicians establish mental landmarks, known as *performance cues (PCs)*, which act as retrieval cues and help prevent memory failure (Chaffin, Imreh & Crawford, 2002; Chaffin, Lisboa, Logan, & Begosh, 2010). The current investigation expands upon a previous set of studies by Begosh, Chaffin, Silva, and Lisboa (2009) to further explore how musicians might use PCs to recover from a memory failure if one occurred during live performance. Specific consideration is given to the possible effects of movement on musicians' ability to use different types of PCs.

Highly skilled musicians establish performance cues during the many hours of preparation leading up to a performance in order to ensure that they can maintain cognitive control as the piece unfolds (Chaffin et al., 2002). Doing so provides them with *content addressable access*, meaning that they have multiple locations available to serve as mental checkpoints or starting locations. For example, they could begin playing at the start of the second theme or from the beginning of a technically challenging section. Chaffin et al. (2002) described four different types of PCs. *Structural cues* correspond to important locations in the formal structure of the music. *Expressive cues* represent the musical feelings that the performer wants to convey. *Interpretive cues* represent changes in modifiable dimensions of the music such as tempo and dynamics. *Basic cues* represent locations where the musician must attend to an aspect related to the execution of the piece, such as bowing or fingering.

Several types of evidence support the claim that musicians use PCs as they prepare and later perform a piece of music from memory. At different phases of the learning process, the musicians were significantly more likely to start and stop their practice segments at different types of PCs (see Chaffin et al., 2002 & Chaffin et al., 2010 for details). Early in the learning process, when practicing the piece from memory, musicians were likely to decrease tempo at basic cues, indicating a need to work through a technically difficult portion of the composition. After bringing the piece to performance level, the musicians were most likely to slow down at expressive performance cues, consistent with literature on expressive timing (Clarke, 1999).

Begosh et al. (2009) found support for the claim that highly experienced musicians could use PCs as starting locations if they had a memory failure during a live performance. Two professional musicians sat still as they listened to short sound clips from a recording of one of their own performances, which corresponded to various PC and non-PC locations. They responded by playing what came immediately after that segment as quickly and accurately as possible. Both musicians responded fastest to the expressive cues and were slower when responding to basic cues. The researchers interpreted this to mean that should the musicians experience a memory failure during a live performance, it would be easiest to begin playing from an expressive cue location, and difficult to begin playing from a basic cue location.

One explanation offered for the difference in response times between expressive and basic cues was that they differ with respect to the extent that they are conceptual in nature. Specifically, expressive cues are related to how the performer thinks about the musical meaning of the piece, and are thus conceptual in nature. Basic cues are related to the execution of the piece, and are instead more closely tied to the motor system. Because the musicians did not move as the stimuli were presented, Begosh et al. (2009) suggested that this disruption of the motor system interfered with their ability to utilize the basic cues that were established. If such a disruption occurred, then allowing musicians to engage the motor system while listening to the stimuli should eliminate the difference between the conceptual types of cues (i.e. expressive cues) and those linked to the motor system (i.e. basic cues).

Although highly skilled musicians use PCs to establish content addressable access, *serial memory* is a second type of memory that is available. This means that playing the first bar cues the second bar, which then cues the third bar, and so on (Chaffin, Logan & Begosh, 2009; Rubin, 1995). Begosh et al. (2009) examined musicians' ability to use serial memory and content addressable access by respectively presenting the stimuli in the same order as they appeared in the piece (*sequential condition*) or in random order (*random condition*). There were no reliable differences in response times for the highly skilled musician when she was tested in these two different conditions, indicating that she had established both serial memory and content addressable access as she learned the piece.

