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Short Communication

Joint action coordination in expert-novice pairs: Can experts predict novices' suboptimal timing?

Thomas Wolf*, Natalie Sebanz, Günther Knoblich

Department of Cognitive Science, Central European University, Budapest, Hungary

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ABSTRACT

Previous research has established that skilled joint action partners use predictive models to achieve temporal coordination, for instance, when playing a music duet. But how do joint action partners with different skill levels achieve coordination? Can experts predict the suboptimal timing of novices? What kind of information allows them to predict novices' timing? To address these questions, we asked skilled pianists to perform duets with piano novices. We varied whether, prior to performing duets, experts were familiar with novices' performances of their individual parts of the duets and whether experts had access to the musical scores including the novices' part of the duet. Familiarity with the score led to better coordination when the score implied a difficult passage. Familiarity with novices' performances led to better joint action coordination for the remaining parts of the duet. Together, the results indicate that experts are surprisingly flexible in predicting novices' suboptimal timing.

1. Introduction

When people perform joint actions together, they need to coordinate their actions in time (Butterfill, 2017; Keller, Novembre, & Hove, 2014; Pecenka & Keller, 2011; Sebanz & Knoblich, 2009). Previous research has demonstrated that internal models enable joint action partners to predict each other's timing if both are skilled in performing the individual parts of a joint action (e.g., Kourtis, Knoblich, Woźniak, & Sebanz, 2014). However, an open question is how joint action partners who differ in their individual skills achieve joint action coordination. For instance, when two musicians play a piano duet together, they need to adhere to certain tempo requirements and to minimize interpersonal asynchronies, regardless of differences in their skills. How coordination is achieved despite large differences in skill is an important question because it pertains to many joint actions performed in the context of teaching (Csibra & Gergely, 2009). The aim of the present study was to investigate whether skilled performers can ensure successful interpersonal coordination despite novices' suboptimal timing, and what kind of information helps them to achieve this.

We started from the hypothesis that interpersonal temporal coordination can be achieved if the skilled joint action partner compensates for a novice's suboptimal performance. When adapting to novices' suboptimal timing experts have to go beyond using their own internal models to predict a joint action partner's performance in real time (Noy, Dekel, & Alon, 2011; Wolpert, Doya, & Kawato, 2003). The reason is that, according to internal model accounts, the accuracy of predictions of a joint action partner's performance should depend on a high degree of similarity of the predicting and the predicted system (Grèzes, Frith, & Passingham, 2004; Knoblich & Flach, 2001). The dimensions of similarity that can affect the accuracy of coordination range from a shared preference for a general tempo (Loehr & Palmer, 2011) to fine-grained similarities in micro-timing that characterize particular individual performances (Keller, Knoblich, & Repp, 2007). Although there is some evidence that, in the context of action observation, predictions can be adjusted to reflect general differences in action capabilities (Ramenzoni, Riley, Davis, Shockley, & Armstrong, 2008; Welsh, Wong, & Chandrasekharan, 2013), it is an open question whether temporal predictions can be adjusted to the suboptimal timing that characterizes novice performance in domains such as sports, dance, and music where such joint actions are frequent.

We studied this question in the domain of musical joint action, where continuous and accurate temporal coordination is crucial to achieve successful joint performance (Keller et al., 2014). It is well established that music experts use internal models to predict the outcomes of their own and others' actions (Haueisen & Knösche, 2001) and experts' performance parameters differ systematically from novices' performance parameters (Aoki, Furuya, & Kinoshita, 2005; Loehr & Palmer, 2007).

Observation of music ensembles rehearsals (Ginsborg, Chaffin, & Nicholson, 2006; Ginsborg & King, 2012) suggested two important sources of information for improving temporal coordination:

* Corresponding author at: Department of Cognitive Science, Central European University, Október 6 utca 7, 1051 Budapest, Hungary.
E-mail address: wolf_thomas@phd.ceu.edu (T. Wolf).

