The Audio-Visual Aesthetics of Music and Dance

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Abstract and Keywords

Dance and music appear to belong together: Conventional definitions of dance often conceive it as a rhythmical activity in which a series of steps is performed to musical accompaniment. Indeed, dance and music share many similarities such as rhythm and may have co-evolved as a form of nonverbal communication between groups of people. Despite a rich history of composers and choreographers exploring the aesthetic relationship between dance and music, only a few scientific studies have systematically explored how the visual aesthetics of dance interact with the auditory aesthetics of sound and music. In this chapter we will focus on such interactions; we will explore the common evolutionary origins of dance and music and review existing research on how dance and music influence each other to produce an audio-visual aesthetics of sound and movement. The chapter will explore interactions in both directions: music influences dance perception by altering movement expressiveness, orienting visual attention, and by modulating memory. At the same time music perception strongly depends on groove and danceability and is shaped by the listener's dance experience. The chapter closes with a review of methodological challenges to studying the audio-visual aesthetics of dance and music and suggestions for future research in this field.

Keywords: Dance, Music, Congruency, Movement, Sound, Groove, Rhythm

Shared Evolutionary Origins of Dance and Music

Dance and music are cultural practices that may have evolved for similar purposes. In fact, rhythmical structure and performing in groups are arguably the only two universally shared features of music performance across the globe (Savage, Brown, Sakai, & Currie, 2015). Evolutionary theory suggests that dance and music co-evolved across all known cultures (Brown, Merker, & Wallin, 2001; Laland, Wilkins, & Clayton, 2016; Ravignani & Cook, 2016). The origin of the word music itself from ancient Greek *mousiké* encompasses several rhythmical art forms including music and dance, but also poetry (Merker, 2001);

separating dance and music into different art forms is a relatively recent cultural phenomenon. Evolutionary accounts indeed focus on two putatively adaptive functions common to both: mate selection and social bonding.

Mate selection

Good dancers are attractive. Female observers associate attractive male dancing with positive personality attributes (Weege, Barges, Pham, Shackelford, & Fink, 2015). Proficient male dancers are rated as more extroverted, conscientious, and less neurotic. The perceived quality of male dancing correlates with grip strength, suggesting that dancing may indeed serve as an honest signal to male fitness or at least competitiveness (Hugill, Fink, Neave, N., & Seydel, 2009). Similarly, males spend more time looking at attractive females dancing than looking at unattractive females dancing (Röder et al., 2016) and women appear to dance more attractively during high-fertility periods (Fink, Hugill, & Lange, 2012). These findings suggest a clear link between attractiveness and dancing skill. Though less frequently studied, making music can also boost attractiveness. Female listeners prefer composers of more complex music during high-fertility periods than during low-fertility periods (Charlton, 2014). Together, these findings illustrate that being a good dancer or making music are attractive attributes of a person, yet whether greater attraction to good dancers or musicians indeed predicts greater reproductive success is an open question.

Social bonding

People rarely dance and make music alone. Dance and music are inherently social art forms and the acquisition of both relies on social learning, for exampleimitation (Flinn, 1997; Laland et al., 2016). Dancing together promotes bonding in groups of people. In one of the first experiments to study social bonding in the context of dance. Tarr, Launay and Dunbar (2016) assigned four groups of 60 high school students to perform a sequence of dance moves either in synchrony, or asynchronously. Some people performed movements that required substantial effort and involved the entire body; other people performed smaller movements that were less demanding and limited to a few body parts only. Groups that had exhausted themselves reported greater mutual liking than those groups that had exerted themselves less. Exertion also increased a person’s pain threshold. Importantly, group bonding and pain threshold reductions were greatest if participants had performed the movements in synchrony. The study shows that dancing together can act as a “social glue” that binds people together. Such bonding is not simply the result of exercising together, but requires synchronizing movements in time, see also Reddish, Fischer, & Bulbulia (2013). Singing in choirs can similarly bind people together and reduce people’s sensitivity to pain (Weinstein, Launay, Pearce, Dunbar, & Stewart, 2016).

Moving in synchrony fosters social affiliation. But is it important that people perform the same movements in unison? To answer this question (Zimmermann, Vicary, Sperling, Orgs, & Richardson, 2018) tested people without any dance experience performing simple group dances, such as walking or running in circles. As in previous studies, these

tasks were either performed in synchrony or out of synchrony. Wrist sensors recorded the movement of all participants to provided two objective indicators of behavioral coordination. *Unitary synchrony* implies performing the same movements at the same time, as one might see in a traditional ballet performance or during the opening ceremony of the Olympic Games. *Distributed coordination* on the other hand merely implies that movements of one person are coupled in time to the movements of another person, but does not require the same movements to be performed. In ballroom dancing for example, partners don't perform the same movements at the same time. Instead, movements complement each other, so that one person "answers" the movements of the other (Amoruso et al., 2014). Immediately after participating in the dance workshop, measures of group affiliation, bonding, and conformity were collected. Identification with the group, conformity, and mutual liking were correlated with distributed coordination, but not unitary synchrony. In other words, the prosocial effects of dancing together do not require for everyone to do the same thing; only that people tune into each other's actions and time their movements closely to the movements of the other.

