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"Total Inner Memory": Deliberate Uses of Multimodal Musical Imagery  
During Performance Preparation

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## Abstract

Imagery has long been considered an important part of music practice, yet its use in professional musicians' practice and teaching has not yet received a great amount of research attention. A participant observation study of a five-day masterclass for 11 expert pianists, given by the pianist and Alexander Technique teacher Nelly Ben-Or (NBO), examined deliberate multimodal musical imagery techniques in a real-world setting. The study aimed to generate an interpretive description of NBO's pedagogy, to investigate how pianists experienced and implemented her techniques, and to explore the possible mechanisms by which teaching according to these principles might work. Data collection incorporated observation, video documentation, interviews, notes, questionnaires and email correspondence. Thematic analysis was used across the corpus. NBO's pedagogy focuses on creating a clear image of the piece to be performed via multimodal imagery techniques and chunking strategies, which can be used during memorisation as well as to improve problematic aspects of performance. Imagery rehearsal may thus provide a means of managing complex tasks in discrete stages and lead to an enhanced sense of integration between intention and action, by diverting attention from the process of playing to the goal outcome, internalised as a multimodal representation. Deliberate imagery strategies were associated with positive outcomes but were also often experienced as challenging. The findings imply that these strategies can be taught and improved over time, their efficacy modulated by skill level and motivation. Overall, participants reported that imagery rehearsal led to improvements in technical facility, musical quality and memory security. Issues for further investigation and application in other domains are discussed.

*Keywords:* Music imagery; rehearsal; performance enhancement; multimodal integration; pianists.

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Expert pianists are expected to memorise a large and complex repertoire, but there is a lack of clear memorisation pedagogy and considerable variation in the amount and type of practice undertaken by experts (Jørgensen, 2002). Deliberate mental imagery rehearsal has been advocated as a potential means of enhancing memorisation and performance quality (e.g. Gieseeking & Leimer, 1932; Holmes, 2005), improving practice efficiency and reducing the amount of physical rehearsal required for secure performance (Gieseeking & Leimer, 1932; Freymuth, 1999; Connolly & Williamon, 2004). Some experimental evidence supports these views, although precise definitions of imagery rehearsal, and methods for measuring its effects, have varied. In general, a number of studies have found that imagery rehearsal plus physical rehearsal is equal to physical rehearsal alone (Theiler & Lippmann, 1995; Coffmann, 1990; Bernardi, Schories, Jabusch, Colombo, & Altenmüller, 2013), while others have found that imagery rehearsal plus physical rehearsal is superior to physical rehearsal alone (Rubin-Rabson, 1937, 1941). The term “mental imagery rehearsal” is adopted here, in preference to others such as mental practice or mental rehearsal, to express a vivid sense of the activity as an imaginative and constructive act. It also aims to better encapsulate the notion that mental imagery occurs during performance and that mental and physical processes cannot be entirely separated.

Deliberate imagery rehearsal techniques are accepted to be of value by many musicians, and have been shown by some studies to enhance learning (e.g. Rubin-Rabson, 1937; Driskell, Copper, & Moran, 1994). However, instrumental music pedagogy does not appear to incorporate their use widely (Holmes, 2005). Learning and memorisation skills are rarely taught explicitly

(Ginsborg, 2004) and mental skills training programmes are not widely applied within the performing arts (Hays, 2002; Clark & Williamon, 2011). While several types of mental rehearsal for music performance have been identified (e.g. Connolly & Williamon, 2004; Holmes, 2005), and a small number of detailed studies have investigated some of the ways in which musicians implement imagery techniques in practice (Holmes, 2005; Bailes, 2009), it is not yet clear how or to what extent the teaching and implementation of imagery techniques may benefit musicians. There is still much to discover about the nature and relative efficacy of specific techniques (Clark & Williamon, 2012) and how these might most effectively be incorporated into musical training (Wöllner & Williamon, 2007). The current paper describes and discusses an example of an imagery-based musical teaching method that specifically aims to facilitate memorisation and execution of pre-composed, notated music, which performers are required to translate into sound from memory during performance (Bailes, 2009).

Musical imagery is a form of musical thought (Bailes, 2009), and is understood to be multimodal (Keller, 2012), including auditory, motor and visual components. Musical imagery can occur “offline” (in the absence of overt performance) and “online” during performance (Keller, 2012; Bishop, Bailes & Dean, 2013). In fact, as several authors have pointed out, performance necessarily includes mental imagery processes (Bernardi et al., 2013; Connolly & Williamon, 2004), generated either deliberately or in automatic response to internal or external cues (Keller, 2012; Bailes, 2009). We here define mental imagery rehearsal as the deliberate internal generation of imagery in the absence of self-generated sensory feedback in the missing modality or modalities; imagery rehearsal may therefore occur with or without a score, instrument or auditory model, and in the presence or absence of overt movement. Recent neuroscientific research points to both overlaps and differences in cognitive processing between

mental and physical rehearsal that may help to explain some of the effects of imagery rehearsal. Evidence of cross-modal co-activation in trained musicians suggests that mental imagery can activate auditory and motor neural networks in the absence of perceptual input (e.g. Lotze, Scheler, Tan, Braun, & Birbaumer, 2003; Haslinger et al., 2005; Kleber, Birbaumer, Veit, Trevorrow, & Lotze, 2007) and may thus have a preparatory effect on performance in the missing modality.

