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Gender recognition depends on type of movement and motor skill. Analyzing and perceiving biological motion in musical and nonmusical tasks

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ABSTRACT

Gender recognition in point-light displays was investigated with regard to body morphology cues and motion cues of human motion performed with different levels of technical skill. Gestures of male and female orchestral conductors were recorded with a motion capture system while they conducted excerpts from a Mendelssohn string symphony to musicians. Point-light displays of conductors were presented to observers under the following conditions: visual-only, auditory-only, audiovisual, and two non-conducting conditions (walking and static images). Observers distinguished between male and female conductors in gait and static images, but not in visual-only and auditory-only conducting conditions. Across all conductors, gender recognition for audiovisual stimuli was better than chance, yet significantly less reliable than for gait. Separate analyses for two groups of conductors indicated an expertise effect in that novice conductors' gender was perceived above chance level for visual-only and audiovisual conducting, while skilled conducting gestures of experts did not afford gender-specific cues. In these conditions, participants may have ignored the body morphology cues that led to correct judgments for static images. Results point to a response bias such that conductors were more often judged to be male. Thus judgment accuracy depended both on the conductors' level of expertise as well as on the observers' concepts, suggesting that perceivable differences between men and women may diminish for highly trained movements of experienced individuals.

1. Introduction

Human observers demonstrate a highly developed sensitivity to perceiving and interpreting biological motion. This sensitivity has been evidenced for a large visual field including peripheral vision (Findley & Gilchrist, 2003), and for the reduced movement information in point-light displays (Johansson, 1973; Pollick & Paterson, 2008). Observers recognize a seemingly random constellation of dots in point-light displays as derived from human or animal motion as soon as this constellation begins to move. Moreover, it has been shown that people are able to recognize the individual's sex (Kozlowski & Cutting, 1977) or further features such as affect in these point-light displays, indicating the capacity of the human visual system to mediate and utilize cues that provide hints of these features (for a review, see Pollick, Kay, Heim, & Stringer, 2005). Gender recognition has been studied mainly for common daily movements such as walking and running, and relatively little is known about the availability of gender cues in deliberately trained and more technical movement skills. It may well be that in skilled movements, global gender differences diminish due to extensive training. In the present study, we investigate the accuracy of gender recognition for point-light displays of movements performed with different levels of expertise. In particular, observers' ability to recognize the gender of experienced and less experienced orchestral conductors, a professional domain with a large gender imbalance, was analyzed.

The ability to recognize gender in point light-displays evidently implies the existence of specific cues characterizing male and female individuals. Both differences in body morphology and differences in motion may serve as gender-specific cues (Pollick, Paterson, Bruderlin, & Sanford, 2001; Pollick et al., 2005; Cutting, 1978). The visual system has the capacity to attune to these cues, provided observers are presented with a sufficient number of points specifying important body regions, which can then be integrated into a global percept (Mather & Murdoch, 1994). Although differences in biological motion and morphology have been identified and quantified, it remains

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challenging to determine what information observers actually use to infer gender from point-light displays. Taking gait as a thoroughly-studied example, two theoretical models have been proposed to explain individuals' ability to distinguish between displays of males and females. A first model postulates that gender recognition is mainly based on differences in structure (i.e. body morphology), in particular the ratio of the shoulder width to the sum of the hip and shoulder widths ("center of moment"; Cutting, Proffitt, & Kozlowski, 1978). Indeed, anthropometric evidence indicates that shoulder width is greater in men than in women (e.g. Heinz, Peterson, Johnson, & Kirk, 2003), while average hip width is more similar across both sexes (e.g. Horton & Hall, 1989). In relation to height, however, hip width is larger in woman, whereas men possess a larger shoulder width in relation to height (Cho, Park, & Kwon, 2004). Second, the model from Mather and Murdoch (1994) proposes motion differences for gender recognition. In this regard, the lateral body sway of male and female walkers is distinctly different, with increased medio-lateral movement of the hip in women and greater head and shoulder translation in men (Mather & Murdoch, 1994). Further differences specifying potential gender cues include body length, quadriceps angle (subtended by the line connecting midpoint of knee and anterior superior iliac spine, and the line connecting midpoint of knee and tibial tubercle; Ferber, Davis, & Williams, 2003; Horton & Hall, 1989), cadence (i.e. step frequency), and step length.

The finding that gender recognition is possible above chance even for static frontal point-light images (Davis & Gao, 2004) might be interpreted in favor of a predominant reliance on structural differences. Johnson and Tassinary (2005) visually exaggerated contours of figures in morphology ("hourglass" females vs. "tubular" males) and yielded higher effects in sex judgments (female vs. male) based on morphology compared to motion differences (hip sway vs. shoulder swagger). The impact of morphology and motion, however, was similar in judgments of the figures' gender (feminine vs. masculine).[2] Analysis of participants' point of gaze revealed that it was centered on the waist and hip areas, underlining the importance of these body parts for visual gender recognition. In a related study, combinations of morphology with gender-atypical motion (e.g. tubular body motion with hip sway) affected ratings of the figures' sexual orientations (Johnson, Gill, Reichman, & Tassinary, 2007), presenting evidence for the integration of morphological and motion information in perceptual judgments.