The role of movement synchrony for social bonding among performers has been well documented, but does synchrony also carry aesthetic information? To explore the role of synchrony for dance aesthetics, Vicary, Sperling, von Zimmerman, Richardson, and Orgs (2017) measured synchrony among dancers during a 30-min live dance performance. Concurrently, groups of spectators provided continuous ratings of enjoyment and perceived "togetherness" of the group of performers on stage. Using Granger causality analyses, Vicary et al., (2017) showed that dynamic synchrony (distributed coordination, see above) predicted aesthetic ratings and spectators' heart rate. Importantly however, these predictive relationships were only apparent for those audience groups that formed a stable aesthetic evaluation of the entire choreography, suggesting that the aesthetic impact of synchrony strongly depends on the live performance context. Yet measures of performed synchrony contributed more to the aesthetic judgments than overall amount of movement or perceived togetherness. The importance of synchrony for aesthetics may well be rooted in an evolutionary function of social signaling: synchrony in dance and music performance not only promotes group cohesion among performers, but can signal the relative strength of social affiliation to groups of allies or opponents in line with coalition signaling (Hagen & Bryant, 2003).

In sum, these studies testify to the growing evidence in support of the "social bonding hypothesis." Dance and music share a social function that may provide an adaptive evolutionary advantage. They establish kinship and belonging between people and transmit social signals between groups.

Rhythm in Dance and Music

Music making and dancing involve similar brain mechanisms. Often, dancing requires synchronizing movement to a musical rhythm or a beat. Similarly, musicians produce sounds with their rhythmically timed movements. Sensorimotor integration and entrain-

ment to a beat or rhythm are therefore essential to both art forms and mediated by the same brain areas and mechanisms (Brown, Martinez, Parsons 2006; Iversen & Balasubramaniam, 2016; Karpati, Giacosa, Foster, Penhune, & Hyde, 2017; Penhune, Zatorre, & Evans, 1998). These brain areas include the cerebellum, the superior temporal gyrus (STG), the superior temporal sulcus (STS), the middle temporal gyrus (MTG), and the inferior frontal gyrus (Levitin, Grahn, & London, 2018; Penhune et al., 1998). The cerebellum mediates entrainment of movement to visual and auditory stimuli, while the basal ganglia have been shown to be sensitive to the metrical regularity of dance (Brown et al., 2006). Moreover, dancers and musicians exhibit increased cortical thickness in the STG, the STS, and the MTG. These brain areas have been reliably shown to mediate perception of the human body and human movement, but also respond to movement sounds (Keysers et al., 2003) and even movement execution (Orlov, Makin, & Zohar, 2010). Other brain mechanisms respond more selectively to dance or music only; for example, the right medial geniculate nucleus and the posterior cerebellar lobules are only activated in response to dance in the presence of music, and music alone, suggesting that these regions process visual stimuli and rhythms but are not involved in dancing without music (Brown et al., 2006). STG, STS, and MTG are all part of the human mirror neuron system (Kilner & Lemon, 2013; Rizzolatti & Sinigaglia, 2010), which plays a crucial role in dance aesthetics (see previous chapters on this topic in this handbook).

Audio-Visual Aesthetics of Dance and Music

Music and dance interact in complex ways. Combining information from two or more senses leads to cross-modal biases whereby perceiving a stimulus in one domain is altered by simultaneous perception of a stimulus in a different modality. A classic example of audio-visual bias is the McGurk effect: people blend the sound of a person saying “Ga” with the sight of a person saying “Ba” and hear a person saying “Da” (McGurk & MacDonald, 1976). Similarly, affective perception of body movements is influenced by affective information transmitted via voice or music (Van den Stock, Grèzes, & de Gelder et al., 2008; Van den Stock, Grèzes, & de Gelder, 2009). Emotion recognition relies on a combination of visual cues of facial expression with auditory voice cues, i.e. Massaro & Egan (1996). Using abstract simple stimuli, it has been shown that the relative dominance of each modality on the cross-modal experience depends on a mixture of saliency, reliability temporal alignment of the unimodal information (Noppeney & Lee, 2018; Parise & Ernst, 2016). We will look at the interaction of sound and movement from two perspectives: Firstly, we will review studies that examine how sound and music influence the aesthetic experience of dance. Secondly, we will look at how the aesthetics of music depend on dance with a specific focus on the idea of “groove.”

