Analyzing expressive qualities in movement and stillness: Effort-shape analyses of solo marimbists' bodily expression

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Abstract

Laban movement analysis, specifically effort-shape analysis, is offered as a system to study musicians' bodily expression. It proposes others' intentions are manifest in expressive bodily activity and understood through shared embodied processes. The present investigation evaluates whether the basic components of Laban analysis are reflected in perceptual judgments of recorded performances and, specifically, evaluates interjudge reliability for effort-shape analysis. Sixteen audio-visual excerpts of marimba pieces performed by two professional solo marimbists' (female and male) served as stimuli. Effort-shape analyses and interjudge reliability thereof were assessed through three different tasks: 1) verification task, 2) independent analysis task, 3) signal detection yes/no task. Professional musicians — two percussionists, a violinist, and a French hornist — acted as participants. High interjudge reliability was observed for transformation drive and shape components, but less so for basic effort action components. Mixed interjudge reliability results for basic effort actions, and differences between frequency observations, point to differences in participant's embodied expertise, task implementation, and training issues. Effort-shape analysis has potential to drive comparative and predictive research into musicians' bodily expression. Effort-shape provides a fine-grain temporal analysis of ecologically valid performance sequences.

Keywords: musician bodily expression, simulation theory, embodied cognition, Laban Movement Analysis, interjudge reliability.

Bodily movement is integral to the process of music performance and communication. In recent years, the literature investigating the influence of visual information on music perception and cognition has expanded steadily (for a review see Schutz, 2008). The increasing interest in audio-visual integration and crossmodal interactions in music perception and cognition draws lineage from notable research in speech perception. It is well established that a speaker's mouth movements can influence the auditory experience for the listener. The ventriloquism effect demonstrates the perceptual binding of lip movements and sound even though the sound emanates from a loudspeaker that is separated spatially from the moving lips (Thurlow & Jack, 1973). The McGurk effect demonstrates audio-visual integration, in which participants often report perceiving a /da/ or /tha/ sound when an auditory /ba/ is paired with the visual speech movements for /ga/ (MacDonald & McGurk, 1978).

The McGurk effect has also been demonstrated with music stimuli. Visual stimuli of a cello string being either plucked or bowed has been shown to influence participants' auditory judgements of plucked or bowed cello sounds (Saldaña & Rosenblum, 1993). Recently, Schutz and Lipscomb (2007) demonstrated that long or short gestures that accompanied the striking of a marimba note influenced judgements of the note duration as either long or short even though duration did not change. Hidalgo-Barnes and Massaro (2007) showed that visuals of an animated head's articulatory mouth movements when coupled with sound enhanced song-lyric comprehension compared with presenting the sound alone. Thus, across different facets of the human experience, audio-visual integration has been shown to play an important role in how we make sense of multisensory information.

Auditory and visual sensory modalities can also interact modulating the experience of music. Seeing musicians' bodily movements as they perform can influence overall music judgements, as well as judgements pertaining to specific music attributes. These judgments can range from expressive intentions, audience interest, quality assessments, and emotional communication, through to more elemental aspects such as dissonance, pitch distance, and accuracy (Schutz, 2008). While facial expression has been shown to be an effective communicator of emotion (Buck, Savin, Miller, & Caul, 1972; Ekman, 1999), the variable of interest in the present investigation is expressive bodily movement; that is, movements of the body other than those of the face. Our investigation is concerned with studying the core elements of expressive bodily movement in the context of perceiving performance.

An established framework — Laban Movement Analysis (LMA) — will be applied to body movement during music performance. Before introducing LMA, we will review research pertaining to judgements of musicians' expressive bodily movement.

Judgements of Musicians' Expressive Bodily Movement

As well as employing functional bodily movements to play the right notes at the right time, skilled musicians tend to use their bodies in a manner that displays expressive intentions. Using point-light reductions (Johansson, 1973) of performers' bodily movements, Davidson (1993) showed that participants could detect the performers' expressive intentions through sound- only, sound and vision, and vision-only modalities. However, Davidson (1993) concluded that vision alone seemed to provide more information regarding expressive intention. More recently, Broughton and Stevens (2009) showed that, in comparison to a listening-only experience, seeing performers' bodily movements coupled with the sound significantly enhanced differentiation of intentionally expressive from inexpressive performances. Further, audience interest in deliberately expressive, or projected as for public performance, solo marimba performances was influenced positively by the presence of expressive bodily movement (Broughton & Stevens, 2009).

Musicians' expressive bodily movements can affect overall quality assessments of performances. McClaren (1988) found that a positive visual display coupled with a high-quality audio component served to enhance assessments of solo marimba performance on a range of quality measures. In a recent study, Juchniewicz (2008) measured not only overall performance expression, but also expressive music elements of phrasing, dynamics, and rubato. With the audio component held constant, significant increases in all four measures were observed as a result of increases in a pianist's physical movement.

Performers' bodily movements can also influence communication of emotional expression coupled with music. Thompson, Graham, and Russo (2005, Experiment 5) observed significant differences in emotional valence (negative and positive) between assessments of some audio-only and audio-visual presentations of excerpts of music performance sung by Judy Garland. In a vision-only experiment, Dahl and Friberg (2007) reported that participants were generally able to differentiate happiness, sadness, and anger, but not fear, from musicians' bodily movements alone. Moreover, distinctly different movement patterns were associated with the emotions of happiness, sadness, and anger. Vines, Krumhansl, Wanderley, and Levitin (2006)

showed that clarinettists' bodily movements had the capacity to increase or decrease participants' sense of tension (emotional intensity) and phrasing (indicating music structure) at certain points in the performance, in comparison to assessments made when listening only.

The research to date demonstrates that musicians' expressive bodily movements affect perceptual, cognitive, and affective responses to music performance. But just *how* do musicians' bodily movements convey expression to the observer, how do the expressive movements unfold meaningfully over time, and how can we usefully analyze, document, and discuss observed bodily expression? The goal here is to present a system for analyzing and interpreting musicians' perceived bodily expression in conjunction with temporally ordered information such as the music score. An additional aim is for the system to drive future comparative and predictive research that links production and perception at a fine temporal grain, and within the context of ecologically valid performance sequences.

Analyzing, Interpreting, and Recording Musicians' Bodily Expression

Exploratory investigations seeking to analyze, interpret, and record performing musicians' bodily expression have involved varied methodological approaches. These include written description and categorization (Dahl & Friberg, 2007; Davidson, 2001) or classification and codification of perceived bodily expression (Davidson, 2007), written descriptive interpretation of performance (Clarke & Davidson, 1998; Wanderley, 2002; Wanderley, Vines, Middleton, McKay, & Hatch, 2005), and perceptual data (Davidson, 1994, 2002). Advances have been made towards studying nonverbal behaviors in popular music performance by applying categorization methods widely used for studying nonverbal behavior in interpersonal communication (Davidson, 2001; Kurosawa & Davidson, 2005). However, such systems do not easily lend themselves to the study of instrumental musicians' expressive bodily behavior where lyrics or a verbal narrative are absent, and the performer's bodily movements are relatively constrained by the need to manually manipulate their instrument. Therefore, a comprehensive system for analyzing, interpreting, and recording musicians' perceived bodily expression across performance contexts is needed to enable comparative and predictive research in the field.

Descriptive interpretations of perceived bodily expression have been linked temporally through symbolic notation to movement tracking performance data

(Clarke & Davidson, 1998) or the music score (Davidson, 2007). Software has been developed that enables the temporal linking of descriptive interpretations to audio-visual performance data (Campbell, 2005; Chagnon, Campbell, & Wanderley, 2005). However, without the basis of a reliable system for analyzing expressive bodily behavior across a variety of contexts, methods for temporally aligning perceived expression with movement material cannot be utilized to their full potential.

