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Abstract

Recall of complex non-verbal motor sequences, such as contemporary dance, provides insights into the structure and mechanics of human memory – specifically, cues and associations in long-term memory (LTM). In this study, four dancers recalled material – eight exercises in the form of short dances – that they had not performed for between three and 31 years. The dancers initially recalled the exercises in silence, although each one had been learned to a particular piece of music. The exercises were recalled either immediately or after an unfilled delay and using self-motion or a mannequin. Recall rates were similar across immediate and delayed conditions; self versus mannequin motion had little impact on the length of material recalled. Qualitative data indicated that music and dancer movement were important cues to LTM; transitions were sometimes forgotten; images associated with movement recall were kinaesthetic, verbal, visual and auditory. The results are consistent with accounts of LTM for other temporal arts and suggest activation of multimodal associates and images.

Keywords

dance, episodic memory, mimetic tradition, movement, non-verbal behaviour, procedural memory

Introduction

Performers' recall of contemporary dance sequences provides a rich and stimulating medium for the investigation of long-term memory (LTM). Contemporary dance is a form of communication that rarely uses words; rather, it employs visual, spatial, temporal, kinaesthetic and, above all,

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dynamic means to convey information sometimes accompanied by, or expressive of, music or other sounds. Furthermore, contemporary dance is rarely notated. How do dancers remember the sequences of movements that constitute particular dances? What features of these sequences do they remember particularly, and what cues their memory for them? To what extent do they recall the contexts in which they were originally learned, and do these contexts provide associations that are helpful for recall? To what extent is recall determined by the dancer's ability to perform movements, and to describe them? This article reports an investigation of four dancers' recall for complex dance sequences from long-term memory after intervals from three to 31 years. By bringing the dancers together to reconstruct *technique class* material associated with Australian choreographer Margaret Barr, we also commemorate Barr's particular *dance-drama* approach and mimetic tradition. Descriptive quantitative and qualitative data are reported.

Features of music and drama in long-term memory

The cues and strategies used by professional classical and jazz musicians and actors in retrieving complex sequential material from LTM, including memory for particular features and cues (e.g. phrases, expressive, visual, and motor cues), have gained recent attention (e.g. Chaffin and Imreh, 2002; Chaffin et al., 2002; Ginsborg and Chaffin, 2007; Ginsborg and Sloboda, 2007; Noice et al., 2008; Williamon and Valentine, 2002). These findings from other temporal arts inform hypotheses concerning recall of dance material from LTM. Both jazz and classical musicians use their knowledge of formal musical structure to aid retrieval and during practice they use performance cues to retrieve upcoming passages from LTM (Chaffin and Imreh, 2002; Noice et al., 2008). These are features of the music to which the musician [dancer] pays attention during practice and rehearsal and which, as a result, become mental 'landmarks' when the piece is performed. Chaffin and his colleagues suggest that these can be (1) structural – to do with the mental representation of the form of the work to be performed, e.g. in relation to sections, phrases and switches (where the same material can lead in more than one direction); (2) basic – to do with technical issues (for instrumentalists and singers these can include fingering, pedalling, choosing where to breathe, 'placing' the voice, etc.); (3) interpretive – interpreting the composer's [choreographer's] intentions; (4) expressive – conveying those intentions to the audience. A subset of these features becomes (5) performance cues, those to which the performer attends when she or he is actually on stage in front of an audience. According to Ginsborg and Chaffin (2007) memory for melody is more reliable than for words, but both are likely to be forgotten together. For actors, motoric cues are associated with the recall of text (Noice and Noice, 1997) with text recall approaching a ceiling over the first three years and then declining as retention intervals increase; contextual cues significantly aid retrieval (Noice and Noice, 2002). Spatial and visual contextual cues also play a limited role in actors' recall of a play (Schmidt, Boshuizen, and van Breukelen, 2002). Context aids memory because it is part of the to-be-remembered event. So, if part of it is presented, the rest of it is more easily remembered. Music prompts increased recall for prose and verse, and the recall of such material tends to begin and end at breath pause locations (Rubin, 1997). In other words, prose and verse are recalled in meaningful, rather than meaningless, chunks.

In the present investigation, we look for evidence of strategies used by dancers in recalling movement material from LTM. These should include instances of recalling specific phrases and switches, basic technical matters such as use of particular parts of the body, muscles or breathing patterns, interpretive cues associated with particular movement material, and the presence of verbal material associated with the recall of movement phrases. We anticipate that movement material, like prose and music, will be recalled in meaningful chunks.

Memory for dance

Recall of contemporary dance movement is particularly interesting because there are few set repertoires of steps or verbal associates. Classical ballet consists of a vocabulary of discrete, named steps such as *arabesque*, *attitude*, *plié*. These are typically notated using figurative symbols on a musical staff according to a system devised by Benesh. Labanotation is a more flexible system, suitable for notating all dance and movement, in which time is depicted vertically from top to bottom rather than horizontally from left to right, and single symbols indicate the part of the body making the movement, the direction and level of the movement and the length of time it takes. While some choreographers (e.g. Martha Graham, Merce Cunningham, Lester Horton and José Limón) have devised formal vocabularies of movement, there is no single vocabulary (as in ballet) or readily accessible system of notation for dance. Video recording, therefore, has tended to replace written notation, although commercial ballet companies may employ trained notators particularly for archival purposes. The three-dimensionality of dance is reduced in any video recording with movement subtleties, nuance and dancer technique not always discernible. Contemporary dance also involves groups of dancers in different parts of the space performing different phrases of movement and a single camera angle or even edited footage from multiple cameras fails to capture fully the multiplicity of movement in the four dimensions of space and time.