Music Influences on Dance Perception

In one of the first experimental studies on how the experience of dance depends on music, Krumhansl and Schenk (1997) showed videos of George Balanchine's choreography alongside Mozart's Divertimento No. 15 to three groups of participants. The first group watched the video in silence (dance only), the second group listened to the music without seeing the video (music only), and a third group watched the video with sound (music and dance). All participants were asked to identify meaningful structural segments and to provide continuous ratings of tension and expressed emotion. Segmentation of the dance performance was similar across all three conditions, but the lowest amount of agreement was seen among participants in the dance-only condition. Continuous ratings of tension and emotional valence in the dance-only and music-only conditions correlated strongly with tension and emotional ratings for the combined dance and music condition. Interestingly, the music-only condition was a better predictor of the dance and music condition than the dance-only condition, suggesting that the aesthetic experience of the dance performance was primarily determined by the music, rather than the dancing.

Emotional responses

Different pieces of music can influence emotional responses to the same dance performance. In order to delve deeper into the audience experience, Christensen, Gaigg, Gomila, Oke, and Calvo-Merino (2014) decided to focus not only on how different interactions change how the audience see the dance, but also on how it makes the audience actually feel. To achieve this, they examined affective responses to "happy" and "sad" ballet video excerpts using the classic cross-modal paradigm, with congruent, incongruent, or no music (Christensen et al., 2014). Two pieces of music with matching emotional valence were chosen and combined with the dance videos either congruently or incongruently. Participants were asked to rate how the dance clip made them feel after each clip. Additionally, skin conductance was measured as an index of emotional arousal. A cross-modal bias between music and dance was identified. Participants rated the sad dance as significantly sadder in the presence of sad music, and significantly happier in the presence of happy music, compared with a third control condition where videos were viewed in silence. Interestingly, for the happy dance, a cross-modal bias was only observed in the context of sad music but not in the happy music condition. Moreover, low-arousal dance videos were rated as inducing more sadness and high-arousal videos induced more happiness regardless of the intended emotion being expressed. This underlines that the perceived emotional content of the dance performance is influenced by the perceived arousal of the performance. Dance and music combinations that were congruent in terms of arousal and valence led to the greatest physiological arousal responses. In contrast, stimuli that were incongruent in terms of valence and arousal reduced the saliency of the emotion felt, regardless of whether it was positive or negative. This demonstrates that congruence of arousal can be differentiated from congruence of valence. Overall this pattern of results show that there are particular dance and music dynamics that result in a stronger affective engagement than others, with the valence of the music capable of overriding the in-

tended emotion expressed by the dance. This may be due to changes in eye movements in the presence of music, which encourage observers to search the visual display for movements that are in synchrony with the sounds being heard (Woolhouse & Lai, 2014). However, it is possible that such *aesthetic capture* of dance by music is related to the study design. Music was played continuously even after the dance clips had ended, and during the affective ratings, leading to a dominant influence of music on affective judgments. In line with existing theoretical models of aesthetic capture, the degree to which music or dance dominates is likely to depend on specific presentation contexts (Fogelsanger & Afanador, 2006; Mitchell & Gallaher, 2001). Additionally, while Christensen et al. (2014) made some attempt to account for individual differences by administering an art experience questionnaire (Chatterjee, Widick, Sternschein, Smith, & Bromberger, 2010), this questionnaire only examined experience with visual art, but did not assess musicality or musical experience of the participants.

Understanding and learning choreography

Combining dance with music can also reduce the perceived structural complexity of a choreography, and aid memory for the observed movements. Bläsing (2015) studied event segmentation for complex sequences of dance with and without music. Groups of professional dancers and athletes with no dance experience watched contemporary dance videos; the first 15 videos were played in silence; only the final five videos were played with music chosen by the choreographer. The soundtrack did not have any metric rhythm or pulse but consisted of slowly rising and falling chords. In order to examine the impact of music on dance aesthetics, dancers and athletes were asked to press a response button each time a part of the dance phrase ends and a new one begins, based on their own subjective criteria. Expert dancers identified fewer segments than novice spectators, suggesting superior chunking strategies for watching and memorizing movement. Movement segmentation further depended on the presence of music. For dancers, music reduced the number of segments. In contrast, athletes identified *more* movement segments when watching the dance performance with music. When asked how the music affected their segmentation decisions, the dancers indicated that music had a binding effect, and gave the impression that the movement slowed. In contrast music was reported to confuse the nondancing group, leading to a greater number of segments as the music disrupted their ability to recognize previously clear segmentation cues. Therefore, combining dance with music can be both beneficial and detrimental to identifying and understanding choreographic or musical structure, depending on the spectator's prior experience with the art form. Bläsing (2015) argues that for novice spectators, music added a new layer of complexity that effectively interfered with understanding the structural properties of the choreography. For expert spectators, music had the opposite effect.

