The effects of altering environmental and instrumental context on the performance of memorized music

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ABSTRACT Three experiments investigated whether musical memory was context-dependent. Instrumental musicians memorized music in one context and recalled in either the same or a different context. Contexts included atypical performing environments (Experiment 1: lobby/conference room) or commonly encountered environments (Experiment 2: practice room, professor's studio, stage). Experiment 3 extended the definition of 'context' to include instrument. Pianists memorized and recalled on either a grand piano or an upright. In Experiment 2, memory was not significantly different when the learning environment was altered; however, significant context effects were found in Experiments 1 and 3. A memory preference for the one context was discovered in Experiment 1, while in Experiment 3, musicians who memorized and performed on the same piano recalled significantly more than musicians who changed pianos. Some evidence exists for context effects in music; altering the environment at performance may lead to retrieval failure.

KEYWORDS: *context-dependent memory, environment, forgetting, memorization, musical performance, pianists*

Nearly every musician, at one time or another, has been expected to prepare a piece of music to be performed from memory; in particular, pianists and vocalists memorize music on a regular basis. Despite widespread experience with memorization, the process of committing a piece of music to memory is not greatly understood. Nor are the reasons for apparently arbitrary memory slips in performance, which occasionally occur. These seemingly random memory lapses may result in increased anxiety and reluctance or refusal to perform from memory. Yet, memory failures seem to be accepted as inevitable, and the only defense, though not a perfect one, is sheer repetition. So accepted is the inevitability of memory lapses, few have thought to question why they happen. The purpose of this study is to investigate one reason memory lapses may occur during performance.

Encoding music

Research into musical memorization has been concerned predominately with the encoding rather than the retrieval process. Initially, researchers sought to test experimentally various strategies and procedures to facilitate memory. Strategies tested included: whole and part strategies (Brown, 1928; O'Brien, 1943; Rubin-Rabson, 1940), practicing hands separately/together (Brown, 1933; Rubin-Rabson, 1939), the use of aural, visual, or kinesthetic memory (Nuki, 1984; O'Brien, 1943), analysis of music (Jones, 1990; Reynolds, 1975; Rubin-Rabson, 1937; Ross, 1964; Schlabach, 1975), blocking chords (Nellons, 1974), instruction in memory or the memorization process (Bryant, 1985, Ross, 1964, Williamson, 1964), listening to an aural model (Buckner, 1970; Rubin-Rabson, 1937; Schlabach, 1975) and use of incentives (Rubin-Rabson, 1941.) Results from experimental studies have been mixed and a panacea for quick musical memorization has not emerged. For instance, Rubin-Rabson, (1937) and Ross (1964) found a pre-performance analysis of the piece facilitated memorization, but Reynolds (1975), Schlabach (1975), and Jones (1990) found no effects from analysis.

Recent researchers have focused on understanding the process of memorization through interviews (Aiello, 2000; Gruson, 1988; Hallam, 1997) or qualitative observation of expert musicians in naturalistic environments (Chaffin et al., 2002; Ginsborg, 2002; Lehmann and Ericsson, 1998; Miklaszewski, 1995; Nielsen, 1999; Williamon and Valentine, 2002). Quantitative, qualitative case-studies, and interview data are beginning to coalesce and commonalities are emerging.

Among expert musicians, there was a widespread use of segmentation generally influenced by the formal structure of the piece (Aiello, 2000; Chaffin et al., 2002; Ginsborg, 2002; Hallam 1997; Miklaszewski, 1989, 1995; Miklaszewski and Sawicki, 1991; Nielsen, 1999; Williamon and Valentine, 2002). In early research, musicians were restricted to either whole or part strategies, but musicians do not appear to use one or other strategy exclusively; Musicians vary the strategy depending on the nature of the music and over time. The holistic strategy, where the piece or section is repeatedly performed in its entirety, may be used for short, uncomplicated music, while longer, technically difficult pieces, or more difficult sections within a piece, may require the isolation and dedicated attention to smaller segments. Segment size may be related to task difficulty with more difficult sections requiring the practice of smaller segments, while less challenging sections may be longer (Chaffin and Imreh, 1994 and 2000; Miklaszewski, 1989; Nielsen, 1999). It is also common for musicians to alternate between intensive sectional work and performances of the entire piece or section (Chaffin and Imreh, 2000; Chaffin et al., 2002; Hallam 1997; Miklaszewski, 1989, 1995). In addition, segment size lengthens over time as the piece begins to take shape and a concert performance nears (Miklaszewski, 1995) and as practice progresses, the musician performs more complete repetitions of the work with less work on isolated segments. Segment length also increased with practice (Mikleszewski, 1995). The musicians' focus also shifts from technical issues such as fingerings to more interpretative and then expressive concerns (Chaffin et al., 2002; Mikleszewski, 1995).

