INTRINSIC AND INFORMATIONAL COUPLING IN STANCE

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Intrinsic and informational coupling in stance

Standing in order to look at a target or in order to track it with the head impose different constraints on the postural system. Standing for looking favors rotation of the body about the ankles (Stoffregen et al., 1999), whereas standing for tracking favors in-phase or anti-phase coordination between ankles and hips, depending on the frequency of the tracked target (Bardy et al., 1999). Both looking and tracking, however, require an adaptive *intrinsic coupling* between the segments of the postural system, and both looking and tracking require an adaptive *informational coupling* between the body and the target. The vision-and-posture literature has repeatedly demonstrated the importance of informational coupling for the achievement of stance (e.g., Schöner, 1991), but there has been little study of the intrinsic coupling underlying this achievement. Based on previous research on postural dynamics (Bardy et al., 1999, 2000), the aim of this preliminary study was to analyze the reciprocal causality between informational coupling and intrinsic coupling. For this purpose, standing participants in a moving room were instructed to track with the head or simply to look at the fore-aft motion of a target oscillating at various frequencies.

Method

Two task conditions were tested. In the *Looking* condition, twelve participants from the University of Cincinnati stood inside the moving room, facing the front wall. A target (black square against white background) was attached to the front wall at eye level. Participants stood barefooted, with the arms crossed on the chest. They were instructed only to look straight ahead at the target. In the *Tracking* condition, twelve new participants, standing at the same place and in the same position, were instructed to track the target with their head, matching amplitude and phase (Bardy et al., 1999). In each condition, the room moved at a fixed antero-posterior peak-to-peak amplitude of A = 4 cm. The choice of this amplitude was based on a preliminary study with the 24 participants, revealing that the natural 95 % amplitude range of the head displacement during quite stance (with no room motion) was 4.1 cm (SD = 0.75). These two task conditions were independently combined with two conditions of direction. In the *Up* condition, the room frequency increased from 0.15 to 0.75 Hz in 0.05 Hz steps (10 oscillations for each step), leading to a total of 130 oscillations per trial. In the *Down* condition, room oscillation frequency dicreased from 0.75 to 0.15 Hz in a similar way. There was one trial per condition. Each trial lasted 480s.

All data were collected at a sampling rate of 50 Hz. The AP motion of the room and of the head was recorded via two *flock of bird* 3D magnetic motion detectors. The angular position of the right ankle and hip angles was recorded with two electro-goniometers. Two dependent variables were computed for each frequency step: the room-head cross correlation (R_{r-h}),which was used to express the informational coupling, and the ankle-hip cross correlation (R_{a-h}), which was used to capture the intrinsic coupling.

Results

Informational coupling. Figure 1a indicates that room frequency and task instruction differentially affected the coupling between the room and the head. A two-way repeated measures analysis of variance (ANOVA) performed on the Z-transformed values of R_{r-h}, with task (*looking* vs. *tracking*), direction (*Up*, *Down*), and frequency (0.15 Hz to 0.75 Hz) as main factors, revealed a significant main effect of room frequency, $F(12, 264) = 6.47$, $p < .05$, and indicated a decrease in R_{r-h} as room frequency increased. A task effect was also found on R_{r-h}, $F(1, 22) = 40.53$, $p < .05$, confirming that the room-head coupling was stronger when participants were instructed to track the target than when they were instructed to look at it. No significant effect was found for direction, $F(1, 22) = 0.68$, *ns*, nor for any interaction, suggesting that the two effects were independent.

Intrinsic coupling. Figure 1b reveals a change in ankle-hip coordination depending on both task and room frequency, a result that was confirmed by an ANOVA (Task (Participant) × Direction × Frequency) performed on R_{a-h}. A significant main effect was found for the task factor, $F(1, 22) = 44.8$, $p < .05$, suggesting a lower ankle-hip coupling during looking than during tracking. The existence, however, of a significant Task × Frequency interaction, $F(12, 264) = 1.97$, $p < .05$, moderates this result and indicates that increases in room frequency produced decreases in R_{a-h} only in the looking condition (see Figure 1). None of the other factors or interactions reached significance.

