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# Beat It! Music Overloads Novice Dancers

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*Summary: Together with melody, harmony, and timbre, rhythm and beat provide temporal structure for movement timing. Such musical features may act as cues to the phrasing and dynamics of a dance choreographed to the music. Novice dancers (N = 54) learned to criterion a novel 32-s dance-pop routine, either to full music or to the rhythm of that music. At test, participants recalled the dance to the same music, rhythm, new music, and in silence. If musical features aid memory, then full music during learning and test should result in superior dance recall, whereas if rhythm alone aids memory, then rhythm during learning and test should result in superior recall. The presence of a rhythm accompaniment during learning provided a significantly greater memory advantage for the recall of dance-pop steps than full music. After learning to full music, silence at test enhanced recall. Findings are discussed in terms of entrainment and cognitive load.*


Music and dance are present in virtually every culture (Nettl, 2000), and the two are intrinsically linked (Miller, 2000). The call to dance in an ancient rite of passage or a more contemporary nightclub ritual sees a seemingly effortless unfolding of an entire dance routine, but are the dance steps paired in memory with the musical elements that define that particular piece, or is the music merely a trigger for an independent, learned motor program that is simply played out to its rhythm? The few studies, to date, that have explored the effects of music on dance learning and recall have treated the music stimuli as a whole and have not penetrated its depths to ascertain if different elements have specific utility for dance memory. Music has regular patterns of organization that are cognitively processed as *temporal elements* and *pitch elements* (Palmer & Krumhansl, 1987). It is well established that the temporal elements provide a framework for dance moves to be learned and performed (Himberg & Thompson, 2011; Large, 2000; Pollatou, Hatzitaki, & Karadimou, 2003), but it is unclear whether the pitch elements help or hinder the memory process, at least at the novice dancer level.

We consider two possibilities for how novice dancers utilize music, either (i) the array of features in full music provides cues that can be linked to specific dance steps and sequences and thus enhance dance memory (cf. Krumhansl & Schenck, 1997) or (ii) dance is simply motor memory in action, and rhythm aids its timing, but the addition of more complex musical elements interferes with memory for the steps (Large, 2000; Poon & Rodgers, 2000). With a dependent variable (DV) of dance step accuracy during recall of a dance sequence, we compared learning to full music (music) with learning to the rhythm extracted from that music (rhythm), that is, music stripped of its melody, harmony, and various instrumental cues.

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## The mnemonic function of music

While there have been few experiments on the mnemonic potential of musical pitch elements for dance memory, there have been several that report a memory advantage for learning text (e.g., Calvert & Tart, 1993; Mead & Ball, 2007; Rainey & Larsen, 2002; Schön et al., 2008; Wallace, 1994) and song lyrics (e.g., Ginsborg & Sloboda, 2007; Hébert & Peretz, 1997). Wallace (1994) suggested that melody enhances memory for text over rhythm alone because it enables grouping the material into phrases, providing information about the lengths of lines and patterns of intonation. Hébert and Peretz (1997) later added that melody has a greater encoding distinctiveness relative to rhythmic structure. These findings for memory enhancement, however, were not replicated in similar studies that followed (cf. Purnell-Webb & Speelman, 2008; Racette & Peretz, 2007; Silverman, 2010; Sousou, 1997), with Silverman, and Purnell-Webb and Speelman concluding that the dual-task nature of encoding melody along with other stimuli may, in fact, distract the learner.

Results from the handful of music/dance memory studies have similarly been mixed, with music being shown to sometimes help the retrieval of dance steps (e.g., Starkes, Deakin, Lindley, & Crisp, 1987; Stevens, Schubert, Wang, Kroos, & Halovic, 2009; Stevens, Ginsborg, & Lester, 2010) and at other times give no advantage (e.g., Gray, Neisser, Shapiro, & Kouns, 1991; Maher, 2003). Closer inspection of the collective data reveals a pattern: Advanced dancers appear to use music more efficiently and holistically than novices. In an exploratory jazz dance/music study, Poon and Rodgers (2000) have shed light on expert tactics: Advanced dancers use the dynamic, timing, and phrasing cues inherent in music as memory pegs, for example, by linking steps to high and low notes, instrumental highlights, and rhythmic information. It appears that their rapid processing of dance choreography frees up cognitive resources for music processing.

It is telling that in all dance memory studies to date, novice dancers have been required to learn either classical or contemporary ballet or folk dancing. This has meant that along with learning a new motor skill, they have likely been encumbered by an unfamiliar music genre. A scan of popular media such as YouTube reveals that most people would more likely have been exposed to a genre like *dance-pop*. The question we asked, therefore, was ‘Could novices learning in a familiar, popular genre like dance-pop for the masses, tap into its musical mnemonics?’ An affirmative would lend support to the notion of coupling of music and dance in memory.

