IMPROVING IMPROV: EFFECTS OF INTERPERSONAL COORDINATION ON MUSIC IMPROVISATION

by

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ABSTRACT

TEVIN WILLIAMS. Improving Improv: Effects Of Interpersonal Coordination On Music Improvisation. (Under the direction of DR. ALEXIA GALATI)

Previous research has shown that rigidity in interpersonal coordination (too much alignment) is negatively associated with creativity as measured by ratings of aesthetic appeal. In this study, we examine the signatures of music improvisation following a targeted manipulation involving a mirroring task. In 18 pairs, participants completed a series of tasks: a solo music improvisation performance using a percussion instrument (cajón), a mirroring task with a partner, and joint music improvisation. Across pairs, we manipulated three different types of mirroring to examine its effects on coordination during joint music improvisation. A third of the pairs engaged in Hierarchical mirroring, with partner A leading the movement and partner B following. Another third of the pairs engaged in Turn-Taking during mirroring, with partner A leading the first half of this phase and partner B leading the latter half. The final third of the pairs engaged in Egalitarian mirroring, with partners co-creating spontaneous movement together. Partners were video and audio recorded during this phase. From these recordings, we have extracted signatures of interpersonal coordination in terms of acoustic properties of the performance, using cross-correlation.

We predicted that the mirroring conditions involving more rigidity (i.e., more asymmetrical roles) would be associated with more rigidity (i.e., more alignment) during music improvisation. Specifically, We predicted that the opportunity to take the lead during motor mirroring would impact coordination during improvisation as follows: pairs in which both partners had the opportunity to lead (i.e., in Turn-Taking) or co-lead (i.e., in Egalitarian mirroring) would exhibit higher behavioral complementarity (less alignment) compared to those pairs in which one partner had solely taken the lead (i.e., the Hierarchical mirroring). Measures

assessing individual differences in music sophistication, personality, and prosocial orientation were also collected. Regression models with cross-correlation metrics as outcome measures displayed marginally significant differences between the Turn-Taking and Egalitarian mirroring conditions with the Turn-Taking condition displaying lower levels of cross-correlation. Regression models were also built with individual differences measures as covariates suggesting that musical ability may influence music improvisation. However, a study with a large sample size will allow for a more accurate assessment of the impact of partners' movement patterns in a subsequent performance, thus providing theoretical insights about improvisation and collaboration.

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LIST OF ABBREVIATIONS

GMSI	General Music Sophistication Index
MTI	Music Training Index
PBIS	Prosocial Behavior Intentions Scale
BFI-10	Big Five Personality Inventory

CHAPTER 1: INTRODUCTION

Joint creative improvisation is ubiquitous in everyday life. Broadly construed, joint creative improvisation spans a variety of tasks, ranging from students designing a group presentation, university administrators flexibly developing new procedures in response to a pandemic, to a family cooking dinner together using ingredients available in their pantry. In artistic settings, such as music, dance, and comedy, joint creative improvisation is often part of the creative process, practiced methodically in preparation for performances.

In order to unravel the cognitive and social underpinnings of creative improvisation, it is necessary to examine the dynamics of interpersonal coordination during this form of joint action. Although there has been a significant amount of research on interpersonal coordination, we still do not know which aspects of coordination improve task performance and creativity during improvisation.

Interpersonal coordination in joint music improvisation, in particular, remains understudied. Although music improvisation often takes place in ensembles, much of current research focuses primarily on individual performance and does not systematically examine the dynamics of interpersonal coordination during music improvisation. It is for this reason that the current study may improve the existing knowledge of interpersonal coordination as it relates to music improvisation.

In the next section, I review some theoretical frameworks that can account for alignment (synchronized actions between individuals) and complementarity (coordinated actions that are not synchronized between individuals) in interpersonal coordination. In the subsequent section, I explain how music improvisation is a joint action task and the need for knowing whether

alignment of complementary behavior can improve improvisation. Finally, I describe the present study and relate our predictions to the theoretical background discussed in previous sections.

