

SHARED RHYTHM, UNEQUAL EFFORT ENERGY EXPENDITURE, TEMPORAL COORDINATION AND MOVEMENT RECOGNITION IN DANCE

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ABSTRACT

To examine the relationship between bodily demand and participation when dancers maintain a shared phrase through different movements. Salsa observations distinguished energy expenditure from step counts in a sample of 18 adults. Dance experiments also separated social outcomes: a silent-disco study of 94 participants associated synchrony with closeness and pain-threshold change, without greater economic-game cooperation. Kinematic investigations distinguished coordination with music from coordination with a partner. Integrated-dance ethnography and disability dance practice located participation in the translation of movement, communication and shared authorship. Temporal coordination identifies a relation among actions; it does not determine their energetic cost or establish acceptance of a movement adaptation. Lower bodily demand requires a decrease in the specified physiological response. Participation additionally requires evidence about recognition, continuing involvement and the dancer's experience. The kinesiology–anthropology interface is most informative when individual physiological demand is examined alongside the social organization of a danced phrase. Closeness, cooperation and access to participation remain distinct outcomes.

Keywords: dance anthropology; energy expenditure; interpersonal coordination; kinesthetic translation; movement adaptation; participation

INTRODUCTION

A shared dance phrase establishes relationships among performers without prescribing an identical bodily cost for each person. A turn, accent or weight shift can remain recognizable while its displacement, support and muscular demands differ. This creates a specific problem for kinesiology and anthropology: the timing of a contribution, the effort required to make it and its recognition by other dancers must be examined separately.

Research on rhythmic joint action describes anticipation and adjustment between performers, while work on synchrony and shared intentionality examines their relationship with cooperation (Keller et al., 2014; Reddish et al., 2013). Dance research has also manipulated exertion independently of synchrony and measured physiological responses during social dancing (Tarr et al., 2015; Domene et al., 2014). These approaches identify different properties of the activity. A temporal relation describes when actions occur; an energy estimate describes bodily demand over an interval; a social response describes how people relate within or after that activity. None supplies the other two by definition.

The distinction matters when a dancer reduces movement excursion. A smaller trajectory can preserve an accent or partner relation, but visible displacement alone cannot establish a decrease in muscular strain. Equally, temporal accuracy cannot establish that a partner accepts the adjustment. A performer may remain precisely coordinated while receiving correction, losing a valued role or experiencing pressure to match another person's range of movement.

Anthropological accounts of integrated dance, tango and embodied inquiry place movement within translation, gendered interaction and knowledge acquired through practice (Hammer, 2021; Davis, 2015; Borovica, 2020). Their relevance is specific: participation depends on how bodily differences become intelligible within a dance, rather than on resemblance to a single demonstrated form. This paper examines how that recognition relates to individual demand. Its argument concerns coordinated social and community dance; evidence from children, disability dance and ritual activity is evaluated with its population and setting retained.

TEMPORAL COORDINATION AND THE MOVEMENT BEING COMPARED

MUSIC AND PARTNERS PROVIDE DIFFERENT TIMING RELATIONS

Coordination with a beat and coordination with another dancer are different relations. Following the same musical pulse can produce simultaneous events without demonstrating mutual adjustment. Conversely, dancers can maintain a stable complementary relation in which their actions alternate. A competent response may therefore involve a consistent delay rather than simultaneous movement.

Wan and Fu's percussion experiment included 124 children. Cooperative apron-buttoning occurred in 69% of the predictable-beat condition and 42% of the unpredictable-beat condition ($p = 0.022$); the rhythmic-pattern manipulations did not produce the predicted effects (Wan and Fu, 2019). This evidence concerns five-year-old children and a specific cooperative task. It shows why predictability and movement matching require separate interpretation, while supplying no direct test of adult dance adaptation.

Bigand and colleagues recorded 70 participants and identified 15 principal movements accounting for more than 95% of kinematic variance. Musical input and visual access to a partner supported different patterns of synchrony (Bigand et al., 2024). A whole-body value consequently compresses relations that can differ by body part and direction. The proportion of kinematic variance explained concerns the movement decomposition; it is not a proportion of physiological demand explained.