### Music and dance grouping and phrasing

One of the key principles in associative music/dance memory is the concept of grouping and phrasing. Grouping, or *chunking*, is a type of hierarchical compression that occurs when encoding a sequence of items, allowing the storage of larger quantities of information and more efficient retrieval (Miller, 1956). With music, notes and motives are grouped into phrases, phrases are grouped into sections, and sections are grouped to form the full piece (McElhinney & Annett, 1996; Palmer & Krumhansl, 1987; Schmidt-Jones, 2012). Similar hierarchical organization is employed in processing a dance sequence (Jordan, 2011). During learning, each recall attempt of the material impels several chunks to be recoded into a new single chunk, each time diminishing the performance demands of memory recall (Longstaff, 1998). For example, in popular dance, the sequence of movements ‘step, cross, step again, and hold’ could be chunked in memory as simply a ‘grapevine’.

We might classify the grapevine as a phrase, which is the level at which we most easily categorize the majority of music (Snyder, 2000) and dance structure. A phrase is the smallest unit that has a sense of structural completeness (White, 1976) or is a ‘meaningful…chunk’ (Stevens et al., 2010, p. 235). It follows that if a dance routine is choreographed to match the phrasing of a musical piece, the music should act as a continuous, unfolding cue to recall dance phrases. Distinguishable features in the music may further cue the exact content of each of those phrases.

### Distinguishable features in full music

The rapidly changing foreground of music that differentiates one piece from another comprises the pitch elements (Hébert & Peretz, 1997) and, being distinctive, could act as cues with which to pair concurrently learned dance steps. The pitch elements are the following: melody, commonly called the ‘tune’ of a piece; harmony, produced when more than one pitch is played simultaneously; and timbre, the tone color of a sound (e.g., timbre gives an electric guitar a different quality to a flute playing the same pitch at the same loudness; Schmidt-Jones, 2012; Thompson, 2009).

If dance steps are paired in memory with the pitch elements to which they were learned, then presentation of a novel musical accompaniment during a test phase should result in poorer dance step recall. To test this, we created another fully intact musical piece (new music) as a second test accompaniment. To hold the temporal elements constant, new music was identical to music in its underlying rhythm, timing, and phrasing structure but differed in melodic, harmonic, and timbral features. As a new music accompaniment may be even more distracting and interfere with recall during the test phase, we also included a no accompaniment (silence) test condition. On the one hand, the lowest scores would likely be attained for both groups when recalling in the control condition of silence, given that silence provides no musical cues at all. On the other hand, if an auditory stimulus interferes with recall, then silence will be advantageous. The new music accompaniment also served the purpose of being a stimulus check for comparability with the original music. For the group who learned the dance steps with a rhythm accompaniment, redundancy was expected at test when they recalled the dance with the same music and new music accompaniments, given that participants in the rhythm condition during learning would not have been previously exposed to fully intact music.

### Is rhythm enough?

Temporal elements allow humans to move in synchrony with the music and with each other (Demos, Chaffin, Begosh, Daniels, & Marsh, 2012). Temporal elements include the following: beat, the regularly repeating series of sound events that are perceived as points in time; and meter, regular cycles of strongly and weakly accented beats, hierarchically organized so that one level is embedded as a multiple of the next (Palmer & Krumhansl, 1990). A third element, rhythm, refers to the patterned subdivision of meter or pulse. The points at which lines and phrases of melodies start and stop may also contribute to rhythmic structure (Purnell-Webb & Speelman, 2008).

Learning a dance accompanied by the temporal elements alone, compared with full music, should benefit the novice dancer. First, it is the regularity of beat and its rhythmic reinforcement that allow a person to dance to even unfamiliar music because the beat induces covert internal synchronization, whereupon temporal expectations ensue (Bolger, Coull, & Schön, 2014; Large & Jones, 1999; Leman, 2008). Second, working memory is more constrained in the processing of new and unfamiliar pitch elements compared with predictable, regular temporal elements (Thompson, 2009), and the complexity of full music is merely a distraction for a novice dancer (Himberg & Thompson, 2011; Pollatou et al., 2003; Poon & Rodgers, 2000). It is assumed here that rehearsal is the main determinant of expertise and recall, helping develop motor programs that prompt movements to become more automated (Himberg & Thompson, 2011; Wuyts & Buekers, 1995).

Drawing on results from studies that suggest that some expertise is needed to make use of full music in learning dance and theories of the human capacity to entrain to rhythm and beat, it is hypothesized that the temporal structure provided by rhythm is sufficient for learning a new dance-pop routine.

Tacit in the comparison of learning conditions and recall under various test conditions is the principle of *encoding specificity* (Tulving & Thomson, 1973), wherein information learned in one context is better remembered when that same context is present during recall. Accordingly, it is predicted that the two groups learning to either music or rhythm would attain their highest dance step recall scores when performing to that same stimulus at test.

 

## METHOD

### Design

The design was a two (learning: music and rhythm) by four (test accompaniment: same music, rhythm, new music, and silence) factorial with repeated measures on the second factor. Participants were assigned randomly to one of two learning conditions. All possible orders of test accompaniments were used, and in both learning conditions, the order of dancing to each of the four test accompaniments was counterbalanced across participants. As participants were trained in groups of three but tested individually, the test accompaniment orders were also distributed systematically within and across experimental session groups of participants. The DV was the dance step accuracy at test.