Skill level has been found to affect the use of memorization strategies. Gruson (1988) found that the use of repeating sections and playing hands separately increased with skill level as did uninterrupted playing. Gruson (1988) also found that the amount of material repeated following an error also changed; novices tended to repeat only one note or a measure, but more advanced musicians were more likely to repeat a structural unit. The advanced musicians were organizing their practice of the piece based on formal structure rather than proximal or visually defined groupings. Expert musicians reported using a cognitive analysis of the structure of the piece to aid memory for a difficult piece, while more automated strategies were used for short, simple pieces. On the other hand, novices never reported using analytical strategies. (Aiello, 2000; Hallam, 1997).

While much is now known about how musicians encode music into memory during practice, little is known about why musicians forget music during performance. The fear of forgetting during performance produces a great deal of anxiety in musicians and may lead to hours of extra practice. However, memory lapses may occur despite this practice. One theory of forgetting that some psychologists have been pursuing may have implications for musicians; that memorized material is linked to the environment in which it is learned. This context-dependent memorized material is then difficult to retrieve if the environment changes.

Context-dependent memory

The theory that memories may be context-dependent was proposed by McGeoch in 1932. Material learned in one context may be dependent on that context for retrieval; attempting recall in an alternative setting may result in apparent forgetting of material. In a study that sparked the interest and imagination of psychologists, Godden and Baddeley (1975) tested members of a scuba diving club for memory of a list of words. The participants either learned the words while dry, sitting on the dock (D), or wet, while sitting underwater in their scuba equipment (W). All participants heard a list of words played over an ear piece. Later, the participants were asked to freely recall the list of words either in the same context in which they learned (DD and WW) or in a different context (DW and WD). While there were no significant main effect differences (divers were able to recall effectively in both wet and dry conditions), there was a significant interaction. Participants who learned and recalled in the same environment, regardless of whether that environment was wet or dry, recalled more words than participants who changed contexts. Godden and Baddeley's results have been supported by a large number of researchers (see Smith and Vela, 2001 for a review).

Other researchers have expanded the concept of context to include not only the physical environment, but also the musical environment (Balch and Lewis, 1996; Balch et al., 1992; Smith, 1985), internal contexts such as mood-states (see Eich, 1995 for a review), drug states (e.g. Eich et al., 1975), speaker's voice (e.g. Geiselman and Glenny, 1977), aural versus visual presentation mode (e.g. Pessin, 1932) and body posture (e.g. Rand and Wapner, 1967). Although most research studies have focused on memory for verbal information, some have investigated other types of memories such as perceptual-motor task acquisition (Anderson et al., 1998; Wright and Shea, 1991), faces (Dalton, 1993) and time estimations (Block, 1982).

However, context effects have been elusive and unpredictable. Fernandez and Glenberg (1985) attempted to replicate findings of an earlier study (Smith, 1979); using contexts similar to the original, but were unsuccessful. After many attempts, the researchers finally found a significant interaction between context and serial position. Participants who were in the same context for both learning and testing recalled more words from the beginning (primacy) and the end (recency) of the list than participants who were in different contexts for learning and testing. However, an attempt to replicate this interaction failed. One possible explanation for the elusiveness of context effects is the difficulty of defining 'context'. Even when context is restricted to the physical environment, the salient characteristics can only be assumed and altered. To affect retention, the contexts must be perceived by the participants to be qualitatively different. Further, training may allow environmental effects to be suppressed when performing a memory task (Glenberg, 1997).

