Coordination dynamics in crew rowing

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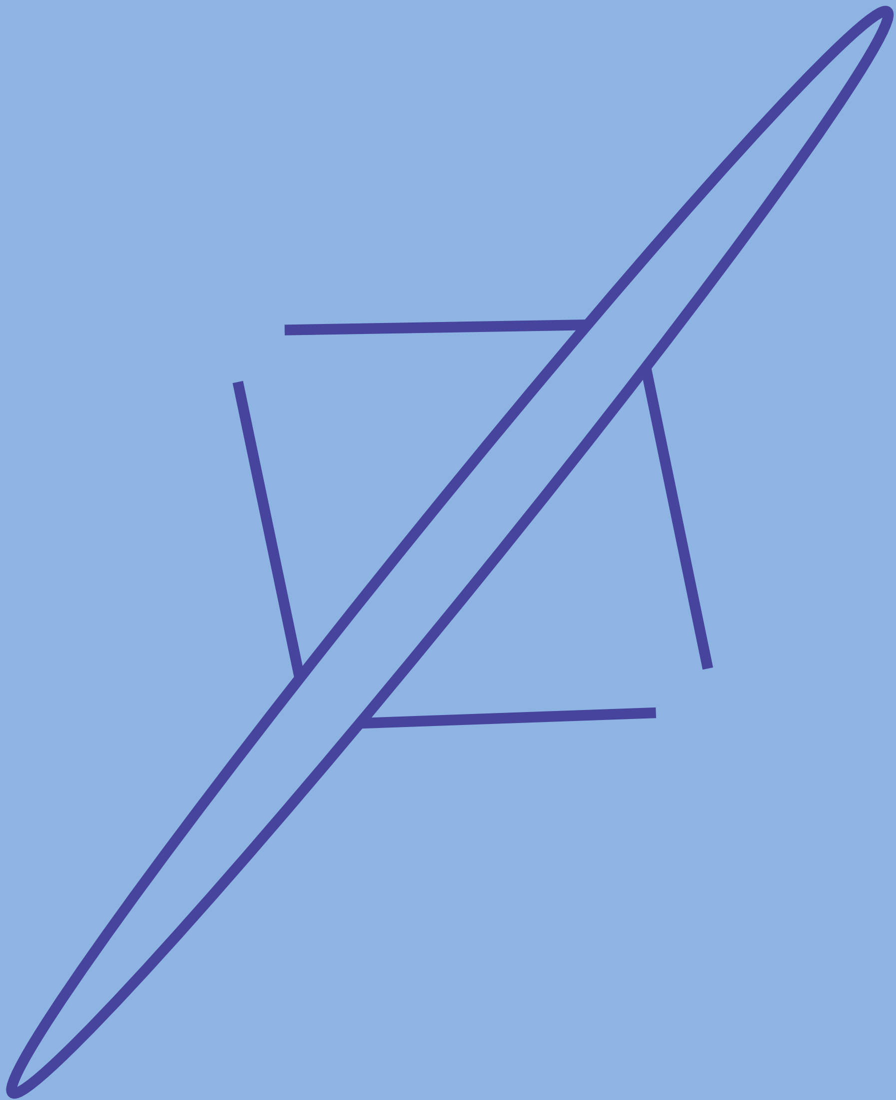
Antiphase crew rowing on water: a first case study

Chapter 6



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Introduction

In crew rowing, agents need to mutually coordinate their movements to achieve optimal performance (De Poel, De Brouwer, & Cuijpers, 2016). Traditionally, rowers aim to achieve perfect synchronous (in-phase) coordination. Somewhat counterintuitively, however, crew rowing in an *antiphase* pattern (i.e., alternating strokes) would actually be mechanically more efficient: it diminishes the within-cycle surge velocity fluctuations of the boat, thereby reducing hydrodynamic drag and hence power losses with 5-6% (Brearly, DeMestre, Watson, 1998; De Poel et al., 2016; De Brouwer, De Poel, & Hofmijster, 2013; Cuijpers, Zaal, & De Poel, 2015, Greidanus, Delfos, & Westerweel, 2016). However, from coordination dynamics an antiphase pattern is expected to be less stable, especially at high stroke rates such as in racing, which may even lead to transitions to the more stable in-phase pattern (Haken, Kelso, & Bunz, 1985). Recent laboratory studies in which rower dyads performed antiphase crew coordination on two mechanically coupled ergometers have provided promising results (De Brouwer et al., 2013; De Poel et al., 2016; Cuijpers et al., 2015;). However, counter to ergometer rowing, rowing on-water also requires handling of the oars and boat movements in three dimensions, such as lateral balance and forward speed. Furthermore, the boat has actual forward speed. Therefore, the next step in this endeavour is to examine antiphase crew rowing and associated boat movements *on water*. Here we report results of the first test case.

Method

Two experienced male rowers (age 32 and 34 years; length 1.93 and 1.94 m; mass 91.8 and 91.3 kg; rowing experience 11 and 7 years, of which 4 years in the same crew) rowed four trials of 1000 *m* rowing in in-phase and antiphase crew coordination at 20 and 30 strokes per minute (*spm)*. The rowers were instructed to maintain a steady state over the length of the course and started rowing approximately 100 m before the start of the trail to achieve their steady state. Next, they were instructed to maintain a similar power output (i.e., by maintaining the same heart rate) per stroke rate condition. For all trials a quad (i.e., a four-person boat) was used; to provide sufficient space for the oars not to collide in the antiphase condition, the two middle seats were left empty. Oar angles and movements of the boat were collected at 200 *Hz* using a customized measurement system including waterproof and a three-axial accelerometer-gyroscope sensor (see Cuijpers, Passos, Murgia, Hoogerheide, Lemmink, & De Poel, 2017). The 1000 *m* times were clocked with a stopwatch. For each of the four trials, the absolute error and variability of relative phase were calculated as coordinative measures.