CHAPTER 2: LITERATURE REVIEW

Theoretical Accounts of Interpersonal Coordination

In order to understand patterns of interpersonal alignment in music improvisation, we will consider the following frameworks of interpersonal coordination more broadly: Joint action, Dynamic systems theory, and priming-based accounts (e.g., Interactive alignment). Across all of these theoretical frameworks, a useful distinction concerns the difference between planned, strategic coordination and emergent, more automatic coordination.

First, we will go over the different aspects of planned coordination and how these aspects relate to improvisation. In theories of joint action, planned coordination is seen as the performance of individuals motivated through the desire to achieve a predetermined goal (Vespers et al. 2009). During planned coordination, individuals not only understand that work needs to be completed by themselves in order to achieve the desired outcome, they also know that there will be contributions from another individual to complete the set goal. Minimal planned coordination allows an individual to plan their own actions to achieve a goal in addition to knowing the need for other agents' actions without the detailed knowledge of those actions (Vesper et al. 2010). However, when an agent begins to account for the actions needed by other agents, it is helpful to have some shared understanding in the form of task representations. With a shared task representation both agents understand the actions needed to complete the goal. This relates to planned aspects in music improvisation. For example, during jazz improvisation, the rhythm section is commonly responsible for providing harmonic and rhythmic support to the soloist. In some cases of jazz improvisation, the amount of time each soloist has to perform can be predetermined as well. However, even in these examples of planning, there is still a significant amount of emergent coordination within creative music improvisation.

Joint action is also relevant to dialogue, as speakers make linguistic contributions to achieve common goals. In Pickering and Garrod's (2004) Interactive Alignment model, conversational partners align their linguistic representations (phonological, syntactic, and semantic qualities) based on a simple priming mechanism. This alignment is seen as supporting mutual understanding between individuals during conversation. An example may be using the same referring expressions to describe a concept or idea throughout a conversation. These referring expressions may be presented by one individual during the start of a conversation and used by other individuals referring to the same concept throughout the rest of the dialogue. In this view, the aligned use of these referring expressions is thought to develop from simple priming mechanisms that operate at different levels.

Another relevant perspective of joint action comes from emergent coordination. This type of coordination involves individuals acting in the same way, not due to shared knowledge or a common pre-established goal, but rather due to processing and reacting to perceptual information (Marsh et al. 2009). Emergent coordination can occur during a planned coordination; however, the joint action that happens during emergent coordination is the result of individuals responding to perceptional information as opposed to the goal itself (Knoblich, et al. 2011). In the context of music improvisation, emergent coordination occurs, for example, when musicians respond immediately to musical phrases or ideas presented by fellow musicians.

Dynamical systems theory emphasizes the emergent behavior of interacting elements in systems (e.g., individuals in an ensemble), and can account for a number of coordination patterns including both alignment and complementarity. This theory explains how teams perform more variable patterns of coordination at local scales that contribute to overall coherence at a global scale (Gorman et al., 2017). A complex dynamical system contains a large number of interacting

agents, exhibiting self-organized emergent behavior, without a central controller (Richardson et al., 2015). Although the interaction between individuals at a local level (within one a small area of a larger system) may not be synchronized, this contrast contributes positively to the overall output of the system. The production of this contrasting behavior is emergent in nature and does not result from the control of one individual. Related to this point, Gorman and colleagues (2017) explain how team dynamics contain metastable states maintained at a cognitive-behavioral level. Although these states are unstable in principle, the balance achieved by the contrast from each individual is what keeps the system stable. During improvisation, the contrast of musical ideas (i.e., offbeat rhythms over a steady melody) between individuals can allow for production of creative musical phrases that build out of contrast as opposed to symmetry and adding stability to the overall performance. Higher-level strategic goals, in dynamical systems theory, can be represented as control parameters that shape the landscape of emergent behaviors. Consistent with this dynamical systems' perspective, in music improvisation, contrast between musicians is necessary to produce complex and pleasant music. Additionally, the complex and pleasant music that is produced is the result of the ensemble as a whole as opposed to one individual controlling the entire group. One example is the production of music coming from a big band jazz ensemble, although the output at local levels (rhythm section, woodwinds, and brass section) may be contrasting one another (such as melodies and counter melodies) the output of the whole ensemble comes together as one entire piece of music.