The current set of experiments was designed to replicate and expand upon the previous findings by Begosh et al. (2009) to gain a better understanding of how a musician might recover from a memory failure if one occurred during a live performance. Specifically, we sought to replicate the finding that highly skilled musicians respond faster to expressive cues than to non-performance cues. In addition, we expected again show that these musicians do not differ in their response times when tested in the sequential and random testing conditions, demonstrating the availability of both serial memory and content addressable access. A movement manipulation in which the musicians were allowed to move during half of the testing sessions, and not permitted to move during the other half tested if allowing them to engage the motor system would eliminate the difference in response times between expressive and basic cues. The current study also expands upon the previous work by examining how a vocalist, rather than an instrumentalist, would attempt to recover from a memory failure.

2. METHOD

2.1 General Method

The two professional musicians who participated in the current study had each previously memorized a composition for public performance. Prior to the present study, they indicated what their performance cues were by marking them on copies of the score. Stimuli consisted of two consecutive bars of the piece cut from a previously recorded performance. Each stimulus was preceded by several indicator beeps played at the average tempo of the sound clip that followed. A final beep on the last beat of the stimulus indicated its end. The musicians were instructed to begin playing from where the stimulus left off, making it sound like a continuous performance.

Both musicians were tested with stimuli that required them to begin playing at the different types of PCs, as well as to locations at which there were no PCs. The stimuli for each musician were divided into two stimulus lists (A-list and B-list). Each list was tested in both the moving and non-moving testing conditions, with order counterbalanced across lists. In the moving condition, the musician was instructed to move in a manner consistent with what they would do when performing the piece as they heard the stimulus. In the non-moving condition, they were instructed to remain still until they were ready to make their response.

The dependent measure was response time, measured from the end of the stimulus, to the first note of the musicians' final decision about what they believed was the correct response. A constant of 1.0 was added to all response times before they were log transformed for analysis.

2.2 Experiment 1

Participant and Music

The pianist (the third author) is a classically trained musician from Brazil where he was a faculty member in the music department of the Universidade do Estado de Santa Catarina.

He had memorized the *Piano Sonata No.2 in F Sharp Minor, Allegro non troppo ma energico* by Johannes Brahms for his dissertation recital. The piece is 198 bars in length, written in ¾ time and takes approximately 6 minutes to perform.

Stimuli

From the pianist's reports of PCs, nine structural, ten expressive, and nine basic cues were identified for use during the experiment. Eight locations where there were no PCs were also included, for a total of 36 stimuli. The stimuli were divided among the two stimulus lists so that approximately equal numbers of each type appeared on each list. The presentation order was randomized.

Procedure

The pianist participated in four testing sessions with one stimulus list and one movement condition presented in each. The order of the sessions was as follows: A-not moving, B-moving, A-moving, B-not moving. During each testing session, the pianist indicated his readiness to begin, and the appropriate stimulus list was then started. The stimuli played continuously, with ten seconds of silence following each one to give the pianist time to respond.

Results and Discussion

One expressive cue stimulus from the movement condition and one non-performance cue stimulus from the no movement condition were identified as outliers and removed from further analysis. A 2 (movement) x 4 (PC-type) mixed ANOVA with PC-type as the between subjects factor revealed a significant main effect of

PC-type $F(3, 30) = 3.156$, $p = .039$. Post hoc analyses showed that the pianist's responses to the basic cues were significantly slower than to expressive cues ($p = .009$) or to non-performance cues ($p = .036$; see Figure 1). These results replicate the findings reported by Begosh et al. (2009). They suggest that the pianist would find it harder to begin playing at a basic cue than either an expressive cue, or a location at which there is no performance cue if memory failed during a live performance.

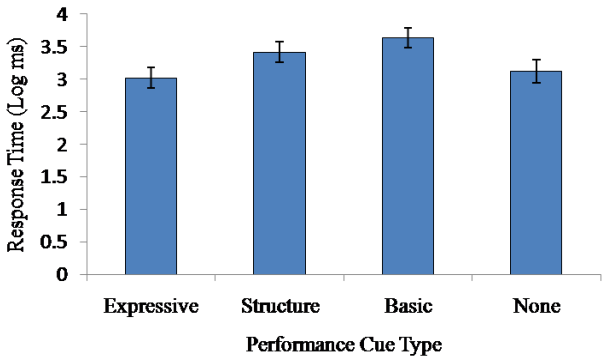

Figure 1. Mean response time for the four different types of stimuli tested.