Variability of surge and heave (accelerometers), and roll and pitch (gyroscopes) were adopted as measures of boat movements.

Results

As expected, larger values of absolute error and variability of relative phase were found for antiphase than in-phase (Figure 1). Nevertheless, the antiphase pattern seemed sufficiently stable to perform on-water, even more so at 30 *spm*. In fact, at the higher stroke rate of 30 *spm* antiphase coordinative variability *de*creased to a level that barely differed from that of in-phase.

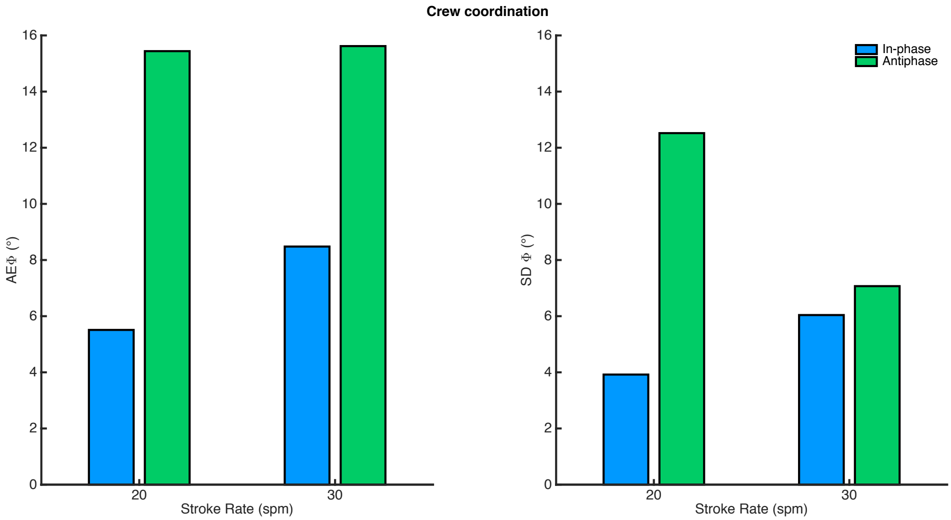

Figure 1. Absolute error (left panel) and variability (right panel) of crew coordination in in-phase and antiphase at 20 and 30 spm.

Surge (reflecting fluctuations in boat velocity) was much lower in antiphase compared to in-phase (Figure 2A), especially at the higher stroke rate of 30 *spm*. Next to that, Figure 2B-D show that also heave, roll and pitch of the boat reduced for the antiphase compared to the in-phase trials, especially at 30 *spm*.

Still, the 1000 *m* times were faster for the regular in-phase than for the 'new' antiphase rowing pattern (4:27 *m* vs. 4:38 *m* for 20 *spm*; 3:56 *m* vs. 4:10 *m* for 30 *spm*, respectively). Note however that the rowers *never* performed this antiphase rowing pattern before.

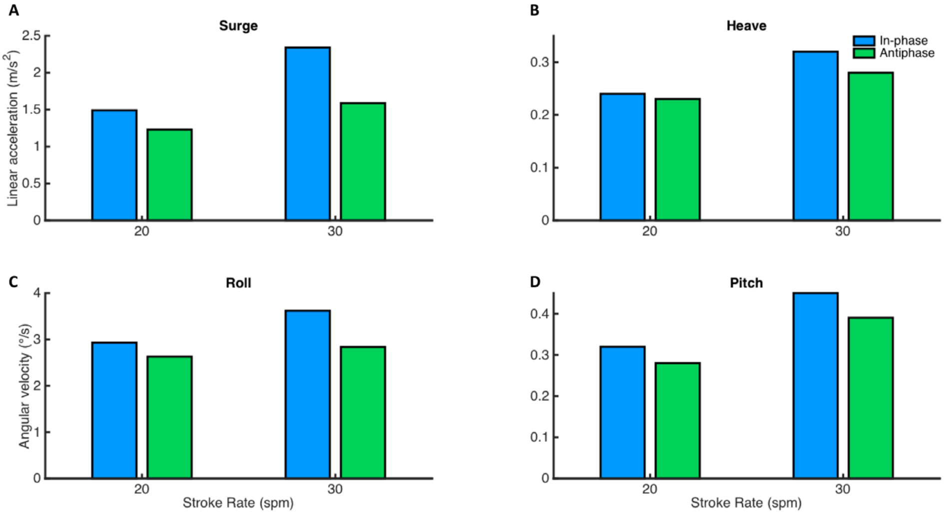

Figure 2. Movements of the boat in terms of (A) surge, (B) heave, (C) roll and (D) pitch in- and antiphase at 20 and 30 spm.

Conclusions

Together, the results of this case study verify the drastic reduction of surge speed fluctuations of the shell for antiphase compared to in-phase crew rowing. Moreover, heave, pitch, and roll also reduced, which may even imply extra benefits of antiphase rowing in terms of drag and balance (Wing & Woodburn, 1995). Importantly, next to in the lab (Cuijpers et al., 2015) also on water the between-agent antiphase pattern appeared sufficiently stable to maintain high movement rate. This is quite promising, given that this was only the very first time these experienced rowers rowed in antiphase. As is obvious, there is room for optimization of the antiphase coordination performance, which likely enhances the currently observed boat speed (as measured by the 1000 *m* times). As such it seems worthwhile to further investigate (the optimization of) the potential benefits of antiphase rowing.