These different theoretical accounts describe how interpersonal alignment occurs, by either prioritizing emergent or planned coordination. Still, the extent to which interpersonal alignment supports task performance remains underexplored.

Effects of Interpersonal Coordination Patterns on Task Performance

A number of studies examining interpersonal coordination show that alignment and synchronization can improve performance or promote prosocial behavior. Hearing an utterance in conversation that relates to a particular situation can make it more likely that the conversational partner will use this same utterance to refer to the situation throughout the conversation. According to the Interactive Alignment model, this is achieved by the resource free and automatic mechanism of priming (Pickering and Garrod, 2004). Pickering and Garrod (2004) suggest that conversation between two individuals is most efficient when the representations of the subject of conversation are aligned.

Similarly, there are documented benefits of interpersonal alignment on social rapport. Chartrand and Bargh (1999) found that individuals who mimic the conversational mannerisms of their conversation partner (such as tapping a finger or touching one's face) have better rapport. For example, individuals who interacted with task partners who aligned with their drumming patterns (vs. not) were more likely to show prosocial behavior towards those task partners (Kokal et al., 2011).

In addition to increasing prosocial behavior, interpersonal synchronization has been shown to increase perceptual sensitivity to temporal movement, which is relevant to music improvisation. In a study by Valdesolo and colleagues (2010), dyads of participants responded to a perceptual sensitivity task individually after rocking in or out of sync in chairs. Dyads that rocked in sync had higher accuracy for judging temporal movement of the perceptual task (determining if there was a delay in the movement of a ball moving on a computer screen when the ball moved through an area that was blocked from view on the screen) compared to dyads that were out of sync. The same study also found that socio-motor improvisation measured through performance in a labyrinth task (participants held opposite ends of a wooden labyrinth

with both hands and moved a steel ball from the start of the labyrinth to the end) can be improved through manipulating synchronization. In a different study, Gueugnon and colleagues (2016) found that similar movement (completing oscillations at the same amplitude) compared to dissimilar movement manipulation (completing oscillations at different amplitudes) leads to improved complexity and synchrony of performance in the joint improvised mirroring task. During the mirroring task, participants were instructed to create interesting and complex movements while staying as coordinated as possible by moving a handle back and forth along a string while facing each other. More complex movements (measured through how dissimilar the patterns of movements were) were produced compared to simple movements.

However, despite some of these documented benefits of interpersonal alignment, there are studies showing that complementarity in behavior benefits performance in joint tasks. Selective alignment of language use (alignment of task-relevant language) was found to be more beneficial compared to general alignment (alignment of all language regardless of task relevancy) during joint tasks (Fusaroli et al., 2012). This was taken to mean that the alignment of task relevant vocabulary is more useful than alignment of general vocabulary when completing a joint task; however, the absence of general language alignment did not necessarily imply the use of complementary language use. Gorman and Crites (2014) found that using complementary behavior instead of synchronized behavior leads to greater levels of success in certain collaborative tasks. In this study dyads were faster at tying shoes using complementary as opposed to synchronized hand movement, suggesting that certain tasks require complementary behavior to be most effective.

In another study, Wallot and colleagues (2016) found that when collaborating partners were allowed to work together in an unconstrained way in a complex motor task (e.g., building

model cars) high levels of alignment were associated with decrements in objective task outcomes and satisfaction about the task. In this study dyads of participants were divided into three different groups: an Egalitarian condition in which both participants contributed equally, a Hierarchical condition in which only one participant was in charge and the other followed, and a Turn-Taking condition in which the participants took turns leading and following. The researchers found that asymmetric Hierarchical interactions were associated with more interpersonal alignment than symmetric "Egalitarian" ones. Similarly, in other complex motor tasks, complementarity in movement dynamics was shown to be more functional than alignment (e.g., when playing Double Dutch, Gorman et al., 2017, or moving dots on a screen while avoiding collision, Richardson et al., 2015). Collectively, these studies suggest that when the task affords more degrees-of-freedom in how to structure the interaction, too much interpersonal alignment can constrain behavioral flexibility and result in performance decrements.