Researchers have sought to identify specific movement patterns reflecting perceptually different expressive intentions through description and/or kinetic measures. Dahl and Friberg (2007) described different movement patterns associated with musicians' intentions to communicate different emotional states. However, seeking patterns of bodily expression in movement tracking data has been problematic as human perception of expressive quality can pertain to vastly different temporal and spatial ranges of movement. While, generally speaking, increased quantities of bodily movement lead to increased overall assessments of expressiveness (Davidson, 1993, 1994), moments of little movement or stillness can also be perceived as expressively charged (Davidson, 2002). Davidson (1994) showed the way performances of intentionally different levels of expression may feature little change in quantity of head movement, yet participants relied on quality information provided by the head to perceive differences in intended levels of expression. It is not only the actual movements them-selves that are important for the detection of expressive intention, it is the quality perceived in those movements (Davidson, 2007). Data from motion tracking technology may not capture the effort or force in expressive movement. Therefore, to analyze and interpret musicians' bodily expression, a system that accounts for quality, and not just quantity, in bodily expression is needed.

Studies of music performance have supported the proposition that certain factors constrain the presence of instrumental musicians' bodily expression in expressive music performance. Technical or anatomical constraints (Davidson, 1994, 2002, 2007; Wanderley, 2002; Wanderley et al., 2005), issues of music structure (Clarke & Davidson, 1998; Davidson, 2002, 2007; Wanderley, 2002; Wanderley et al., 2005), as well as interpretive concerns (Davidson, 2007; Wanderley, 2002; Wanderley et al., 2005) have been proposed as factors that may modify expressive bodily behavior in music performance. However, a systematic means for analyzing and describing bodily expression that could generalize to any instrumental or music context has not thus far eventuated.

Primary reliance on components and cues that are available visually may have distanced researchers from understanding the true nature of embodied expression. It has long been proposed that human action is comprehended through visual observation and kinaesthetic experience (Bartenieff & Lewis, 1980; Laban, 1988). Accordingly, a system for describing, recording, and developing movement — Laban-Bartenieff Movement Fundamentals, developed by Rudolph Laban's student Irmgard Bartenieff — has been adapted and implemented to study standard expressive solo clarinet performances (Campbell, 2005; Chagnon et al., 2005). While the system emphasizes bodily awareness, Laban-Bartenieff Movement Fundamentals primarily diagnoses an individual's overall movement patterns with a therapeutic focus (Bartenieff & Lewis, 1980). We now turn to the work of Laban, as the primary source, to analyze systematically the bodily expression of solo marimba players.

Laban Movement Analysis

Based on the work of twentieth-century choreographer, movement theorist, and analyst Rudolph Laban, LMA encapsulates a range of approaches to identifying and describing the elements of expressive human movement (Groff, 1995). The principal assumption of LMA is that inner motivation for movement is apparent in observable movement (Bartenieff & Lewis, 1980). This assumption received conservative support from a personality study within clinical psychology, with the authors concluding that they were able to establish the assumed relationship between psychological/emotional states and particular movement patterns (Levy & Duke, 2003). LMA also advocates an embodied approach to perception and cognition of human movement behavior. The validity of its embodied perceptual and cognitive basis receives support from a variety of theoretical proposals and empirical findings from the neurosciences.

Many authors have proposed that covert or overt imitation of observed movements of others may play a role in perceiving and understanding the intention underlying such actions (Cox, 2001; Leman & Camurri, 2006; Moore & Yamamoto, 1988). Simulation theory posits that others' mental states are understood through adopting a similar mental state, or by "putting oneself in another's shoes" (Gallese & Goldman, 1998). Common coding theory suggests that both perceived ac-tions and to-be-effected actions activate similar neural representations, enabling sharing of meaning between individuals (Hommel, Müsseler, Aschersleben, & Prinz, 2001; Jackson & Decety, 2004). The hypothesized mirror neuron system is posited as the

neural mechanism that mediates understanding intentions behind auditory and visual communicative signals by transforming sensory information into motor simulations (Molnar-Szakacs & Overy, 2006). Specialist expertise, or training, has been shown to modify an individual's mirror-neuron-system response to observed motor acts in music, specifically piano playing (Haslinger et al., 2005), and capoeira (an Afro-Brazilian martial arts-dance fusion, Calvo-Merino, Glaser, Grèzes, Passingham, & Haggard, 2005). Additionally, muscle innervation has been shown to occur when observing someone performing an action (Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995). In the case of emotion-ally charged expressive action, imitation, rather than mere observation, has been shown to invoke emotionally empathetic neural responses (Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi, 2003). Therefore, it seems plausible that musicians' expressive intentions revealed as bodily activity or embodied thought may be understood through an embodied approach to perception and cognition as proposed by LMA. Moreover, the efficacy of LMA as a research tool for investigating human movement is supported by its adoption in multiple domains.

LMA has been used to analyze, record, and model human movement behavior in a variety of contexts. For example, LMA has been used to analyze and record expressive qualities in human action accompanying kinematic notation of dance movements (Bartenieff, Hackney, True Jones, van Zile, & Wolz, 1984; Hutchinson Guest, 2005), and in anthropological investigations (Jablonko & Kagan, 1988). LMA is used widely in diagnosis and treatment of patients with neurological disorders such as schizophrenia (Higgins, 1993). It has also been implemented as a tool for studying kinematic and expressive movement behavior in people with neurological impairment, such as stroke patients (Foroud & Whishaw, 2006). There has been interest in the application of LMA concepts to computational modelling for more realistic, expressive animation of virtual humans (Badler, Chi, & Chopra, 1999; Bouchard & Badler, 2007; Chi, Costa, Zhao, & Badler, 2000), and robotic humanoids (Nakata, Mori, & Sato, 2002; Masuda, Kato, & Itoh, 2010). Application of LMA to music performance contexts remains relatively unexplored.

While four components comprise the LMA framework (body, space, effort, and shape, Bartenieff & Lewis, 1980), the dynamic, expressive qualities of human movement are encapsulated in the components of effort and shape. It is these components on which we will focus. The aim of analyzing effort and shape — or effort-shape analysis — is to describe the different expressive qualities perceived in

bodily activity; in essence, how the movement is performed rather than what is performed (Davis, 1970).

Effort-Shape Analysis

Effort

The concept of effort is concerned with expressive human movement based on observable dynamic rhythms of physical exertion — tension, release, and phrasing of body movement (Maletic, 1987). Laban (1988) theorized that the effort of inner preparation through attention, intention, and decision for bodily action manifests in discernible effort expressed in movement. Observing and understanding effort in bodily activity requires consideration of the objective function of the movement, and the subjective movement sensation; both objective function and subjective movement sensation are important in expressive settings (Laban, 1988).

Four *motion factors: weight, time, space*, and *flow* constitute the concept of effort. Each motion factor is subdivided into two *effort elements* encompassing a *fighting* and *indulging* quality: *strong* and *light* (weight), *sudden* and *sustained* (time), *direct* and *indirect* (space), and *bound* and *free* (flow) (see Figure 1). Effort elements reveal different movement qualities in the motion factors (Bartenieff & Lewis, 1980). The best way to understand the effort-element concept is to kinaesthetically experience, or embody, the different movement qualities. For example, to understand the difference between strong weight and light weight, try feeling as heavy in your body as you can (imagine being a heavy rock), and compare that with feeling as light in your body as you can (imagine being a helium balloon). You might try this in front of a mirror and notice subtle changes in the car-riage of the body. Combining different effort elements of motion factors reveals a range of different expressive qualities in human movement (Maletic, 1987). Different movement qualities are most easily recognizable as the collection of effort element and motion factor combinations collectively categorized as *effort drives*.