From studies of working memory (WM) it appears that people who view configurational movements of a human body, relative to a pattern of locations in space, can recall the movement configurations in order with a similar level of accuracy after performing an intervening spatial task or no intervening (control group) task (Smyth and Pendleton, 1990). This suggests that the underlying codes for spatial and configurational information are different. However, when the intervening task is verbal, recall of configurational movements is lower than that of a control group (Smyth et al., 1988). Similarly, movements that can be verbalized are better recalled than movement that cannot (Foley et al., 1991; Frencham et al., 2003; Jean et al., 2001). These results imply a verbal component to short-term maintenance of configurational movements, although, with regard to encoding, Rossi-Arnaud et al. (2004) report no impact of a verbal suppression task on recall of configurational movements. While verbal interference causes a decrease in movement recall it does not reduce memory span to the same degree as performing a movement interference task (Rossi-Arnaud et al., 2004; Smyth and Pendleton, 1990; Smyth et al., 1988). Smyth and, most recently, Cortese and Rossi-Arnaud (2010) suggest that this may indicate an additional movement-based – spatial-kinaesthetic – subcomponent of WM.

In addition to memory for the form of a dance phrase, memory is necessary for recall of sequences that constitute a performance (Allard and Starkes, 1991). Serial position accuracy for ballet steps differs from serial position recall for verbal material. Where verbal recall shows both primacy and recency effects, success in recall of ballet steps shows only a primacy effect. With verbal material, the last few items are often recalled first and where an item is forgotten participants may continue to report remaining items. With movement material, items appear to be chained and when one item is forgotten the tendency is for recall of the following items to be doomed (Allard and Starkes, 1991; Deakin and Allard, 1991).

Verbal labels are used in the studio where choreographers and dancers name phrases or sections to communicate the movements to be performed and cue recall for them (Stevens and McKechnie, 2005; Stevens et al. 2003), although often, communication in the studio is through movement (Grove, 2005). The presence of music during learning and subsequent performance of choreographed sequences has been shown to enhance recall of dance steps by expert dancers (Starkes

et al., 1987). Activation of cingulate, retrosplenial and parahippocampal areas of the brain in dancers is consistent with episodic memory for dance material (Calvo-Merino et al., 2005).

The present study investigates the recall of modern or contemporary dance, extending our knowledge beyond memory in oral traditions (Rubin, 1995) to the largely non-verbal but kinaesthetic and somatic traditions of the dance troupe. Recall of complex movement material when features of the original environment are present, such as associated music, should heighten recall, and memory codes may be motoric, kinaesthetic, visual and/or verbal.

Documenting choreographic traditions and styles

The ephemeral nature of dance presents a challenge for those who would document it in detail. 'When a great choreographer dies, does their work die with them?' wrote Mackrell (2009) after the recent losses of Pina Bausch and Merce Cunningham. On a related point, McKechnie (1996) asked where the dances are that have been so ahead of their time that they have been stored in an attic or dusty drawer waiting for a more comprehending and empathic era? She answers that there are no attics or dusty drawers for dances. Only the dancers themselves retain fleeting traces of the movement images. This perishability has both positive and negative effects. In the absence of many treasured dance 'texts' from even the recent past, it ensures the constant creation of new work, but it also leaves little by which to measure the stature of the work so endlessly created. Documentation enables peer review beyond the ephemeral live performance, and detailed analysis, re-visiting and refinement (McKechnie, 1996).

In the spirit of documenting a choreographic tradition, the third author brought four mature dancers together to reconstruct movement material as taught to them by Margaret Barr. As choreographers tend to develop an idiosyncratic approach, influenced by the historical, cultural and social milieu, some background to Barr's approach to movement and influences on that approach will now be provided.

Margaret Barr dance-drama

Margaret Barr had a choreographic career that spanned more than 60 years and three continents. Her final 40 years of practice took place in Sydney, Australia. Barr described her work as dance-drama because she was interested in both the inherent drama of the body in motion and its ability to create and sustain the human drama of her primarily narrative-based works. There were three interconnected strands in her approach to creativity: technique classes, improvisation and the creative exploration of the rehearsal process (see Lester, 2006, 2007).

Technique classes – the focus of the present reconstruction and exploration – consisted of a series of set studies performed to the driving rhythms and often deceptively simple melodies of Carl Orff's *Carmina Burana*. This choreographed material explored a broad range of movement dynamics from the elegant simplicity of lyrical studies to the extremes of strong, direct, thrusting sequences.