For fluent expert performance with or without a score, multimodal mental representations of the music need to be securely encoded in memory in order to be recalled under performance conditions (Hallam, 1997; Chaffin & Imreh, 2002). Auditory, motor, conceptual, structural, visual and linguistic images may all concurrently contribute to performance (Williamon & Valentine, 2002; Mishra, 2005; Chaffin, Logan, & Begosh, 2009). The manner in which performers attend to different aspects of a musical image is likely to be context-dependent and idiosyncratic. Individual performers report conscious reliance on certain mental images more than others; for example, some musicians report vivid visual recall of the score, while others have no conscious access to a visual image of the text (Chaffin et al., 2009). The ability to imagine in various modalities varies widely, even amongst experts (Brodsky, Henik, Rubinstein, & Zorman, 2003; Highben & Palmer, 2004; Brown & Palmer, 2012), and the depth of processing of different types of image may vary depending on the performer, the nature of the task and the stage of learning - and potentially irrespective of the degree to which the mental representation of the music is consciously accessed by the performer (Chaffin et al., 2009).

Imagery and memory are closely linked; mental imagery is considered to be an important component of vivid remembering of past events, as well as of working memory rehearsal (Baddeley 1992, Greenberg & Rubin, 2003). Conversely, memory is a necessary component of

deliberate imagery, with both working memory and long-term memory contributing to imagery vividness (Baddeley & Andrade, 2000; Navarro Cebrian & Janata, 2010). Imagery has long been established as a mnemonic aid in associative memory (cf Bower, 1970), providing a strategy to remember complex verbal or visual material (cf. Morris, Fritz, Jackson, Nichol, & Roberts, 2005). Moreover, musical imagery ability is mediated by musical expertise (Aleman, Nieuwenstein, Böcker, & de Haan, 2000; Pecenka & Keller, 2009; Janata & Paroo, 2006), a finding that is mirrored in movement experts for movement imagery (cf. Malouin et al., 2009), suggesting that better knowledge of a stimulus or action may support imagery. Similarly, musical memory capacity is better in musicians (cf. Williamson, Baddeley & Hitch, 2010), which supports the intricate connection between memory and imagery. In the brain, processing overlap has been described for episodic memories and imagined future scenarios (Schacter, Addis & Buckner, 2007) for imagery and working memory of visual material (Albers, Kok, Toni, Dijkerman, & de Lange, 2013) as well as music (Herholz, Halpern, & Zatorre, 2012). Despite the known effects of imagery strategies for memorisation, these techniques are not widely or consistently incorporated into musical pedagogy, even though the memorisation of large corpi of musical material is important aspect of the work undertaken by musicians within the Western classical tradition. Arguably, by setting up a rich representation (or memory trace) that includes detailed information in multiple (somato-)sensory modalities, the memorisation process can be facilitated.

Some expert musicians are known to use various imagery strategies during learning (Giesecking & Leimer, 1932; Hill, 2002), including movement imagery (e.g. Holmes, 2005) and body awareness techniques (Davidson-Kelly, 2014). The use of multimodal imagery in learning presupposes a specific mechanism by which memorisation and performance are facilitated by

imagery techniques. The implication would be that by creating a multimodal representation through imagery rehearsal techniques, information in different modalities is integrated into a multifaceted unit, allowing for a reduced cognitive load when the representation needs to be recalled. This idea is in line with existing knowledge about chunking mechanisms (cf. Bousfield, 1956, Bushke, 1976), creating higher-level chunks by not only combining many elements (or notes) into meaningful units, but also including multiple modalities so that fewer chunks have to be retrieved. Moreover, the involvement of movement imagery and body awareness speak to the theoretical framework of embodied cognition, resting on the key assumption that the body is directly involved in the representation of movements rather than a passive perceiver and actor serving the mind (cf. Gallese, 2000; Wilson, 2002). By creating a clear mental representation that includes structural, auditory, visuo-spatial (keyboard) as well as movement information, only an integrated, embodied image of the music being performed would ideally need to be recalled during performance. Although the initial effort of memorising is increased by this practice, cognitive resources may be fully allocated to musical expression during performance, whereas these would otherwise need to be divided over multiple processes.

An example of a pedagogy that uses multimodal imagery to enhance learning is Nelly Ben-Or's approach. Nelly Ben-Or (NBO) is a distinguished pianist and a senior teacher of Alexander Technique (AT) who teaches deliberate, multimodal imagery strategies. NBO's pedagogy has not been systematically documented (although see Ben-Or, 1995; Brandes & Davis, 2007; Davidson-Kelly, 2014). AT proposes that by increasing awareness of body use, one can be trained to stop habitual patterns of misuse (Brandes & Davis, 2007), and that by learning to avoid unhelpful or damaging unconscious movement habits (i.e. superfluous movements and tensions) the body can be retrained to work more economically and effectively. In AT, deliberate



body imagery strategies are applied during preparation for action; during action, intention and execution are integrated in order to affect the perception of events and the outcome of intended results (McEvenue, 2002). NBO's principal aim is to find the simplest and clearest means to express musical intention at the instrument. In order to do this she applies AT principles to piano playing, proposing that awareness of how the body is used facilitates clear musical thinking - and equally, that clear musical thinking facilitates effective use of the body during piano playing. To this end, NBO teaches a sequence of deliberate imagery strategies for learning new material, for dealing with technical difficulties, and for enhancing performance. Her practice methods are especially interesting to study when investigating the use of imagery in memorisation of music, given that this is explicitly how she teaches memorisation.

