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# Pianists duet better when they play with themselves: On the possible role of action simulation in synchronization

Peter E. Keller [a,d,*], Günther Knoblich [a,c], Bruno H. Repp [b,c]

[a] Max Planck Institute for Human Cognitive and Brain Sciences, Munich/Leipzig, Germany
[b] Haskins Laboratories, New Haven, CT, USA
[c] Rutgers University, Newark, NJ, USA
[d] Department of Cognitive Psychology, University of Finance and Management, Warsaw, Poland

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**Abstract**

Ensemble musicians play in synchrony despite expressively motivated irregularities in timing. We hypothesized that synchrony is achieved by each performer internally simulating the concurrent actions of other ensemble members, relying initially on how they would perform in their stead. Hence, musicians should be better at synchronizing with recordings of their own earlier performances than with others' recordings. We required pianists to record one part from each of several piano duets, and later to play the complementary part in synchrony with their own or others' recordings. The pianists were also asked to identify their own recordings. The pianists were better at synchronizing with their own than with others' performances, and they were able to recognize their own recordings. Furthermore, synchronization accuracy and recognition were correlated: Pianists who were relatively accurate at synchronizing with their own performances were also good at recognizing them. Thus, action simulation may underlie both synchronization and self-recognition.


*Keywords:* Music; Synchronization; Action simulation; Self-identity; Action identification

## 1. Introduction

How do musicians playing in an ensemble, such as a piano duo, synchronize their actions with one another? Although the cognitive challenges associated with ensemble performance are manifold (Keller, 2001), one crucial skill for ensemble musicians is the ability to stay in synchrony with one another in spite of the systematic timing irregularities that characterize expressive musical performances (see Rasch, 1988; Repp, 1999; Shaffer, 1984). Hence, the opening question can be rephrased: How does an ensemble musician predict the variable timing of the sounds produced by other ensemble members, to coordinate his or her own sounds with them? The current study investigates the possibility that synchronization in musical ensembles is achieved by

* Corresponding author. Fax: +49 341 9940 204.
*E-mail address:* keller@cbs.mpg.de (P.E. Keller).

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performers simulating—during ensemble performance—how the accompanying parts might be played (somewhat independently of how they actually are being played). If this is the case, then the simulated parts should bear traces of the performer's own idiosyncratic way of playing, i.e., they should reflect the way in which he or she would perform them. Thus, a musician's actions are steeped in his or her *self-identity*, a term which we use here to refer to procedural knowledge about behavioral consistencies that are used to distinguish one's own actions from those of others. Any evidence in favor of the proposed relationship between action simulation and ensemble synchrony would suggest that music performance may be a novel and fertile domain in which to investigate the role of such self-identity in the cognitive control of interpersonal coordination.

### *1.1. Action identification*

Human individuals have privileged access to their own perceptions and actions. Apart from allowing the individual to regulate his or her behavior, this privilege allows one to recognize the effects of one's own actions as self-generated (Frith, Blakemore, & Wolpert, 2000; Jeannerod, 1999, 2003; Wegner, 2002). It has recently been claimed that self-recognition involves accessing one's own knowledge about how to perform an action (Knoblich & Flach, 2003). This knowledge encompasses all of the movements that an individual has the potential to execute; it relies on the individual's anatomical constraints, learning history, and level of expertise. Thus, during the course of everyday experiences, individuals learn about the peculiar ways in which they do things such as walk, talk, and play the piano.

There are two main sources of experimental evidence supporting the assumption that action identification relies on an individual's action knowledge. First, it has been shown that people are more accurate at predicting the location and timing of forthcoming events for their own actions than for others' actions (Flach, Knoblich, & Prinz, 2003, 2004; Knoblich & Flach, 2001; Knoblich, Seigerschmidt, Flach, & Prinz, 2002). Second, studies of diverse behaviors including handwriting, body movements, clapping, and piano playing have demonstrated that individuals are able to distinguish between recordings of actions performed by themselves and recordings of actions performed by others (Flach, Knoblich, & Prinz, 2004; Grèzes, Frith, & Passingham, 2004; Knoblich & Prinz, 2001; Loula, Prasad, Harber, & Shiffrar, 2005; Repp, 1987; Repp & Knoblich, 2004). Importantly, actions were recognized as self-generated even when the recordings were edited to remove salient cues that may facilitate easy identification. For example, Repp and Knoblich (2004) found that expert pianists were able to recognize their own performances equally well in the original recordings and in recordings that were normalized in terms of tempo (overall rate) and dynamics (changes in loudness). Notably, these authors also found that pianists were able to recognize their own performances even when they had not heard any sound during the recording session, which suggests that episodic memory cannot provide a full explanation of how self-generated actions were recognized.

### *1.2. Action simulation*

We hypothesize that to recognize an earlier action as self-generated, or to predict action-related effects accurately, individuals access their action knowledge by internally simulating the action. This process of simulation involves imagining—in anticipation—the movements and effects that characterize the event, and it is triggered automatically when an action is observed (Dokic & Proust, 2002; Jeannerod, 2003; Knoblich & Flach, 2003). Thus, the notion of action simulation presupposes close links between perception and action. In fairly direct support of action simulation, research in neuroscience has revealed brain areas—e.g., the so-called 'mirror neuron' system in the pre-motor cortex—that are active not only when carrying out a goal-directed movement, but also when simply observing somebody else performing the movement (Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Rizzolatti & Craighero, 2004; Rizzolatti, Fogassi, & Gallese, 2001).

Research on action identification suggests that, once the observation of a recording of an action triggers its simulation, the degree of discrepancy between the simulated and the observed action determines whether the action is attributed to self or other, and whether or not accurate predictions can be generated about forthcoming events. The match between simulation and observation is better in the case of self-generated actions than for other-generated actions because in the former the simulation is carried out by the same system—with all its idiosyncratic constraints—that produced the observed action. In other words, the action system resonates