To determine whether context effects were reliable, Smith and Vela (2001) conducted a meta-analysis using 93 environmental context studies. They found evidence of an overall memory advantage when recalling in the learning environment. Smith and Vela also attempted to add to the understanding of when context effects could reliably be predicted. Associative tasks showed smaller context effects than non-associative memory tasks, and longer retention intervals (one day to one week) were more likely to elicit context effects.

Despite the difficulties that remain in understanding context effects, sufficient evidence exists that recall may be diminished if attempted in an alternative context. While music has been used to affect mood states and as part of the background environment, memorization of musical material has not been investigated for context effects. This question is particularly important as musicians commonly memorize music in one context, such as a practice room or another space reserved for musical rehearsal, and then recall the musical material in performance on a concert stage. An auditorium generally has vastly different physical features from a practice room. The purpose of this article is to report on three experimental research studies, which investigated the extent to which memory for music was context dependent.

Method

The procedures utilized in each of the following experiments follow the well-defined procedures for conducting research into context-dependent memory.[1] Participants memorized music in one context (learning context) and then performed an incidental memory task in either the same or different context (recall context). Incidental memory tasks are standard in studies of context-dependent memory to control for silent practice effects during the retention interval and to acclimate participants to a novel environment if applicable. To further suppress silent practice, the musicians were unaware that a final memorized performance would be required.

Participants were allowed to use any memorization strategy desired and were allowed as much time as necessary to memorize the exercise to a criterion of one complete, errorless performance. Before the study continued, the accuracy of memorization was verified by the researchers. Participants who performed the exercise incorrectly were shown the error(s) and asked to perform the entire exercise again from memory or to continue practicing.

Following regular procedures of context-dependent memory research, all participants were removed from the original context and directed to a novel environment. In the present studies, musicians were given a short (10-minute) rest period before being returned to the learning context or directed to a new environment. Following completion of the incidental memory task, musicians were asked to perform as much of the memorized piece as possible.

Experiment 1

PARTICIPANTS

The participants were 10 university music education majors, seven females and three males. Four were vocalists and six were instrumentalists. Each participant was randomly assigned to one of two learning contexts and one of two recall contexts.

MATERIALS

A 16-bar exercise was adapted from *Watkins–Farnum Performance Scale* (WFPS) (Watkins and Farnum, n.d.), Exercise 5. This exercise was technically simple for the musicians with primarily step-wise motion and a range of approximately 1–1/2 octaves. The exercise was equated for difficulty across the instruments and vocal qualities and exercises were transposed as necessary. Vocalists were instructed to memorize the piece using either *solfège* syllables or numbers (either fixed or movable *do*). The correct use of syllables was not considered when scoring the performances. Vocalists were also provided with a tuner that could be used to check sung-pitches if desired.

PROCEDURE

To control for the effects of familiarity, the contexts chosen for this experiment were atypical of musical practice and performance environments. Participants were asked to memorize the exercise in one of two contexts: an auditorium lobby (Context A) or a conference room (Context B). Context A was the mezzanine floor overlooking a large, open auditorium lobby. One side of the mezzanine was enclosed and contained doors opening into the balcony of the auditorium, the other side was open with a low metal railing. Glass and metal sculptures were suspended above the lobby at approximately eye level from the mezzanine. The lobby was predominately white with a white and grey stone floor. The mezzanine itself was carpeted and included two padded benches. A music stand was added to the environment for the purposes of the study. Context B was a conference room that included a long, wooden table flanked by large, comfortable office chairs. The room was carpeted and decorated with large posters of theatre productions. The room included a small kitchenette and a media center. The participants had never performed in either context. Participants learned and recalled either in the same context (Conditions AA and BB) or in alternative contexts (Conditions AB and BA).

RESULTS

Three judges scored the recorded recall attempts for pitch and rhythmic accuracy. The unit of measurement was the beat with each correctly performed beat receiving two points: one for rhythmic accuracy, the other for melodic accuracy. Beats were scored as correct if they were performed in sequence, even if intervening beats were omitted. Beasts that were performed correctly, but out-of-sequence were scored as incorrect. One point was deducted from the total score for each repeated beat. Judges were unaware of the identity of the participants or the environmental context in which recall was attempted. Two points were awarded for each correctly performed beat for a total memorization score of 128.