In order to generate an interpretive description of NBO's pedagogy and explore the possible mechanisms by which teaching according to these principles might work, an in-depth observation of a five-day course was undertaken in July 2007, with the aim of identifying aspects of the method that were particularly useful for the participants. The study used a qualitative participant observation method (DeWalt & DeWalt, 2002) in order to elaborate more fully the nature of real world, deliberate imagery techniques used by expert musicians, and how they can be taught. The first author – a professional pianist with international performing experience, who had studied previously with NBO - participated fully as a member of the group, with complete disclosure as to the intended investigation (Bryman, 2012). Methods selected (particularly the adoption of an active participant role and the use of unobtrusive video techniques) were designed to minimize observer effects and to elicit explanations of “behaviors, intentions, situations, and events as understood by one's informants” (deMunck & Sobo, 1998) (i.e. by recording course discussion on video and by probing participants' views through the use of open questionnaires,

informal interviews and email correspondence). The descriptive findings were then interpreted from the perspective of a more generally assumed mechanistic model, with participants' responses used to inform the description of NBO's method and the exploration of long-term outcomes and possible mechanisms.

## **Method**

### **Participants**

Eight female and three male pianists attended the course in July 2007, including the first author. The participants gave written consent to be a part of the research. Towards the end of the first day of the course, the research project was briefly introduced, both verbally and in writing, and consent was procured for video registration. Table 1 shows more detail of the participants' main musical activities, years of playing, and previous experience with NBO's method.

**[TABLE 1 HERE]**

### **Materials and Methods**

Data collection incorporated observation, participation, the first author's handwritten notes, questionnaires, email correspondence with NBO and participants, video documentation of piano sessions, photographs, and video documentation of informal and semi-structured interviews – all of which were considered part of the participant observation process (Bernard, 1994). Three questionnaires contained a mixture of open and Likert-type pre-coded questions. Questionnaire 1 (Q1) contained questions about musical activities and self-ratings of specific skills. This was administered at the end of the first day and was completed by ten participants.

Questionnaire 2 (Q2) contained questions about the participants' experience of the course and how they expected their playing to be affected. This was administered at the end of the final day and was completed in full by nine participants, and partially by the tenth. In addition, both Q1 and Q2 asked participants to rate the importance of 12 learning strategies in their own practice. Questionnaire 3 (Q3) was sent out by email and post nine months after the course and was completed by seven participants. This follow-up questionnaire contained questions about how participants' playing had been affected by NBO's teaching, and asked whether they had increased, decreased or maintained the amount of time they spent using each of seven learning strategies<sup>1</sup> since beginning their studies with NBO. The questionnaires can be found in the Supplementary Materials, Appendix A.

As the participant observer role was a demanding one, video data were collected as an aide-mémoire and essentially functioned as components of the course notes (Bryman, 2012). Consent to video was given at the end of the first day, however, and course activity on this day was therefore documented via detailed handwritten notes. From the second day, all activity at the piano was recorded using a Sony DCR-TRV950E digital video device and via sparser written notes. The video camera was placed on a tripod between one and two metres to the left of the keyboard (the exact position varied in order to compromise between framing pianists' whole bodies and focusing on their hands); on the final day the camera was moved to the right of the keyboard, approximately one metre behind the pianist.

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<sup>1</sup> Twelve strategies listed in Qs 1 & 2 were reduced to seven in Q3. Two strategies - listening to recordings and visual imagery of the score- were removed because NBO had stated that she did not use them, and Qs 1 & 2 found that the course had no impact on participants' use. Four strategies – analysing content, understanding form, thinking about mood and narrative – were merged into the single category 'analyse/explain' in keeping with NBO's training approach. NBO's terminology for learning strategies was adopted in Q3.

The day after the course, a semi-structured interview with NBO explored her learning history and her views on learning and memorisation. Informal interviews with three pianists during the course provided a means of probing issues arising from the observation and cross-checked for shared understanding with other participants’ perspectives (Colwell, 2006). All interviews were videoed. During the analysis phase, brief email correspondence with NBO and two participants provided clarification where required.