The Effort Drives

Effort drives result from combining an effort element from three of the four different motion factors.
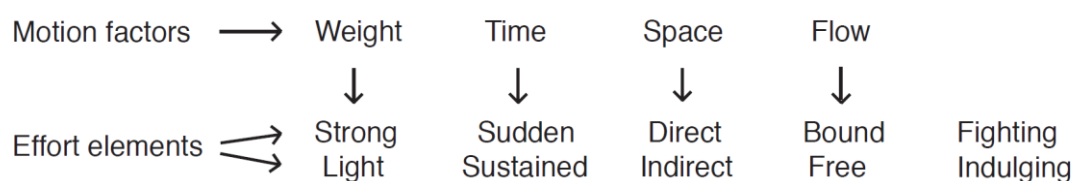
FIGURE 1. Motion factors and associated effort elements – the effort components in effort-shape analysis.

These combinations are easily recognizable as expressive (Bartenieff & Lewis, 1980), and are taken as core components in the analytical system presented here. For example, a combination may be strong (weight), sudden (time), and direct (space). A contrasting example might be sustained (time), indirect (space), and free (flow). The effort drive is divided into the *action drive* and the *transformation drive*. This division occurs according to which three of the four motion factors are involved. The action drive involves the motion factors weight (strong or light), time (sudden or sustained), and space (direct or indirect). For the transformation drive, the motion factor flow (bound or free) replaces one of the three motion factors of the action drive (see Figure 2A). Movements belonging to the action drive are "goal-directed," whereas those of the transformation drive are "nongoal-directed." For example, punching someone or something is a goal-directed movement, whereas wild arm gesticulations performed in a fit of rage are nongoal-directed movements. Next we shall describe analysis of the action drive in more detail.

The action drive. The action drive comprises eight *basic effort actions*. The eight basic effort actions are the result of the eight possible unique combinations of the effort elements associated with the motion factors weight, time, and space. Figure 2B displays the basic effort actions and their composition of effort elements. The metaphoric names for the basic effort actions are: *punching, dabbing, pressing, gliding, flicking, floating, slashing, and wringing* (Laban, 1988; Laban & Lawrence, 1974). They refer to both the action itself and the kinaesthetic feeling of performing the action. Each basic effort action features two rhythmic phrases — exertion and relaxation. These goal-directed actions are essential rhythmic human working actions (Laban & Lawrence, 1974), and are inherently expressive of emotional and mental states (Bartenieff & Lewis, 1980). As human working actions, it is conceivable that basic effort actions could exist in a music context where playing an instrument constitutes working movements. Now we turn to analyzing the other component of the effort drive — the transformation drive.
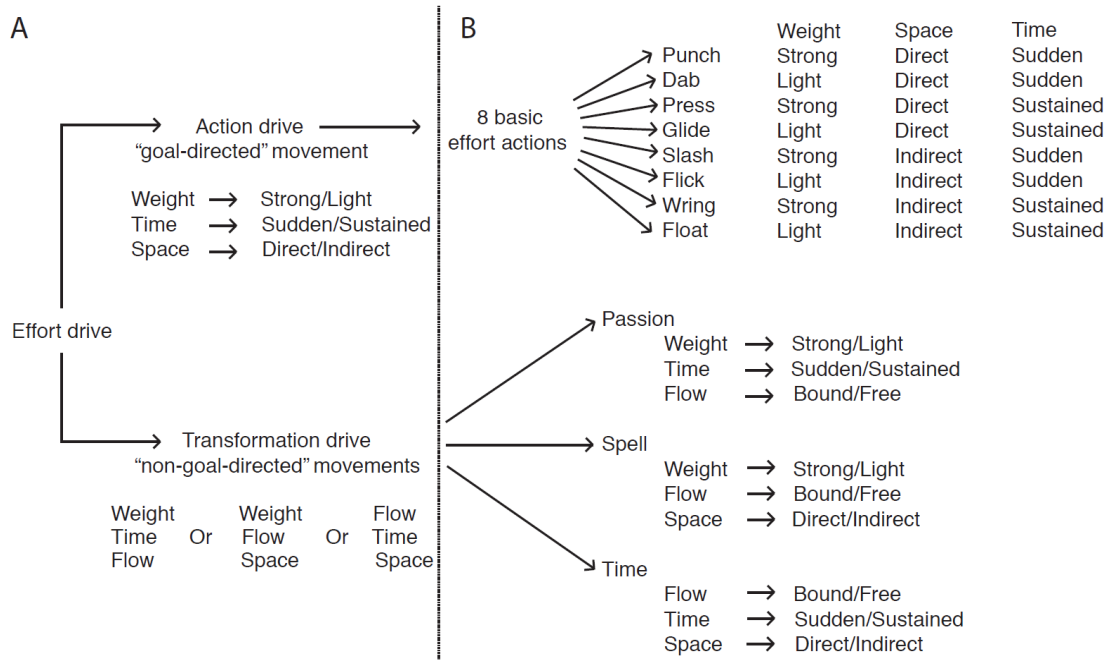
A

Action drive ⟶
"goal-directed" movement

Weight ⟶ Strong/Light
Time   ⟶ Sudden/Sustained
Space   ⟶ Direct/Indirect

Effort drive

Transformation drive ⟶
"non-goal-directed" movements

Weight		Weight		Flow
Time	Or	Flow	Or	Time
Flow		Space		Space

B

	Weight	Space	Time
Punch	Strong	Direct	Sudden
Dab	Light	Direct	Sudden
Press	Strong	Direct	Sustained
Glide	Light	Direct	Sustained
Slash	Strong	Indirect	Sudden
Flick	Light	Indirect	Sudden
Wring	Strong	Indirect	Sustained
Float	Light	Indirect	Sustained

8 basic effort actions

Passion
Weight ⟶ Strong/Light
Time   ⟶ Sudden/Sustained
Flow   ⟶ Bound/Free

Spell
Weight ⟶ Strong/Light
Flow   ⟶ Bound/Free
Space   ⟶ Direct/Indirect

Time
Flow   ⟶ Bound/Free
Time   ⟶ Sudden/Sustained
Space   ⟶ Direct/Indirect

FIGURE 2. Breakdown of the effort drive into the action drive (and the eight basic effort actions) and the transformation drive (passion, spell, vision). Constituent motion factors and effort elements are detailed.

The transformation drive. Replacing one of the motion factors in the action drive (weight, time, or space) with flow results in a transformation drive. The three possible combinations are metaphorically named: passion (weight, time, flow), spell (weight, flow, space), and vision (flow, time, space). Passion demonstrates a focus on emotion — either wildly passionate or gentle and sensitive. The focus of spell is fascination, or a hypnotized quality, as if time is standing still; movement has a stabilized quality. Vision has a mentally alert focus and a feeling of precision in time and place. A disembodied state, as if one is drawn out of oneself, vision can seem as if the individual is concerned with thought, or deep in concentration, rather than the here and now. Figure 2B also displays the motion factors comprising each of the transformation drives.

Once an expressive movement has been categorized as nongoal-directed, to identify which of the transformation drives it is, analysis of the movement is only necessary to the level of the particular motion factors involved. However, analyzing the movement's constituent effort elements can provide greater detail as to its expressive quality. For example, effort elements differentiate the quality of passion observed of someone in a wildly passionate rage (strong weight, sudden time, bound flow), and the gentle passion displayed in caressing or massaging a baby (light

weight, sustained time, free flow). A transformation drive reveals different qualities of mood or emotion and can appear amorphous compared to basic effort actions, which feature distinct rhythmic phases of exertion and relaxation (Bartenieff & Lewis, 1980). A transformation drive and a basic effort action cannot occur at the same time; they follow one another sequentially (Bartenieff & Lewis, 1980). Having considered the effort component of effort-shape analysis, we turn attention now to the shape component.