### Participants

The 54 participants (46 female participants and 8 male participants) were University of Western Sydney undergraduates, receiving course credit for participation, and their friends. Ages ranged from 18 to 54 years old ($M = 27.24$, $SD = 10.85$), and all were novice dancers with less than 5-year dance training ($M = 0.43$, $SD = 0.86$), and some but minimal years of musical training ($M = 2.08$, $SD = 5.05$). Table 1 shows mean age, dance and musical training in years in the music and rhythm learning conditions; there were no significant differences in age or years training as a function of condition, $p > .05$.

### Stimuli

*Dance routine*
A 32-s, eight-step 'dance-pop' routine was choreographed by the first author, who had 10-year dance training, checked by a professional choreographer. Piloting with novice dancers refined the routine until no floor or ceiling effects of difficulty were evident. Nonjargon labels were verbally given to each step, as previous research had shown that without labels, some dancers invent their own as memory prompts (Poon & Rodgers, 2000), forming a possible confound if not controlled. Still frames from each dance step are displayed in Figure 1. Each dance step consisted of several movements, and most often, a movement occurred every beat. Occasionally, a movement occurred every two beats or two movements every beat. The tempo was 120 beats per minute (bpm).

*Music*
Original music tracks were created to match the phrasing of the dance routine. The two fully intact music pieces (music and new music) were both 32-s 'dance-pop' tracks, comprising 16 bars, segmented into 4 × 4 bar phrases by way of changes in melodic, harmonic, and timbral phrasing. The meter was 4/4 at a tempo of 120 bpm. Music featured an electric guitar melody, while new music featured a different marimba melody. Stripping music (and new music) of its melody, harmony, and timbre components above the level of the synthesized drum machine created the rhythm stimulus. A fourth track, silence, consisted of only a verbal countdown as a cue for the participant to start dancing. The synthesized spoken countdown preceded each condition. The music, rhythm, new music, and silence accompaniments are available here: http://katestevens.weebly.com/stimuli.html

Table 1. Mean age, dance and musical training in years in the two learning conditions

| Learning condition | Age | Dance training | Musical training |
|---|---|---|---|
| Music | 28.63 (12.33) | 0.55 (1.00) | 2.55 (6.41) |
| Rhythm | 25.85 (9.17) | 0.32 (0.69) | 1.60 (3.21) |

Standard deviations are shown in brackets.

*Questionnaire*
A post-experiment questionnaire was devised to supplement the quantitative results. It included open-ended questions about the participants' use of the music, labels, and counting.

### Equipment

The experiment took place in a dance studio equipped with Meyer Sound studio speakers, connected to a Mackie 1202-VLZ3 mixer. The music was played from a laptop computer running Windows Media Player software, and the test trials were recorded on a 5-MP digital media camera.

### Procedure

The experiment was run with groups of three participants to capture the nature of a small dance class, taught by a live instructor following scripted instructions. In order to avoid overrehearsal of the first few moves of the sequence and to minimize primacy and recency effects in learning (cf. Starkes, Caicco, Boutilier, & Sevsek, 1990), the last three steps were taught first; then, the rest of the sequence was taught from the beginning, with the last steps tagged on later. Each group of steps was first taught without an accompaniment and then practiced with an accompaniment (either music or rhythm as per group assignment), with the total number of accompaniment exposures being eight. As this study was concerned with memory and not with measuring individual learning differences, participants were taught to criterion level, demonstrated by unassisted performance at any time within the 15-min 'dance class'.

After a 10-min filler task, consisting of a word search puzzle unrelated to music/dance, each participant was tested separately on performing the dance routine under the four accompaniment conditions. Each was video recorded for later analysis and scoring. Participants then completed a questionnaire about their learning strategies.

### Scoring

Forty-five choreographic elements were scored dichotomously as either 1 (achieved) or 0 (not achieved) for each of the four test conditions. Thirty-five elements were movement criteria, such as 'right arm is dipped to right hip first, with left arm up', and 10 were timing criteria, such as 'dances step without hesitation and in time with music' to account for memory lapses. Given that the study was testing