Bläsing (2015) reported a second experiment that indicated that the disruptive effect of the music disappeared after a small group of participants learned to perform the dance over a 6-week training period. This was accounted for by the fact that the nondancers practiced the dance routine alongside the music in training sessions. The authors suggest that the dance was not subsequently experienced in isolation from the music and was in-

stead part of a combined integrated representation of the music and dance in their long-term memory (Land, Volchenkov, Bläsing, & Schack, 2013). The study demonstrates that dance expertise and competence with the task at hand directly modulate the way a person interprets, understands and subsequently appreciates interactions between dance and music. Moreover it suggests that abstract musical relationships with dance can lead to increased uncertainty at musical transition points that might otherwise be clearly discernible (Sridharan, Levitin, Chafe, Berger, & Menon, 2007). Perhaps with increased expertise the uncertainty caused by the abstract relationship is lessened to and reduces the potential for confusion or irritation. As people become more familiar with the relationship, music provides additional cues to the structure of the choreography, and binds movement segments together that otherwise appeared to be distinct. If music helps to structure the choreography, it may also amplify aesthetic pleasure. Spectators who are sensitive to intentional matching of sound and movement recognize temporal structures between music and dance intended to go together, even when each form is presented independently, and can differentiate between dance choreography and music that are intended to match and those that are not (Mitchell & Gallaher, 2001).

A detrimental effect of music on memory for movement sequences was also observed by Betteridge, Stevens, & Bailes, (2014). Novice dancers remembered complex sequences better if they learned them with an underlying pulse provided by a metronome. If movements were learned while music was playing, recall deteriorated. A shared rhythmical structure therefore provides additional cues that help encoding and retrieval. In contrast, nonrhythmical features of music seemed to distract from learning the dance movements. Neither study collected aesthetic ratings, yet other studies with similar learning paradigms (Kirsch, Drommelschmidt, & Cross, 2013) clearly suggest that acquiring experience in performing and watching specific dance sequences increase the aesthetic appeal of both movements and music. Arguably, the effect of music on the aesthetic experience of dance may thus be related to improving memory and segmentation of dance movements.

Together these studies demonstrate that music can act as a scaffold to learning and segmenting dance, but sufficient expertise is required to cognitively benefit from structural interactions between music and dance. If the relationship music and dance is too complex the spectator-listener may become confused or overwhelmed by both inputs. At the same time sufficient complexity between the music and dance interaction needs to be present to provide ambiguity and surprise, and can enrich aesthetic experience by generating more opportunities for discovering structural relationships between the two modalities.

Visual attention

Music influences where spectators allocate their visual attention while watching dance. Woolhouse and Lai (2014) conducted an eye-tracking study to investigate the factors within dance and music that impact visual attention to dancers. This was a lab-based experiment in which participants were asked to tap along to a piece of music while simultaneously watching videos of two dancers; only one of the dancers was synchronized to the

music. Woolhouse and Lai (2014) found that there was a greater proportion of dwell time for the synchronous dancer compared with the silent or asynchronous dancer, when two dancers were presented at the same time. This means that people prioritized looking at the dancer with movements matched to the music, compared with the dancer who did not move in time to the music. Moreover, this effect was present regardless of the musical tempo, but disappeared when the dancers moved in silence, with equal dwell time observed to the fast, medium, and slow moving dancers in the silent condition. An additional finding from this study was that participants exhibited exaggerated scan paths, with fixations at relatively distant locations on the dancer's body, when observing out-of-step dancers on their own. These exaggerated scan paths indicate that observers search more of the visual display when presented with incongruent presentations, which aligns with multi-modal models of neuroaesthetics that emphasize curiosity and exploration (Marin, 2015). Woolhouse and Lai (2014) conclude that observers search for time points when music and dance correspond, by integrating perceptually disparate sensory information. An important aspect of this study is that it demonstrates quite clearly that dwell time to dancers is influenced by the presence of music irrespective of whether it is synchronous or asynchronous with the dancing. However, previous studies without music reveal expertise effects, with dancers having shorter fixation times while watching dance movements compared with nondancers (Stevens et al., 2010). It is thus likely that dance expertise also modulates eye movements in the presence of music.

Aesthetic perception of dance

We have seen that combining dance and music can both enhance and diminish the aesthetic experience of each art form individually. Not surprisingly, Western artistic traditions in dance choreography and music composition have extensively explored this relationship (Jordan, 2011): Some 20th-century choreographers have eliminated music from their choreography altogether, often arguing that music "takes over" if combined with dance. Other choreographers and composers explicitly avoid choreomusical parallels: dance and music are created and presented alongside one another. In these cases any illustrative relationships should be accidental rather than intentional (Cunningham & Lesschaeve, 1985). In the next section we will discuss some of the psychological mechanisms that underlie the audio-visual aesthetics of movement, and in particular the idea that one modality might dominate over the other. Although not specifically focused on the aesthetics of dance and music, research on the cross-modal biases will help us to understand some of the determinants of dance capturing music, or music capturing dance. Furthermore, Gestalt laws play a prominent role in aesthetic perception (Wagemans et al., 2012). Combining dance and music, perceptual grouping operates within modalities and across modalities (Sloboda, 1985). For example, perception of meter in dance choreography has been shown to be disrupted by a competing musical meter, and this effect is even stronger when well-known choreography is used, such as the popular dance to "Gangnam Style" (Lee, Barrett, Kim, Lim, & Lee, 2015).

