Air Tandem: A Collaborative Bodily Game Exploring Interpersonal Synchronization

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Abstract
In this paper we introduce a game design that utilizes the synchronization and flow of the movement in contrast to the pace of movement (speed) utilized in many exertion games. We present Air Tandem, a bodily game that explorers synchronized limb movements to move a shared avatar from a start to a finish line on a projected route. The game is designed for a two player team. In the future we plan to use this game to gain insight on the sensory cues the players use to achieve synchrony.

Author Keywords
Joint action; synchronized movement; interpersonal synchronization; movement partnering; exergames; cycling

ACM Classification Keywords
H.5.3 Group and Organization Interfaces: *Synchronous interaction*

Introduction
When a person performs a task with his/her limbs in coordination it is called intrapersonal coordination. Two people performing the same task together also requires interpersonal coordination. The underlying mechanism

for innate cooperation is unknown. Many of us have though experienced interpersonal synchronization when adjusting our gait to another's while walking together [1, 2, 3].

In this paper we introduce a game that utilizes interpersonal synchronization of movement through the performance of a joint exercise in the form of air cycling. We have designed, developed and playtested a prototype of the game, with 18 participants over a two week period. In the following chapters we discuss the findings from this playtest, the design process and explain our next steps/future work. First, however, we consider related work.

Related Work

Some work has occurred concerning the combination of exercise devices and digital video displays. Virkku (Virtual Fitness Centre), for example, uses a real-world exercise bike to navigate a projected virtual scene [4]. A more recent adaptation is CyberBike [5], a stationary exercise bike that can be used as a controller in racing games on the PlayStation 3, Wii, tablets or a smart phone. What these games or exercise systems have in common is that they require real-world physical input, in the form of cycling with pedals, in order to control the virtual game world in some way, such as navigating a cycling character through it. They also suggest that pedaling movement can be a spontaneous way of propelling a character through a game scene.

Life is a Village is a two player game where players in a shared location play using an exercise bike and a Wii remote. Both players control one avatar, but the biker alone controls the speed and the player with the Wii remote controls the upper body of the avatar [6]. This example is interesting because it shows joint interaction in controlling an avatar yet the players' actions have been separated within the shared space.

Interpersonal synchronization is utilized in many exergames. Swann Boat [7] is a game where two players steer one pilot of a two pilot paddle boat. The running speed of the players is directly proportional to the speed of the virtual pilot. If the other player runs slower the paddle boat turns to his/her direction. Alternately ExerSync [8] is an exercise system that uses audio visual cues to synchronize the rhythm of movement of the participants. The system picks up the speed and frequency of any rhythmic exercise and transfers the pace as audio visual cues to people in various locations. This makes it possible to combine different forms of exercise into a shared experience.

Although the mechanism for interpersonal synchronization is complex and many aspects of it are unknown. The coupling between perception and action plays a significant role in the process. Visual cues in particular have been found important in achieving synchrony. The importance of vision has been observed with people that are situated in separate locations [2, 8, 9, 10, 11]. There are team sports requiring synchronization that also rely on haptic feedback for instance dancing [12]. Outside auditive cues have been found influential in achieving synchronization, especially in social setting [13].

We believe, however, that there is still a need for a closer investigation concerning the main sensory avenues to facilitate the achievement of synchrony in exergames. A system or a game that eliminates as much of the physical surroundings as possible would

also allow game designers to consider the haptic feedback that they provide players of games that require intrapersonal interactions. To this end, we created a game that explores these variables: visual, auditive and physical/haptic feedback between players, while they try to achieve synchrony. In the next section we introduce and describe our game, Air Tandem.

Air Tandem

Air Tandem is a variation of a commonplace exercise, air cycling, where one lies on their back on the floor and pedals into the air. Two players take part in Air Tandem. They lie on the floor parallel to each other. They are also strapped together at their ankles and wrists (see Figure 2). In order to move an avatar projected above them, they need to peddle synchronously to achieve maximum velocity (Figure 1).

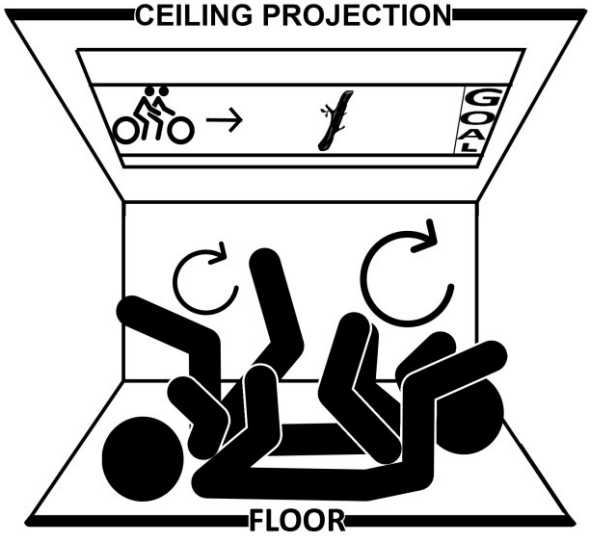

Figure 1. Set up of Air Tandem from the side.

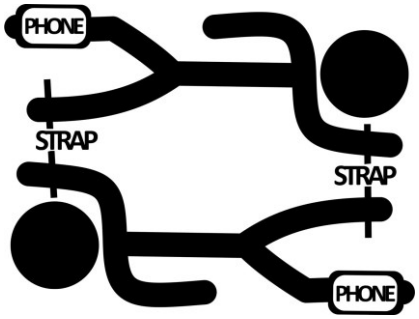

Figure 2. Set up of Air Tandem from above.

The movement is tracked by a mobile application that follows the accelerometer of a phone strapped to players' legs (Figure 2). Their joint progress can be seen from a projection of a track (Figure 3).