In preparation for movement in her technique classes the dancer would stand with her body in parallel with her feet, hip-width apart, consciously softening behind the backs of her knees so that the weight could travel down into the floor enabling a feeling of being earth-bound and grounded. There would be a slight lift in the sternum and the arms would hang freely at the side of the torso. Even before attempting to move, conscious attention would be given to the cycle of the breath. Sequences would often be initiated by a simple pulsing of the knees, creating a gentle rhythmic bouncing action. This action would be further developed into a 'ripple through' of the body, a

sequential action of pushing the knees, hips, chest and head forward creating a ripple effect, permitting the body to move forward and backwards. Following on from this, the torso would be activated by twisting the spine so that the body created a spiral effect, allowing for greater movement possibilities. In *The Falls* Barr used Martha Graham's principle of 'contraction and release' to initiate and sustain the movement sequence. The dancer would curve the pelvis and torso as she hinged her knees in a deep thigh pull, lowering herself toward the floor, then release this contracted energy at the final moment so that she could soften into the floor. From there she would contract once again using the resistance of the floor to push out of the ground and into a standing position. Throughout her classes great attention was given to the rhythm of the breath cycle as the dancer moved. For Barr the dramatic moment in a breath cycle was the 'breath pause' – the moment of stasis between the inhalation of breath and its exhalation.

Long-term recall of dance: Choosing a method of investigation

With an opportunity to observe four mature dancers recalling movement material that they had not performed for between three and 31 years, dancer age, years of exposure, years since previous recall/performance, current dance involvement and body flexibility varied. Thus the data reported here can be considered as four case studies; similarities across cases will also be discussed.

Two independent variables (IVs) that have broad relevance to memory for dance were manipulated: (1) kinaesthetic recall (using own body or a small wooden mannequin); and (2) recall interval (immediate or delayed). Music as a feature of the original to-be-remembered environment was controlled. In Barr's studio, particular exercises were always performed with specific musical pieces. Theories of long-term and associative memory predict that recall of movement material is enhanced when a consistent and strong contiguous cue, such as an associated musical excerpt, is present (Godden and Baddeley, 1975; Starkes et al., 1987; Tulving and Thompson, 1970). Moreover, the sequential nature of music is likely to be a particularly potent cue for sequential and motoric behaviour, risking a ceiling effect in a memory study such as this. Thus, in the first phase of the study, music was deliberately absent allowing a focus on dance recall in response to spoken verbal cues.

Dancers were asked to recall a specific exercise prompted initially by its verbal label, and to recall either immediately or after a 20-second delay, using either their own body or a small wooden mannequin. Delayed rather than immediate recall gives time for mental rehearsal and visual and/or motor imagery that should enhance recall. The body versus mannequin conditions permitted the investigation of procedural recall in the form of self-motion versus externalized motion of another figure but still without use of words. We anticipated greater recall using self-motion and kinaesthesia. There was also the possibility of frustration at the recalcitrance of the wooden mannequin. In a subsequent phase, music associated with particular exercises was presented and the group of dancers in the presence of the associative musical cues reconstructed full exercises.

Method

Participants

Four female dancers who had all trained with the same choreographer volunteered for the study (mean age = 55.38 years; SD = 10.13 years; range: 44 to 68.5 years); from here on they are distinguished by pseudonyms. They worked with the choreographer for between two and 10 years, between once and three times a week, at a semi-professional level, learning the to-be-recalled exercises at the ages of 17–21 years. Two had performed the choreographer's dance material within

the past three years (Wendy, Kristy) whereas the oldest participant had not performed it for 22 years (Carmen) and the second youngest participant for 31 years (Fiona). The level of experience learning and performing dance among the participants more generally was 11 years (Carmen), 27 years (Wendy), 48 years (Kristy), and more than 20 years (Fiona). The to-be-recalled studio exercises had been learned in the: 1960s by Carmen from 21 years of age; 1980s by Wendy from 17 years of age; late 1960s by Kristy from 17 years of age; and 1974–76 by Fiona from 20 years of age.

To rule out the possibility that differences in the proportion of dance material recalled is the result of individual differences, working memory spans for movement were obtained from each dancer in a separate experiment session conducted on the final day of the dance reconstruction process. Sets of four, simple body movements (e.g. head forward bend, left arm above head, right leg raised to the side, etc., taken from Smyth et al. 1988) were presented on video and participants asked to watch and then recall the configurational movements by performing them. There were two trials with no interval between presentation and recall and two trials with a 12-second interval between presentation and recall. The latter condition afforded time for mental rehearsal. The order of conditions was counterbalanced across participants. As shown in Table 1, mean free recall span (i.e. the number of movements recalled correctly) for the four dancers ranged from 2.25 to 4 out of a possible 4. The results indicate that, while there is some variability across respondents, three out of four of the dancers recalled three or more configurational movement items, suggesting comparable recall rates. The most striking observation is that where immediate recall is less than four for an individual, there is a trend for those dancers to recall a greater number of items after the unfilled interval of 12 seconds compared with the immediate recall condition. This implies that some form of rehearsal strategy was used in the delayed recall condition relative to the immediate recall situation.