Still, it is unknown whether these findings extend, beyond complex motor tasks, to other cognitively complex domains such as music improvisation. Studies on interpersonal coordination generally report that an individuals' joint behavior is greater than and distinct from the sum of behaviors produced by each individual alone (Gorman, et al. 2017). When partners create spontaneous motion together, their personal signatures of movement (observed during individual performance) can no longer be recognized and new signatures of movement emerge ("co-confidence motion", Hart et al., 2014). Hart and colleagues (2014) used a mirroring task to measure moments of individuality and togetherness. Dyads of participants were encouraged to create interesting, synchronized motion with and without a leader. The experiment consisted of three rounds, in the first-round player A led while player B followed, in the second round the roles of player A and player B switched, in the third round there was no designated leader or

follower. They found that individual motion signatures disappeared during moments of joint improvisation. However, more research is needed to understand how this joint behavior differs based on the domain of improvisation.

Music Improvisation as Joint Action

Now we will begin to look at how improvisation is part of a joint creative process. Improvisation is a medium that can express creativity, consciousness, and intuition (Pressing, 1994). Creative activity is in many ways a collective effort, which is why in order to understand creative improvisation, it is vital to understand interpersonal coordination. When learning music as well as other forms of artistic expression, creativity is of great importance. Increasing novel approaches in expressing ideas can be developed through improvisation, suggesting that music improvisation is highly related to creativity (Johnson-Laird, 2002). Additionally, coordinated improvisation could be associated with trust and freedom of expression (Johnson-Laird, 2002). Coordinated improvisation can influence not only the quality of joint performance, but it can also have positive social effects. Interpersonal coordinated improvisation encourages social interaction as well as working towards a common goal of creating good work (Alterhaug, 2004). Successful improvisation rehearsal may also involve potential problem solving through simulating issues that may arise during a performance.

The perspective of team cognition also becomes relevant when examining improvisation between multiple people. Team cognition is the result of interactions at a compositional and compilation level building to form patterns and create a group cognition (Dechurch & Mesmer-Magnus, 2010). At the compositional level, the emergence of group cognition matches the output of the entire team. However, the cognition is coming from individuals as opposed to the entire group. At the compilational level, the emergence of cognition is different compared to the

individual level (Dechurch & Mesmer-Magnus, 2010). This means that the output of the team does not match any of the output that could be produced by the individuals alone. Team emergence, as it relates to improvisation, could be responsible for creating moments that do not match patterns of any individual improvisor.

According to DeChurch and Mesmer-Magnus (2010), teams are able to perform complex information processing tasks through the use of collective cognition as opposed to individual cognition. This is due to emergent cognition that allows for team members to predict and anticipate the actions of one another. Training along with leadership can influence the cognition of the team. A similar comparison can be made to the development of improvisation among musicians. Although jazz combos may have a dedicated lead instrument during a piece, the anticipations and predictions made by the ensemble in response to a leader's solo contribute to the overall production of music (Sawyer, 2006). For example, there could be melodic and rhythmic ideas produced by the ensemble as a whole that would otherwise not be present without the ensemble's collective cognition. Team cognition can also have a strong positive relationship on motivational states (Dechurch & Mesmer-Magnus, 2010). This suggests that working in teams can lead to higher levels of motivation and ultimately better performance.

Understanding how improvisation changes based on the roles of individuals within a group is also important. One aspect of creative music improvisation that is often misunderstood is the idea of group creativity being attributed to one individual (Sawyer, 2006). Many times when listening to live improvised solos, the listener attributes the complexity and creativity of the solo to one individual. This is due to the mindset that complex behavior is the result of a central controller as opposed to dynamic interactions between agents (Wyman, 1995). However, this is not the case; the creativity of the solo can be attributed to the entire ensemble responding

to and developing ideas without a designated leader (Sawyer, 2006). It is for this reason that it becomes important to understand emergent coordination in situations where there is a pre-established leader and follower vs situations where there is no designated leader and follower.