So far, we have discussed laboratory experiments which typically use recordings of dance and music. This approach allows movements to be randomly paired with a soundtrack. Unimodal control conditions can be created easily by muting the soundtrack to a dance, or playing music without showing the video. While this approach provides good experimental control, it lacks ecological validity. Dance performances in particular are typically experienced live. The live aesthetic experience can be substantially different from the experience of recorded dance. To address the need for enhanced ecological validity, several researchers have begun to examine aesthetic experience of live dance performances (Jola, Pollick, & Calvo-Merino, 2014; Reason et al., 2016; Vicary et al., 2017).

The first two studies to examine music and dance interactions in a theater setting used the same dance performance, “Double Points: 3X,” in the presence of either classical music composed by Bach, electronic music, or a soundtrack of the dancers breathing (Jola et al., 2014; Reason et al., 2016). Jola et al. (2014) asked 52 participants to rate how much they liked each combination of dance and music at the end of each performance. Participants rated the nonmusic condition as being significantly different than either of the music conditions, but no difference was found between the two music conditions. The personality trait openness to experience predicted people’s for dance with or without music: Spectators who scored high on openness enjoyed dance without music – when only the dancers’ breathing and footfalls could be heard – and responded less favorably to dance paired with classical music. The second study, by Reason et al. (2016) used a similar research paradigm in that they asked 15 participants to watch three live performances of “Double Points: 3X” in combination with the same three sound conditions mentioned above. Unlike the first study, Reason et al. (2016) used focus groups to gain a greater insight into the phenomenological experience of watching the dance, as well as a follow-up functional magnetic resonance imaging (fMRI) study using a recording of the same performance. Similar to Jola et al. (2014), there was a bigger difference in the aesthetic evaluation made between the music and no-music conditions compared with the two music conditions, and this finding was not related to the level of dance-*watching* experience. However, it was noted by participants that the different soundtracks produce different emotional characterizations of the dance performance, and led to the illusory impression that different dance moves were used in each condition. Specifically participants characterized the performance alongside Bach as more “flowing,” “elegant,” and “relaxing,” while the performance alongside the electronic music was characterized as “big,” and “brighter” with “more competition between the dancers.” Additionally, they found that audience members found the nonmusic condition more intense with a heightened sense of physical presence due to the sound of the dancers breathing. Interestingly, for many audience members this sense of bodily awareness was a negatively valenced experience, particularly for those who scored low on the openness personality trait. While this study maintained the ecological validity of a real dance performance, Reason et al. (2016) did not assess aesthetic preferences for each soundtrack, leaving open the possibility that preferences for certain combinations of dance and music reflected specific preferences for different musical compositions (Fogelsanger & Afanador, 2006; Howlin, Vicary, & Orgs, 2020). Nonetheless these two studies suggest important differences between

sounds that are arbitrarily added to the dance, such as music and sounds that are produced by the performers themselves. Moreover, they show that the audio-visual aesthetics of dance and music depend on personality traits of the spectator.

Congruency and Aesthetic Capture

More recently, attempts have been made to control the congruency of the soundtrack more rigorously, while maintaining an ecologically valid atmosphere in which aesthetic evaluation could occur in response to the dance performance (Howlin et al., 2020). In this study 34 participants were randomly assigned to watch a 34-min video of a full-length contemporary dance performance, “Group Study,” with a soundtrack that included the performer’s steps, breathing sounds, and vocalizations, but no music. Dance and sound were paired congruently, i.e., as recorded, or incongruently with the same soundtrack played back in reverse so that the performers’ sounds no longer aligned with their movement. In a third condition the dance videos was shown in complete silence. This allowed the researchers to isolate the effect of congruency, since soundtrack and video were identical in congruent and incongruent conditions, only their temporal alignment was altered. Audience members were asked to continuously rate how much they enjoyed the performance on a tablet computer, and physiological responses were continuously collected using a wrist sensor throughout each performance. Some participants had completed some formal dance training, but both dance experience and musicality were comparable among the three groups. Surprisingly, the incongruent condition was rated as more enjoyable than the congruent and silent conditions. Furthermore, only the incongruent elicited an electrodermal activity (EDA) response coupled to the synchrony of the group dancers. Conversely the silent and congruent conditions were rated as less enjoyable and the features in these videos were not related to spectator arousal. This corresponds with the finding from Reason et al. (2016) that audience members often dislike the sounds of dancers breathing alongside dance performances. Importantly, Howlin et al. (2020) found that sound itself did not predict spectator arousal directly but that the performed synchrony predicted arousal in combination with the incongruent soundtrack. This suggests an indirect influence of the sound on the way the audience viewed the movements, because the sound is no longer coupled in time to the dance movements that produced the sounds. This corresponds to the concept of “capture,” whereby the presence of one element affects how the other element is perceived (Mitchell & Gallagher, 2001). It also coincides with the previous finding that people use different strategies to examine dancers depending on whether the music is in time or out of time with the dancers (Woolhouse & Lai, 2014). It seems that by removing the direct link between the performers’ actions and the corresponding sounds, an arbitrary relationship was created, similar to the arbitrary relationships observed when dance is presented with music. This lack of an explicit connection in turn invited spectators to actively search for structural correspondences between movement and sound, emphasizing the role of exploration and meaning making for the audiovisual aesthetics of combined dance and music (Marin, 2015; Woolhouse & Lai, 2014). Howlin et al. (2020) suggest that the incongruent condition created accidental audiovisual gestalts, paradoxically heightening the experience of congruency, with one par-

