

Hand-foot coupling: An advantage for crossed legs

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It is difficult to perform distinct, simultaneous motor actions with the ipsilateral hand and foot; for example, clockwise circles with the right hand and counter-clockwise circles with the right foot. By chance, we discovered that this hand-foot coupling task is easier when seated with legs crossed. We consider various explanations. First, that there are reduced demands on the contralateral hemisphere when the motor programme of the right foot is executed on the left side of the body. Second, that the legs-crossed scenario is easier because movements are symmetrical with respect to body midline. By considering related motor actions, we conclude that neither of these explanations provides a full account. Thus, we suggest a third explanation, which is that coupling effects are reduced by virtue of increased postural stability and reduced anticipatory postural adjustments.

When we attempt distinct, simultaneous motor actions with the left and right hands, the two hand actions interfere with one another; a phenomenon termed *bimanual spatial coupling* (Franz, Zelaznik, & McCabe, 1991). For example, hold a pen in each hand, and attempt to draw circles with one hand and straight lines with the other. You will likely find that the motor programmes of the two hands converge, so that both hands are producing elliptical figures. Coupling effects are also observed when we simultaneously attempt distinct motor actions with the ipsilateral hand and foot (Baldissera, Cavallari, & Civaschi, 1982); a phenomenon termed *hand-foot coupling*.

A simple task enables the reader to experience the effect. Whilst seated, (1) raise your right arm in front of your body so that your forearm is pronated (facing down) on the transverse (horizontal) plane, and (2) with your leg still bent at the knee, lift your right foot from the ground. Now, attempt to draw clockwise circles with the hand and counter-clockwise circles with the foot (Figure 1a), rotating only the wrist and ankle joints. The circles should be coplanar with one another, and in a plane parallel to the frontal (coronal) plane of the body. You will likely find that, contrary to intentions, your hand and foot are moving in the same direction. If you switch feet, so that you are drawing clockwise circles with the right hand and counter-clockwise circles with the left foot (Figure 1b), you will find the task to be significantly easier.

While reading about hand-foot coupling, one of the authors attempted distinct ipsilateral actions with the right hand (clockwise circles) and foot (counter-clockwise circles). She was surprised to find that she could do so without difficulty. Perplexingly, a few moments later, she tried again and was now unable to rotate the limbs in opposite directions. She recognised that on the first attempt her legs were crossed (Figure 1c), whereas on the second attempt, she had uncrossed her legs. It is intriguing to stumble upon an example such as this, in which a task is shown to be easier with legs crossed. This posture is known to impair performance on other tasks; for example, localising tactile stimuli both on the feet and hands (Schicke & Röder, 2006).

Following from our chance discovery, we invited ten attendees at our lab meeting to attempt the ipsilateral motor task, both with legs crossed and uncrossed. Timing of hand and foot rotations were self-generated, rather than imposed by an external rhythm. Most lab members reported that the motor task was noticeably easier with legs crossed. We wondered if this was due to a reduction in contralateral (left) hemisphere demands in the legs-crossed condition. When we move right-side body parts, the left hemisphere is more active than the right

hemisphere. It is also more active when we attend to the right side of space. With legs crossed, the left and right hemisphere share the burden of attending to the sides of space in which motor actions are unfolding, and this may free up left-hemisphere resources for coordinating distinct motor actions.

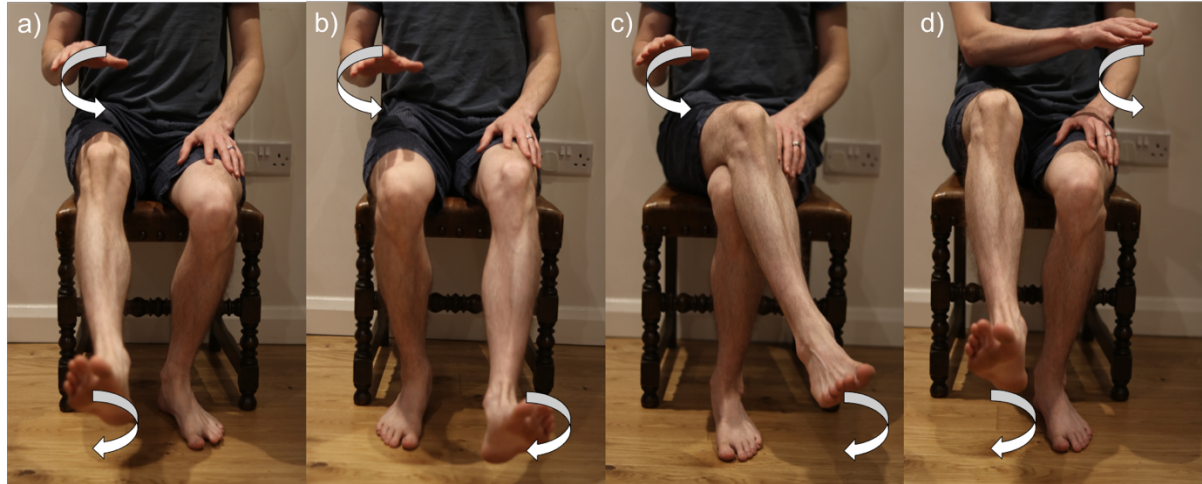


Figure 1. Posture during hand-foot coupling task: (a) ipsilateral hand and foot, (b) contralateral hand and foot, (c) ipsilateral hand and foot with leg crossed over body midline, and (d) ipsilateral hand and foot with arm crossed over body midline.

Another possibility is that the task is easier with legs crossed because the individual can use body midline as a reference point, generating mirror-symmetrical circles away from midline. This interpretation is borrowed from research showing that it is easier to produce circular movements of the two index fingers when they are rotating in the opposite direction – either towards or away from one another (and body midline) – rather than in the same direction (Kelso, 1984).

Both of these explanations predict that distinct ipsilateral (right limb) actions should also be significantly easier with the legs uncrossed and the right arm crossed to the left side of the body (Figure 1d). However, we did not find this to be the case. Thus, explanations in terms of demands on the contralateral hemisphere, and symmetry relative to body midline do not provide a complete account, and a further explanatory factor is required.

Baldissera and Esposti (2005) suggest that ipsilateral hand-foot coupling can be explained by the motor system being programmed to deal with postural stability and instability. When we perform voluntary movements with the right foot, the motor cortex sends signals via the corticospinal pathways to both the right foot *and* the right forearm. This may be a type of anticipatory postural adjustment (APA), whereby movement of one body part elicits parallel activation of the muscles of other body parts, which are thereby readied to counterbalance the primary motor action (see also Baldissera et al., 2002, Baldissera & Tesio, 2017). When the right foot is rotating in the counter-clockwise direction, the excitability of the forearm is aimed at facilitating corresponding counter-clockwise movements of the right wrist (Baldissera & Esposti). Thus, to perform distinct (i.e., clockwise) ipsilateral movements of the right wrist, voluntary motor commands need to overwhelm or suppress the APA. The central nervous system uses flexible control strategies to adjust APAs (Aruin & Shiratori, 2003), such that in highly-stable postural conditions APAs are scaled down (Kanekar & Aruin, 2015). When

seated with one foot raised, postural stability is likely greater with legs crossed. As such, APAs may be scaled down, with the result that it is easier to perform distinct ipsilateral actions.

Our chance discovery inspires many questions, and we hope that this Short and Sweet contribution leads to further work investigating factors that reduce interference effects during hand-foot coupling tasks.

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