Studying music improvisation performance can be challenging for several reasons. When developing the skill of improvisation, focus is placed on the creative process as opposed to the actual product (Charyton, 2015). The development of the creative process of improvisation also depends on the medium of art. However, all of the mediums can still be influenced by coordination with other individuals. When it comes to music, another aspect that influences the creative process is the instrument and genre of music. This is because the improvisation for jazz drumming will be significantly different compared to the improvisation of an opera singer during the performance of an Aria. In this example there is a fundamental difference in overall skill set, musical context, accompaniment, and performance environment, although both examples can be classified as music improvisation. This also means that the process of evaluation will be different for the jazz solo compared to the opera solo. Although the differences between the musical genres require different skill sets in music improvisation, there are still some aspects that are shared between musical improvisation. In the present study we have chosen to use cajón percussive instruments due to the ease of playability for novice players.

Finally, a challenge of studying creative improvisation is the use of objective measurement. In prior work, observer ratings, for instance by expert judges, have been used to evaluate the quality of improvisation based on a set of predetermined criteria (May, 2003). Self-report measures have also been used, with individuals evaluating themselves on their improvisation ability (Charyton, 2015). Standardized measures of music improvisation have even been developed, namely, the harmonic improvisation readiness record (Gordon, 2000).

Nevertheless, none of these approaches objectively quantify how a particular music improvisation session unfolds. In this work we attempt to bridge the gap by using objective measures of improvisation obtained from acoustic analysis.

The Current Study

The current study seeks to examine the role of interpersonal coordination in an initial task (involving mirroring) on subsequent creative improvisation. Specifically, we ask how manipulating the initial dynamics of interpersonal coordination through the mirroring task will impact the dynamics during music improvisation.

Our decision to manipulate coordination through mirroring is motivated by prior research. There is evidence, for example, that mirroring exercises can enhance mathematical learning ability. Smyrnis and Ginns (2016) found that university students who completed a pre-lesson mirroring exercise were faster at completing a math test after viewing a one-page instruction sheet. This suggests that a mirroring task can have downstream effects when used as an experimental manipulation.

We follow the experimental manipulation of Wallot and colleagues (2016) who induced three conditions of coordination: an asymmetrical, Hierarchical condition (where only one participant leads and the other follows), a Turn-Taking condition (where both participants lead and follow, in sequence), and an Egalitarian condition (where both participants create with no designated leader and follower). Whereas Wallot and colleagues (2016) examined the effects of these patterns of interpersonal coordination during a task on the outcomes of the same task (building model cars), we examine the downstream effects of coordination patterns in a new task.

Specifically, we examine the effects of a targeted mirroring task (Phase 1) on subsequent music improvisation using cajón percussion instruments (Phase 2), thus assessing whether

patterns of interpersonal coordination are transferable across tasks. The dyads of participants were assigned to one of three groups (Hierarchical, Turn-Taking, and Egalitarian) and completed a period of solo improvisation followed by a joint mirroring task. The dyads then completed a period of joint improvisation.

In this study, we audio recorded sessions to extract signatures of interpersonal coordination in terms of body movement and acoustic properties of the performance. Cross-correlation analyses were applied to pairs of time series from each dyad to capture time-aligned covariation in their music output (in terms of volume).

We predicted that the pairs in which both partners have the opportunity to lead (i.e., in the Turn-Taking condition) or co-lead during mirroring (i.e., in the Egalitarian mirroring condition) would have higher behavioral complementarity (less alignment) during music improvisation, compared to those pairs in which one partner had solely taken the lead (i.e., the Hierarchical mirroring condition). This prediction follows the findings of the Wallot and colleagues (2016) study: dyads in which participants were able to co-lead or take turns had lower levels of synchrony compared to Hierarchical groups.