### **Data Analysis**

Qualitative data were labeled according to their source. Handwritten notes made throughout the course will be referred to as “Notes”. Discussion and events recorded on video were transcribed and are cited as “Video transcript”. Data from the informal interviews with three participants are labeled “Informal interview”, and data from the semi-structured interview with NBO referred to as “NBO, Interview”. Finally, email correspondence with NBO and two participants took place during the data analysis phase (“Email correspondence”). For data analysis, numerical data generated by Likert-type questionnaire responses were explored in descriptive terms through tabular analysis. All video footage (approximately 25 hours) was reviewed and a new set of notes, detailing video time points and observations, was prepared. Course notes and interview recordings were transcribed, and open questionnaire responses were tabulated. Then, all sources were combined and an iterative process of thematic analysis was used across the entire data corpus. Thematic analysis is a method for identifying, analysing and reporting patterns (themes) within data and interpreting various aspects of the research topic (Braun & Clarke, 2006). Here, the data were initially coded using “in vivo” terminology used during the course. Themes were identified, and coded data were assigned to thematic categories.

As the thematic mapping of the analysis became clear, the analysis was re-worked, re-coded and interpreted in accordance with the literature on music psychology and expert learning.

## **Results**

In order to describe and discuss NBO’s pedagogy, we will first give an overview of the key elements that were observed in the 5-day course, followed by the data from participants concerning their experience and the long-term outcomes of their participation in terms of their practice habits.

### **Key Elements**

From the thematic analysis bringing together different types of observational data and interviews, the key features of NBO’s teaching were identified. The main concept that drives the pedagogic method is prior memorisation (or total inner memorisation), carried out before any kind of physical rehearsal. To accomplish this, mental imagery techniques are taught that include multimodally integrated imagery (i.e. mental images containing auditory, motor and visual aspects in an integrated manner), chunking of the auditory image and visuo-spatial imagery. These imagery techniques can be used during prior memorisation, but also when encountering technical difficulties during rehearsal. Also, focus is given to so-called psycho-physical performance enhancement, which focuses on clarity during initial learning, psycho-physical re-education, how physical clarity can lead to enhanced listening and how physical ease affects mental clarity and vice versa. Here, AT principles are applied to piano playing to enhance performance. These concepts will be briefly explained in turn, with descriptive examples added in the Supplementary Materials, Appendix B.

**Prior memorisation, or ‘total inner’ memorisation before physical rehearsal.** Total inner memorisation refers to the process whereby a detailed representation of the musical piece is built up away from the piano, using the score and identifying musically meaningful units, thereby reducing the time needed at the piano to learn the piece. This representation is created using deliberate rehearsal of multimodal mental images that include visual, motor and auditory aspects. For NBO, the memory that is developed during imagery rehearsal is “[...] a kind of memory that includes an inner sense of the action of playing that music which I see [and it] has to include a vision of the keyboard. Otherwise I’ll come to the keyboard and the vision of the keyboard will confuse me.” Furthermore, “[T]he mental image includes the image of each happening on the keyboard, which includes a sense of the layout and how the hand proceeds on it, how it walks and runs around it, so that becomes a kind of total memory.” (NBO, Interview.) While acknowledging that some other musicians do find it useful to memorise the score visually, NBO does not. She relies on a secure and detailed structural image, or mental map: “There are lots of details, lots of points that have to be in my inner map.” (NBO, Interview). Interestingly, during the course, NBO stated that she did not imagine movement in her fingers, but “much deeper inside” (Video transcript). On further questioning, NBO explained that she does not “imagine finger movements, though I am internally aware of their situation within the music’s structures.” (NBO, Email correspondence). NBO proposes that physical rehearsal should occur only once the material has been explored and understood, and at a point where memorised mental recall is fluent. She argues that getting to know the music should be “the most important aspect, and then the mechanics of playing [...] [are] the last bit that has to be dealt with.” (NBO, Interview).

**Deliberate imagery techniques.** Alongside the explanation of the material, NBO advocates the use of deliberate imagery techniques (to which she refers as “techniques of mental representation”). Auditory, structural and visuo-spatial imagery, combined with whole body imagery, featured most prominently in the course; when technical difficulties arose during playing, NBO only occasionally advocated planning finger sequences and usually preferred visuo-spatial imagery for technical problem solving. These techniques are used during the initial learning phase but may also be applied to the rehearsal phase. In this way, the pianist may be able to create, integrate and manipulate multidimensional mental images of the score and of its performance without actually playing on the keyboard. Themes identified within the imagery techniques were the multimodal integration, and specifically the inclusion of visuo-spatial imagery, which does not appear to have been investigated experimentally and has only been rarely documented (although see Holmes, 2005). By visualising the patterns of the consecutive piano keys alongside the sound, the focus is thought to shift from that of technically difficult movement to the music that results, in other words, to the intended effects of the movement rather than the movement itself. NBO explicitly uses the method of chunking musical materials, by first identifying manageable sub-units within complex material, which might eventually be organised as one chunk. Once all sub-units have been clarified, the group of sub-units is multimodally re-imagined, reconstituted as one whole unit (chunk), and the organisation of the material thereby returns to the meaningful phrase level.