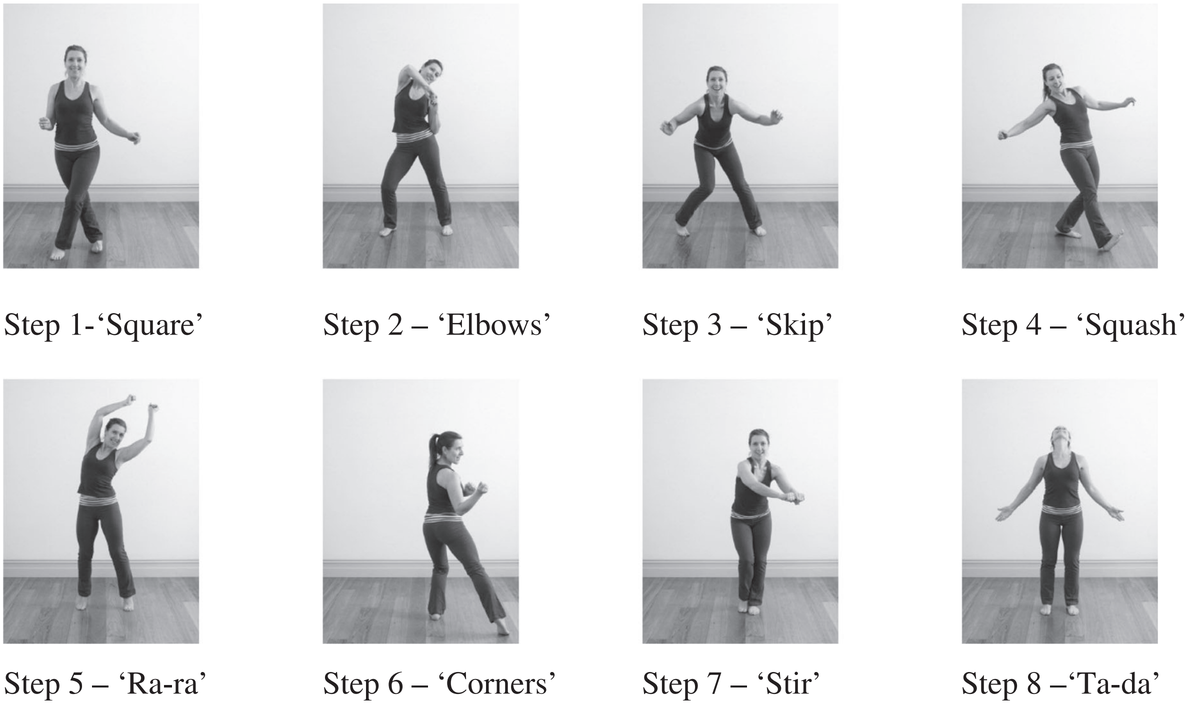


Figure 1. Stills of the dance routine showing the eight steps and verbal labels that matched the musical phrasing of music, rhythm, and new music accompaniments

memory and not individual dance ability, the scoring was designed to minimize subjective judgment of performance. Videos were scored by the first author. To check reliability, six videos (11% of total) were randomly selected and scored by a second independent researcher, blind to the condition. A Pearson correlation analysis indicated that there was high interrater reliability, $r(4) = .98$, $p < .001$. The pattern of movement scores (out of 35) to timing scores (out of 10) was similar for learning conditions; therefore, the movement and timing scores were combined into an accuracy score out of 45.

## RESULTS

Data screening revealed no outliers. All statistical analyses on test scores were planned contrasts according to the hypotheses, with $\alpha$ set at .05. Descriptive statistics are displayed in Figure 2.

The first planned contrast ascertained if learning to rhythm was more advantageous for dance memory than learning to music. There was a main effect of learning with significantly greater recall after learning to rhythm ($M = 32.72$, $SD = 10.00$) than learning to music ($M = 25.36$, $SD = 7.86$), $F(1, 52) = 9.04$, $p < .05$. Comparing the congruent learning test conditions revealed that rhythm learning–rhythm test accuracy was significantly greater than music learning–same music test accuracy, $F(1, 52) = 22.23$, $p < .001$, $\eta^2 = .30$ (Figure 2). Learning to rhythm and recalling to music ($M = 32.30$, $SD = 11.29$) led to significantly greater recall than learning to music and recalling to music ($M = 22.93$, $SD = 9.16$), $F(1, 52) = 11.22$, $p < .01$.

Two planned contrasts tested the encoding specificity hypothesis that matched learning and test conditions lead to good recall. One contrast compared the music learning group's recall to the same music with the mean recall scores of new music and rhythm, revealing no significant