Individual differences in music sophistication, personality, and prosocial orientation were also taken into account. We conducted exploratory analyses that include these individual difference measures as covariates, but we did not have explicit predictions regarding how they might relate to interpersonal coordination. Lastly, we examined how mirroring condition influenced subjective perceptions of the music improvisation performance through exploratory analyses. These measures included perceptions about the amount of fun, difficulty, and effort the improvisation task had.

CHAPTER 3: METHODS

Participants

A total of 36 participants were recruited in 18 dyads. The participants were students and employees recruited from the community of University of North Carolina at Charlotte (UNCC) through email announcements. Six dyads (12 participants) were in the Hierarchical mirroring condition (partner A leads movement partner B follows movement for 8 minutes), 6 dyads (12 participants) were in the Turn-Taking mirroring condition (partner A leads first for 4 minutes followed by partner B leading for 4 minutes); and 6 dyads (12 participants) in the Egalitarian mirroring condition (neither partner A nor B leads; they are instructed to create spontaneous movement together). The age of the participants ranged from 19 – 62 with a mean of 26.83 (*SD* = 9.62). There were 21 participants identifying as male and 15 identifying as female. Of the 18 dyads, 7 were male-male, 4 were female-female, and 7 were mixed gender pairs. There were 15 (41%) participants identifying as Asian, 10 (28%) identifying as White, 7 (19%) identifying as Black, 2 (6%) identifying as Hispanic, and 2 (6%) identifying as Mixed race or other. Lastly, there were 17 (47%) undergraduate students, 16 (44%) graduate students, and 3 (9%) other individuals from the UNCC community.

Measures

We included measures to assess individual differences in musical ability, personality, and prosocial orientation. In individual testing rooms, participants completed four individual ability measures in the following order: the adapted Goldsmiths Musical Sophistication Index (Gold-MSI), the Beat Alignment Perception Task, the Prosocial Behavioral Intentions Scale (PBIS), and four items on extraversion and openness from the Big-Five Inventory (BFI-10). The adapted Gold-MSI questions, the PBIS, and the extraversion and openness items from the BFI-10 were

presented to participants in Qualtrics. The Beat Alignment Perception Task was administered through PsychoPy software.

Goldsmiths Musical Sophistication Index (Gold-MSI)

Self-Report Question Items. The Goldsmith's Musical Sophistication Index (Muellensiefen, et al., 2014) assesses self-reported musical skills and behaviors. It includes a categorical question about the instrument played best and 38 question items across 5 subscales (on active engagement, perceptual abilities, musical training, singing abilities, and emotions). Participants respond to these items using a 1-7 agreement scale, with the exception of some of the items on musical training (e.g., on the number of years of formal training, the number of hours practiced per day, or the number of instruments played). A general factor "musical sophistication" score is computed using a subset of 18 of these items. For our purposes, we used the 18 items of the general factor "musical sophistication" scale. We also included all 7 items of the musical training subscale (5 of which are part of the "musical sophistication" scale) and the categorical question about the instrument played best, yielding a total of 21 questions (see Appendix A). Thus, we obtained two final measures from these two subscales: the mean general factor music sophistication score (which we refer to as GMSI) and the mean musical training score (MTI).

Beat Alignment Perception Task. In addition to the self-report items described above, the Gold-MSI also includes two behavioral tests: the melodic memory task and the beat alignment perception task. We chose to use only the beat alignment perception task, since the instruments in our study (cajóns) are non-melodic instruments and focus only on rhythm.

In this task, participants heard 17 music clips in which music is presented together with a "beep-track" (a series of beeps like a metronome). The beep-track is on or off the beat of the

music (4 clips are on beat and 14 clips off beat). The sound files clips range from 10-16 seconds long. Upon hearing the clip, participants were prompted to respond whether the beep was on beat or off beat, and to provide a confidence rating of their response on a three-point scale. Before the experimental trials, participants heard 3 examples, two of which were off-beat and one was on beat. This task can be used to identify individuals who may have poor beat perception processing, as reflected by their ability to assess whether recordings are off or on beat. The final measure of interest was each participant's overall accuracy of beat perception computed by taking their mean accuracy across the 17 trials.