**Psycho-physical performance enhancement.** Finally, psycho-physical performance enhancement is a concept that relies heavily on AT principles, emphasizing that AT is about awareness of mind, and that the mind becomes clearer when the body is not engaged in “unnecessary reactions”. NBO advocates a style of playing which involves no excess physical

movement. There is no sense of restricting movement, rather of moving as simply as possible in order to produce the required sound. By creating a clear mental image of various aspects of the music, decisions about performance may be made before the difficulties of physical performance impose restraints on the intended performance, possibly incorporating tensions and unhelpful habits into the learning. By attending to bodily tensions that pianists show while playing, NBO aims to “psychophysically re-educate” the body in performing fewer unnecessary movements. By increasing the “clarity” of the movements, NBO aims to increase the attention that can be paid to listening and focus. Taken together, the claim is that by imagining musical material clearly, the physical aspects of performance will be facilitated, and if the player learns to perform without excess tension or unnecessary movements, this will support their clarity of mind in imagining the musical material.

### **Participant Experience**

Thematic analysis of open questionnaire responses found that a variety of factors affected the extent to which participants were able to successfully adopt the prior memorisation approach. Prior memorisation was difficult for all those with less experience of imagery rehearsal, and impossible for an amateur player with little aural and analysis training. The two respondents who already had extensive experience of imagery rehearsal found it easy: one had several years’ experience of using NBO’s techniques, and the other, although new to NBO’s training, had extensive experience of using analysis and imagery rehearsal during learning, advanced composition and singing training, and excellent aural skills. The suggested procedure was only possible for those with adequate technical, sight-reading, aural and theoretical skills and required the ability to maintain mental focus and the motivation to spend time practising a new approach. Respondents generally found that learning material away from the piano required time, patience



and motivation, commenting that “It requires enormous (+ rewarding) time, effort and concentration.” (P10, Q3); “[I]t is really difficult to change 17 years habit...” (P6, Q3); “It is extremely challenging to study and memorise a piece with little familiarity with it beforehand. I have trouble hearing the music in my mind when reading the score of a piece that I am not quite familiar with.” (P11, Q3); or “I’m too lazy to do it. This is a higher form of technique!” (P4, Video transcript).

Participants reported that adopting physical aspects of NBO’s approach gave them greater freedom to connect with the music and to think more clearly (Video transcript, Q2, Q3). Interestingly, although pianists were taught to become more aware of how they used their bodies, they reported that NBO’s approach helped them to focus their awareness on the sound and the instrument and that their focus on the body’s movements actually decreased. All participants reported that the concept of “doing only what is necessary” (P2, Q3) was a central benefit of NBO’s teaching: “[U]nderstanding the difference between doing too much and doing only what is necessary” (P2, Q3); “[U]sing only the movement crucial to making the desired sound, much other movement is in many ways wasted effort” (P8, Q3); “[P]aying close attention to what the body is doing” (P10, Q3); “The concept of playing with only the necessary physical movements, so that the body is quieter and better listening can occur” (P10, Q3). Furthermore, several participants reported that NBO’s approach helped to enhance their connection with the music and, consequently, with the self: “[I took part in the course] [t]o liberate my playing further and therefore arrive more at myself and my perception of the music [sic] (P2, Q1); “[...] get back into the contact with music/piano/myself” (P10, Q1); “NBO’s approach to music [...] enables a really profound connection with it” (P10, Q2).

**[FIGURE 1 HERE]**

Comparisons of questionnaire ratings at the beginning and the end of the course (Q1 and Q2) explored how much the course had affected attitudes towards 12 different learning strategies and examined which strategies had been most affected, as shown in Figure 1. At the beginning of the course, practising on the piano was ranked as the most important learning strategy. At the end of the course, practising on the piano was ranked, on average, seventh in order of importance (even though the mean score was marginally increased). At the end of the course, mental strategies were ranked in the following order: imagery of keyboard, analysing content, understanding form, auditory imagery, movement imagery, visual imagery of hand position, visual imagery of score. Ratings of all imagery strategies explicitly taught by NBO increased to a greater extent than ratings of strategies not taught during the course (associative imagery of mood or narrative; listening to recordings) or which NBO stated she did not use (visual imagery of score). According to these responses, at the end of the course participants felt that the most important strategies were visuo-spatial imagery of the keyboard, deep learning (analysing content, understanding form), and auditory imagery; movement imagery, actual movement and “mood” were slightly less important; the least important strategies were visual imagery of the score, associated narrative and listening to recordings.

**Long-term Outcomes**

All respondents to the follow-up questionnaire (Q3) had adopted some of NBO’s recommendations, but no-one followed her learning sequence exactly. The majority (5 out of 7) preferred to work in sections rather than to memorise a whole piece prior to playing on the instrument. The only player who reported learning whole pieces from memory before playing

had modified what NBO herself reported doing. This respondent avoided an initial play-through at the piano due to poor reading skills, and two others reported that for particularly complex music they also preferred to use analysis before any playing took place. Physical practice time had decreased (five respondents) or had been maintained at levels similar to those prior to the course (two respondents, both of whom were students on advanced conservatoire courses at the time of questioning) (see Table 2). Six out of seven Q3 respondents reported that, since beginning their studies with NBO, they had increased the amount of time they spent analysing or “explaining” the musical material and imagining sound (both with and without the score). The seventh maintained previous (high) levels of these activities. Six pianists reported increased use of keyboard imagery and four their imagery of hand positions. Four pianists maintained previous levels of movement imagery and two increased its use. One participant, who was one of the less experienced players in the group (P11), reported being unable to use some of the mental imagery techniques.