A two-way ANOVA was computed to determine whether there was a difference in the recall scores based on context (see Table 1). There were no main effect mean differences by context (Learning Context: $F(1,6) = 1.44$, $p = .275$; Recall Context: $F(1,6) = 5.12$, $p = .064$); however, a significant interaction effect ($F(1,6) = 8.07$, $p = .03$) was found when considering the similarity of learning and recall contexts (see Figure 1). The mean recall scores revealed higher recall and practice scores in the conference room (see Table 2).

TABLE 1 *Two-way ANOVA of all effects for Experiment 1*

Tests of between-subjects effects

Dependent variable: SCRNOTE

Source	Type III sum of squares	d.f.	Mean square	*F*	Sig.
Corrected model	1721.767[a]	3	573.922	4.589	.054
Intercept	118815.000	1	118815.000	950.098	.000
LRNCXT	180.267	1	180.267	1.441	.275
RECALLCX	640.267	1	640.267	5.120	.064
LRNCXT * RECALLCX	1008.600	1	1008.600	8.065	.030
Error	750.333	6	125.056		
Total	130841.000	10			
Corrected total	2472.100	9			

Note: [a] R squared – .696 (Adjusted R squared = .545)

TABLE 2 *Cell means and standard deviations in Experiment 1 representing the amount of music recalled when learning contexts were the same or different*

Context	Learning context	Recall context	Mean score (SD)
Same	Lobby	Lobby	88.50 (23.33)
Same	Conference	Conference	113.50 (9.19)
Different	Lobby	Conference	125.33 (2.08)
Different	Conference	Lobby	117.67 (7.51)

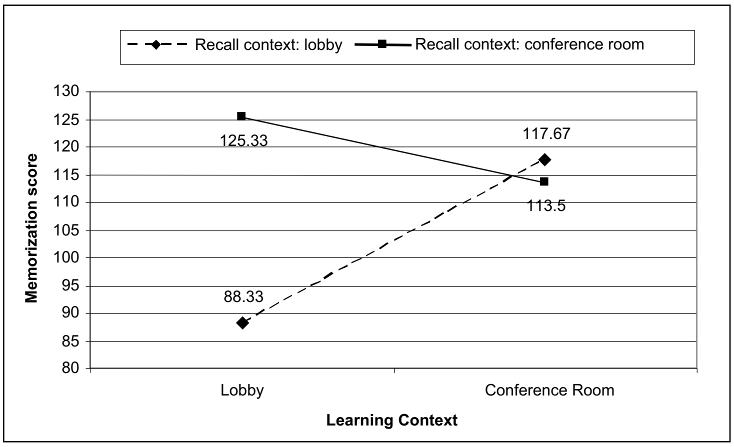

FIGURE 1 *Graph of significant interaction (Experiment 1) between learning and recall contexts.*

DISCUSSION

Musicians appeared to recall a similar amount of music in the conference room, regardless of learning context. The musicians who remembered the least music both learned and recalled in the auditorium lobby. Although there was a significant interaction, the pattern of results varied from that of Godden and Baddeley (1975) in which learning context did not affect memory, but changing contexts between learning and recall environment did. In this experiment, context affected memory, though not in the predicted pattern.

Context effects have been elusive and unpredictable. It is possible that an underlying feature of one or both environments affected the results, though what feature or features of the lobby environment could inhibit memory is not immediately apparent. It is possible that the conference room was generally a more familiar environment and even though the participants had never performed in this room, features of this environment may have been encountered elsewhere. Smith (1982) found that contexts effects could be mediated by learning in multiple contexts regardless of whether these contexts matched the recall environment.

The results may also be the result of a sampling error. The standard deviation for both conditions AA and BB were higher than for the shifting contexts. In particular, one participant in the BB condition remembered much less than the other performers (this participant's recall score was 72 compared to the overall average recall score of 117). Also problematic for a discussion of differences was the relatively high level of recall. Most musicians were able to recall nearly all of the exercise, indicating the possibility of a ceiling effect in three of the four conditions. Nearly half of the musicians scored within five points of the total recall score of 128. To control for possible ceiling effects, a more difficult exercise was employed in Experiment 2.

Experiment 1 demonstrated that memory for musical material may be susceptible to context effects; however, musicians rarely practice or perform in a conference room or lobby. One primary purpose for investigating whether context influences memory for musical material is to determine whether musicians should be concerned about memory lapses when moving from a practice room to a concert stage. To that end, Experiment 2 was designed to investigate context effects in environments and circumstances commonly encountered by college musicians preparing for a performance.