The pianist's responses in the movement condition were marginally faster than his responses in the no movement condition $F(1, 30) = 3.407$, $p = .075$ (Figure 2). The interaction between movement condition and PC-type was not statistically significant, $p > .05$. This suggests that overall, activating the motor system when trying to recall part of the piece provided additional context that was not available when not allowed to engage the motor system, resulting in faster responses. The inability to detect a significant interaction between movement condition and PC type suggests that all types of PCs equally benefit from the musician being permitted to move during recall. It also points to the possibility that even though some PCs are more conceptual in nature, they are all in some way tied to the motor system, because movement is required to produce the music.

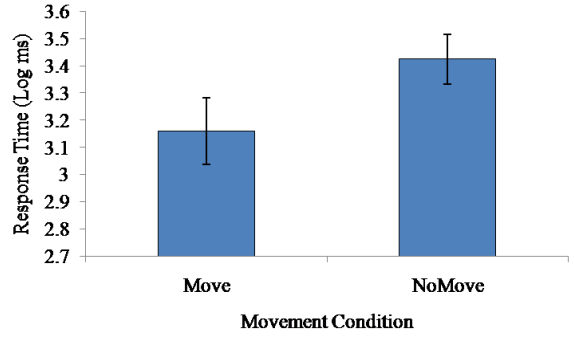

Figure 2. Mean response time in the move and no move conditions.

2.3 Experiment 2

Participant and Music

The vocalist (the forth author) performs regularly as a solo soprano. She is also a faculty member at the Royal Northern College of Music where she is actively involved in research on music performance.

The vocalist had previously memorized the *Ricercar I* from Stravinsky's *Cantata* as part of her concert repertoire. The piece is 70 bars in length, and alternates between 4/8 and 3/8 time. It takes approximately 4 minutes to perform.

Stimuli

From the vocalist's PC reports, six basic, six expressive, and six structural cues were identified for use in the current experiment. Seven locations where there were no performance cues were also included for a total of 25 stimuli. These items were divided among the A and B stimulus lists so that approximately equal numbers of each type appeared on each.

To evaluate the vocalist's ability to use serial cuing and content addressable access, stimuli were presented either in sequential or random order. In the sequential condition, the stimuli were presented in the same order that they appeared in the piece. Each bar that was not used as a stimulus was muted, and an additional beep was placed on the downbeat of those bars. This was intended to allow the vocalist to keep track of where she was in the piece even when no stimulus was playing. The stimuli in the random condition were presented in random order with ten seconds of silence between each stimulus to allow for time to respond.

Procedure

The vocalist participated in four testing sessions. Each was divided into two parts, with a different stimulus list, movement condition, and order condition (sequential or random) tested in each part. In session 1 she was tested on the A-sequential-moving list and then the B-random-not moving list. In session 2, she was tested on the A-random-not moving list and then the B-sequential-moving list. In session 3, she was tested on the B-sequential-not moving list and then the A-random-moving list. In session 4, she was tested on the B-random-moving list and then the A-sequential-not moving list.

Results and Discussion

The data were analyzed using a 2 (order) x 2 (movement) x 4 (PC-type) mixed ANOVA with PC-type as the between subjects factor. When the vocalist was not permitted to move during the stimulus presentation, response times were faster during the sequential condition than during the random condition. The opposite effect was found when she was instructed to move during stimulus presentation, with faster responses in the random condition than in the sequential condition. This resulted in a significant two-way interaction between order and movement, $F(1, 21) = 14.857$, $p = .001$ (Figure 3). No other interactions or main effects were significant (all p's $> .05$).