Materials

The seeds of the project were sown by the third author, keen to document dance exercises that would otherwise have been forgotten. He selected eight exercises created by the choreographer that fell into this category and met the criterion that they could be recalled by dancers as individuals rather than in pairs or groups. Barr referred to each exercise, in each studio class, by a descriptive verbal label; each exercise was always accompanied by a particular piece of recorded music. The exercises were: Monday night class: *Headwork Series*; at the barre: *Simple Arms, Complex Arms, Egyptian, Spiral*; Thursday night class 'Lyric': *Assyrian Bull, Figure 8 Arm Rolls, The Falls*. In this study, each participant performed the exercises in roughly the same order, once only, but the conditions were ordered in such a way that each participant began with a different condition applied to the same exercise. Participants recalled four exercises using their own body and

Table 1. Mean free recall of four simple body movements observed on video across two trials; standard deviations are shown in brackets. Movements were recalled by performing them either immediately after the presentation of movements or after a 12-second unfilled interval had elapsed

Recall condition	Wendy	Kristy	Carmen	Fiona
Immediate	4.0 (0)	2.0 (0)	1.5 (.71)	3.0 (0)
Unfilled 12 s interval	4.0 (0)	2.5 (.71)	4.0 (0)	3.5 (.71)



Figure 1. Mannequin used for recall of movement material to minimize the dancer's use of movement of their own body or kinaesthetic sense

Photo: Catherine Stevens.

four using the mannequin, either immediately or 20 seconds after the label had been given. The mannequin was a 30 cm wooden artist's doll as used in life drawing and art (Figure 1). The small size of the mannequin was deliberate to minimize the amount of movement the dancer needed to make with their body to make the mannequin dance, i.e. minimal kinaesthetic activity in this condition was the goal. Experiment and reconstruction sessions were recorded using a Sony digital video camera. A questionnaire regarding the act of recalling movement material asked two questions: (1) 'Would you describe how you felt performing under each of these conditions: (i) immediate body; (ii) immediate doll; (iii) delayed body; (iv) delayed doll?' (2) 'How do you feel that music, others in room, social and emotional factors affected recall of this movement material from your long-term memory?'

Procedure

Participants read an information sheet and signed a consent form. Participants were tested individually for their recall of the eight exercises under the various conditions. In a subsequent session, the music for each exercise was played and the dancers asked to recall the exercise in a group in the presence of the musical cues. A short questionnaire containing open-ended items concerning the act of recalling the movement material was administered to each participant immediately after completing the experimental session (music absent) and administered a second time after the group

reconstruction of the exercise material (music present). Interviews with the dancers as a group, were conducted at the conclusion of the four-day reconstruction event.

Results

Both descriptive quantitative and qualitative data were collected during the recall experiment and qualitative material was obtained from the written questionnaires and interview transcripts. To describe and quantify effects of recall delay and recall medium a benchmark of veridical performance of each exercise was needed. To summarize the dancers' recall in descriptive terms, there was a good deal of 'fluent forgetting' (Tribble, 2005) such that there was considerable cross-dancer variability in movement on the same exercise. To quantify the effects of recall delay and medium, the durations of musical excerpts associated with each exercise, as used in the later reconstruction phase, were used as benchmark values. The duration of recalled material performed by individual participants was calculated as a proportion of the music excerpt duration. This controlled for five factors: (1) the difficulty of scoring accuracy of movement material performed by different dancers, of different ages and flexibility; (2) the confound of duration of material recalled and the length of an exercise (i.e. raw values rather than proportions would skew results with higher recall scores being given for recalling longer exercises); (3) identification of one of the eight exercises (*Assyrian Bull*) as not being familiar to all four dancers; (4) the subtle changes in exercises as taught by Barr to dancers across three different decades; and (5) the exclusion of data from the dancer who had performed the material most recently and whose performance of the exercises in the reconstruction phase strongly influenced, sometimes directed, the group reconstruction. This dancer, Wendy, had not only worked with Barr in the last years of her life but also taught Barr's choreography to younger students. Proportion of duration of material recalled by this dancer for many exercises was close to 1.0 (100%) and had the potential to inflate recall scores if included and pooled. Therefore, the majority of quantitative recall data reported below has been calculated from the three participants who had not performed the material for three years (Kristy), 22 years (Carmen) or 31 years (Fiona). Recall rates from Wendy are noted in Table 2 but have not been included in calculating the means.

Table 2. Duration of recall by dancer and seven exercises showing raw scores in seconds and as proportions of the duration of the associated musical excerpt (proportions are shown in brackets); 0 refers to zero recall

	<i>Headwork Series</i> 199 s	<i>Simple Arms</i> 50 s	<i>Complex Arms</i> 50 s	<i>Egyptian</i> 150 s
Wendy	175 (.88)	48 (.96)	50 (1.0)	142 (.95)
Kristy	68 (.34)	34 (.68)	45 (.90)	27 (.18)
Carmen	29 (.15)	78 (1.0)	31 (.62)	54 (.36)
Fiona	23 (.12)	36 (.72)	34 (.68)	10 (.06)
Mean (of 3)	40.00 (.20)	49.33 (.80)	36.66 (.73)	30.33 (.21)
	<i>Spiral</i> 50 s	<i>Figure 8 Arm Rolls</i> 135 s	<i>The Falls</i> 50 s	
Wendy	38 (.76)	84 (.62)	50 (1.0)	
Kristy	36 (.72)	30 (.22)	53 (1.0)	
Carmen	25 (.50)	0	27 (.54)	
Fiona	67 (1.0)	15 (.11)	42 (.84)	
Mean (of 3)	42.66 (.74)	15.00 (.11)	40.66 (.79)	