Shape

Shaping is analyzed in relation to the basic axes of bodily movement in space: vertical (*rising or sinking*), horizontal (*widening or narrowing*), and sagittal (*advancing or retreating*) (see Figure 3, Bartenieff & Lewis, 1980; Davis, 1970). Shape refers to postural body moulding in surrounding space; it is a concept interconnected with effort qualities (Royce, 2002). The extent of bodily shap-ing reveals personal commitment to an activity; for example, bodily shaping highlights whether a musician is fully engaged in their performance or just "going through the motions." *Postural effort* displays whole-bodily involvement in an activity as opposed to *gestural effort* where only the body part required to perform the job is utilized (Bartenieff & Lewis, 1980; Lamb & Watson, 1979).

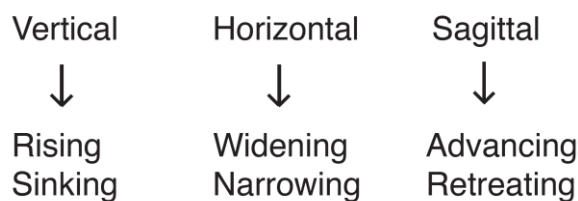| Vertical	Horizontal	Sagittal
↓	↓	↓
Rising	Widening	Advancing
Sinking	Narrowing	Retreating

FIGURE 3. Shape terms associated with the vertical, horizontal, and sagittal axes of spatial movement.

For the purposes of the present investigation, identi-fication of which part(s) of the body is/are involved in the perceived expressive movement is not made. Any movement behavior perceived as expressive and observed in any part of the body is analyzed in terms of effort and shape. McCoubrey (1984) also took this approach in an interjudge reliability study of motion factor and effort element components, which will be reviewed in the following section.

Reliability of Effort and Shape Analysis – Empirical Evidence

It could be argued that analyzing effort and shape is a highly subjective task. It is therefore prudent to consider interjudge, or inter-subjective, reliability before the sys-tem is accepted as a method for analyzing musicians' expressive bodily behavior.

Although we found no published reports of interjudge reliability for effort drives (action drive or transformation drive), some evidence exists for interjudge reliability in relation to motion factors and effort elements. McCoubrey (1984) reported significant interjudge reliability for the motion factors weight, space, and time, but not flow. Also reported was significant interjudge reliability for the effort elements bound (flow), strong (weight), light (weight), direct (space), and sudden (time). However, free (flow), indirect (space), and sustained (time) did not reach statistically significant interjudge reliability. In McCoubrey's study, the judges were predominantly Certified (Laban) Movement Analysts, although their practical experience with detailed effort observation was varied. The stimulus for the study was a 50 s clip of cello performance. It is unknown whether any of the analysts were also expert cellists, or even musicians. This brings into question whether a possible lack of embodied experience with cello or music performance could have affected results. McCoubrey also reported that most of the participants expressed frustration and confusion with the task and various methodological issues, such as not being able to review the film clip at will. While McCoubrey's study addressed motion factor and effort element components, other studies report evidence for interjudge reliability for effort and shape components.

Davis (1987) reported reliable effort element and shape frequency observations in response to solo dance and talk footage. However, results must be viewed with caution as methodological issues, such as problems with computers and the selected stimuli, marred the study. Teams of three early career graduates of Laban certification programs, the majority of whom were dancers and dance therapists, analyzed 45 s dance and talk segments. These test analyses followed three hours of training with practice videotapes. Results of the initial part of the study indicated interjudge reliability for the effort elements strong (weight), direct (space), and sudden (time), as analyzed in dance and talk segments. Reliable agreement was also obtained for observations of sustained (time) and light (weight) for dance segments. Interjudge reliability was also observed for the frequency of shape observations. However, reliability of judged spatial direction (e.g., vertical, horizontal, sagittal) was not noted.

Davis (1987) also reported high interjudge reliability for observations of expressive postural adjustments, called posture-gesture mergers (PGMs), though these were only studied in talk segments by expert coders. "PGMs are defined as instances where a gesture (partial body movement) flows into a posture (full body movement) or vice versa." (Du Nann Winter, Widell, Truitt, & George-Falvy, 1989, p. 212). Du Nann Winter and colleagues (1989) similarly reported high interjudge reliability for frequency of observed PGMs. The judges in their study were trained with practice (video-only) tapes for about 15 hours over a five-week period. Taken together, these studies offer some empirical evidence of reliability in support of most of the concepts and components of effort-shape analysis. However, other studies report more varied interjudge reliability for effort and shape concepts and components incorporated into higher-order systems of movement analysis.

Davis (1983) incorporated effort and shape concepts into a system called The Davis Nonverbal Communication Analysis System (DaNCAS). DaNCAS is aimed at assessing movement behavior in individual psychotherapy settings. Generally, good interjudge reliability was reported for parts of the DaNCAS incorporating effort and shape concepts in a small pilot study. However, agreement on effort element and shape qualities was not reliable. Davis pointed to a need for more intensive training, or a substantial training period between 15 and 30 hours. Analysts, who were training in the LMA Certification Program, viewed whole-body footage of the patient and therapist without sound. The analysts made naturalistic, real-time observations of movement sequences and were free to review the footage as much as needed.

A widely used system in developmental, clinical, and psychotherapeutic settings that was designed incorporating effort and shape concepts into higher- order movement variables is the Kestenberg Movement Profile (KMP). Interjudge reliability in implementing the KMP has been moderately supported (Sossin, 1987) and queried (Koch, Cruz, & Goodwill, 2001). The level of expertise of the movement analysts may account for inconsistencies in results across studies. The KMP is said to be an intricate system to learn and a basic training course takes 45 hr (Koch et al., 2001). While the KMP incorporates effort and shape concepts, these systems have been developed to document a range of nonverbal behavior patterns for specific contexts. They are therefore not readily applicable to a music performance context. Nonetheless, what these studies support is the possibility of interjudge reliability for higher-order movement variables integrating effort components. Analyzing effort, as

proposed in the present study, employs higher-order movement variables — the action drive and its eight basic effort actions, and the transformation drive — based on effort elements.

The studies reviewed here report interjudge reliability coefficients primarily based on overall frequencies of observations. However, expressive bodily movement usually unfolds in time. It is also possible to calculate reliability for the temporal unfolding of observations and, further, there is precedence in the literature for temporal coding of effort and shape observations.

Temporal Coding of Effort-Shape Analyses

For full understanding, the temporal aspect is critical for analysis of audio and visual materials that unfold over time, such as music and movement. Labanotation is a widely used system for notating human movement as it unfolds in time (Hutchinson Guest, 2005). Labanotation results in a continuous movement score of meaningful symbols much like a music score. Maletic (1980) notated effort observed in filmed dance in a continuous fashion to accompany the footage. The DaNCAS codes movement of a patient and patient-therapist interactions in a continuous manner to accompany videotaped sessions (Davis, 1983). Davis (1987) worked with computer programmers to develop a means of recording effort and shape observations in a continuous fashion in real time. Therefore, interjudge reliability for effort and shape observations should be able to include both overall frequencies of observations and the location of observations in the temporal sequence.

Assessing Inter-Judge Reliability

Correlating sets of results from participants who have been trained on, and subsequently completed, an analysis task is a common way to assess interjudge reliability. Accordingly, in the present study, we calcuated interjudge reliability in the frequency and temporal domains using correlation. A weakness of the method, however, is that it does not take into account the possible confound of response bias with stimulus detection. Response bias, or the willingness of a participant to report the presence or absence of a stimulus, presents nonsensory error. Signal detection theory provides a way of assessing the detectability of a stimulus separately from response bias (Levine & Parkinson, 1994). Controlling participants' expectations of the proportion of signal to catch-trial (no-stimulus) events controls response bias to an extent. This means informing the participant that the signal will be present on 50% of trials, and absent in the other 50% of trials. However, response bias cannot be

completely con-trolled and is therefore measured in the signal detection experimental paradigm.