ticipant explicitly reporting a sense of congruency in the incongruent condition. This sense of accidental or unintended congruency has been reported in previous studies (Bolivar, Cohen, & Fentress 1994; Chion, 1994; Iwamiya, 1994; Lipscomb & Kendall 1994). It seems the occurrence of accidental congruency may be what leads to aesthetically interesting correspondences and conflicts between music and dance stimuli.

Looking at these results together, it seems that congruency between music and dance is not strictly preferred by the audience. In a dance context, perfect congruency between movement and sound, such as the sounds of the moving and breathing dancers, does not seem to lead to superior aesthetic outcomes (Howlin et al., 2020). Instead, optimal combinations of sound and movement appear to be characterized by two features: structural and expressive scaffolding, and certain level of ambiguity. Audiences use one stimulus to interpret features in the other stimulus (Bläsing, 2015). Arbitrary and somewhat ambiguous relationships between sound and music may increase enjoyment because they honor individual differences in what might constitute an optimal pairing between dance and music. Less obvious relationships between dance and music allow spectators to experience surprise and discover idiosyncratic patterns between the music and dance (Muth & Carbon, 2013).

These ideas align with Berlyne’s (1971) optimal arousal hypothesis: an optimal amount of complexity is required to facilitate aesthetic pleasure. One way to achieve such optimal arousal, increasing arousal-based aesthetic responses, is to present two discriminately different qualities simultaneously. Therefore, the role of congruency in dance may depend on the perceived complexity between the performers’ actions and their auditory consequences, with complexity providing an opportunity for perceptual and intellectual analysis. This would correspond to a changing role of congruency depending on the complexity of the movements involved. Future studies should seek to delineate the relative contributions of stimulus complexity and congruency to the audiovisual aesthetics of dance with music.

Dance Influences on Music Perception

So far, this chapter has focused on the impact of music on our perception of dance, but dance also alters music perception. Much of classical Western music is designed for listening only, yet even passive listening often involves not just auditory but also motor processing in the brain. The experience of musical tempo is closely linked to body movement (Dahl & Huron, 2007; Fitch, 2016; MacDougall & Moore, 2005; Todd et al., 2007; Trainor, 2007) and activations in motor brain areas are most pronounced if people listen to musical tempos that they prefer (Kornysheva, von Cramon, Jacobsen, & Schubotz, 2009). The link between making and experiencing rhythm is most obvious in playing percussive instruments. Fitch (2016) argues that the origin of 4/4 meter lies in the natural rhythm of human walking. Downbeats signify making contact with the floor; quite literally upbeats are related to lifting the foot off the ground. More complex rhythmical patterns then re-

sult from placing notes in upbeat positions (Janata, Tomic, & Haberman, 2012; Madison, 2006).

Indeed, evidence suggests a close link between beat perception and walking (Dahl & Huron, 2007; MacDougall & Moore, 2005; Todd et al., 2007; Trainor, 2007). People's tendency to walk at a rate of 120 steps/min (MacDougall & Moore, 2005) is mirrored by the popularly preferred tempo of 120 beats/min, which pervades much of popular music (Fraisse, 1982; Moelants, 2002). Similarly, individual preference for musical tempo has been related to differences in body sizes (Trainor, 2007). Listening to a sequence of clicks resembling the rhythm of the Christmas carol "Jingle Bells," people with increased body size tended to prefer slower beat rates (Todd et al., 2007). A similar relationship between body size and preferred tempo emerges if listeners freely choose which songs they would like to dance to (Dahl, Huron, Brod, & Altenmüller, 2014). Leg length is the strongest predictor of preferred beat rate in music, followed by height (Dahl & Huron, 2007; Dahl et al., 2014), accounting for 16% of the variance. In order to understand how beat preferences emerge from rhythmical movement, Phillips-Silver and Trainor showed that bouncing impacts preferences for musical meter in both infants (Phillips-Silver & Trainor, 2005) and adults (Phillips-Silver & Trainor, 2007). In these experiments, infants were bounced, and adults were asked to bounce to every second or third beat to an ambiguous rhythm pattern, and then listened to music in either double or triple time. As predicted, both infants and adults tended to prefer the metrical structure that reflected their previous bouncing experience. This effect was not dependent on visual information, or transmitted when the participants stayed still, emphasizing the role of movement in mitigating this effect. Subsequently, Philips-Silver and Trainor (2008) demonstrated that even passive movements can impact preferences for musical meter, where the participant did not initiate any movements.