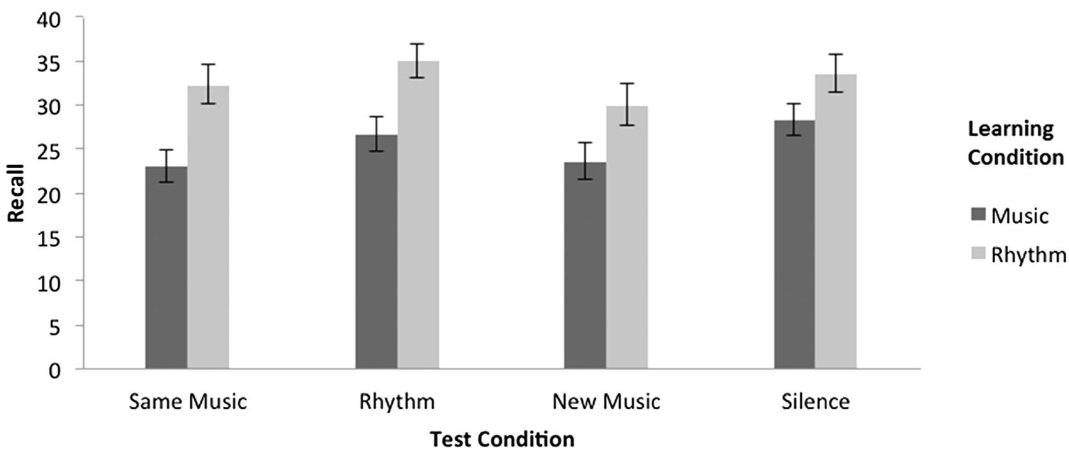


Figure 2. Mean dance routine accuracy for the two learning conditions under each test condition. The maximum possible score was 45. Error bars show standard error of the mean

 

difference, $F(1, 26) = 1.04$, $p = .318$, $\eta^2 = .04$. Another contrast compared the rhythm learning group's scores for recalling to rhythm with their mean scores of recalling to same music and new music. The scores for recalling to rhythm were significantly greater than recalling to same music and new music, $F(1, 26) = 8.70$, $p = .007$, $\eta^2 = .51$.

To test for the effectiveness of recalling dance to an accompaniment in general, two planned contrasts compared each learning group's recall scores in the silence test condition with all accompaniment conditions (same music, new music, and rhythm). For the rhythm learning group, there was no difference, $F(1, 26) = 1.24$, $p = .274$, $\eta^2 = .04$. For the music learning group, the result was significant, $F(1, 26) = 11.93$, $p = .002$, $\eta^2 = .31$, with recall in the silence condition significantly higher than in the other accompaniment conditions. Participants recalled the dance at a similar pace in the silence and accompaniment test conditions.

A Pearson product-moment correlation was conducted on the rhythm learning group's accuracy in the same music and new music tests to check similarity of the musical stimuli. A significant high positive correlation between the scores, $r(25) = .75$, $p < .001$, indicated that the two versions of full music were comparable. There was no effect of the order in which participants in groups of three were tested, $p = .79$.

### Questionnaire responses and ratings

Frequency analyses were conducted on the rating scales in the post-experiment questionnaire to establish how much participants felt they used the various possible mnemonic devices (pitch cues, rhythm, and counting).

Questionnaire responses indicated that participants found the music accompaniment frustrating after learning to rhythm: 'As soon as the music came on I lost my concentration and got flustered' (Zoe, rhythm learning group)[1] ; 'The melody overpowered the beat and I got out of time. I couldn't hear the beat'. (Aaleyah, rhythm learning group). Only 37% of those who trained to full music indicated that they used pitch cues such as melody. A general lack of awareness of such cues was common: '[I] Didn't really notice change in music as brain was preoccupied trying to remember dance steps' (Anna, music learning group); 'I knew music different but I wasn't aware what was different' (James, music learning group).

After learning to rhythm, some participants appeared to process the additional elements in the full music accompaniment as giving the music a different time signature or rhythm: 'It was hard to recall order/dance moves and to try and keep in time as the beat seemed faster and very different' (Minh, rhythm learning group); 'The beat seemed much faster as it was a heavier beat, so counting the beats didn't do much' (Justine, rhythm learning group).

A large number of participants—89% in both learning groups—reported that they felt that the rhythm was useful for learning the dance, whether rhythm alone or rhythm within full music. One strategy used to recall the dance routine in the test phase was counting silently, which was reported 81% in the rhythm learning group and 70% in the music training group.

[1] Names have been changed for ethical reasons.

## DISCUSSION

The current study sought to establish whether the pitch cues in full music enhance memory for a dance sequence in novice dancers or if rhythm alone is a better mnemonic. The results support the latter. Recall was greater overall after learning to rhythm than to music and, in particular, after learning to rhythm and recalling to music; participants who learned the dance to the rhythm performed significantly better than those who learned with full music and recalled to that same full music. Encoding specificity applied when the dance had been learned to rhythm but not when learned to music. When the dance had been learned to music, recall was the greatest in the silence test condition compared with the other test conditions.

### Music and cognitive overload

The results suggest that learning a dance-pop routine to unfamiliar music disadvantages individuals above timing cues alone because of 'overtaxing the cognitive processing system' (Purnell-Webb & Speelman, 2008, p. 953). While past research has shown that expert dancers use the full range of musical cues as 'mental landmarks' (Stevens et al., 2010), this was not the case with novices as reflected in their open-ended comments concerning their frustration with the music after learning to the rhythm. These dancers were likely attending to each step part by part, being inexperienced in the technique of larger 'chunking' of multiple steps that experts exhibit (Poon & Rodgers, 2000). When starting from a basis of inefficient memory strategies and perhaps also some physical demand, music only adds to the load. A 10-min filler task between learning and test phases ensured that recall was from long-term memory. However, future studies could investigate retention over a longer period. For example, in the verbal domain, music has sometimes had little or even detrimental effects at immediate recall and then revealed an advantage for music conditions after a delay (Calvert & Tart, 1993; Rainey & Larsen, 2002). Advantage from music over a longer time frame may be relevant in applying the present results to educational and therapeutic contexts. In future studies, criteria for scoring the chunking of material could also be developed.