Calculating temporal accuracy comes with the signal detection method. For example, for a yes response to be correct or accurate (a *hit*), the response must be given in relation to the presence of a signal within the temporal sequence of a trial. Likewise, an erroneous yes response (a *false alarm*) refers to a yes response to a no-stimulus or catch-trial event within the temporal sequence. If a signal is present but not detected in a trial, it is considered a *miss*. Finally, a no-stimulus or catch-trial event correctly identified as such is considered a *correct rejection*. The hit and false alarm rates are used to calculate sensitivity (d') and response bias (β) (Levine & Parkinson, 1994). Therefore, there is no need to assess separately temporal accuracy of signal detection in this method.

In the following sections, we investigate the efficacy of effort-shape analysis using three different approaches to assess interjudge reliability. The three approaches are: a verification task, an independent analysis task, and a signal detection theory-driven yes/no task.

Aim and Research Questions

The aim is to investigate the LMA effort-shape para-digm as a reliable system for analyzing and describing musicians' expressive bodily movement. We hypothesize that, following training in the effort-shape system, participants are able to apply reliably the effort-shape system to analyze musicians' expressive bodily behavior. Interjudge reliability was assessed through three different tasks conducted sequentially in the following order: 1. verification task, 2. inde-pendent analysis task, 3. signal detection theory- based discrimination yes/no task. The materials for analysis, described in detail below, are audio-visual recordings of excerpts of solo marimba pieces performed in a projected (standard public performance expression) and deadpan (minimized expression) manner. Following an overview of the general method in the next section, the method specific to each task is reported.

General Method

Participants

Four professional instrumental musicians were recruited as participants through a convenience strategy from the first author's professional contacts. Two professional percussionists who were experienced marimba players (one female, one male) verified the first author's suggested effort-shape analyses (verification task).

One female, professional violinist performed independent effort-shape analyses of the movement material in the audio-visual recordings (independent analysis task). One male, professional French hornist responded to suggested effort-shape analyses in a signal detection theory-driven yes/no task. Suggested effort- shape descriptions were those agreed upon by both percussionist verifiers with the inclusion of catch trials. Each musician had completed an undergraduate degree in music performance and was currently active in the music profession as a performer and teacher. The violinist and French hornist had never received any training in percussion performance and had negligible experience playing percussion instruments, including the marimba. Participants were reimbursed AUD150 for their time, effort, and music expertise. All participants reported normal hearing and normal or corrected-to- normal vision.

Materials for Analysis

Sixteen audio-visual recordings of 20-25 s excerpts of solo marimba performance were selected from stimuli used in an experiment reported elsewhere (Broughton & Stevens, 2009). In the previous experiment, a female and a male professional marimba player performed excerpts of standard solo marimba repertoire with the intention of minimal expression (deadpan), and with the intention of an expressive public performance (projected). The excerpts were drawn from Suite No.2 for Solo Marimba, III by Japanese composer and marimba player Takayoshi Yoshioka (1995), Marimba Dances, II & III by Australian composer Ross Edwards (1990), Nancy by French com-poser Emanuel Séjourné (1989), and Merlin, I by Andrew Thomas (1989) from the United States of America. The marimba pieces were representative of normal performance techniques and music styles in the genre. The sound files were normalized for each excerpt so that the possible dynamic range was comparable across performers and performance manners (projected or deadpan). The selection of stimulus excerpts for the present study was based on expressiveness ratings attributed by music-trained and music-untrained participants to audio-visual presentations of performances.

Eight excerpts were selected from the previous study. From rank ordering of the stimuli according to mean expressiveness ratings, four highly rated excerpts performed in a projected manner were selected together with four poorly rated excerpts performed in a deadpan manner. The selected projected performance excerpts scored in the top 17.71% of ratings for expressiveness, and the selected deadpan performance excerpts received expressiveness ratings in the lowest 11.46%.

Represented in the selected excerpts were two projected and two deadpan performances given by both the female and male musicians. Additionally, a fast and a slow tempo excerpt performed by both the female and male performer was represented in the four projected and four deadpan audio-visual excerpts. Finally, for each selected projected excerpt, the same music performed by the same musician in a deadpan manner was selected for comparative analysis. Likewise, for each selected deadpan excerpt, the same music performed by the same musician in a projected manner was selected for comparative analysis. This yielded a total of 16 excerpts.

All of the selected 20-25 s audio-visual (.avi) excerpt files were edited using Adobe Premier Pro 1.5 software. An opaque box was included on the screen masking the performer's head in each excerpt and thus any facial expressions; head movements were still visible. As bodily expression was the variable of interest and to avoid a possible confound, we masked facial expressions. A title screen preceded and introduced each excerpt. After applying an auto-color correction effect to balance lighting changes across all excerpts, the sequence was then exported to DVD for playback on commercially available DVD players and televisions. Finally, the section of music score relative to each performance excerpt was prepared in accordance with the different task requirements for distribution with the DVD.

Procedure

An individual appointment was made with each participant to provide the analysis materials and to conduct a one-hour training session on the effort-shape analysis system. Participants were provided with an information sheet outlining the task; written consent was gained prior to commencement of the training session. The package of analysis materials contained the DVD of 16 audio-visual excerpts of solo marimba performance, excerpts of music scores for each performance excerpt (annotated for the verification and signal detection yes/no tasks [see Music Example 1], and blank for the independent analysis task), and written reference material describing effort-shape analysis with instructions about how to perform the analysis. The reference material and instructions were designed following discussion with a Certified (Laban) Movement Analyst regarding LMA theory and methodology (see Appendix). Although supplementary information regarding effort-shape symbolic notation was provided in the written reference material, participants were informed that they were only required to understand and utilize the system by way of the metaphoric names for each component.

In the training session, participants read through the written reference material. Each component of the analytical system was discussed and illustrated with audio- visual and actual movement practice examples until the participant was satisfied that they understood. The procedure, relative to the specific task each participant was asked to perform, was then discussed. Participants were free to perform their individual task at their convenience over a period of one week. During this time, they were able to seek clarification on any issue at any time via phone call to the first author. The three tasks are described below.

1. Verification Task

The primary aim of the verification task was to develop a baseline consensus on effort-shape analyses of the excerpts of solo marimba performance for the signal detection yes/no task. As a control measure for embodied knowledge, the two expert percussionist marimba players shared a background of training and expertise similar to that of the first author.

1.1 Method

The music scores accompanying each performance excerpt were annotated with effort-shape analyses by the first author in the following manner. To clearly show to participants which section of the music score matched the movement material for analysis on the DVD, we marked two sets of parallel vertical lines above the stave in the music score that indicated the start and end locations. Between these markers a horizontal line was drawn above and parallel to the music score (the action stroke, Hutchinson Guest, 2005). The action stroke indicated the presence of movement and marked out the section of music for analysis (see Music Example 1). Observations of effort and shape features were hand-written in words where they were observed. Basic effort action and transformation drive observations were notated above the action stroke, and shape features notated below the action stroke. To differentiate less from more effortful movements observed within each category of the effort-shape system, brackets were used to enclose the name of a movement that was deemed to be relatively less effortful. For example, an effortful punch was notated as "punch" and a less effortful punch was notated as "(punch)."

In light of debriefing discussions with the expert participants, this level of analysis was deemed unnecessarily detailed. Therefore, responses in these dual categories were collapsed into single categories stipulated by the effort-shape system

for analysis. For example, "(punch)" and "punch" were collapsed into a single category named "punch."