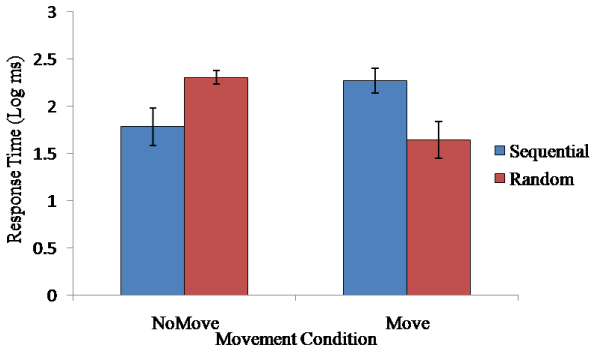

Figure 3. Mean response time in the no move and move conditions as a function of order of presentation (sequential or random).

The significant interaction between order and movement condition indicates that being able to move or not had a different effect on the vocalist's response time depending on whether the stimuli were presented in sequential or random order. The effect of the no movement condition, in which she responded faster to sequential stimuli than to random stimuli, could be because the sequential presentation allowed her to know where she was, providing her with enough information to quickly make her response. In the random condition, the only information came from the two-bar stimulus itself. The results of the movement condition suggest that when the stimuli were presented in random order and the musician could not be sure of where in the piece a stimulus came from, being able to move provided useful information in addition to that present in the stimulus. However, when the stimuli were presented in sequential order and the musician could track where she was, being required to move instead interfered with her ability to respond.

The results from the vocalist tested in the present investigation were different from the other highly skilled musicians studied in Begosh et al. (2009) because she did not show any differences in response time to the different types of PCs. The inability to detect a main effect of PC-type is likely because of the extensive amount of time that the vocalist has spent practicing and studying the piece. As of this writing, she has spent more than six years working on the piece, either preparing it for performance or engaged with it for other performance cue research. All of this work has likely led her to have an accurate and stable memory for the entire composition.

3. GENERAL DISCUSSION

The current set of experiments used a modified cued recall task to determine how a professional pianist and professional vocalist might resume performing from the middle of a piece if a complete memory failure occurred during a live performance. Because of the significant difference in response times to expressive and basic cues reported in Begosh et al. (2009) we were particularly interested in examining how manipulating movement during stimulus presentation would affect response times. Possible reasons for the different patterns of results obtained for the two musicians are explored below.

For the pianist in the current study, the main effect of PC-type is consistent with the previous results from Begosh et al. (2009), with responses to expressive cues being reliably faster than responses to basic cues. The current study expanded upon the previous research by showing that engaging the motor system is helpful when beginning to play from the middle of the piece. However, the inability to detect a significant interaction between movement condition and PC-type suggests that basic cues do not benefit more so than the other types of PCs when the motor system is engaged, as was originally hypothesized.

The vocalist's interaction between order and movement suggests that whether or not it is beneficial to engage the motor system to begin playing from the middle of the piece depends on the other information that is available. Having a sense of where one is within the piece (as in the sequential condition) is likely enough information to allow the musician to continue. Attempting to use additional information, such as movement, might actually overload the system and cause worse performance. However, when the musician does not have a sense of where s/he is within the piece (as in the random condition), moving provides additional information and allows him/her to respond more rapidly.

One possible explanation for the differences between vocalist's results and the other professional musicians that have participated in this and similar cued recall tasks on performance cues is that she used her voice to make music while the other performers have been instrumentalists. This difference in the manner in which the music is produced could lead the musicians to use PCs in ways that are subtly different from each other, and that therefore have an effect on how they might recover from an error during live performance.

In summary, the pianist would be most likely to use expressive cues to recover from a memory failure during a live performance. Engaging the motor system benefitted all types of PCs equally. For the vocalist, under certain conditions it may be beneficial to engage the motor system when trying to begin playing from in the middle of the piece, but in other situations this movement could overload the system. Additional studies are needed to examine the differences in the ways in which instrumentalists and vocalists use PCs to begin playing from the middle of the piece, and determine in what situations movement helps recall.

4. REFERENCES

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