In a research review on gender recognition in walking, Pollick et al. (2005) report average proportions correct of 66% for side views, and 71% for other viewpoints (frontal and oblique). A reason for the slightly higher accuracy for the non-side views may lie in the fact that the aforementioned morphological structure differences between men and women can be perceived more easily from a frontal or oblique perspective (cf. Jokisch, Daum, & Troje, 2006, for a study of view-point dependent effects on agency recognition). Nevertheless, human observers do not necessarily recognize gender in all types of movements. In a study using point-light displays of arm movements (knocking, waving, and lifting), Pollick, Lestou, Ryu, and Cho (2002) asked observers to identify gender and affect (angry vs. neutral) of these movements. Human recognition accuracy was compared to an automatic "ideal observer" based on a pattern classification algorithm using 2D motion information. While human observers were able to indicate the intended affect above chance level, gender was not reliably recognized in the arm movements. The algorithm, on the other hand, achieved high sensitivity in gender recognition (expressed as d-prime scores relating correct to erroneous classifications). Point-light displays of the arm may only provide reduced cues for gender discrimination, yet it can still be concluded that there was sufficient information available for automatic classifications, which human participants failed to use in this study. Recent evidence suggests that gender recognition of single arm movements may be confounded by the speed of the movement (Johnson, McKay, & Pollick, 2011), which highlights the role of such secondary factors in gender recognition. These studies also suggest that the extent to which observers are able to use gender-specific information appears to be task dependent.

A pertinent question that has not been addressed in previous research is whether technical expertise or expert motor skill may affect gender-specific cues in point-light displays. Performing arts, such as dancing, playing a musical instrument, or orchestral conducting require deliberate and extensive training with the aim to achieve a high degree of perfection. The outcome of motor training has been studied across various fields (for an overview, see Magill, 2004), indicating that expert motor performance is characterized by accuracy, precision, consistency and persistence. In a study of violin playing – evidently among the skills requiring very high motor skill – Konczak, van der Velden, and Jaeger (2009) found that for particular movements, expert violinists possessed a higher degree of motor consistency and precision compared to novices. Moreover, experts reach high levels of adaptability (Gentile, 2000) and generalizability of their motor skill over situational or personal invariants (Magill, 2004), suggesting that motor performance becomes more stable and independent from external or individual-related factors. As a consequence, the kinematics and kinetics of expert performance are defined more by the laws of mechanics and motor control specifying the goal of the task, and less by individual motion characteristics that are still observable in less trained individuals. Accordingly, one could argue that experts' motor performance is also more independent from gender factors, especially for tasks that do not differentiate per se between a performer's sex (as opposed to gender-specific dance movements, Calvo-Merino, Grèzes, Glaser, Passingham, & Haggard, 2006). If this tentative hypothesis is correct, then point-light displays of expert motor performance should afford fewer or no gender-specific cues compared to novice displays. In the current study, we ask whether motion invariants permitting the recognition of gender in point-light displays of male and female orchestral conductors are more controlled in experienced individuals as compared to less experienced individuals. In contrast to the study of Pollick et al. (2002), stimuli were not limited to the arms, but contained all markers defining the whole body.

Taken together, cues for gender recognition are provided in morphological or motion invariants, and there is reason to argue that for highly-trained motor skills, gender-specific motion characteristics are moderated with increasing expertise. Apart from the parameters present in point-light displays of motor performance, perceivers' internal concepts may shape recognition accuracy. One area in which differences between male and female individuals have remained pervasive for a long time is the professional domain of music. Studies reveal gender differences in activities of both performing and listening, for instance regarding musical genre preferences or prevalent gender stereotypes associated with playing specific musical instruments (for an overview see North & Hargreaves, 2008). Among various musical professions, conducting appears to be one of the last fields principally dominated by males, and only recently more female conductors have been taking over responsibilities in orchestras (cf. Edwards, 2003). Experimental research on musical conducting has concentrated on beat perception in point-light displays (Luck & Sloboda, 2009; Wöllner, Deconinck, Parkinson, Hove, & Keller, 2012) and expressive features of conductors' gestures in relation to motion quantity (Wöllner & Auhagen, 2008). Typically only a limited number of conductors were studied, and to this end, gender-specific characteristics were not scrutinized in empirical performance research. Therefore it is not known whether movements of male and female orchestral conductors differ.

1.1. Hypotheses

Based on research into structural and motion differences between male and female walkers, we investigated whether observers

[2] While Johnson and Tassinary (2005) differentiated between sex and gender in judgments of point-light displays, we refer to "gender" throughout the paper for participants' perception of potential gender-typical features in different types of movements.