**[TABLE 2 HERE]**

Participants reported that NBO’s approach helped them to reduce physical tension, to reduce tiredness and to prevent technical difficulties. Understanding and being aware of movement appeared to lead to greater control and to a reduction in physical effort: “She made me pay attention to quick ease of muscle tension after making a finger move [sic]. In fact it helped me in my deep inner understanding of move [sic] and opened the way to the better control.” (P4, Q3); “[I] used to suffer from tendon pain and numbness after long periods of practising. This is now eliminated.” (P5, Q3) While all participants reportedly considered all

aspects of the prior memorisation approach to be beneficial, not all participants felt that the benefits outweighed the difficulty of applying the method in full and no one had adopted the process exactly. All participants reported having adopted some aspects of NBO’s approach, but the majority reported learning unfamiliar music in sections, either learning and memorising away from the piano and then playing on the piano, or combining periods of learning and memorising away from the piano with periods of learning and memorising at the piano. Some participants commented that applying the method required significant discipline: the physical act of playing is important and enjoyable, and, especially when time was limited, pianists were likely to choose playing in preference to mental imagery rehearsal: “I have got only 2 hours a day to practise, so I want to play also as I do need playing in order to keep my limbs moveable.” (P2, Q3); “I combine NBO’s approach with work on the piano. I do not learn the whole piece by memory, but small parts and then play these parts on the piano - I am too impatient otherwise.” (P2, Q3).

However, several pianists did also report knowing a piece more clearly when it had been thoroughly memorised prior to physical practice and some participants reported enhanced memory security. Participants at both virtuoso and amateur level who had previously memorised, successfully, via repeated playing stated at the end of the course that their learning would be enhanced by working away from piano: “It [prior memorisation] changes the quality of awareness of the piece” (P6, Q3); “It helps in better learning – helps to see more sharply all nuances” (P4, Q3); “I am more secure and have less memory mistakes [sic]” (P6, Q3); “These pieces stay in my head and I can refresh my memory very quickly. They are very reliable.” (P2, Q3).

### **Discussion**

The current work aimed to shed light on the use of imagery in music pedagogy, specifically concerning music memorisation. To investigate a real-world situation in which imagery is used as a pedagogical tool, a 5-day course for pianists was described using a participant observation study. As key elements of the teaching, pianists were taught: 1) to use prior memorisation, a technique in which learning and memorisation occur away from the keyboard, prior to rehearsal on the instrument; 2) to use mental imagery techniques, both during prior memorisation and when encountering technical difficulties during rehearsal; and 3) to enhance performance by applying AT principles to piano playing. NBO's imagery strategies were found to be easier for more expert players and were reported to improve with practice over time, and were thus identified as acquired skills that can be taught. A number of factors mediated their successful adoption, including skill level and motivation. Participants reported that deliberate musical imagery rehearsal, combined with whole-body awareness, provided a means of managing complex tasks in explicit stages and led to an enhanced sense of integration between intention and action, greater technical control, reductions in physical effort, and improvements in musical quality and memory security. Nine months after the course, most participants had changed their practice habits.

The data from the questionnaires administered at the start and the end of the course highlight that during the course, participants altered their opinions concerning the importance of different learning strategies for memorisation and performance improvement. The strongest increases were seen for visuo-spatial imagery of the keyboard and imagery of movement, whereas no real change was seen for actual practice at the piano or the visual imagery of the score. These changes likely reflect the specific focus of NBO's teaching, and specific aspects

that may have been new to the participants, but that had gained their interest. It should be noted that none of the strategies were seen as decreasing in importance, although the relative importance changed after the course. In the follow-up questionnaire after nine months, the majority of the respondents had integrated some aspect of the teaching into their practice, although none did so exactly as they had been instructed at the course, and some reported that it was difficult both to change their habits and to acquire the imagery skills that are necessary to use the techniques that NBO had taught. The implications are that although the proposed mechanism, namely the construction of a highly structured, multimodal inner representation may be very useful in memorising and performing complex musical material, even limited adoption of these principles was useful to the course participants. However, the biggest drawback to fully use the techniques was the effort that was perceived to be necessary to achieve prior memorisation. The finding that pianists in this group who had experience with this method (or were otherwise skilled at imagery techniques) reported fewer of these problems implies that this skill may be developed, although the small participant sample precludes strong conclusions based on experience. Issues with imagery ability are also common in mental rehearsal methods used for motor rehabilitation (Malouin & Richards, 2010), and interpersonal differences in imagery ability are often assumed but rarely explored (although see Clark & Williamon, 2012; Malouin et al., 2009; Gregg et al., 2011).

NBO's teachings imply that successful memorisation consists of the creation of a rich, multimodal representation of a musical piece that is built up into meaningful chunks by first creating accurate representations of smaller units. Moreover, the use of efficient movement - removing any excess tension or non-essential movement - is thought to bring extra clarity to this representation, which underwrites the close connection of the physical and mental aspects. In

contrast to the more common practice of initially learning via physical rehearsal, NBO's teaching prioritises imagined rehearsal of the musical material. Explaining the material – identifying patterns and their meaning – is a “deep” learning approach (Cantwell & Millard, 1994) and takes place before the specific motor programmes required to perform it are explicitly encoded and rehearsed. Many performers incorporate score study at some stage during the memorisation process (Hallam, 1997) but NBO argues that study of the written text should take place after only a very brief preview of the material at the keyboard; she advocates playing through the piece from the score to get a sense of how the piece sounds, but only once or twice, so that the pianist does not inadvertently encode a motor memory of the music.