Insert Figure 1 about here

Conclusion

Changes in intrinsic (ankle-hip) and/or informational (room-head) coupling were observed as a function of changes in task demand. Increasing room frequency was accompanied by decreasing informational coupling during both looking and tracking, but it was accompanied by decreasing intrinsic coupling only during the looking last. These results suggest differential preferred oscillation frequencies for looking and tracking. They also suggest that adaptive changes in postural coordination underly the tracking task, but not the looking task. In continuing research we will investigate the existence and nature (continuous or abrupt) of these changes.

References

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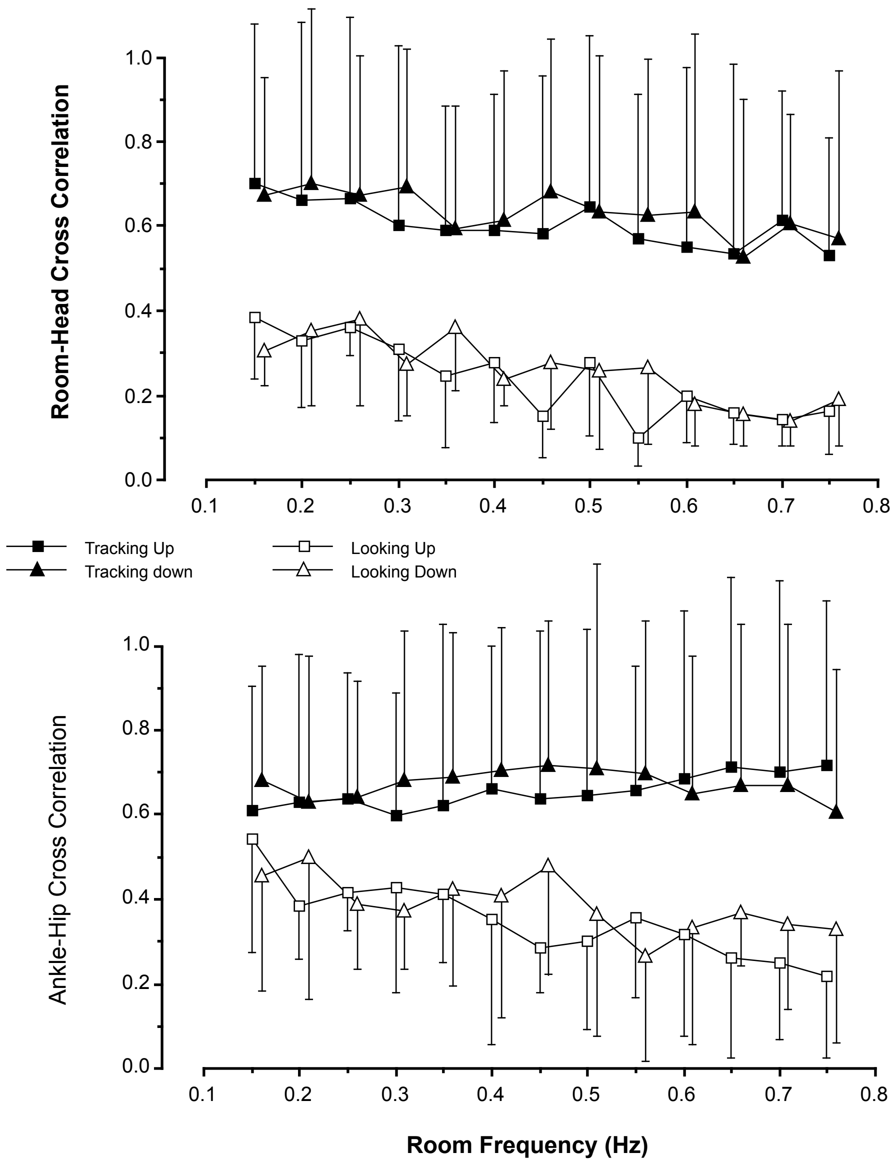
Figure caption

Figure 1. Mean value and standard deviation of $R_{r\text{-}h}$ (1a) and $R_{a\text{-}h}$ (1b) expressed as a function of room frequency and direction (*Up* vs. *Down*) in each experiment (*Looking* and *Tracking*).

Figure 1



Room-Head Cross Correlation
Tracking Up
Tracking down
Looking Up
Looking Down
Ankle-Hip Cross Correlation
Room Frequency (Hz)