The event selected for analysis must match the dance task. A shared vertical accent, alternating foot contact and a partner's turning response require different reference events. Analysis of joint action accordingly begins with the intended relation, including its direction, delay and role allocation (Keller et al., 2014). Calling all temporal differences errors erases the organization of complementary movement.

SENSORY ACCESS AND SIGNAL PROCESSING AFFECT THE ESTIMATE

Chauvigné and colleagues examined auditory, visual and haptic coupling in a circle of 13 expert folk dancers (Chauvigné et al., 2019). The study ties coordination to sensory access within a specific group. Its expert sample and single circle do not establish the same relation in novice groups or in activities with different contact rules.

Ellamil and colleagues recruited 75 club participants, of whom 46 supplied complete dance records for analysis. Their synchrony estimates depended on preprocessing and the movement component emphasized (Ellamil et al., 2016). The analytical sample, rather than the recruitment total, determines the available observation. Filtering and selecting a spatial component also determine what a coordination estimate represents. These choices require explicit description before a synchrony value can support an interpretation of shared movement.

A difference between event times has meaning only relative to the relation the task requires. For matched events k , a phase-adjusted discrepancy can be expressed as

$$e_{ijk} = \text{wrap}_{(-T/2, T/2]}(t_{ik} - t_{jk} - \tau_{ij}), \quad (1)$$

where t_{ik} and t_{jk} are event times in seconds, τ_{ij} is the intended delay between dancers, and T is the cycle duration. The wrapping operation selects the corresponding discrepancy within one cycle. A root-mean-square summary of e_{ijk} describes deviation from that relation and can be expressed in milliseconds. It does not measure energy expenditure, affiliation or permission to modify movement. Eq. (1) defines an analytical distinction; it is not fitted to a new participant sample here.

ENERGETIC DEMAND CANNOT BE READ FROM TIMING OR COUNTS

Domene and colleagues observed 11 women and seven men, aged 27–57 years, during two two-hour salsa sessions in London over two weeks. Field estimates combined wrist accelerometry and heart-rate monitoring. Energy expenditure was 479 ± 125 kcal for women and 651 ± 159 kcal for men, whereas the step-count comparison was not significant

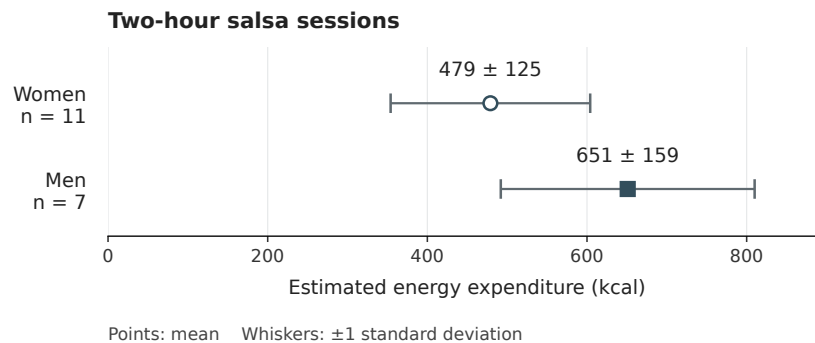


FIGURE 1. ESTIMATED TWO-HOUR SALSA ENERGY EXPENDITURE IN DOMENE ET AL. (2014). POINTS INDICATE MEANS; WHISKERS INDICATE ONE STANDARD DEVIATION. THESE DESCRIPTIVE GROUPS WERE OBSERVED WITHOUT AN IMPOSED MOVEMENT ADAPTATION.

($p = 0.71$). The difference in mean expenditure was 172 kcal, with a 95% confidence interval of 30–314 kcal (Domene et al., 2014). Figure 1 displays the expenditure means and standard deviations.

The study separates two measurement questions: how many steps were counted and how much energy the estimation method assigned to the activity. Its observational design does not isolate sex, body mass, partner role or movement excursion as a cause of the energetic difference. Nor does a nonsignificant step-count comparison establish equivalence. Equivalence testing requires a justified interval and an analysis designed to evaluate that interval (Lakens, 2017).