Music Example 1. Effort-shape analysis by the first author of *Marimba Dances, III*, by Ross Edwards (1990), bars 1-20 as performed by a male marimba player in a projected manner. *Note*. © Copyright Ross Edwards. Reproduced by permission of Hal Leonard Australia pty ltd the exclusive agent for Ross Edwards. Used By permission. All Rights Reserved. Unauthorized Reproduction is Illegal.

The two professional percussionists undertook the verification task separately. The expert participants were asked to view each audio-visual excerpt on the DVD as many times as they liked in whatever order they chose both with and without sound. Their task was to indicate their agreement with a tick (✓), or disagreement with a cross (✗), with the suggested analyses that had been written on the music score. They were also invited to offer alternate analyses, though only the forced-choice agreement data would be used.

1.2 Results and Discussion

Very high agreement was reached with the first author's effort-shape analyses by both percussionists. For basic effort actions, the female percussionist agreed on average 96.15% (SD = 5.15%) of the time, and the male percussionist 98.80% (SD = 1.98%) of the time. The female percussionist agreed on average 96.08% (SD =

6.79%) of the time, and the male percussionist 90.20% (SD = 16.98%) of the time with the suggested transformation drives. For shape features, the female percussionist agreed on average 99.71% (SD = 0.66%) of the time, and the male percussionist 96.13% (SD = 8.66%) of the time. Although these results point to very high agreement, they could also be viewed as reaching ceiling level. Such high agreement could be due to demand characteristics. That is, the stimulus or task provided a cue suggesting the expected behavior to the participants. Therefore, an independent analysis task was conducted to assess further interjudge reliability.

2. Independent Analysis Task

2.1 Method

The professional violinist was asked to view each audio- visual excerpt on the DVD and note on the accompanying music score any bodily activity or stillness she perceived to be expressive at the relative location. Each observation was to be analyzed using the effort-shape system and recorded in words. Basic effort actions and transformation drives were to be notated above the action stroke, and shape features below the action stroke on each music score. The action stroke indicated the section of music score matching the movement sequence for analysis on the DVD. As in the verification task, the action stroke was a horizontal line running above and parallel to the music stave; the beginning and end of the action stroke was marked clearly by two short parallel lines perpendicular to the action stroke. The remainder of this section describes the task in more detail.

2.1.1 Procedure

Each excerpt was viewed at will with sound to focus the participant's attention on how the performer's movements related to the music score, and without sound to focus attention on bodily movement and expression alone. Freedom was granted to stop and start playing the excerpt at will, especially when there was a need to observe a section in more detail. Switching between watching the deadpan and projected performance of the same excerpt was permitted so as to distinguish movements that were necessary to play the notes of the piece from movements that demonstrated more effort.

First, when viewing a performance excerpt, any moments perceived as expressive were noted at the appropriate location on the music score. With each subsequent viewing of an excerpt, attention was concentrated on one element of the

analysis. Any basic effort actions of the action drive or any transformation drives that were identified were to be recorded at the observed locations on the music score above the action stroke. The actions or drives were recorded in words using their metaphoric names (e.g., punch or passion). Observed shape features were recorded using metaphoric words with reference to the relevant axis of space: rising or sinking (vertical), widening or narrowing (horizontal), or advancing or retreating (sagittal). Shape features were recorded below the action stroke.

2.2 Results and Discussion

Interjudge reliability was assessed by correlating the violinist's effort-shape analyses and the effort-shape analyses of the first author that were also corroborated by both percussionists in the verification task. Correlation coefficients were calculated for frequency of observations of basic effort actions, transformation drives, and shape features. Additionally, a measure of shared locations of observations was also used as the basis for correlation.

To calculate the shared locations of observations measure, the number of observation locations shared by the percussionists and violinist for each basic effort action, transformation drive, and shape feature in each item was calculated. These were aggregated for each item to give shared observation location scores for basic effort actions, transformation drives, and shape features. The proportion of shared observation locations, relative to the total number of observations for each component in each item made by the percussionists and violinist, were calculated. Items where both the percussionists and violinist agreed that no expressive action occurred were given a perfect agreement score of 1.

Due to the small sample size, and with the data failing to meet the assumption of normality, Spearman's rho was used to compute inter-judge correlations. For basic effort actions, no relationship was observed between the percussionists' and violinist's frequency of observation ($\rho = -.00$, $n = 16$, $p = .99$). However, the correlation between the percussionists' and violinist's frequency of observation was positive and significant for transformation drives ($\rho = .95$, $n = 16$, $p < .001$), and shape features ($\rho = .86$, $n = 16$, $p < .001$). Correlations for the proportion of shared locations of observations between the percussionists and violinist were positive and significant for basic effort actions ($\rho = .91$, $n = 16$, $p < .001$), transformation drives ($\rho = .81$, $n = 16$, $p < .001$), and shape features ($\rho = .86$, $n = 16$, $p < .001$).

A chi-square goodness-of-fit test showed a significant difference between the frequency with which the percussionists and the violinist observed basic effort actions $\chi^2 (1, n = 144) = 30.25$, $p < .001$, and shape features $\chi^2 (1, n = 306) = 6.92$, $p < .01$. Basic effort actions were observed significantly more often by the percussionists (105, 72.92%) than the violinist (39, 27.08%). Similarly, shape features were observed significantly more often by the percussionists (176, 57.52%) than the violinist (130, 42.48%). The difference between the percussionists' and violinist's frequency of observations of transformation drives approached significance $\chi^2 (1, n = 52) = 3.77$, $p = .052$ (percussionists = 33, 63.46%; violinist = 19, 36.54%).

That no correlation was observed between the percussionists and violinist for basic effort actions could be due to differences in the participants' embodied music knowledge. That is, with no percussion playing experience, the violinist may not have been easily able to interpret expressive marimba playing techniques as goal-directed basic effort actions. This interpretation is supported by the significant one-way chi-square result for basic effort actions showing that percussionists reported observations more frequently than the violinist. That the percussionists reported observing basic effort actions and shape features significantly more often than the violinist indicates possible differences in fluency, interpretation, or fastidiousness in implementing the system. Refinement of training and instructions may further improve interjudge reliability across participants with differing specialist music training and experience.

3. Signal Detection Yes/No Task

3.1 Method

The annotated scores given to the professional French hornist contained 50% signal and 50% catch-trial (no-stimulus) effort-shape analyses. The music scores were annotated with effort analyses above the action stroke and shape features below the action stroke. The signal effort-shape analyses were those that were agreed upon in the verification task. The same numbers of signal effort-shape analyses in each subcomponent of the system were distributed randomly across the 16 performance excerpts as catch-trial events. Care was taken to add the catch-trial component at musically plausible locations, for example, avoiding inserting a punch action during a passage marked for the roll technique — creating the illusion of a sustained sound by striking marimba notes one after the other in quick succession — at a quiet dynamic. Care was also taken to avoid inserting catch-trial events at locations of dis-agreement

gleaned from the results of the verification task. There were 105 instances of both signal and catch- trial basic effort actions, 33 instances of both signal and catch-trial transformation drives, and 176 instances of both signal and catch-trial shape features across the 16 performance excerpts.

As is the convention in signal detection tasks, the participant was informed of the ratio of signal and catch-trial events; the signal presentation probability was .5. Their task was to indicate agreement with the suggested analyses with a tick (✓) on the score or disagreement with a cross (✘). Participants were also invited to offer alternate analyses, although these data would not be used in the present study. As in the two previous tasks, the participant was free to view the excerpts with and without sound at will. They were also permitted to review excerpts on the DVD as often as desired.