Table 2 shows the duration in seconds of material recalled by exercise and by recall condition for each dancer. The proportion of recalled material duration as a function of the musical (veridical) excerpt is also shown. The proportion duration recall for Kristy, Carmen and Fiona was .58, .35 and .33 respectively, ranging from 0 to 1.0. Four exercises, *Simple Arms*, *Complex Arms*, *Spiral* and *The Falls*, elicited relatively high mean recall duration proportions of .80 (SD = .17), .73 (SD = .15), .74 (SD = .25), and .79 (SD = .23), respectively. Even though it must be acknowledged that these were the shorter exercises, they nevertheless consisted of a number of component phrases all of which had to be recalled.

Description of dance recall in silence and with music

The following description for each exercise documents what is recalled and what appears to have been forgotten by the four dancers. The description by exercise refers to individual recall in silence, followed by group reconstruction in the presence of music.

Simple Arms. The opening of the exercise was recalled by all of the dancers except Fiona. All recalled a few poses or phrases and Wendy and Carmen recalled the 'ripple through'. For Kristy and Fiona there was some confusion or substitution from other exercises such as *Complex Arms* or *Egyptian*.

Group recollection began in silence, at the barre, with dancers watching each other. After five minutes there was little consensus. The music was then presented and there was increased structure and form in their movement with the music appearing to provide structural cues for counts and timing. While some variations between group members were evident, the dancers concluded the exercise by performing a similar phrase in time with each other. The reconstructed exercise consisted of four different phrases, with each phrase repeated before progressing to the next new phrase.

Headwork Series. The opening of the exercise was recalled by all of the dancers. Even when using the mannequin for this exercise, the dancers moved their own heads during recall. Only Wendy recalled later phrases that involved movement other than just the head. An impulse or movement in the shoulder was observable in Kristy and Carmen.

The *Headwork Series* is a relatively long exercise with greater variety and contrast in movement than *Simple Arms*. The presence of music did not elicit visibly greater recall of material. Reconstruction for the group took place without music and with phrases described with counts by Wendy and the third author. The exercise begins with a still body and movement only of the head, repetition of the phrase a number of times, and then the introduction of arm and leg extensions. Descriptive labels used for phrases included 'sweep floor, arm out to side', 'pull the sheet and stretch', 'toreador cloak and step around'. The exercise as reconstructed consisted of nine different phrases, each repeated before progressing to the next phrase.

Complex Arms. Simple and complex arms studies were confused in recall by Carmen. Kristy and Wendy demonstrated detailed recall. Fiona recalled the preparatory and end phrases but could not recall transitions between phrases.

Upon presentation of the music, dancers immediately began to move without any other cue to do so. Observing the first impromptu recollection, the third author commented that the four dancers were 'reasonably close'. *Complex Arms* consists of repeating phrases with more drama than *Simple Arms*. Confusion between the two exercises appears to occur at switches or transitions.

Egyptian. All the dancers except Wendy recorded poor recall of this exercise. A single phrase was often repeated and there was no development or transition.

This exercise begins with the dancers facing front and in front of the barre. After the opening phrase they stand side on to the barre and perform eight phrases with repeats, then turn and repeat the same phrases facing in the other direction.

Spiral. The opening of the *Spiral* was recalled; many subsequent phrases were not recalled and transitions lost.

Performed at the barre, *Spiral* consists of sweeping actions. During group reconstruction, Wendy recalled and described the exercise as being built around seven positions of the arms with a pull back each time: ‘up to ear, over hip, horizon, picture rail, beam, ceiling and over’. Movement of the upper torso helps to create the spiral effect.

Figure 8 Arm Rolls. Some dynamic of hand movement and sway were recalled here. Kristy noted that she was aware that she was making errors but in the absence of perfect recall tried to show the spirit of the movement or exercise.

This complex exercise consists of a number of distinct phrases, each repeated. It begins with Figure 8 motion of the wrists, then arms, then ‘lotus’ shape of the hands, progressing to arm movements, hands with the Figure 8 trajectories becoming larger, step, head rolls, arms positions at increasing heights, balance, slide and ripple through to the end.

The Falls. This exercise was generally recalled well. It is dramatic, physically taxing and risky so it has a different dynamic and shape from other exercises used in the experiment session. Carmen had difficulty recalling transitions but was effective at providing a verbal description. Kristy had difficulty starting so went to the end of the phrase and worked backwards to find the beginning of the phrase; this strategy was effective in cueing her recall. Fiona started in the middle of a phrase and recalled the end point but could not recall getting up from falling, i.e. a transition.

In the presence of music, the dancers described *The Falls* aloud, together, with some recollection through movement, e.g. six repeats of stretch and fall on alternating sides (repeated), with leg kick to enable rise from the floor. Also, all the dancers beat time when the music started, using rhythmical movements of their body.