Experiment 2

PARTICIPANTS

Participants were woodwind (n = 20), brass (n = 26), and string players (n = 14) participating in a university ensemble. Approximately half were male (n = 29) and half were female (n = 31). Four were graduate students, 14 were seniors (fourth-year), four were juniors (third-year), 16 were sophomores (second-year), and 22 were freshmen (first-year).

MATERIALS

Each participant was asked to memorize a 36-bar exercise based on Exercise 11 from the *Farnum String Scale* (FSS) (Farnum, 1969). Exercise 11 was difficult enough to elicit errors in performance, but simple enough to be memorized in one sitting by college musicians. This exercise was technically more difficult than the exercise used in Experiment 1, however the performers were able to sight read the exercise with few technical errors. The similarity of this exercise to one in the WFPS allowed for adaptation of the woodwind and brass parts.

PROCEDURE

Naturalistic environments were selected for this experiment to determine whether context effects could be detected in common musical practice and performance situations. Three contexts frequently encountered by college musicians were chosen: a practice room in a university school of music (Context A), a professor's studio/office (Context B), and an auditorium stage (Context C).

Context A was a small practice room measuring 9 ft × 9 ft. The specific practice room used for this study was not in general use, thus none of the participants had played in this particular space prior to the study. The practice room was furnished with an upright piano, a piano bench, a music stand, a trash can, and a wooden chair. Sound-absorbing panels were attached to two of the four walls; however, other students could be heard practicing in adjacent rooms.

Context B was a composition professor's studio/office. This context was larger than the practice room (15 ft × 12 ft), but many of the basic features of the studio were similar (i.e. white tiled floor, white walls, white sound-absorbing panels and soundproofed door). The room was furnished as a typical office with desks, bookcases, file cabinets, a stereo system, a computer, plants, carpets, pictures, etc. The furnishings were covered with various papers, books, CDs, coffee mugs and other office paraphernalia. A large window overlooked a grassy courtyard. None of the students had performed in this environment prior to participating in the study.

Context C was a stage overlooking a small auditorium (65 ft × 28 ft), which included 13 rows of padded chairs. The elevated stage contained only a baby grand piano and a piano bench. From the stage, spotlights and stage lights could be seen, as could the backstage area, which contained chairs, stands, another piano, a podium and metal storage cabinets. Unlike the other two contexts, the auditorium was quiet and the acoustics were quite different from the smaller rooms.

As Experiment 2 was designed to be as naturalistic as possible, a variation of the research design utilized by Smith (1979) was used rather than the more typical two-by-two design. Participants learned the exercise in a practice room and recalled either in the same practice room (Condition AA), the professor's studio (Condition AB) or on stage (Condition AC). The conditions reflected common circumstances of practice and performance for college musicians. In a two-by-two design, musicians would have been asked to memorize on the concert stage and perform in a practice room, a highly unusual circumstance.

RESULTS

Scoring procedures were similar to Experiment 1; however, the increased length and difficulty of the exercise resulted in many more recall errors. Thus, the bar, rather than the beat, served as the unit of measurement. The highest possible score for a complete, errorless performance of the 36-bar exercise was 72 (1 point awarded for rhythmic accuracy, another for pitch accuracy). Inter-judge reliability was computed at .970.

A one-way ANOVA was computed to determine the effects of context on memorization scores (see Figure 2). While there was a difference in the amount of material recalled, this difference was not significant (see Table 3). Post-hoc analyses confirmed that participants who performed in the practice room did not recall the memorized exercise significantly more accurately than participants who performed in the professor's studio (p = .832) or participants who performed in the auditorium (p = .235).