In the context of folk or jazz dance, the effect of complexity of full music has been noted (e.g., Himberg & Thompson, 2011; Pollatou et al., 2003; Poon & Rodgers, 2000). Expert dancers express multiple metrical levels of music simultaneously in their moves, whereas novices only embody the most basic level, the beat (Himberg & Thompson, 2011).[2]

### The beat goes on

While pitch elements appear to be a distraction to the novice dancer, entraining to rhythm is posited to be an inherent human quality (Trehub & Hannon, 2009), underpinned by an internal clock or oscillator (refer to Zatorre, Chen, & Penhune, 2007 for a review). The beat of music or rhythms

[2] Himberg and Thompson refer to—more technically—the *tactus*, defined as the level at which it is most natural to tap along with the music (Thompson, 2009).

of another person moving impel humans to entrain (Demos et al., 2012). While proper execution and artistic expression of dance moves may take years to master, novices have been shown to be able to perceive beat and synchronize movements as well as experienced dancers (Huff, 1972). The temporal framework seems sufficient for recall. A repeating and even metrical structure (e.g., 4 beats per bar), as used here, minimizes cognitive load because the listener entrains to the regular pulse or beat. Such entrainment happens online without the need for chunking or long-term storage of the temporal structure (Large & Jones, 1999). Similarly, Schön and colleagues have demonstrated the benefit of a rhythmic pulse in processing speech and in visual discrimination (Bolger, Trost, & Schön, 2013; Cason & Schön, 2012). Encoding specificity also reveals a differential effect of rhythm and music learning conditions with the matching of accompaniment during learning and test phases being advantageous when the accompaniment had been rhythm but not music. Music interfered even under ideal encoding specificity conditions. The music was not learned and then interfered during the test phase. By contrast, the rhythm did not need to be learned because its regularity triggered entrainment and online temporal expectations for an evenly spaced series of events. The introduction of a different rhythm or meter at test would be one way to further interrogate the online entrainment hypothesis.

### Silence is golden (too)

Although silence provides no musical cues, the music learning group attained their highest scores recalling in silence. This conforms with the idea that a complex auditory stimulus at test can be distracting and adds to load. It can also be explained by another feature of an internal clock: The mechanism is self-sustaining, meaning that once a beat has been established, it tends to continue in the mind, even when the audible stimulus has ceased (Large, 2000). This is reflected in up to 81% of all participants reporting that they counted silently during the test condition. Silence may have enabled people to 'recreate' the rhythm to help recall the dance, and this may be particularly so for a rhythm-heavy genre like dance-pop. Tempo reproducing the dance across the four test conditions did not differ, including silence. A future study could provide a metronome cue to the beat during test to bring tempo under experimental control when recalling the dance steps in silence. However, the inclusion of a metronome is not straightforward, as it provides an auditory beat track, and a visual metronome would introduce a new form of load.

### Conclusion and future directions

The current study produced significant results regarding the efficacy of rhythm for beginners learning a choreographed dance sequence. It is acknowledged, however, that the dance-pop genre has a very pronounced rhythm, and the same results may not be replicated with music that is less rhythm oriented, or with song music, when lyrics may dominate as cues. While the music was original to avoid practice effects, it is also possible that learning to more familiar music, as would happen in many dance classes, would require less attention to the music, thus freeing up cognitive resources for motor learning (Purnell-Webb & Speelman, 2008). Familiar music would also enable new dance material to be linked and organized with existing knowledge in long-term memory.

The results inform the teaching of dance and other practices where movement is performed to music, such as figure skating and rhythmic gymnastics, as well as rehabilitation settings. It would likely benefit beginner programs to present music with graduating levels of complexity, building up from the rhythm to the complete musical piece. In dance and movement therapy too, where patients with disabilities and illness may be compromised in their ability to engage in dual tasks, simplification of music could help with movement and entrainment.

Criterion level of performance was necessary to ensure that learning had occurred before assessing recall. A next logical step would be to investigate the learning and recall processes separately, to ascertain if music has different utility at those different stages. As observed in studies of verbal memory, music may not increase the amount of material recalled but may help information in memory to be better organized (McElhinney & Annett, 1996). The inclusion of expert dancers, although previously shown to already process music in efficient and beneficial ways (Poon & Rodgers, 2000; Stevens et al., 2010), may help to discover how routines can be learned even faster. Recall after extended periods of retention also warrants investigation for direct application to teaching and therapy contexts.