A movement's visible extent supplies incomplete information about its cost. Raising the body against gravity, maintaining support, stabilizing a partner and producing co-contraction can alter demand without a corresponding change in step count. A smaller arm or trunk trajectory can also accompany greater stabilization elsewhere. The term *lower demand* therefore requires a named response and a defined observation period.

Beck and colleagues examine the difficulty of documenting intermittent dance activity across class, rehearsal and performance (Beck et al., 2015). Oxygen uptake, heart rate and perceived exertion are related observations with different temporal responses and limitations. Oxygen uptake characterizes a cardiorespiratory response; perceived exertion characterizes the dancer's assessment of effort; neither alone captures every local load. A value averaged over an entire session also answers a different question from a value restricted to active dancing.

Correlated heart rates present another interpretive problem. Konvalinka and colleagues examined synchronized arousal in fire-walking performers and related spectators (Konvalinka et al., 2011). The participants' different motor involvement prevents shared arousal from being treated as evidence of equal exercise demand. The connection with dance is a measurement caution, not a claim that ritual fire-walking and dance impose the same physiological response.

For an individual dancer, the relevant comparison is the response accompanying a particular movement and participation pattern. Group means do not reveal whether a person pauses, compensates through another segment or experiences a local symptom. Body-mass-relative oxygen uptake, absolute expenditure and discomfort each describe a different aspect of that pattern. The physiological interpretation must retain the chosen quantity and unit rather than merge them into a single account of effort.

CLOSENESS, COOPERATION AND ACCESS TO PARTICIPATION

Dance experiments demonstrate why social endpoints require equally careful separation. In Tarr and colleagues' factorial study of 264 school participants, synchrony and exertion each affected in-group ratings, with $p = 0.015$ and $p = 0.016$, respectively; their interaction was not significant ($p = 0.129$) (Tarr et al., 2015). Higher exertion involved standing whole-body dancing and lower exertion seated hand gestures. This contrast changes posture and movement content, so it cannot isolate excursion alone.

The later silent-disco study analyzed 94 participants after exclusions. Synchrony was associated with social closeness and pain-threshold change, but no increase in economic-game cooperation was detected (Tarr et al., 2016). Pain threshold is an indirect response rather than a direct assay of a neurochemical mechanism. Closeness is also different from cooperation and from acceptance of a dancer's adjustment. Retaining the null behavioral finding prevents a positive rating from standing in for every social consequence.

Bamford and colleagues studied 48 adults in 24 self-selected dyads using synchronized, tempo-shifted and phase-shifted music. Interaction ratings were higher for synchrony than phase shift ($p < 0.01$), while the other pairwise comparisons were not significant. Interpersonal distance showed no significant condition effect ($p = 0.22$) (Bamford et al., 2023).

Motion analysis included 19 dyads after recording loss. These findings relate to immediate interaction among selected partners, not to entry into a group or recognition of an adapted phrase.

Mogan and colleagues' meta-analysis brings together synchrony's behavioral, perceptual, cognitive and affective outcomes across different tasks (Mogan et al., 2017). That breadth supports examination of synchrony as a social process. It also requires attention to what each study actually measured. An aggregate across heterogeneous tasks cannot identify which movement variation is acceptable within a particular dance practice.

The Inclusion of the Other in the Self scale gives a further example of outcome specificity. Gächter and colleagues evaluated it as a relationship-closeness measure (Gächter et al., 2015). Despite the word *inclusion* in its name, the scale does not by itself measure access to dance, authority over a phrase or freedom to adjust movement. A partner-closeness rating and a record of who receives an invitation to dance answer different questions.

MOVEMENT TRANSLATION, COMMUNICATION AND AUTHORSHIP

BODILY DIFFERENCE AND RECOGNIZABLE EXPRESSION

Hammer's ethnography of integrated dance in Israel and the United States examines translation through verbal, bodily, kinesthetic and material practices (Hammer, 2021). Kinesthetic commensurability concerns the production of related expression through bodies with different movement possibilities. The anthropological significance lies in the relation that performers create between actions, rather than in the requirement that every performer execute the same trajectory.