TABLE 3 *One-way ANOVA table of all effects for Experiment 2*

Score	ANOVA				
	Sum of squares	d.f.	Mean square	F	Sig
Between groups	734.680	2	367.40	1.163	.320
Within groups	18004.587	57	315.870		
Total	18739.267	59			

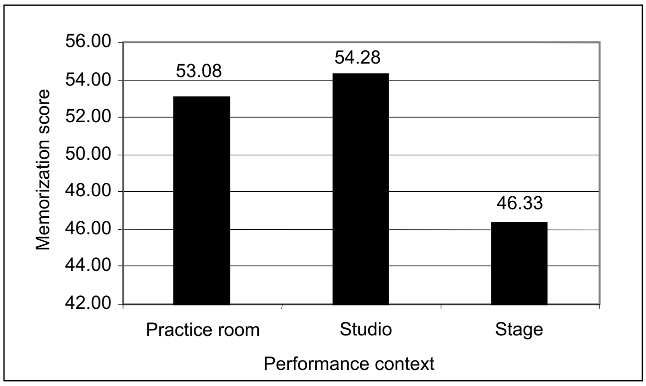

FIGURE 2 *Mean memorization scores from Experiment 2 reflecting pitch and rhythmic accuracy in three recall contexts (practice room, professor's studio, and auditorium stage).*

DISCUSSION

In Experiment 2, context effects were not found in naturalistic environments. Both the practice room and professor's studio, while novel to the participants, were similar to other practice rooms and studios to which the musicians had been exposed. All students had attended concerts in the auditorium and many had performed on stage. The familiarity of the auditorium context and the features of the studio and practice room may have influenced recall. Although the mean performance scores decreased for musicians who performed on the stage, the decrease was not significant. This result may be comforting for musicians who commonly memorize in one room and perform on stage. Familiarity with the types of environments commonly encountered by college musicians may have mediated context effects.

For pianists, familiarity with the room may be less important than familiarity with the instrument. Pianists were excluded from both Experiments 1 and 2 as a change in room also necessitated a change of instrument. The problems encountered when performing on an unfamiliar piano are frequently discussed in the pedagogical literature. For Experiment 3, the instrument was isolated from the environmental context to determine whether a change of instrument would influence recall.

Experiment 3

PARTICIPANTS

Participants were randomly selected college piano students (n = 32). The sample comprised 14 males and 18 females; 17 were freshmen (first-year) and 15 were sophomores (second-year).

MATERIALS

Participants were asked to memorize a 16-bar piano composition especially written for this study by one of the researchers (see Figure 3). The composition was written to be simple enough to be memorized in one sitting but challenging enough to evoke some performance errors. Two pianos were employed in this study: a 7 ft Steinway and Sons grand piano (Context A) and a Kawai upright studio piano (Context B). Both instruments were housed in the same room – a college piano professor's studio.

PROCEDURE

Participants learned the piece on either the Steinway grand piano or the Kawai studio upright piano and then were asked to recall on either the same instrument (Conditions AA and BB) or the different instrument (Conditions AB and BA).

FIGURE 3 *Notation memorized in Experiment 3.*

RESULTS

Each exercise was scored for rhythmic and pitch accuracy using the bar as the unit of measurement for a total of 32 points. Inter-judge reliability was computed at .960. A two-way ANOVA reveled no significant main effect mean differences (Learning: $F(1,28) = .652$, $p = .426$; Recall: $F(1,28) = .008$, $p = .929$) in recall by instrument (see Table 4). However, a significant interaction effect ($F(1,28) = 33.968$, $p = .000$) was found (see Figure 4). The mean recall scores revealed higher recall scores for same-instrument conditions and lower scores for changed-instrument conditions (see Table 5).

DISCUSSION

In Experiment 3, there was a clear context effect with a pattern of interaction very similar to that presented by Godden and Baddeley (1975). Memorization was not affected by the instrument itself, as demonstrated by the non-significant main effect mean differences, but was only affected when

TABLE 4 *Two-way ANOVA table of all effects for Experiment 3*

Tests of between-subjects effects

Dependent variable: SCORE

Source	Type III sum of squares	d.f.	Mean square	*F*	Sig.
Corrected model	1211.241[a]	3	403.747	11.543	.000
Intercept	14267.406	1	14267.406	407.891	.000
LRNCXT	22.798	1	22.798	.652	.426
RECALLCX	.283	1	.283	.008	.929
LRNCXT * RECALLCX	1188.159	1	1188.159	33.968	.000
Error	979.396	28	34.978		
Total	16458.043	32			
Corrected total	2190.637	31			

Note: [a] R squared – .553 (Adjusted R squared = .505)