3.2 Results and Discussion

For the signal distributions of basic effort actions, transformation drives, and shape features, the assumption of normality was not met. The comparative catch-trial distributions did meet the assumption of normality on the Kolmogorov-Smirnov test. However, the assumption was only met by the basic effort action catch trial distribution on the Shapiro-Wilk test of normality. It is not surprising that the signal distribution failed the assumption of normality as the vast majority of signal effort-shape analyses were observed in projected performance excerpts. In comparison, the catch-trial effort-shape analyses were randomly distributed across projected and deadpan excerpts. Therefore the nonparametric measures of sensitivity and response bias, A' and B'' respectively, were used instead of the parametric versions, d' and β, or c. A' values range from zero to one; an A' value of 0.5 indicates chance performance. B'' values range from -1 one to +1. B'' values deviating from zero in a negative direction indicate response bias towards yes responses (Stanislaw & Todorov, 1999).

Performance at correctly detecting basic effort actions was no better than chance ($A' = .47$). The participant was very slightly biased toward giving yes responses ($B'' = -.06$). Accurate detection of transformation drives was better than chance ($A' = .70$), again with a slight bias towards yes responses ($B'' = -.38$). Detection accuracy was better for shape features ($A' = .78$), and with only a slight yes response bias ($B'' = -.28$). Results for basic effort actions suggest two possible

interpretations. Either the instructions were unclear leading to confusion, or the participant lacked embodied knowledge to identify goal-directed, expressive marimba performance movements. High sensitivity to transformation drives and shape features in the effort-shape system indicates that the instructions were understood and on these components signal events were clearly differentiable from catch-trial events. However, further refinement of the instructions and training process may yield improved results.

General Discussion

Building on previous research involving post hoc analyses of musicians' expressive bodily behavior, we investigated effort-shape analysis as a reliable system for analyzing and describing expressive aspects of performance as it unfolds in time. As hypothesized, following training, participants were able to apply the majority of the effort-shape analysis system reliably to analyze musicians' expressive bodily behavior. High and significant interjudge reliability was attained for transformation drives and shape features across the three tasks, these being the verification task, the independent analysis task, and the signal detection yes/no task. The proportion of shared locations for observations of basic effort actions, transformation drives, and shape features between the percussionists and the violinist yielded positive and significant correlations. This indicates high interjudge reliability for the different types and qualities of expressive bodily behavior, revealed through effort-shape analysis, in the temporal domain. However, for basic effort actions, results were mixed.

Basic effort actions only received high interjudge agreement in the verification task. Very poor interjudge reliability was observed for basic effort actions in the independent analysis and signal detection yes/no tasks. This may be due to differences in task demands; that is, the verification task was much easier to undertake than the independent analysis task, or the signal detection yes/ no task. Also plausible, given the similar results yielded from the violinist and hornist by way of two different unprimed tasks, is a lack of embodied knowledge regarding percussion performance techniques.

Participant expertise may have been a factor differentiating high interjudge reliability for transformation drives and shape features from lack of interjudge reliability for basic effort actions. Mirroring observed bodily expression — as stipulated by the effort-shape system — may have contributed to the high interjudge

reliability observed in temporal positioning and frequency of observation for nongoal-directed (nonmarimba-playing) expressive transformation drive and shape movements. The mirroring process, whether covert or actual, may play a role in understanding the expressive intentions of others (Bartenieff & Lewis, 1980; Cox, 2001; Laban, 1988; Leman & Camurri, 2006; Moore & Yamamoto, 1988). The hypothesized mechanism at work is the human mirror neuron system transforming audio-visual sensory information into motor activation in participants, in turn, associated with understanding the performers' intentions (Molnar- Szakacs & Overy, 2006). Mirroring transformation drives may also have activated similar neural pathways invoking empathetic, emotional responses (Carr et al., 2003). In the case of basic effort actions, they may have been difficult for the violinist and hornist to analyze because the link between neural networks activated in mirroring an observed action, and neural networks pertaining to knowledge about the music consequence of that goal-directed movement on the marimba is absent. The percussionists' perceptual system may have been primed due to expertise in marimba playing (Calvo-Merino et al., 2005; Haslinger et al., 2005) resulting in activation of neural networks associated with the consequences of goal-directed basic effort actions. This raises the issue of expertise in judging music performances. Specific technical and general music expertise may contribute to assessments in different ways.

From a theoretical perspective, common coding theory explains the positive interjudge reliability results for transformation drives and shape features, and the lack of interjudge reliability for basic effort actions (Hommel et al., 2001; Jackson & Decety, 2004). If perceived actions and to-be-effected actions activate similar neural networks, then the goal-directed (marimba-playing) expressive movements would be difficult to interpret by participants lacking motor expertise in marimba playing. Similarly, a case for these results can be made from the perspective of simulation theory (Gallese & Goldman, 1998). That is, direct bodily experience of the types of nongoal-directed (nonmarimba-playing) movements in the transformation drive and shape categories would make them easier to interpret through a mirroring process where simulation activates the same neural networks. On the other hand, in the case of basic effort actions, without direct bodily experience and neural networks for marimba playing actions, drawing that link between the action and the musical intention of the action through a simulation process would have been difficult. Results for basic effort actions indicate that the violinist participant could reliably detect

expressive bodily behavior at the same locations as the expert percussionists, they were just less attuned and less able to categorize it as the percussionists could. The extent to which information in the music score cued the percussionists to expect certain basic effort actions — where the nonpercussionists were unable to — is unknown and remains for future studies to address.

Results from the independent analysis task demonstrating that the percussionists reported more basic effort action and shape observations than the violinist may reflect differences in music and motor exper t ise, differences in difficulty regarding implementing the task, or limitations in the training process. Similarly, the lack of interjudge reliability for basic effort actions from both nonexpert-percussionist participants may reflect similar issues. From the perspective of task differences, the verification task was easier to undertake than both the independent analysis and signal detection yes/no tasks. Regarding participant training, unlike other studies reporting reliability measures for effort and shape components (Davis, 1983, 1987; McCoubrey, 1984), the participants in the present study were not Certified (Laban) Movement Analysts nor had they any previous training in LMA or effort- shape analysis. In the present study, a limited period of time was available for training participants in comparison with other studies that have incorporated effort and shape components (Davis, 1983, 1987; Du Nann Winter et al., 1989; Koch et al., 2001). A future study will reassess interjudge reliability for basic effort actions using modified training and instructions. Future work will also assess interjudge reliability for the effort elements and motion factors involved in basic effort actions.

In sum, results from this investigation suggest psychological or perceptual validity of transformation drives and shape components of effort-shape analysis; interjudge reliability for basic effort actions remains to be confirmed. Through this reliability study possibilities for future directions have surfaced. For example, a future study will investigate relationships between music elements, such as the staccato, and particular effort and shape components. In the present study, performances with both sound and vision were available to the analyst. Future research could compare analyses between performances where the analyst could hear as well as see the performer and performances where the analyst could only see the performer. This may highlight a potential modifying effect that auditory information exerts on the analytical process, and differences in the perception of expressive bodily behavior

between ecological audio-visual and more artificial visual-only music performance experiences.

The effort-shape system may offer a useful solution to the myriad exploratory studies seeking to analyze and interpret musicians' bodily expression and perhaps marry it with other performance, perceptual, or kinematic data (Campbell, 2005; Chagnon et al., 2005; Clarke & Davidson, 1998; Dahl & Friberg, 2007; Davidson, 1994, 2001, 2002, 2007; Kurosawa & Davidson, 2005; Wanderley, 2002; Wanderley et al., 2005). Further, results conservatively support effort-shape analysis as a means to progress from global intention-perception measures (Broughton & Stevens, 2009; Dahl & Friberg, 2007; Davidson, 1993; Juchniewicz, 2008; McClaren, 1988), towards more fine-grained prediction, analysis, and understanding of expressive bodily behavior as it unfolds. Finally, effort-shape analysis offers a means of analyzing different expressive qualities perceived in bodily movement (Davidson, 2007). These are separate from and complementary with measures of movement quantity obtained using motion capture technology.

