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THE INFLUENCE OF BODY MORPHOLOGY ON PREFERRED DANCE TEMPOS

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ABSTRACT

Thirty participants tuned a drum machine to their preferred dance tempo. Measurements of height, shoulder width, leg length, and weight were taken for each participant, and their sex recorded. Using a multiple regression analysis, leg length was found to be the single best predictor of preferred dance tempo. The results are consistent with a biomechanical "resonance" model of dancing.

1. INTRODUCTION

In previously unpublished work, the second author and several of his students observed the dance behaviors of males and females at a popular university discotheque. A one-hour music program was presented in which successive dance tunes were randomly varied in tempo. While female dancers always out-numbered male dancers, there was a significant association between sex ratio and tempo: a greater proportion of males was evident for those selections exhibiting a slower tempo.

Such apparent preferences may be stylistic in origin. For example, women appear to have a greater stylistic affinity for "dance" or "disco" rhythms, whereas a greater proportion of men appear to have a stylistic preference for "rock" or "reggae" rhythms. While an association between sex and style would seem to provide the most parsimonious account for the observed link, other interpretations are also possible. In general, males are larger than females. From a biomechnical perspective, the act of dancing can be regarded as a stylized form of "bouncing", where optimum bouncing rates would depend primarily on kinematic factors, such as the mass of the body or the elasticity of the achilles tendon. It may be the case that the observed sex-related differences in preferred dance tempos are an artifact of differences in body morphology between men and women.

The possible importance of anthropometric factors in rhythm-related behaviors has figured prominently in the work of Todd [5][6][7][8]. In the first instance, Todd has noted that the vestibular system is shared with the sense of hearing within a single anatomical organ which includes both the cochlea and the semi-circular canals. Todd has proposed a physiologically-based model that attempts to account for the often observed parallel between musical "motion" and corporeal motion. Evidence in support of an association between rhythm and locomotion is found in research by Friberg and Sundberg [1] and by MacDougall and Moore [2]. In their study of ritardandi, Friberg and Sundberg found that the final slowing in recorded music closely corresponds to the application of a constant breaking power similarly to the manner in which runners stop. In their more recent study, MacDougall and Moore had participants wear an accelerometer that continuously monitored head movements in three dimensions over the course of a day. In analyzing the recorded data, MacDougall and Moore found a marked peak at about 2 Hz for vertical movements. This 2 Hz resonance is strongly related to the pace of walking. MacDougall and Moore plotted their aggregate results against a histogram of tempi from a large database of contemporary Western music [3] that also displayed a dominant peak at 2 Hz. In recently published research by Todd, Cousins and Lee [9], a significant correlation was found between tempo classification of different auditory rhythms and anthropometric measures such as leg length. Where Todd's work suggests a relationship between body and perception, the current work investigates whether there might be a relationship between body and preferred dance tempo. In light of the extant research, it is not implausible that preferred dance tempos might relate to anthropometric factors like body mass or height.

1.1. Hypothesis

In order to investigate this hypothesis, we carried out a simple experiment. In brief, participants were asked to adjust the tempo of a "drum machine" to their preferred dance tempo. We subsequently took morphological measures of each participant.

We predict that mass and height will negatively correlate with preferred dance tempo (in beats per minute). That is, we predict that larger body size (in weight, height, or width) will be associated with slower preferred dance movement.

2. EXPERIMENT

2.1. Subjects

Thirty subjects were recruited for the experiment, 18 females and 12 males. The participants were drawn from a convenience population of sophomore music students participating in an experimental subject pool at the Ohio State University. Subjects chose to participate in this experiment from a list of current studies. The soliciting materials included information indicating that participants would be asked to dance unobserved in a room by themselves and that physical measurements, including height and weight, would be recorded. As self-selected participants, it should be noted that significant sampling bias cannot be excluded. In particular, students who enjoy dancing are more likely to have participated, whereas students embarrassed by their weight or body features are less likely to have participated. Voluntary subject recruitment is apt to reduce the variation in body types, and therefore reduce the potential statistical power.

2.2. Procedure

Participants were tested individually in an isolated room. A computer display included a vertical slider that influenced the tempo of a Max MSP software patch. The patch implemented a drum-machine playing an alternating bass-drum/snare-drum rhythm (i.e., "standard backbeat"). The sound stimuli were reproduced over two loudspeakers. The tempo slider could be controlled using a computer mouse. The range of possible tempos spanned 40–239 beats per minute (bpm). After receiving the instructions (see below) participants were left in the room alone to try out different tempi.