TABLE 5 *Cell means and standard deviations in Experiment 3 representing the amount of music recalled when learning contexts were the same or different*

Context	Memorize	Perform	Mean Score (SD)
Same	Steinway grand	Steinway grand	26.46 (9.70)
Same	Kawai upright	Kawai upright	27.96 (3.19)
Different	Steinway grand	Kawai upright	14.08 (7.34)
Different	Kawai upright	Steinway grand	15.96 (7.57)

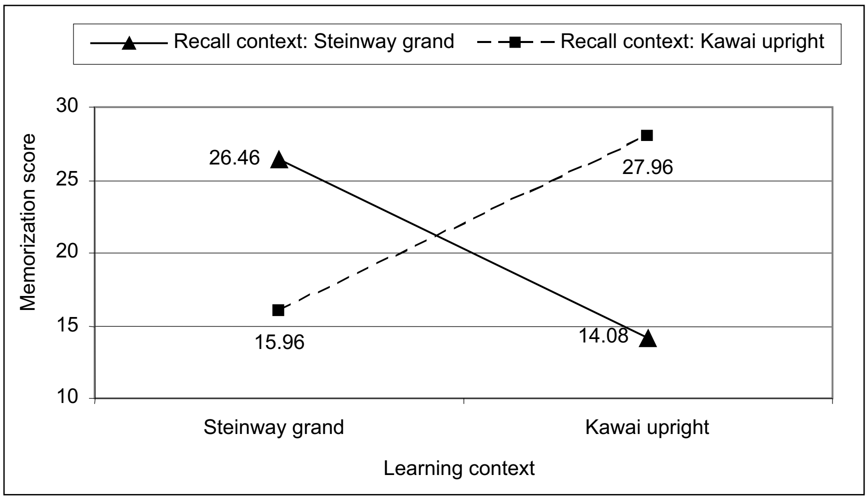

FIGURE 4 *Effect of matched and mismatched learning and recall instruments on memory for music.*

musicians recalled on a different instrument. Changing instruments for performance negatively affected recall. Discussions in the pedagogical literature of the negative effects of performing on an unfamiliar instrument are supported by this research. Recall was negatively affected by a change of instrument.

General discussion

Although music has been used in studies of context-dependent memory, it has generally been used as a mood-producing agent. In this series of studies, music was used as the material to-be-learned. As the nature of the material and the process of memorizing music for performance may prove to be distinct from learning word lists in the context of an experiment, the purpose of this series of studies was to investigate whether musical information was context-dependent. While elusive, Smith and Vela (2001) demonstrated that a change of context generally resulted in the retrieval of less information than when contexts were uniform. For musicians, this theory of context-dependent memory may be discouraging since, after hours of practice in the hopes of preventing a memory slip in performance, the very act of changing rooms may partially negate the effort.

The results from this series of studies were varied. In two of the three experiments, significant interactions were discovered (Experiments 1 and 3). The study with the more naturalistic design (Experiment 2) did not show evidence of context effects; while the more controlled experiments did. One explanation is that context effects are not sufficiently robust to be found outside of the laboratory. Memory effects may be mediated by a familiarity with the practice and performance environments. For performing musicians who may be adversely affected by context dependency, this finding is encouraging.

Smith (1982) discovered that learning in multiple environments reduced context dependency, regardless of whether the performance environment matched a learning environment. Experiment 1 was undertaken to investigate whether context effects could be found in unfamiliar environments. The results from this study did demonstrate a significant interaction, but not one that is consistent with known research findings. Learning and recalling in the conference room rather than in the lobby generally resulted in better memory for music. While a sample anomaly may have influenced the results, the significant interaction suggests further study is warranted.

Smith and Vela (2001) and Glenberg (1997) argued that the way in which information is processed determines the strength of context effects. When learning is associative, the internal associations overshadow environmental contexts. Rather than rote learning, musicians may be associating the memorized music with other pieces or styles of music and labeling collections of sounds (e.g. as an arpeggio or particular chord) to aid memory, thus reducing the importance of environmental memory cues. Meaningfully encoding music and relating the music to other music encountered in terms of form, harmony, rhythm, etc. was specifically noted by many of the participants in the study. Perhaps the way in which music is encoded limits context effects. While the effects of processing strategies on context effects deserves further study, it does not fully explain the results found in this series of studies. Is it implausible that musicians in Experiment 2 were adopting associatively learning strategies, thus weakening context effects, while musicians in Experiment 3 were not, which allowed context effects to surface.