Effort-shape analysis is potentially a valuable tool for innovative comparative and predictive research in music perception and cognition using ecologically valid performance sequences. The groundwork has been provided for future studies to validate and investigate the reliability of the effort-shape system in other instrumental and vocal performance contexts. As the visual aspect of the music experience appears so potent, it makes sense to investigate this facet of human creativity and communication to the fullest.

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Appendix

Explanation of the Effort-Shape Analytical System

Conducting effort-shape analysis of expressive bodily movement involves consideration of *effort* (comprising the *action drive* and the *transformation drive*) and *shape* (Davis, 1970). Movement sequences for analysis are denoted with the *action stroke* (Hutchinson Guest, 2005). This section will briefly explain each of these components and how to analyze and record them.

Analysis of Effort

Laban identified four motion factors involved in human movement: *space, weight, time* and *flow*. A person's attitude towards each of these motion factors reveals the effort in their action. Each motion factor has a bipolar continuum of effort associated with it ranging from an "indulging" quality to a "fighting" quality. Analysis requires both visual inspection of movement and kinaesthetic observation. Kinaesthetic observation involves sensing within one's own body how it may feel to perform the movement.

Please take a moment to experience the four motion factors and their associated effort elements shown in Table A1. The goal is to recognise how the movement might *look visually*, and *feel kinaesthetically*.

TABLE A1. The Motion Factors and Effort Elements Involved in Human Movement.

Motion Factors	Effort Elements		Notes
	Indulging	Fighting	
Space	Indirect	Direct	Does the movement take a wavy path, or go straight from point A to point B?
Weight	Light	Strong	Does the movement appear and feel light or heavy?
Time	Sustained	Sudden	Does the movement seem unhurried or urgent?
Flow	Free	Bound	Does the movement flow freely (relaxed), or does it seem to be stopping and starting (constrained)?

Action Drive

The action drive is composed of three motion factors: space, weight and time. Different combinations of the bipolar effort elements associated with the three motion factors results in eight possible *basic effort actions* (Bartenieff & Lewis, 1980; Laban, 1988; Laban & Lawrence, 1974).

Basic effort actions

Each of these basic effort actions displays two rhythmic phrases of exertion and relaxation; they are goal-directed actions (Laban, 1988; Laban & Lawrence, 1974; Maletic, 1987). The eight basic effort actions represent the complete range of working actions performed in human movement. Experiment yourself with a few of these actions to understand how they feel and look (see Table A2). Think of everyday actions you might do as examples of each of the basic effort actions (e.g., gliding the iron over a shirt on the ironing board).

TABLE A2. The Effort Elements Associated with Space, Weight, and Time Motion Factors for the Basic Effort Actions.

Basic Effort Actions	Effort Elements		
	Space	Weight	Time
Float	Indirect	Light	Sustained
Glide	Direct	Light	Sustained
Wring	Indirect	Strong	Sustained
Press	Direct	Strong	Sustained
Flick	Indirect	Light	Sudden
Dab	Direct	Light	Sudden
Slash	Indirect	Strong	Sudden
Punch	Direct	Strong	Sudden

Transformation drive

Transformation drive. A transformation drive occurs when flow replaces one of the motion factors of the action drive: space, weight, or time. There are three possible combinations (see Table A3). Transformation drives differ from the action drive in that they are more expressive of mood or quality rather than goal oriented (Bartenieff & Lewis, 1980). Whereas the basic effort actions have distinct rhythmic phases of exertion and relaxation and are performed over a relatively short duration, the transformation drives can occur for longer periods of time. A transformation drive and a basic effort action cannot occur at the same time. They follow one another in movement phrases.

TABLE A3. The Effort Elements Associated with Space, Weight, Time, and Flow Motion Factors for the Transformation Drives.

Transformation Drives	Space	Weight	Time	Flow	Notes
Passion	-	Light/ Strong	Sustained/ Sudden	Free/ Bound	Has a feeling or emotive focus – either wildly passionate or gentle and sensitive. Weight and time are accentuated; flow pulsates.
Spell	Indirect/ Direct	Light/ Strong	-	Free/ Bound	Has a focus of fascination or hypnotic quality as if time is standing still. Space and weight are accentuated. Movement has a stabilised quality.
Vision	Indirect/ Direct	-	Sustained/ Sudden	Free/ Bound	Has a mentally alert focus. Precision in time and place. A disembodied state as if one is drawn out of one-self. Can be as if concerned with thought rather than the here and now, or concentration. Space and time are accentuated.

Shape

Shape features involve movement of the torso (and may consequently include head, arm, or leg movements) that deviate from the neutral upright standing posture. Shaping reveals to what degree the whole body, or person, is involved in the activity. *Postural effort* shows that the person's whole body is involved in the activity they are performing as opposed to *gestural effort* which involves only the body parts required to perform the job (Bartenieff & Lewis, 1980; Lamb & Watson, 1979). Shaping is noted in relation to the axes of space: vertical, horizontal, and sagittal (see Table A4, Bartenieff & Lewis, 1980; Davis, 1970).

TABLE A4. Shaping Movements Associated with the Vertical, Horizontal, and Sagittal Axes of Space.

Vertical	Horizontal	Sagittal
Rising	Widening	Advancing
Sinking	Narrowing	Retreating

Method of Recording Movement Observations on the Music Score

Two parallel vertical lines indicate the beginning and the end of the movement sequence for observation. Between these two markers runs a horizontal line above and parallel to the music score (the action stroke, see Figure A1). The action stroke indicates that movement (beyond functional movement) is taking place. A break in the action stroke represents a pause in movement, or stillness.

FIGURE A1. The action stroke, rotated from its vertical position for use in dance to a horizontal position, runs above and parallel to the music stave.

Record your observations of the performers' body movements in words; that is, the metaphoric names including the involved motion factors and related effort elements. You may also record your observations in symbolic shorthand using Laban's *effort graph* (see Figures A2, A3, and A4, Bartenieff & Lewis, 1980) though this is not required. The effort graph depicts the motion factors in a linear fashion, with each end of the continuum representing the indulging or fighting quality of effort.

Notate your interpretation of the basic effort actions and transformation drives (passion, spell, and vision) above the action stroke and the presence of shaping features below the action stroke. Position the notations of the action drives and shaping features at specific points on the music score that correspond with where they were observed.
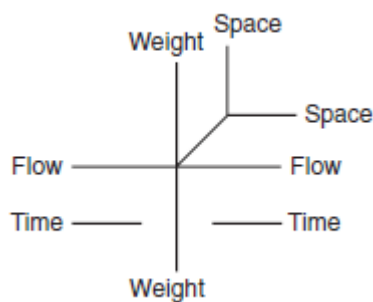

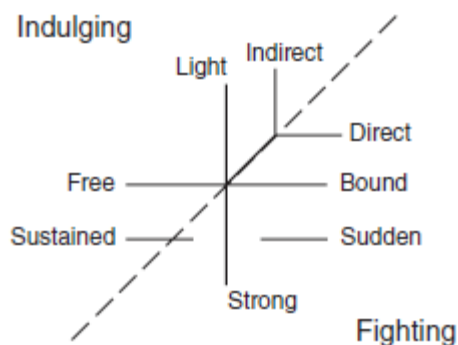**FIGURE A2.** Motion factors depicted on Laban's effort graph.

FIGURE A3. Effort elements associated with the motion factors depicted on Laban's effort graph.

Opening   Widening

Closing   Narrowing

Rising   Advancing

Sinking   Retreating

FIGURE A4. Laban's shaping notation for postural movements on the vertical, horizontal, and sagittal axes of space.

Author Note

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