Groove and danceability

Music varies in how much it induces an urge to dance. Listeners prefer groovy music even if people don't actually dance to it (Fitch, 2016; Janata et al., 2012). Groove can be defined as the desire to move some part of the body in relation to some aspect of a musical pattern (Etani, Marui, Kawase, & Keller, 2018; Janata et al., 2012; Madison, 2006; Madison, Gouyon, Ullén, & Hörnström, 2011; Witek, Clarke, Wallentin, Kringlebach, &Vuust, 2014), such as repetitive rhythm at a comfortable tempo (Madison et al., 2011). High-groove music is associated with greater excitability of the motor cortex (Stupacher, Hove, Novembre, Schütz-Bosbach, & and Keller 2013), and is often linked to specific genres such as funk, soul, hip-hop, and electronic dance music (Witek et al., 2014), as well as jazz, salsa, and waltz (Fitch, 2016). Rhythmic movement is naturally a core factor in a wide variety of musical genres, despite the tendency of contemporary art forms to separate the two (Fitch, 2016). Additionally, groove has been linked to Japanese definitions of *nori*, which is related to sensations of vertical and horizontal movement, indicating that the appreciation of music through danceability may be shared across cultures (Etani et al., 2018). Both groove and nori highlight the sensation of wanting to move the body in different directions. Importantly, it has been shown that the more people desire to move

to the music, the more they enjoy the music (Janata et al., 2012). Significant correlations are found between groove and enjoying music or pleasure responses to music (Labbé & Grandjean, 2014; Witek et al., 2014), with syncopations in the music seen as the common denominator (Witek et al., 2014).

In order to gain greater insight into how musical preferences are shaped by perceived danceability, several studies have examined the factors that create a sense of groove, namely tempo and syncopations. Initially it was thought that decreasing the tempo of the music would also decrease the potential for groove (Madison, 2003); however, more recent studies indicate that there is in fact an optimal tempo for groove. Etani et al. (2018) used a series of drum breaks to investigate how the sensation of wanting to move in particular patterns or directions is influenced by varying tempos. They found that the relationship between groove and tempo was an inverted U-shaped relationship, with very low and very high tempo music rated as having the least amount of groove. Groove ratings were higher at tempos between 100 and 120 beats/min, with tempos between 107 and 126 beats/min considered optimal. Interestingly, the optimal tempo for groove overlaps with the optimal tempo for enjoying listening to music (~108 beats/min; Holbrook & Anand, 1990), and the preferred tempo peak seen in dance music, 120–130 beats/min (Moelants, 2002). Along with optimal tempo the second prerequisite for a grooving rhythm is optimal syncopations. Syncopations involve introducing sounds that are asynchronous to the tempo of the music, and in theory should create a sense of cognitive dissonance since they violate the pattern. However, syncopations on the downbeat make perfect sense when seen in the context of dancing, since they energize the second half of the periodic movement, which allows people to finish or close the circular movements with a renewed energy (Fitch, 2016). The relative contribution of syncopations to groove was demonstrated in an online survey examining desire to move in response to listening to a series of drum breaks with varying degrees of syncopation (Witek et al., 2014). Sixty-six participants completed the survey, which included questions on musical training, groove familiarity, and dance experience. Witek et al. (2014) demonstrate that rhythms that elicit feelings of wanting to move elicit feelings of pleasure characterized by an inverted U-shaped relationship in line with Berlyne’s (1971) inverted U-shaped hypothesis. Intermediate levels of syncopation elicited the greatest degree of desire to move and pleasure associated with groove. This means that people prefer some structural resistance against the regular meter in the music to make the music more interesting, but not so much that the secondary rhythm overrides or drowns out the primary meter. Additionally, Witek et al. (2014) also found that dance experience but not musical training or familiarity with groove affected subjects’ aesthetic ratings of the music. This demonstrates that knowledge of dance movements affects how people interpret musical beats. It also lends support to the claim that knowing the dance movements to a particular style of music can enrich the musical experience leading to a greater appreciation of the music, even in the absence of dancing activity (Fitch, 2016; Kirsch Drommelschmidt, & Cross, 2013). This further emphasizes the importance of action for the aesthetic experience of music, as knowledge of body movements in dance influences the effect of syncopation on subjective experience of groove more robustly than musical training. This is mirrored by studies that

demonstrate that dance performance can be improved by simply listening to the sound of the dance steps combined with accompanying music (Kirsch, Drommelschmidt, & Cross, 2013). This is an interesting finding and may be accounted for by audio-motor coupling, which outlines that sound–movement pairings can reinforce kinesthetic learning (Altenmüller, Marco-Pallares, Münte, & Schneider, 2009).