The pedagogy is centered on the concept of clarity, with the intention of reducing the cognitive load during musical performance through a higher quality of knowing or understanding the piece. The integrated representation apparently allows more attention to be directed to expressive performance goals rather than to technical aspects of playing. Focusing on what has to happen to the instrument rather than the body may lead to a greater sense of connection with the sound. Milton, Small, & Solodkin (2008) argue that, for optimal motor performance, attention should be diverted away from the process of its performance. In a review of studies examining attention to movement, Wulf & Prinz (2001) found that paying attention to the external effects of movement, rather than to the movement itself, enhances learning. For musical performance, Highben & Palmer (2004) suggest that performers should focus on the sound, not on the actions that produce the sound. According to common-coding theory (Prinz, 1997), perception and action require a common representational medium. Thus, actions will be more effective if they are planned in terms of their intended outcome or effect, rather than in terms of the specific movement patterns (Wulf & Prinz, 2001). This notion fits with what is known about

how goal-directed movements are imitated (Wohlschläger, Gattis & Bekkering, 2003) as well as with how the brain implements the various stages of movement planning and execution (Grafton & Hamilton, 2007). In this context, ideas have been put forward distinguishing perception-guided from so-called idea-guided movement (Ondobaka & Bekkering, 2012), which is especially interesting in the context of piano performance (or music more generally), given that the more distal idea of the music is the actual goal rather than the mere depression of keys. By using deliberate imagery rehearsal before physical rehearsal, NBO prioritises non-motor aspects of the task. In other words, the initial encoding directs attention towards the results of motor performance: the structured musical intention, the sound, and note patterns on the keyboard. NBO's students reported that by using her approach they reduced their focus on physical action and increased their focus on sound and on the instrument: “[Memorising before playing enables the pianist to be] freer while performing, it decreases the unnecessary body movement, it helps focusing more on the sound, being more connected with the instrument” (P6, Q3). The effective (“economical”) encoding of motor programmes may be enhanced when material is pre-learned: several aspects of the task have already been automated, thus reducing cognitive load and enabling the performer to focus on minimising movement and on the distal effects of that movement. By reducing movement and tension to the optimal minimum, more attention may be available for performance outcomes (i.e. the expression and manipulation of expressive intention, as embodied in the sound).

In considering the use of imagery techniques for pedagogical purposes, the observational study provides support for the use of imagery in piano memorisation, but also inherently has some limitations in terms of answering theoretical questions about pedagogy. Firstly, the study was of a descriptive nature and as such did not compare any conditions or manipulations. It did



not use a random sample of pianists but rather a self-selected group who were already interested in the pedagogical approach. Findings (themes) were identified through the interpretative analysis of a variety of data. Finally, although differences between participants that may be related to specific types of expertise (such as good aural skills) appeared meaningful, the sample size was not sufficient to fully address the heterogeneity of the students. Future work will need to address the scientific questions that arise, for instance concerning the efficacy of multimodal, integrated imagery as compared to single modality imagery, whether there are large interpersonal differences in terms of imagery skills and whether those may be addressed with specific teaching methods. It is clear that NBO's teaching, informed by AT concepts, includes a very distinct way of approaching the body and movement, and introduces the concept of physical clarity, which could be further explored to gain a better understanding of what such physical clarity entails. Other, more specific ideas for future work include testing the use of non-motor imagery by advanced musicians to encourage focus on distal effects, or the testing of a condensed imagery of the keyboard (see Appendix B) to improve the performance of complex music. A different aspect of the current study that can be further explored is the possible carry-over from this methodology to other interventions that make use of imagery, such as high-level skill acquisition in sports (cf. Cumming & Hall, 2002), other skilled movement domains such as surgery (Cocks, Moulton, Luu, & Cil, 2014) and rehabilitation methods (cf. Malouin & Richards, 2010). The use of inner simulation to gain a better understanding of something to be learned (or relearned after injury) may lead to innovations in paradigm design in other settings.

Imagery has long been considered an important part of music practice, yet its use in professional musicians' practice and teaching has not yet received a great amount of research attention. With the current study, we aimed to add to the existing knowledge of the real-world

applications of imagery techniques in music memorisation and performance. In this way, deliberate mental rehearsal of multimodal, structured units within a large, complex musical piece might lighten the cognitive load in recalling the music and assist in producing efficient and fluent movements in performance. Although the development of imagery skills may require effortful practice, these skills appear to provide the performer with an opportunity to substantially improve their sense of understanding of a musical piece, which may in turn lead to improved memory security and musical quality.