Quantitative results – recalling in silence

In Table 3, proportion of recall duration for three dancers is presented according to recall condition. It was hypothesized that recall would be greater in the delayed than in the immediate recall condition. The Wilcoxon Signed Ranks Test for matched samples showed no significant difference between the proportion recalled in the immediate recall condition (Mean = .55, SD = .38) and in the delayed recall condition (Mean = .44, SD = .31), $z = -.98$, $p > .05$. The mean recall recorded by Wendy was .95 recorded in the immediate condition and .79 recorded in the delayed condition.

Dancers commented in the following ways about the immediate versus delayed conditions. ‘Immediate and delayed body didn’t make much difference more that it immediately came to mind or not’ (Kristy) whereas in the immediate body recall condition Carmen noted she ‘had to pause to find “start” position’. Wendy commented that having time to rehearse the exercises in the delayed recall condition led to some confusion because of the opportunity to focus on ‘what’s right’ while Fiona wrote that in the delayed body recall condition she ‘had a lot of trouble remembering anything first without moving’.

There was no significant difference between the means of proportion recall durations when the dancer’s own body was used ($M = .50$, $SD = .29$) compared with when the mannequin was used

Table 3. Mean duration recall proportions collapsed across seven exercises and three dancers, shown as a function of recall condition; standard deviations are noted in brackets

Recall condition	Immediate body	Immediate mannequin	Delayed body	Delayed mannequin
Mean proportion	.53 (.35)	.56 (.40)	.47 (.24)	.41 (.39)

for recall ($M = .49$, $SD = .40$), $z = -.15$, $p > .05$. Wendy recorded a mean of .84 in the body condition compared with .89 in the mannequin condition. In the post-experiment questionnaire, Kristy stated that the ‘Immediate doll condition required thinking as I moved it, i.e. feeling it in my own body as I moved the doll’ and ‘Moving the doll was awkward and made me feel frustrated. The memory seems to be in my body and am aware when I have recalled it correctly.’ According to Carmen: ‘Doll [was] totally unable to move – disjointed – results lacking flow and staccato positioning which [is] what all/most dancers try to avoid’ and ‘unable to communicate any ‘passion, emotion, etc, became aware of joints and therefore stopping points’. Fiona said that she ‘Could not visualize movement on the doll. Perhaps a real body would have triggered more memory’. No greater variability across dancers was observed in the mannequin condition. In general, once music was available and the exercise had been reconstructed, the dancers were uninhibited in using the mannequin to perform an exercise and they took turns in doing so.

Dancers’ accounts of their approach to recall

Reflecting on their recall after each exercise and in questionnaire responses the dancers commented on verbalization during recall, what they had forgotten, the role of music, the role of mood and various other cues to recall. Each of these sets of responses will now be described.

Verbalization during recall. During different exercises (*Headwork*, *Simple Arms*, *Spiral*), all four dancers noted that during recall an inner voice was active: ‘forward, back, bring wrist forward, bring wrist back’ (Wendy); ‘forward, back, forward, back, side, side, then around’ (Kristy); ‘forward and right, up and over’ (Carmen). Words were triggered by performing the exercise and served to ‘count in steps’ (Wendy) or anticipate where the head was going to go (Kristy), or reflect a dynamic such as ‘ripple through’ (Carmen). Nonetheless, in interviews at the end of the reconstruction process, three dancers commented that there was generally little or no overt counting. The fixed Orff music would have provided temporal cues and structure but counting was relatively rare occurring just occasionally in the context of a ‘pure technique demonstration’ (Carmen). One possibility raised by Carmen on remembering Barr ‘starting to count a couple of times for performance’ was that it was related to her hearing being ‘not quite as good as it was’.

All dancers commented on their recall of Barr’s voice as they performed one or two particular exercises and reported rich and varied intonation in their imagery. There was a handful of words the dancers recalled, for example, ‘Punch’ (Kristy), ‘Pull’ and ‘Stretch’ (Wendy), and ‘Posture’ (Fiona). The inflection, prosody and drama of Barr’s voice was recalled by all and in one case the sound of the voice was recalled more than actual words (Fiona). ‘Posture’ was said as a directive whereas ‘Punch’ and ‘Pull’ were said with a particular inflection conveying a dynamic and shape. For example, ‘Pull’ had a ping sound to it that ‘was like pulling an elastic that kind of went pop at the end’ (Wendy). It could be concluded that the verbal descriptions of the movement were strongly associated with the dynamics and intonation of the choreographer’s voice eliciting recall for the

movements themselves. However, it was evident that Wendy, who had worked most recently with Barr, and therefore during the choreographer's later years, recalled more movements in response to the verbal descriptions compared with a dancer who had worked with her some four decades ago. There are two possibilities here. First, that the more mature dancer forgot some of the verbal instruction or, second, that as Barr aged she relied more on description and vocal inflection to convey dynamic and shape than when she was more able to demonstrate. Nevertheless, it was noted that in her 80s Barr continued to demonstrate to classes and was able to arch and balance effectively on the ball of the foot. Kristy noted:

I never saw her do floor work but I can see clearly before my eyes her expressing the movement with her body, arms and feet. Before starting runs there is a forward starting point where the dancer is anticipating the run, almost falling into the run. I remember her exemplifying that very vividly and other movement like arm work, spirals at the barre, and so on. It may still be true that she used her voice more than her body but ... her movement influenced and helped me personally master certain exercises rather than her voice.