The instructions read to the participants were as follows:

> In this experiment we want to get an idea of your preferred dance tempo. That is, we want to find out at which speed you are most comfortable when dancing. When the time comes, I will leave you alone in this room, you'll be able to dance around without anyone seeing or hearing you. This is a drum machine which plays a standard backbeat rhythm. You turn it on by pressing the space bar [demonstrates]. You can adjust the volume here [demonstrates volume control]. You can adjust the tempo by moving this slider [demonstrates slider]. You stop it by pressing the space bar again [demonstrates]. We want you to try out different tempos until you find a tempo that you feel is most natural for the way you dance. That is, find a slider position that corresponds to the movement you find most comfortable. You may feel that there is more than one tempo that you like; if so, simply choose the tempo that you think is the best. Don't be afraid to take your time. When you have settled on the best tempo, don't move the slider; simply leave the room and come and get me.

After demonstrating the drum-machine patch, the tempo slider was left in an initial pseudo-random position in the area roughly between 25 and 75 percent of the maximum tempo value. The drum-machine was turned on as the experimenter left the room.

After the participant was satisfied with the selection of the tempo, the experimenter recorded the tempo in beats per minute. Four anthropometric measurements were then taken: height, shoulder width, leg length, and weight. For the length and shoulder-width measures, the participant stood against a wall that had been marked with a measurement grid. By placing a ruler on the participant's head the experimenter read the height off of the wall grid. Similarly, the width of the shoulders was determined by the experimenter placing a ruler against the participant's shoulders and observing the corresponding the left and right shoulder points along the horizontal wall grid. The leg length was estimated by asking the participant to point to the lower part of the hip bone protuberance (anterior inferior iliac spine) on their left and right sides. After locating these points, the experimenter measured the length between the hip bone and the ankle (malleolus lateralis) using the wall grid behind the participant. The average between the measures of the left and right leg was taken as an estimate of the participant's leg length. Finally, the participant stood on a domestic electronic scale and their weight was taken.

3. RESULTS

Figure 1 shows the distribution of selected dance tempi for the 30 participants. The distribution is presented in bins of 10 beats per minute. The mean tempo was 152.6 bpm with a standard deviation of 44.9 bpm. The response data do not appear to be normally distributed. Indeed, there is some suggestion of a possible bimodal distribution. The data ranged from a low of 89 bpm to a high of 239 bpm (the maximum possible). This extreme range might suggest that participants were "doubling" (or "halving") the tempo slider for a given dance gait. Unfortunately, we were not able to observe the dance activity so this conjecture cannot be confirmed.

One might argue that the tempo range of the slider should have been narrowed so as to minimize inadvertent doubling or halving of the tempo. However, this presumes that forcing participants to respond using a more narrow distribution would represent the "true" distribution, and there seem little *a priori* logic to warrant this assumption. Acknowledging the messiness of our data, we nevertheless continued with our planned analysis.

Table 1 shows a simple correlation matrix including both the dependent measure and the independent measures. The best predictor of tempo is average leg length ($r = -0.671; r^2 = 0.450$). The second and third best predictors of tempo were height ($r = -0.668; r^2 = 0.446$)

	Tempo	Sex	Height	Shoulders	Legs	Weight
Tempo	1.00					
Sex	0.58	1.00				
Height	-0.67	-0.84	1.00			
Shoulders	-0.13	-0.32	0.28	1.00		
Legs	-0.67	-0.65	0.80	0.10	1.00	
Weight	-0.38	-0.67	0.65	0.44	0.42	1.00

Table 1. Correlation matrix for the recorded variables.

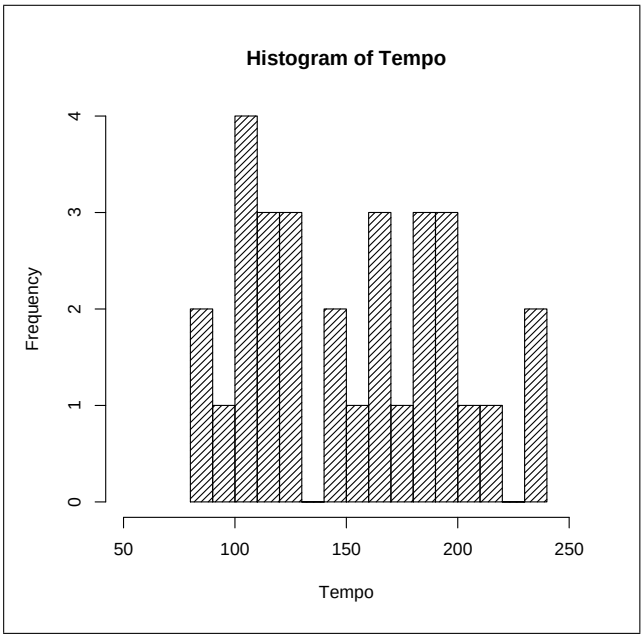

Figure 1. Distribution of selected dance tempi for the 30 participants. The tempi are sorted in bins of 10 beats per minute.