Figure 3. Air Tandem track user interface

We employ interference strategy in Air Tandem gameplay. This means the players have to share space and interfere bodily in order to reach a common goal. The synchrony of the players' movement is translated to the speed that their avatar moves on the virtual track. The players' peddling speed in real life, however, has no effect on the avatars movement speed. In fact, if the players move very fast it can have a negative

effect to the speed of the avatar because the mobile application is more attuned to the angle the players' limbs are than it is to their peddling speed. The players need to mirror their posture and peddle at the same time. The track also contains obstacles like rocks, logs or potholes. If the players' avatar meets an obstacle they are prompted to do an extra bodily gesture, raise one leg up. The players need to decide amongst themselves which player does this, simultaneously the other player needs to place their leg down in order for the avatar to slide past the obstacles. Obstacles are implemented in order to allow the players to rest and to challenge them when getting back into synchrony.

Design Process and Evaluation

The design and development of the game took place at the one week UBI Summer School held in Oulu Finland. There AirTandem was designed and play tested as a concept game and as functioning prototype (Figure4).

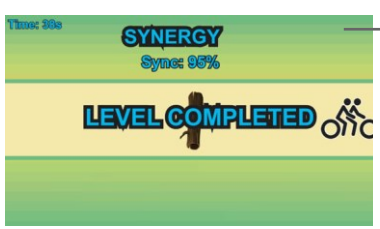

Figure 4. Playtesting Air Tandem with audience.

We complemented the early trials later by subsequent round of playtesting without audience to minimize the effect of social pressure to the performance of the participants (Figure 5). We did not use music because its tempo could have given the players outside influence in achieving synchronization.

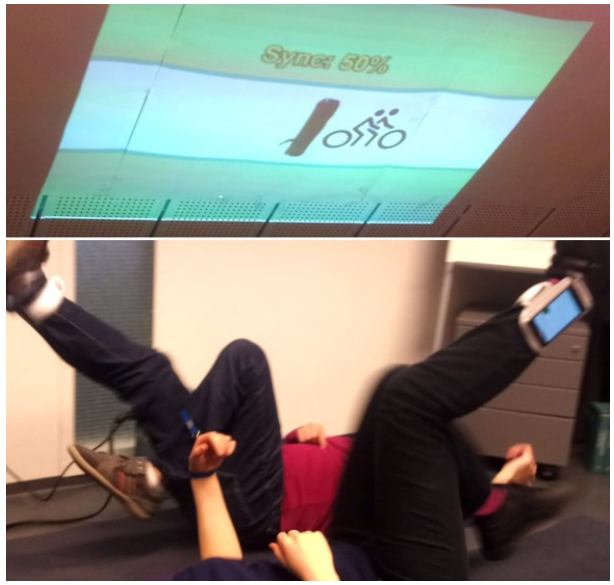

Figure 5. Playtesting Air Tandem with the projection on the ceiling and without audience

Using mobile phone accelerometer as a measuring device enables us to remove the physical bicycles. Instead of exercise device we bind the players to each other to enhance interpersonal haptic feedback. The strap is inflexible and functions as a device of giving instant feedback to a fellow player. This also forces the players to involve their upper body and innermost leg into the exercise. Strapping two players together

further enhances the aspect of interpersonal synchronization in the game. Although the word *sync* i.e. synchronization (Figure 3) is used in the game visuals, the game is as much about the flow of the movement. We noticed while playtesting the game that big round synchronized movement yielded 100% sync, jittery synchronized but not smooth movement 50% (or random fluctuation in the numbers) and one leg up gesture 10-30%.

In Air Tandem the modalities for getting feedback on the performance of the fellow player are not just visual. The projected game scene shows the joint performance of both players, but gives no feedback on individual performance. When the projection of the track is on the roof the only way to get visual cues on the pace and posture of a fellow player is to take a glance at him/her. We observed during playtesting that the players did speak to each other about their performance and also grabbed each other's ankles to aid in adjusting their movement. We noticed that using flexible material for the straps made it more difficult for players to find synchrony. Possibly because of the weakness of haptic feedback and because elastic bouncy material also transfers false and delayed feedback.

Conclusion & Future Work

Based on our playtests Air Tandem is a fun game for participants as well as spectators. During the latest playtest the players would not settle for just one play through of the game.

The current setup of Air Tandem can provide insights on alternate avenues of sensory perception in achieving interpersonal synchrony. We wish to conduct further experiments to come to a definitive conclusion on what the main avenues of sensation for Air Tandem players are and how they develop.

We plan to set controlled experiments to gain insight on questions set in Table 1. On Q1 and Q2 we plan to compare the role of visual, auditive and physical/haptic feedback between players during game play. The strap between players transfers the haptic feedback in Air Tandem. In the subsequent work we aim to compare groups of players that use various strap materials with groups that have no strap or are in direct physical contact by touch. We also plan to conduct video analysis complemented with interviews in order to answer the research questions Q3 and Q4.

Q1.	What modality i.e. main avenue of sensation has the most impact on synchronized movement among tandem air cyclers?
Q2.	How does the preferred modality for achieving synchronization change or develop over time?
Q3.	How do the users react to the challenges presented during the gameplay (getting into sync, overcoming obstacles, etc)?
Q4.	Does Air Tandem aid in increasing interpersonal connection by encouraging synchronization?

Table 1. Questions for future research

We intend to further develop the game prototype. One approach could be to employ machine learning methods to build and train a statistical model to recognize

periodic movements among different styles of air bikers.

Further work with Air Tandem fits our ongoing research agenda. We are looking into alternative ways of joint orienteering in virtual environments, especially the kinds that utilize widely available equipment (like mobile phones) or encourage exercise (like movement based interaction in exergames).

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