The dancers recalled that spoken praise and correction served to reinforce enactment of the movement in a particular way (Kristy). Group praise was not given but rather individual praise that was rare and therefore the more meaningful.

What is forgotten? Two of the four dancers reported forgetting a transition: at the opening of *Spiral* (Wendy); forgetting how to get up after a particular phrase (Fiona); and finishing an exercise suddenly having forgotten the middle section (Fiona). In the latter case, one might surmise evidence of primacy and recency effects. This pattern of forgetting is consistent with schema theory 'junction errors', and also with what Chaffin et al. (2002) call 'switches', one kind of structural performance cue. Switches are locations in the music [dance] where the same material is repeated one or more times, followed by different material on each occasion. Sometimes the dancers did not recall the exercise from the verbal label suggesting that the associated music rather than a name may have been a crucial cue. Carmen 'felt MB didn't "name" exercises very much'.

The role of music. All dancers commented on the importance of music in Barr's studio. For Wendy recalling *Spiral*, 'music is such a key; it tells you there's nine swings' and more generally 'absence of music meant that I had to "hum" the music to myself as I was dancing/recalling'; 'The music for me is essential to conveying the "right" sequence'. Carmen commented that she didn't think she knew some exercises without the music; the music rather than a label would trigger recall; 'with music comes in the emotional ... a big trigger ... quite often [one] can remember the whole emotion, passion of it'; and 'music is the biggest most dominant factor for recall, especially in relation to phrasing'. For Fiona the rhythm of the music was important. For Kristy, the music timed the movement, 'lack of the music made remembering more difficult' and 'music especially created some automatic movement segments [that] come back into my memory. The movement and music to some pieces also brought an emotional intensity that gave my body physical energy.' Kristy alluded to the sequential nature of the memory noting that for one exercise she 'might have to go to the end and go back'. Once the music was presented, all dancers moved in response to it. They later used the mannequin to perform an exercise to music, showing it is possible to make the mannequin dance!

Kristy commented on images brought to mind and the way the Orff music was in a sense the teacher:

She was ... very good at picking very good music and marrying ... the work to the music so ... your teacher was the music sometimes in class ... because that's where you, you became the music in a way.

The role of mood. Two of the dancers commented that they recalled an exercise because it was a favourite for them: 'I do remember this ... because I loved it' (Carmen) and *The Falls* 'they're the most fun of all; even if you can't do them, you want to do them!' (Kristy, 100% recall) – 'some pieces I had particularly enjoyed emotionally helped me recall the actual movements'. 'MB gave you the freedom to be "in your own world". Rehearsal and performance totally different in this respect ... being in one's own world, there was a feeling of being enveloped as a group 'whole'. The emotion and passion was aligned at Carl Orff's intricate music and different every time' (Carmen). Fiona recalled the risk-taking in class and feelings associated with those risks.

What other cues are elicited by recalling movement and/or are triggers for recall? In one case, *Figure 8 Arm Rolls*, Kristy commented that the spirit of the exercise was recalled if not the full motor sequence (as confirmed by the quantitative data). During the discussion that followed the experimental phase Carmen recalled more movement material as she talked and gestured; according to the third author, an impulse or the 'dancer's twitch' was evident. On another occasion Fiona recalled the 'thigh-pulling' sensation associated with a particular floor exercise: 'As the movement was learnt by looking at others this would be a strong trigger'. Similarly, Kristy wrote at the end of the reconstruction phase that 'music cues and visual reminders by watching others helped bring back movement'. Wendy reflected that '...it also brought up class/technique scenarios of being in the studio with Margaret's voice in the background – even the "smells" (all friendly and fond ones) returned'.

Discussion

For an art form such as contemporary dance where formal notation is more the exception than the rule, dancers' brains and bodies are repositories of works of art that have been learned and memorized. In such a somatic, rather than oral, tradition, dance works, phrases and choreographic styles and technique are passed on by showing and doing (Grove, 2005). Investigating memory for dance, then, is relevant not only for testing and challenging psychological theories of memory for non-verbal material, but is also integral to documenting the traditions (and, importantly, the breaking of traditions) in dance.

A mixed-methods approach has revealed evidence of long-term memory for dance of up to 31 years. Comments from dancers during individual recall and group reconstruction revealed memory for: meaningful chunks (Rubin, 1997), specific phrases of movement, use of particular limbs or parts of the body, and particular breathing patterns (cf. Chaffin et al. 2002). The experimental trials revealed good recall of opening and preparatory movement. At times, the final phrase of an exercise was also recalled suggesting the presence of both primacy and recency effects. Transitions were forgotten with phrases or discrete poses retained. The presence of music in phases after the experimental trials cued the recall of timing and dynamics of movement material. Integrity of dance movement memory is likely related to the relative recency of performance.