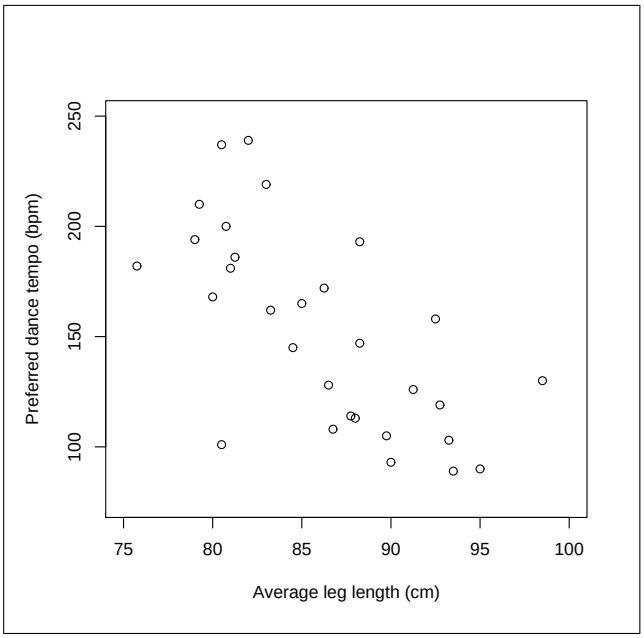

Figure 2. Preferred dance tempo vs. average leg length. The plot shows that a long average leg length is associated with a slow tempo.

and sex ($r = 0.579; r^2 = 0.335$). In the case of sex, females preferred a faster dance tempo.

Using preferred tempo as the predicted variable, we carried out a multiple regression analysis, with height, shoulder width, average leg length, weight, and sex, as the predictor variables. Using a step-wise linear regression, the only predictor variable to enter into the model was average leg length ($\tilde{R}^2 = -0.430$); with this variable in the model, none of the remaining predictor variables was found to contribute significantly in determining the variance of the predicted variable, preferred tempo.

Figure 2 plots the significant relationship between preferred tempo and average leg length. As can be seen, there appears to be a negative correlation, with longer leg length associated with lower preferred tempo ($r = -0.671; df = 29; p < 0.001$).

4. DISCUSSION AND CONCLUSIONS

This research was originally motivated by the observation of sex-related differences in preferred dance tempos. In the ecologically valid context of a discotheque, we had observed a significant association between musical tempo and the proportion of females-to-males on the dance floor. Consistent with these observations, the current experiment also revealed an association between sex and preferred dance tempo. However, in the multiple regression analysis, sex was eliminated as a significant co-variate due to its shared variance with leg length.

At face value, the results of the current study imply that the earlier observed relationship could be an artifact of body size. In general, males are larger than females, and so more likely to move efficiently at a slower tempo. These findings are consistent with the view, expressed by MacDougall and Moore [2], Todd and others [8][9], that the dynamics of body movement shape rhythm-related behaviors – at least with respect to tempo.

Recently Phillips-Silver and Trainor [4] showed that body movement shapes our perception of auditory patterns. With this in mind it is plausible to assume that body morphology could, albeit indirectly, shape our experience of music. People with long legs that are more comfortable moving at a slow pace would then also be more likely to feel the rhythm accented at this tempo rather than at alter-

native (higher) metrical levels.

These results may have implication for controlling computer-music applications, such as interactive performances or dance video-games. By recording the height of a user one may be able to better tailor the systems to a more optimized control.

In interpreting the results of this study, however, some caution is appropriate. The physics of moving objects suggests that mass is an important factor in any oscillating system. While increased weight is correlated with a lower preferred dance tempo, the shared variance between weight and leg length caused the variable to be discarded in the multiple regression analysis. This would be expected if the body shapes of our participants were fairly uniform, with the exception of overall size. In recruiting volunteers for this experiment, potential participants were informed that their weight would be measured. This might be expected to reduce the number of heavy-set volunteers, and so reduce the weight-related variance, with the predictable loss of statistical power.

Nor should the possible influence of sex be necessarily dismissed. A larger sample of participants might yet reveal that sex has some impact on preferred dance tempo. Since women generally have a lower center-of-gravity than men, in some ways it would be surprising not to find some sex-related difference in dance movements. Note however, that such a difference would still implicate body morphology rather than social or psychological sex-related differences. To fully explore this kind of influence, recruitment of participants would be preferably be made so as to balance height and weight between males and females.

Further research is clearly warranted as we explore the possible influence of other anthropomorphic factors on music-related preferences and/or behaviors.

5. ACKNOWLEDGMENT

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