This distinction directs attention to the feature retained through an adjustment. A phrase may be recognized through an accent, direction, partner response or expressive intention. These possibilities must be established within the activity; they cannot be selected solely because a sensor records them conveniently. A reduction in excursion changes one physical property. Whether it also changes the phrase's identity is a question about practice and interaction.

Davis's account of tango in Amsterdam and Buenos Aires places danced encounters within gendered relationships and the social organization of salons (Davis, 2015). Partner roles consequently require examination as learned expectations and relationships, rather than as fixed bodily capacities. Borovica's creative inquiry into the embodiment of womanhood through dance likewise treats dancing as a way of knowing (Borovica, 2020). The dancer's account contributes information about the movement's experienced meaning that a displacement trace cannot supply.

These anthropological contributions do not establish a universal rule of acceptable adaptation. Their implication is to retain the setting, the relationship and the participant's account when describing what a movement accomplishes. A variation accepted in one rehearsal can carry a different significance in another group or role.

COMMUNICATION CHANGES THE CONDITIONS OF PARTICIPATION

Slaney and Easton's study of a dance class for adults with intellectual disabilities combined ethnographic observation with interviews, questionnaires and assessment tools. It identifies communication strategies and social connections as elements of interaction and joint participation (Slaney and Easton, 2022). The relevant observation concerns the communicative environment: opportunities to understand, respond and connect form part of participation alongside the physical movement.

A correction consequently has both instructional and relational significance. Its words, gesture, timing and recipient help determine whether it assists a contribution or marks that contribution as unacceptable. Analysis must distinguish the organizer's intention, the partner's response and the dancer's interpretation. Their disagreement is evidence about the activity's social organization, rather than an error to remove from the account.

Smaller movement also admits several explanations. It can express a chosen adjustment, uncertainty, discomfort or withdrawal. A trajectory alone cannot decide among them. An episode-level description connects the observed change with the dancer's explanation, the response of others and what participation remained available afterward. This makes the object of analysis specific: a movement change within an identifiable interaction.

AUTHORSHIP IS AN OBSERVABLE FORM OF PARTICIPATION

Millard and colleagues' cerebral-palsy project took place in September–October 2018, with nine children and 17 classically trained buddies completing four 45-minute classes over two weeks and a public performance. Their autism project ran from July to December 2019 and used an eight-week program with weekly one-hour classes (Millard et al., 2021). The article describes buddy support, movement generation and shared authorship; it does not provide the quantitative benefit estimates from those programs.

The practices are relevant because participation includes contributing to what is danced. Who introduces movement material, whose material is retained and who can change it are observable questions about authorship. A dancer who helps generate a phrase occupies a different position from one permitted only to imitate a completed demonstration. The distinction concerns control over the activity, not simply attendance or temporal accuracy.

The child programs do not establish the effect of an excursion adjustment among adults. They identify concrete social arrangements that an account of participation can examine: accompaniment, communication, movement contribution and access to performance. Applying those questions elsewhere requires retaining differences in age, disability, expertise and institutional setting.

INTERPRETING PHYSICAL AND SOCIAL OBSERVATIONS TOGETHER

A claim about lower-demand participation contains three distinct judgments. First, the named physiological response decreases for the person or population being compared. Second, the movement retains the relation required by the phrase. Third, the adjusted contribution remains available and recognizable within the activity. The observations for each judgment differ. An energy estimate cannot substitute for partner recognition; an invitation cannot establish reduced oxygen uptake.

The unit of observation also matters. A participant-level physiological value describes an individual over time. A temporal discrepancy describes a relation between events or performers. An interactional episode can involve an instructor, several partners and the dancer. Treating every pair of dancers as independent duplicates information because the same people occur in multiple pairs. Likewise, averaging accounts across roles can conceal a disagreement between the person authorized to correct and the person receiving the correction.