The study demonstrates that memory for dance reflects the multimodal features that characterize dance and the surrounding context in which dance takes place. Music, with its inherent sequential and temporal order, is a provocative and effective structural feature of the dance environment; verbal labels serve as cues for some participants and are used to communicate and reconstruct material in the studio. As Noice and Noice (2002) note, contextual associates – visual, spatial, emotional,

olfactory – accompany recall. Imagery in this ecologically valid dance studio setting is similar to that observed under laboratory conditions by Overby (1990) and Smith (1990) – imagery is not only visual and verbal but also kinaesthetic and auditory. Interestingly and countering the benefits that might be proposed of imagery prior to movement (as practised by musicians who have to produce or adjust their own pitches such as singers and string players among others) is the present observation that the recall rates are similar under immediate or delayed conditions. However, this conclusion is tentative, requiring investigation using a larger sample size affording greater statistical power.

The dancers commented that the opportunity to move was important for dance recollection, although movement using a mannequin was sufficient. The absence of a difference between recall using own body or a small wooden mannequin is intriguing given phenomenological reports of bodily memory (Foster, 1976). Although caution is needed because of the small sample size, the result suggests that memory is transferable to another form and implies cognitive representation; kinaesthetic feedback from specific effectors appears unnecessary.

Transitions between movement sequences or links between boundaries or segments may be susceptible to forgetting, especially in the absence of structural cues from music. A logical question that follows is to find out to what extent the music is important because it provides a metrical framework, and to what extent because it provides other e.g. ‘emotional’ information. Wallace (1994) looked at this experimentally in the context of ballads demonstrating that text is better recalled when heard as a song rather than as speech, provided that the music repeats. Wallace concluded that musical structure aids chunking words and phrases, segmentation of line lengths, identification of stress patterns and adds emphasis. Such an investigation would be worth re-visiting with dance.

We have noted that dance knowledge is most often communicated by showing and doing and have remarked on these dancers’ memory for the spoken cues and intonation of choreographer Barr. The basis of Barr’s extraordinary voice that appears etched in each of the dancers’ memory was drama training in the USA during her 20s. The third author notes that, as an actress, Barr’s voice was imposing, authoritative, and at other times cajoling and warm. It is also notable that the amount of vocal instruction from a dance teacher or choreographer is likely to increase as he or she ages and is less able or willing to demonstrate. One of the dancers commented on her memory for Barr demonstrating movements such as arm work and spirals at the barre. The change in flexibility and mobility with age or injury raises research questions concerning the effects of body flexibility on choreographic cognition and creativity. Human figures rendered in software using *LifeForms* was one means by which choreographer Merce Cunningham continued to create dances and movement well into his 80s.

In this study, we have observed that features of a dance environment are part of people’s memory for dance. What is the mechanism? Through repeated presentation, associations between contextual features – particular music, verbal descriptors, particular bodily configurations, kinaesthesia, breath patterns – are formed. Hebb’s Law (1949) states that neurons that fire together, wire together. When some or all features of that original environment are re-presented, the network of associations is stimulated. Thus, memory involves the interaction of past experience with the present situation. The construction of an episodic memory requires the interaction of all relevant systems – vision, audition, olfaction, other senses, spatial imagery, language, emotion, narrative, motor output, explicit memory, and search and retrieval (Rubin, 2006).

To redress the unavoidable limitations of the present exploration, future studies could focus on the learning and memorization of new material. For example, one factor that could be controlled is experience with dance material by testing the recall of ballet steps and conventional sequences after set periods of time have elapsed. Participant age and years of training could also be controlled in such a study. A range of memory tests with norms could be deployed to investigate the domain-specific or

general nature of memory for movement in dancers compared with their memory for sequences and visuo-spatial patterns. A comparison of expert and more novice dancers learning new phrases of movement would allow investigation of explicit and implicit learning, forms of resulting knowledge, and correlations between dancer attributes (e.g. experience, expertise, recall strategies) and both quality and quantity of material recalled. A longitudinal approach to the learning and retention of new dance material could be undertaken (cf. Ginsborg and Chaffin, 2007) with regular documentation of the type and number of memory lapses. Ethnographic approaches including participant observation would capture learning and recall in the moment (e.g. Kirsh et al., 2009; Mason, 2009). For an increasingly analytic approach and when a veridical version of movement material is available, experiments could be designed to manipulate the presence and absence of formal structural markers and breath or phrase markers (Rubin, 1997) as potential cues and strategies for retention and recall.

While dance is one means through which societies communicate their identities and stories, the largely unspoken knowledge of dancers offers a lens on LTM. Analysis of memory for dance offers potential advantages for testing, and perhaps broadening, theories of human memory. The concomitant documentation of choreographic and mimetic traditions then available for scrutiny and teaching, and for posterity, provides poignant, palpable outcomes.

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Garry Lester, PhD, has over 30 years' experience, working throughout Australia and overseas, as a choreographer, performer and teacher. He is an independent researcher, writer and advocate in the field of dance. Garry holds a PhD in Dance History, Criticism and Analysis (Deakin University, Australia) after completing an MA in Visual and Fine Arts. Garry has been Head of Dance at two Australian Universities and has taught at many more. He has published widely in Australia and internationally and is currently researching the work of Margaret Barr. Garry works for the National Aboriginal and Islander Skills Development Association (NAISDA), a connection he has maintained since the mid 1970s.