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Tables

Table 1

*Showing participant details, self-description of performing status and activity, and previous contact with NBO.*

P <sup>1</sup>	Sex	Age	Start Age	Years Playing	Self-Description	Main Activities <sup>2</sup>	Previous NBO Contact
1 <sup>3</sup>	F	40	6	34	Professional	EP; PT	Yes (courses, lessons)
2	F	36	5	31	Professional	SP; PT	Yes (courses, lessons)
3	F	29	7	22	Professional	EP; MT	Yes (course)
4	M	25	7	18	Professional	SP; PT; IC	No
5	M	30	7	23	Professional	SP; PT	Yes (courses, lessons)
6	F	21	5	16	Student	PS	Yes (course)
7	F	25	5	20	Student	PS; IC	No
8	M	19	7	12	Student	PS; IC	No
9	F	58	10	48	Teacher	O	Yes (course)
10	F	68	9	59	Teacher	PT	Yes (course observer)
11	F	44	8	36	Amateur	PS	No

<sup>1</sup> Participant number

<sup>2</sup> Ensemble Performance (EP); Solo Performance (SP); Piano Tuition (PT); Musicianship Tuition (MT); Piano Study (PS); International Competition (IC); Other classes (O).

<sup>3</sup> Denotes first author

Table 2

*Showing the number of participants who reported at follow-up that time allocation to practice strategies had increased, decreased or remained the same since beginning studies with NBO, or that strategies were not adopted (Q3) (n=7)*

Strategy	Increased	Decreased	Equal	Not adopted
Imagine sound + score	6	0	1	0
Analyse content	6	0	1	0
Imagine keyboard	6	0	0	1
Imagine sound - score	6	0	1	0
Imagine hand positions	4	0	2	1
Imagine movement	2	0	4	1
Piano practice	0	5	2	0

Figures

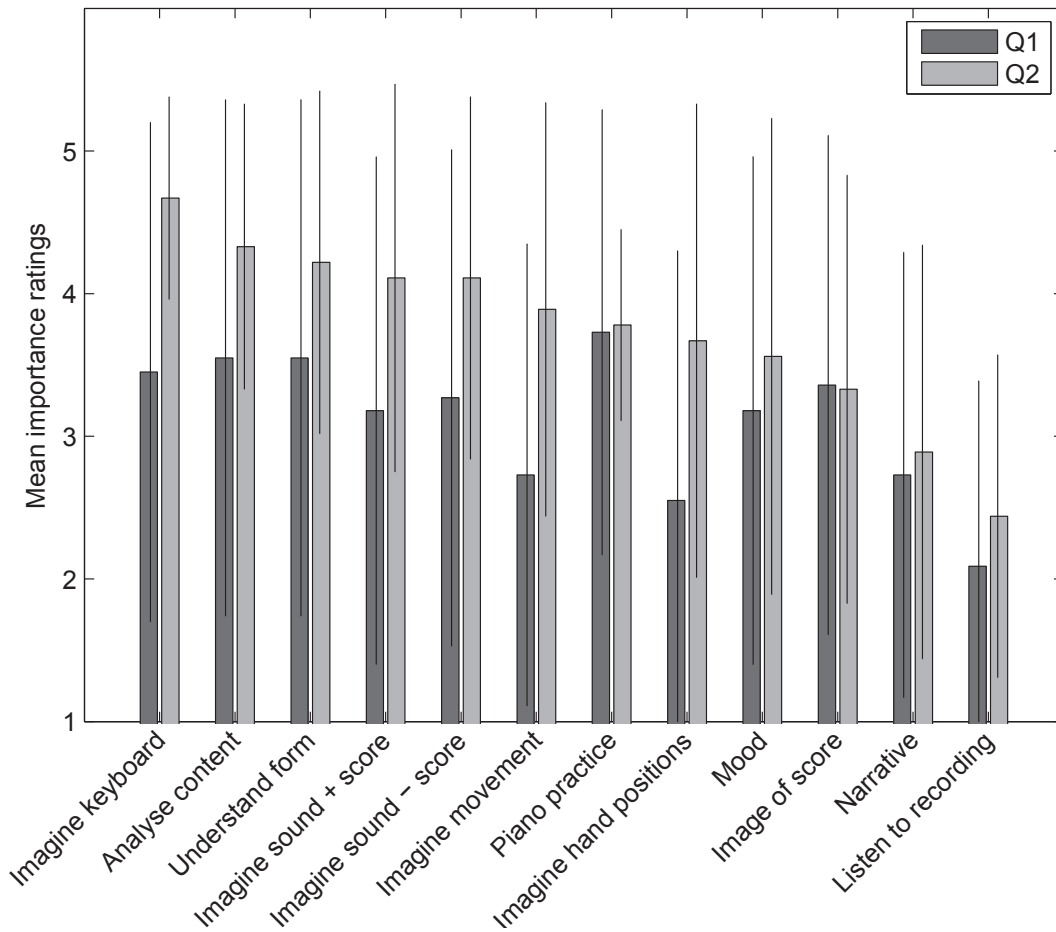


Figure 1. Bar chart showing averaged ratings (with error bars denoting SD) of 12 learning strategies at the beginning (Q1) and end (Q2) of the course, rated on a 5-point scale where 1 = “not important” and 5 = “very important” (n=10) and ranked for rated importance after course completion.

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