In Experiment 2, no significant differences were found when environmental contexts were altered between learning and performing. In Experiment 3, a significant interaction demonstrated that changing instruments between learning and performing hindered recall. It is possible that the nature of the contexts involved in these two experiments influenced whether associative learning mediated context effects. The slight drop in mean memorization scores when performance rooms were altered in Experiment 2 may hint at an underlying context effect, but this effect may be overshadowed by associative cues developed during the memorization process. In effect, the associative cues used to memorize the music are stronger than the cues provided by the environment. But how does this explain the elegant interaction found in the final experiment?

It is possible that if internal associations are directly related to the context in which the material is learned and performed, as may be the case when using a piano as a context, the cues developed during associative learning and the cues related to the physical environment are linked. Pianists often use the kinesthetic and tactile feel of the fingers on the instrument as well as the visual finger patterns to aid memory. Strategies such as blocking chords (playing isolated pitches, simultaneously) aid in the memorization of a piece. Muscle movements and the visual hand patterns are directly connected with the instrument, but are not directly connected with the room. In studies of cued-recall or recognition, for instance, context effects are not predicted because the salient cue is more powerful than the context effects. It is possible that musicians use aural, visual and kinesthetic cues when memorizing and these cues are more powerful than contextual cues.

Suggestions for future research

For purposes of control in this study, musicians were asked to learn short and relatively simple exercises. Musicians of the technical ability represented in this sample would never be asked to perform such a simple exercise outside of an experiment. Music of the difficulty normally performed by these musicians requires long-term practicing, which potentially occurs in different contexts. Since the context effects observed in this study reflect only short-term memory for a simple piece of music, further research is needed to study context effects using longer retention intervals and standard repertoire that is memorized over time and in multiple contexts.

To avoid confounding variables, one important feature of the performance environment was omitted from these studies – the audience. The effects of an audience on memory have been investigated by Burri (1931) who found that the presence of an audience at the time of testing disrupted memory. The presence of an audience not only changes the physical features of the context in terms of acoustical properties, but the audience may also have an effect on the performer's internal state. Similar to changes to the physical environment, changes in internal states, whether mood, physiological, or drug states, between learning and testing have been shown to disrupt memory. Performing for an audience, a musician generally experiences an increase in anxiety levels. Since rarely do high levels of anxiety occur during practice, it could be argued that a musician's internal state changes between learning and performance. In the present studies, attempts were made to control for changes in anxiety levels. Audiences (including the researchers) were excluded from both the practice and recall contexts and a tape-recorder, which was necessary to record the final performance but which may cause increased levels of anxiety, was also used to record the practice sessions. These controls were thought to equalize anxiety levels in the practice and performing contexts. This assumption, though, cannot be verified without further research.

Conclusion

It is a mistaken belief that all memory slips in performance can be eliminated by practice and sheer repetition. The knowledge that memory lapses in performance may occur due to factors other than insufficient practice may be enlightening to musicians. Ideally, musicians want a guarantee that memory will not fail in performance. However, the human memory is complex and the best we can hope for is a deeper understanding of the limitations of memory and the factors that influence memory. One influential factor is that changes in seemingly irrelevant features of the physical environment can affect memory.

The inconsistency of results in this series of studies was not unexpected. The history of research into context-dependent memory includes many examples of inconsistent research results. Although a real phenomenon (as demonstrated in Smith and Vela, 2001), it is not a robust phenomenon and many variables conspire to mediate context effects. Not all pertinent variables have been isolated and explored in depth in the research. Environmental changes do not appear sufficient to significantly impair memory; however in performance situations when even one lapse in memory can be devastating the observed mean decrease in memory when performing on stage in Experiment 2 may still be alarming. Changing instruments can result in less accurate performances from memory. Based on the results in Experiment 3, pianists who learn and perform on the same instrument will perform more accurately than pianists who change instruments.

NOTE

1. The procedure first utilized by Godden and Baddeley, 1975 was refined through research of Smith (1979) and application of research by Strand (1970).

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