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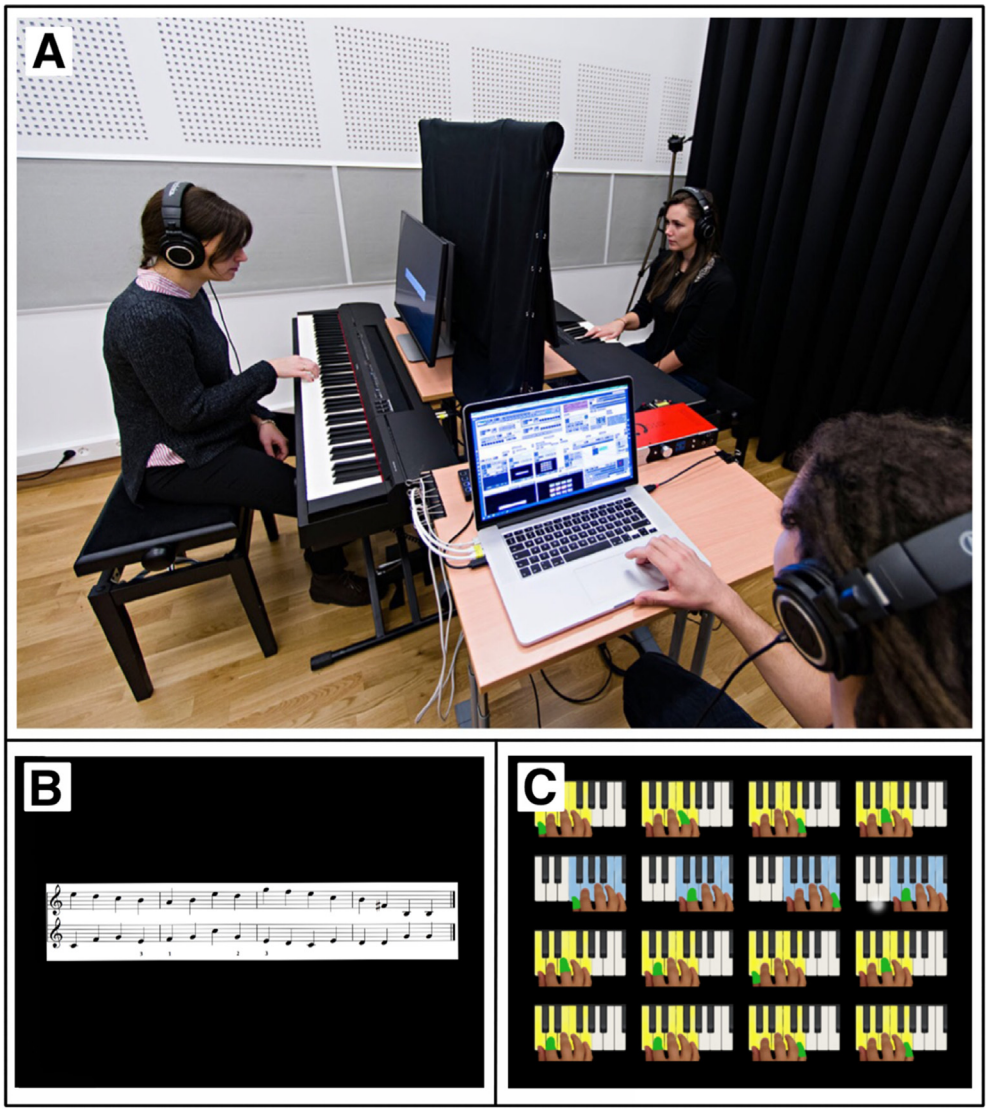

Fig. 1. (A) Experimental setup. (B) Experts performed their own part based on a standard musical notation (upper row). For half of the duets experts received the full musical score including the novice's part (lower row). (C) Novices performed their part based on a simple custom notation that was read line by line from top to bottom. Each picture corresponded to one beat and showed one of two hand positions (color-coded with yellow and blue) and the finger to be used to press one of the piano keys (green). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

knowledge of the structure of a partner's part, and knowledge of a partner's interpretation of her part, including expressive timing (Repp, 1990). The former can be acquired in the absence of a partner from musical scores. In contrast, a partner's idiosyncratic interpretation will need to be experienced first-hand.

A study by Ragert, Schroeder, and Keller (2013) provided support for the importance of experiencing a partner's performance. They asked highly trained pairs of piano experts to repeatedly perform duets. Temporal coordination between the pianists improved across consecutive repetitions of the same duet, supporting the claim that increasing familiarity with a partner's playing style improved interpersonal coordination. This finding indicates that pianists were able to adjust their predictions to capture parameters of an expert partner's timing. However, it is an open question whether experts are also able to adjust to novices' suboptimal timing that does not express a certain musical style. This may be a precondition for teaching through joint actions where experts provide a timing scaffold for novices.

But are there any regularities in novices' timing that experts could pick up on to improve their predictions? In order to address this question, we varied whether experts were familiar with novices' performances of their individual parts before performing a duet with them. We hypothesized that experts' familiarity with novices' playing would improve temporal coordination during ensuing duet performance. This is only expected to occur if experts can extract from a novice's performance idiosyncratic patterns that help them to improve their real-time predictions of the novice's performance during a joint performance. One factor that is likely to produce predictable timing variability in the novice is encountering particular motor difficulties such as having to switch the hand position on an instrument. Such difficulties are often visible from the musical score because these scores can include particular instructions for the positioning of fingers and hands. In order to find out whether experts can translate such symbolic information into real-time predictions during joint performance we used music notation from the tradition of Western classical music and varied whether experts knew in advance the musical score including the novices' parts of the duets. Knowing novices' scores is only expected to help experts to improve temporal coordination during joint performance if they can identify difficulties for the novices and translate these into accurate delays in their own performance to match delays in the novice's performance. Finally, to check that timing variability in