Taking these studies together it seems that physical size and simple movements can influence our preference for musical tempo, while experience of more complex movements through dance training helps us to appreciate more complex musical patterns such as syncopations, with people preferring music that combines tempo and syncopations in an optimal fashion so that the music induces a desire to move. This process facilitates the reciprocal transfer of musical metrical information and kinesthetic metrical information (Brown et al., 2006), which in turn results in dance as the embodiment of music. In this way it seems that the body plays an integral role in interpreting if not feeling the music. Future studies should examine whether groove happens as a matter of purely auditory pattern recognition, or whether muscle responses occur automatically as part of groove perception. This would help to determine whether physical responses to music moderate aesthetic responses in a bottom-up or top-down manner.

Methodological Challenges to Studying Dance and Music Interactions

Examining the interaction of music and dance in aesthetic judgments is challenging methodologically due to the presence of two dynamic stimuli and the importance of the live performance context for dance in particular (Howlin et al. 2020; Christensen & Jola, 2015; Stevens et al., 2009). Generally, it is important that full-length performances designed by dance professionals are used to investigate aesthetic interactions between music and dance (Christensen & Jola, 2015). Moreover, composers and choreographers should lead on the design of congruent and incongruent experimental conditions to guarantee ecological validity (Bläsing, 2015). This will help to ensure that there is an intended aesthetic quality within the stimulus presentation, while controlling for tempo relationships within the music (Woolhouse & Lai, 2014), to facilitate a measurable disruption of congruency.

Additionally, to account for the dynamic experience of the performing arts (Orgs, Caspersen, & Haggard, 2016; Vicary et al., 2017), it may be preferable to use continuous rather than discrete measures to capture audience enjoyment as performances unfold (Schubert, Vincs, & Stevens, 2013; Stevens et al., 2009; Isik & Vessel, 2019). This involves the introduction of continuous enjoyment response tools, which have benefits over a paper-based questionnaire in that they capture audience reaction as the performance unfolds and so give a more complete picture of audience enjoyment (Stevens et al., 2009). This method can also be used to evaluate audience agreement in response to disrupted audio-visual components of dance performance (Cohen, 2016), and has been introduced in the context of dance and sound interaction (Howlin et al., 2020). Measuring audience

responses over time allows the interaction between music and dance to be examined at individual moments as well as across longer durations.

Finally, the role of individual differences should be explored in the audio-visual aesthetics of music and dance. It is well documented that personality traits such as openness to experience and extraversion modulate levels of appreciation of dance with and without sound (Jola et al., 2014). People scoring high on the personality trait openness to experience are more likely to appreciate dance without music, because dance without music violates the mainstream conceptualization of dance as movement to music. It would be interesting to see if openness could also account for more unusual combinations of music and dance depending on the complexity, congruency, or abstract nature of the combination. Similarly, since understanding and familiarity are well documented as modulating factors in music appreciation (Brattico, 2015; Brattico & Pearce, 2013) as well as dance appreciation (Calvo-Merino, Glaser, Grèzes, Passingham, & Haggard, 2005, 2006), studies on the aesthetics of both music and dance need to account for musical expertise and dance expertise. To date most studies only measure expertise in one domain (Bläsing, 2015; Jola et al., 2014; Reason et al., 2016), or examine art experience more generally (Christensen et al., 2014), with only a minority of studies accounting for music and dance experience (Howlin et al., 2020; Witek et al., 2014; Woolhouse & Lai, 2014). Future studies should evaluate the relative contributions between music and dance expertise in modulating the cross-modal bias and determine whether expertise in either domain predicts how people prioritize different aspects of music and dance combinations. Moreover, experience needs to be carefully delineated in terms of visual experience of dance, as opposed to professional dance experience, and musicality, as opposed to professional musicianship.

Summary

The relationship between music and dance is incredibly complex, and while participants tend to be good at identifying music and dance that are intended to match (Mitchell & Gallagher, 2001), it almost seems more challenging for people to dissociate the dance and music stimuli. This may be due to evolutionary development, encouraging the brain to search automatically for meaning of a combined stimulus and the shared evolutionary origins of music and dance (Hagen & Bryant, 2003). It may also be because the 20th century has seen an increasing aesthetic tendency towards dance compositions where sound and movement tend to be more complementary. Another increasing aesthetic tendency is to present music and dance in direct competition (Fogelsanger & Afanador, 2006), where each source is perceived as two separate stimuli rather than promoting congruency. In this regard, arbitrary combinations of dance and music benefit from being relatively abstract, allowing people to project their own interpretation onto the performance. In contemporary dance, cross-modal incongruence can be perceived as aesthetically more pleasing. This is likely due to the fact that viewers actively look for cross-modal perceptual congruence formed by capture (Fogelsanger & Afanador, 2006; Mitchell & Gallaher, 2001), where each separate stimulus is perceived to complement the other rather than

compete with it. This suggests that in the context of contemporary dance, searching for a meaningful relationship between sound and movement is aesthetically pleasing, and more enjoyable than perfectly congruent relationships. Future studies should actively try to understand the different conditions in which the visual or auditory elements will dominate, assess which combination is perceived as the most enjoyable, and integrate this information with current models of aesthetic experience, which tend to focus on single artforms and sensory modalities.

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