Timing and pauses must be interpreted jointly. Timing is undefined while a participant is not performing the selected event. Restricting an analysis to completed events can make coordination appear better when those having difficulty stop. The relevant record therefore includes the duration and circumstances of pauses alongside timing during active movement. A pause that permits continued involvement differs from a pause followed by exclusion, even if both remove events from the timing record.

Demand reduction and movement recognition can also diverge. A smaller excursion may preserve timing while increasing discomfort through altered support. Another adjustment may reduce a measured physiological response but draw criticism from a partner. These combinations identify different problems: bodily compensation in the first case, social restriction in the second. Collapsing them into a single favorable or unfavorable score erases the explanation needed to understand participation.

Qualitative interpretation requires equal precision. Braun and Clarke describe reflexive thematic analysis as an interpretive practice in which researchers account for their positions and decisions (Braun and Clarke, 2019). In dance, that includes the researcher's movement experience, relationship with the group and assumptions about competent performance. Coding an episode as accommodation or withdrawal requires attention to the sequence and participants' accounts; an agreement coefficient alone cannot establish that interpretation.

Acceptance must also be distinguished from an explanation of acceptance. A dancer's post-activity statement that an adjustment was welcomed is an outcome account. Customary correction, prior teaching and judgments about other movement variations describe the conditions preceding that account. Using the same statement as both outcome and explanation produces a circular argument. Keeping their temporal order explicit allows authority and established expectations to be examined without defining them by the response they are meant to explain.

ANTHROPOLOGICAL INTERPRETATION AND LIMITS OF THE EVIDENCE

The relationship between bodily demand and participation is neither solely physiological nor solely interpersonal. A dance organizes who moves with whom, which differences are meaningful and which contributions receive recognition. Physical adjustments enter that organization through teaching, correction, partner expectations and performance. Anthropology makes those processes available for analysis; kinesiology specifies the movement and response involved.

This connection changes how a mean energetic difference is used. A lower average response describes the selected population and observation period. It does not establish that every dancer experiences less strain or retains access to the same role. Individual response, pauses and locally valued contributions remain necessary to interpret the consequence of an adjustment. Equally, an accepted movement can serve expressive or relational aims without reducing the physiological quantity selected for measurement.

Synchrony cannot be assumed to confer an unconditional social benefit. Gelfand and colleagues examine beneficial and detrimental consequences of ritualistic synchrony, while Wiltermuth investigates destructive obedience under syn-

chronized authority relations (Gelfand et al., 2020; Wiltermuth, 2012). These findings do not identify harm in the dance settings considered here. They establish reasons to examine voluntariness and authority alongside affiliation. Pressure to continue and the consequence of declining a movement are part of the social account even when closeness ratings rise.

The review has four material limitations. Purposive retrieval cannot estimate how often a finding occurs across the full literature. Abstract-level access restricts the detail available for several anthropological accounts. Studies of children, expert folk dancers, club participants and disability programs cannot be treated as one population. Finally, the reviewed investigations do not jointly manipulate movement excursion while measuring physiological demand and the local recognition of that adjustment. The present evidence therefore supports distinctions among observations rather than an effect estimate for reduced-excursion community dance.

No common effect was calculated because the studies address different outcomes and comparisons. Pain threshold, estimated energy expenditure, cooperation tasks and kinesthetic translation do not share a measurement scale or a single causal contrast. The substantive connection is instead a precise question about each danced contribution: what bodily response accompanies it, which relation it preserves and how others respond to its form.

CONCLUSION

Shared timing does not establish shared energetic cost. Nor does greater closeness establish cooperation or acceptance of an adapted movement. The studies examined here separate these outcomes through physiological observation, timing analysis and accounts of movement translation. For kinesiology and anthropology, the central task is to connect individual bodily demand with the interaction through which a contribution becomes recognizable. Lower-demand participation requires evidence of a reduced specified response, maintenance of the phrase's relevant relation and continued access to the activity. Each judgment retains its own observations, population and setting.

DECLARATIONS

CONFLICT OF INTEREST

The author declares that there are no conflicts of interest related to this study.

DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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