Dancing a common choreography with others is being shown to have beneficial psychological effects, for example, increasing positive affect (Quiroga Murcia, Bongard, & Kreutz, 2009) and reducing the decline of perceptual, motor, and cognitive abilities (Kattenstroth, Kolankowska, Kalisch, & Dinse, 2010). With the popularization of dance in the media, attendance at dance classes is 'rocketing' (e.g., Australia Council, 2012), and there is a call for innovative curricula to support its growth. Understanding the perceptual and cognitive mechanisms that underpin learning dance sequences therefore has implications for development, education, and rehabilitation as well as explaining the universal human phenomena of dance and entrainment.

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## REFERENCES

Australia Council (2012, May 24). Dance plan 2012. Retrieved from http://www.australiacouncil.gov.au/resources/reports_and_publications/artforms/dance/dance_plan_2012

Bolger, D., Coull, J. T., & Schön, D. (2014). Metrical rhythm implicitly orients attention in time as indexed by improved target detection and left interior parietal activation. *Journal of Cognitive Neuroscience*, *26*, 593–605.

 

Bolger, D., Trost, W., & Schön, D. (2013). Rhythm implicitly affects temporal orienting of attention across modalities. *Acta Psychologica*, *142*, 238–244.

Calvert, S. L., & Tart, M. (1993). Song versus verbal forms for very-long-term, long-term, and short-term verbatim recall. *Journal of Applied Developmental Psychology*, *14*, 245–260.

Cason, N., & Schön, D. (2012). Rhythmic priming enhances the phonological processing of speech. *Neuropsychologia*, *50*, 2652–2658.

Demos, A. P., Chaffin, R., Begosh, K. T., Daniels, J. R., & Marsh, K. L. (2012). Rocking to the beat: Effects of music and partner's movements on spontaneous interpersonal coordination. *Journal of Experimental Psychology: General*, *141*, 49–53. doi:10.1037/a0023843

Ginsborg, J., & Sloboda, J. A. (2007). Singers' recall for the words and melody of a new, unaccompanied song. *Psychology of Music*, *35*, 421–440. doi:10.1177/0305735607072654

Gray, J. T., Neisser, U., Shapiro, B. A., & Kouns, S., (1991). Observational learning of ballet sequences: The role of kinematic information. *Ecological Psychology*, *3*, 121–134. doi:10.1207/s15326969eco0302_4

Hébert, S., & Peretz, I. (1997). Recognition of music in long-term memory: Are melodic and temporal patterns equal partners? *Memory & Cognition*, *25*, 518–533. doi: 10.3758/bf03201127

Himberg, T., & Thompson, M. R. (2011). Learning and synchronising dance movements in South African songs – Cross-cultural motion-capture study. *Dance Research*, *29*, 305–328. Retrieved from http://www.euppublishing.com/doi/suppl/10.3366/drs.2011.0019/suppl_file/himberg%20&%20thompson%20learning%20and%20synchronising%20dance%20movements.pdf

Huff, J. (1972). Auditory and visual perception of rhythm by performers skilled in selected motor activities. *Research Quarterly*, *43*, 197–207.

Jordan, S. (2011). Choreomusical conversations: Facing a double challenge. *Dance Research Journal*, *43*(1), 43–64. Retrieved from http://muse.jhu.edu/journals/dance_research_journal/v043/43.1.jordan.html

Kattenstroth, J., Kolankowska, I., Kalisch, T., & Dinse, H. R. (2010). Superior sensory, motor, and cognitive performance in elderly individuals with multi-year dancing activities. *Frontiers in Aging Neuroscience*, *2*, 31.

Krumhansl, C., & Schenck, D. (1997). Can dance reflect the structural and expressive qualities of music? A perceptual experiment on Balanchine's choreography of Mozart's Divertimento No.15. *Musical Science*, *1*, 63–85.

Large, E. W. (2000). On synchronizing movements to music. *Human Movement Science*, *19*, 527–566. doi:10.1016/S0167-9457(00)00026-9

Large, E. W., & Jones, M. R. (1999). The dynamics of attending: How people track time-varying events. *Psychological Review*, *106*, 119–159.

Leman, M. (2008). *Embodied music cognition and music mediation technology*. Cambridge, MA: MIT Press.

Longstaff, J. S. (1998). Subjective organisation in the recall of abstract body movements. *Perceptual and Motor Skills*, *86*(3, Pt 1), 931–940. doi:10.2466/pms.1998.86.3.931

McElhinney, M., & Annett, J. M. (1996). Pattern of efficacy of a musical mnemonic on recall of familiar words over several presentations. *Perceptual and Motor Skills*, *82*, 395–400.

Maher, L. S. (2003). Retrieving movement memory with and without the use of musical cues. (Unpublished master's thesis, University of Nebraska, Omaha). Retrieved from http://www.oregonpdf.org/print-script.cfm?path=../pdf\&src=PSY2282Maher%2816-2%29.pdf

Mead, K. M. L., & Ball, L. J. (2007). Music tonality and context-dependent recall: The influence of key change and mood mediation. *European Journal of Cognitive Psychology*, *19*, 59–79. doi: 10.1080/09541440600591999

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, *63*, 81–97. doi: 10.1037/h0043158

Miller, G. F. (2000). Evolution of human music through sexual selection. In N. L. Wallin, B. Merker, & S. Brown (Eds.), *The origins of music* (pp. 328–360). Cambridge, MA: MIT Press.

