

# On Context Dependence of Behavioral Variability in Inter-Personal Coordination

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## Introduction

Results from recent studies investigating the dynamics of bimanual coordination have led to contrasting viewpoints concerning the relative contribution of perceptual and motor processes in mediating coordinative stability. At one end of the spectrum is the belief that coordination is governed primarily by physical limitations such as neuro-muscular constraints and that perceptual factors play little role (Carson, 2004). At the other end, the stability of bimanual coordination is depicted as completely arbitrary with respect to the physical properties of the individual components, depending instead only on the directional and visuo-spatial relationship between them (Mechsner, 2004).

An alternative to these segregated approaches is provided by coordination dynamics (Kelso, 1995) which proposes that the relative contribution of perceptual and motor processes depends on the context as determined by an ensemble of constraints acting both within (Kelso et al., 2001) and between individuals (Schmidt et al., 1990; Temprado et al., 2003) as well as between stimuli and responses (Kelso et al., 1990). In the present study we investigate the relative role of visual and motor (a)symmetries in finger coordination between individuals. Our aim is to demonstrate that even with no structural coupling between the components, both co-activation of homologous muscles and visuo-spatial constraints influence the stability of the coordination. Further, we hypothesize that stability is determined not only by the relative contribution of these two constraints, but by the mutual influence they have on each other.

## Methods

Pairs of participants were required to make index finger flexions while seated facing each other. The first participant (denoted by D, for Driver) maintained a pronated hand position throughout the experiment and produced finger movements synchronized to a metronome that systematically increased in rate every 20 cycles (from 1.5 to 3 Hz in 0.25 Hz increments). The second participant (denoted by F, for Follower) was required to coordinate rhythmic finger movements with D without hearing the metronome (i.e. visual coupling only). To facilitate interactions between D and F, the metronome was silenced for the second half of each frequency plateau and D was asked to continue moving at the rate determined during the first half. F participated in four conditions determined by a combination of coordination mode (in-phase or anti-phase) and hand position (supination or pronation).

The relative phase requirement was always defined by the spatial configuration (i.e. the position of the endpoint of the finger). In this way, co-activation of homologous muscles (finger flexion by F and D) produces both an in-phase (pronated in-phase) and antiphase (supinated anti-phase) relationship between the effector endpoints. If purely directional constraints determine the stability of coordination, a typical anti-phase to in-phase transition should be observed for the supinated anti-phase condition. If there is a tendency towards co-

activation of homologous muscles, even between people, two configurations should be equally stable. We expect, however, that a coalition of these constraints will combine in determining stability.

## Results

Statistical comparisons reveal a more stable coordination between the driver and the follower when the metronome is off, regardless of the adopted mode and/or hand position. That is, there is evidence for stronger mutual entrainment when the driver no longer has external pacing information. This is indicated by the overall variability in each condition. A visually mediated coupling enables stabilizing coordination between the driver and the follower when the metronome is off.

Each experimental condition represents a combination of musculo-skeletal and visuo-spatial constraint. In-phase is very stable when using homologous muscles in the pronated position (same direction, same muscles recruited by both subjects). Relative degradations in stability in the other conditions are observed in the following order: anti-phase supine (opposite direction, same muscles), anti-phase pronate (opposite direction, opposite muscles) and in-phase supine (same direction, opposite muscles).

## Discussion

The primary contribution of this research comes from two observations. First, when coordinating between people, the presence of a metronome, presented to only one participant, can serve as an additional constraint that reduces coordinative stability. Second, coordination stability was determined by a coalition of muscular AND directional constraints. However, these two constraints did not exert equal influence on stability. The coordination between individuals was consistently more stable when homologous muscles were activated, while movement direction played a role in modulating this stability, thereby suggesting a hierarchy of constraints.

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