Nettl, B. (2000). An ethnomusicologist contemplates musical universals. In N. L. Wallin, B. Merker, & S. Brown (Eds.), *The origins of music* (pp. 463–472). Cambridge, MA: MIT Press.

Palmer, C., & Krumhansl, C. L. (1987). Independent temporal and pitch structures in determination of musical phrases. *Journal of Experimental Psychology: Human Perception and Performance*, *13*, 116–126.

Palmer, C., & Krumhansl, C. L. (1990). Mental representations for musical meter. *Journal of Experimental Psychology: Human Perception and Performance*, *16*, 728–741.

Pollatou, E., Hatzitaki, V., & Karadimou, K. (2003). Rhythm or music? Contrasting two types of auditory stimuli in the performance of a dancing routine. *Perceptual and Motor Skills*, *97*, 99–106. doi:10.2466/PMS.97.4.99-106

Poon, P. P. L., & Rodgers, W. M. (2000). Learning and remembering strategies of novice and advanced jazz dancers for skill level appropriate dance routines. *Research Quarterly for Exercise and Sport*, *71*, 135–144. Retrieved from http://search.proquest.com/docview/218497323?accountid=36155

Purnell-Webb, P., & Speelman, C. P. (2008). Effects of music on memory for text. *Perceptual and Motor Skills*, *106*, 927–957. doi:10.2466/PMS.106.3.927-957

Quiroga Murcia, C., Bongard, S., & Kreutz, G. (2009). Emotional and neurohumoral responses to dancing tango Argentino: The effects of music and partner. *Music and Medicine*, *1*, 14–21. doi: 10.1177/1943862109335064

Racette, A., & Peretz, I. (2007). Learning lyrics: To sing or not to sing? *Memory & Cognition*, *35*, 242–253. doi:10.3758/BF03193445

Rainey, D. W., & Larsen, J. D. (2002). The effect of familiar melodies on initial learning and long-term memory for unconnected text. *Music Perception*, *20*, 173–186.

Schmidt-Jones, C. (2012, May 24). The basic elements of music. Retrieved from http://cnx.org/content/col10218/1.8/

Schön, D., Boyer, M., Moreno, S., Besson, M., Peretz, I., & Kolinsky, R. (2008). Song as an aid for language acquisition. *Cognition*, *106*, 975–983.

Silverman, M. J. (2010). The effect of pitch, rhythm, and familiarity on working memory and anxiety as measured by digit recall performance. *Journal of Music Therapy*, *47*, 70–83.

Snyder, B. (2000). *Music and memory: An introduction.* Cambridge, MA: MIT Press.

Sousou, S. D. (1997). Effects of melody and lyrics on mood and memory. *Perceptual and Motor Skills*, *85*, 31–40. doi: 10.2466/pms.85.5.31-40

Starkes, J. L., Caicco, M., Boutilier, C., & Sevsek, B. (1990). Motor recall of experts for structured and unstructured sequences in creative modern dance. *Journal of Sport & Exercise Psychology*, *12*, 317–321.

Starkes, J. L., Deakin, J. M., Lindley, S., & Crisp, F. (1987). Motor versus verbal recall of ballet sequences by young expert dancers. *Journal of Sport Psychology*, *9*, 222–230.

Stevens, C., Ginsborg, J., & Lester, G. (2010). Backwards and forwards in space and time: Recalling dance movement from long-term memory. *Memory Studies*, *4*, 234–250. doi: 10.1177/1750698010387018

Stevens, C. J., Schubert, E., Wang, S., Kroos, C., & Halovic, S. (2009). Moving with and without music: Scaling and lapsing in time and in the performance of contemporary dance. *Music Perception*, *26*, 451–464. doi: 10.1525/mp.2009.26.5.451

Thompson, W. F. (2009). *Music, thought and feeling: Understanding the psychology of music*. New York: Oxford University Press.

Trehub, S. E., & Hannon, E. E. (2009). Conventional rhythms enhance infants' and adults' perception of musical patterns. *Cortex*, *45*, 110–118. doi:10.1016/j.cortex.2008.05.012

Tulving, E., & Thomson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, *80*, 352–373. doi:10.1037/h0020071

Wallace, W. T. (1994). Memory for music: Effect of melody on recall of text. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*, 1471–1485. doi:10.1037/0278-7393.20.6.1471

White, J. D. (1976). *The analysis of music*. London: Scarecrow Press.

Wuyts, I. J., & Buekers, M. J. (1995). The effects of visual and auditory models on the learning of a rhythmical synchronization dance skill. *Research Quarterly for Exercise and Sport*, *66*, 105–115.

Zatorre, R. J., Chen, J. L., & Penhune, V. B. (2007). When the brain plays music: Auditory–motor interactions in music perception and production. *Nature Reviews*, *8*, 547–558. doi:10.1038/nrn2152