Measure of prosocial motivation

Individual differences in prosociality were measured using the Prosocial Behavioral Intentions Scale (PBIS) (Baumsteiger and Siegel, 2019). This is a 4-question inventory (see Appendix B) used to predict prosocial behavior. Participants responded to each question using a 1-7 agreement scale with 1 being “definitely would do this” and 7 being “definitely would not do this”. The final score was the mean of the 4-item questionnaire.

Big-Five Inventory (BFI-10)

The personality traits of extraversion and openness were measured using a modified version of a 10 item Big Five personality traits scale (BFI-10) (Rammstedt and John, 2007). This inventory (see Appendix C) was selected to keep the measures of extraversion and openness concise and reliable. The BFI-10 is a condensed version of the Big Five Personality inventory used to measure extraversion, agreeableness, conscientiousness, neuroticism, and openness. For the purposes of this study we are only interested in the traits of extraversion and openness. We used a subset of 4 questions to measure the two traits. Participants responded using a 1-5

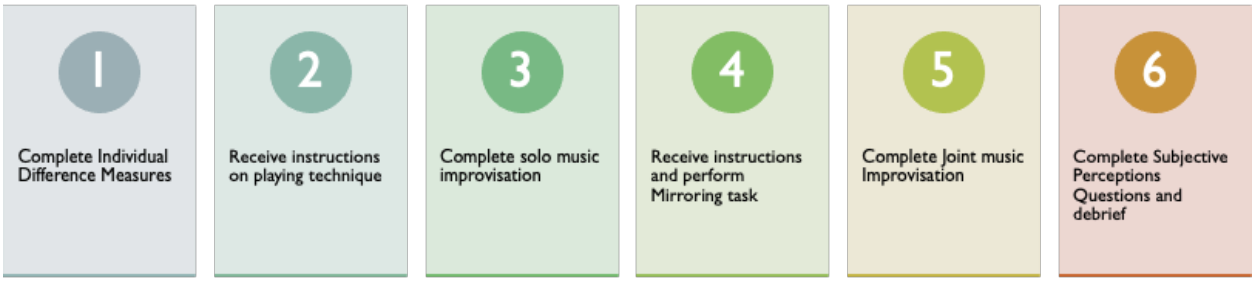
agreement scale with 1 being disagree strongly and 5 being agree strongly. The BFI-10 is computed by taking the mean of the two scores for each dimension (extraversion and openness).

Subjective perceptions questionnaire and debriefing.

After the music improvisation phase, participants responded to the Subjective Perceptions Questionnaire. This included questions about their perceptions of how fun, difficult, and effortful the improvisation and mirroring task was, as well as their view of their contribution to joint music improvisation, partner cooperation, and quality of music improvisation (see Appendix D).

Figure 1

Visualization of phases of experiment



Procedure

First the participants received and signed a consent form which contained an overall description of the study. After this, as shown in Figure 1, participants were randomly assigned to role A or B and both participants completed the individual ability measures in separate booths in the lab. The participants then moved to the open space area of the lab, where they completed the solo improvisation, mirroring task, and joint improvisation. Lastly, the participants completed the subjective perceptions questionnaire and were then debrefibed.

Phase 1: Solo Improvisation

During solo improvisation, only one participant was at the lab at time, while the other participant waited outside, in an area of the building where the music performance wasn't audible.

Each participant was given video instructions on proper playing technique. They were told about the three basic tones they could produce on the instrument. They were then given examples of how these tones could be combined to create different combinations during music improvisation. Lastly, the video showed how these combinations could be used during a brief example of music improvisation with the cajón instrument. Participants were allowed time to practice and become comfortable with the instruments for a period of one minute before solo music improvisation. Then, they performed a solo for 4 minutes, while being video recorded (with Sony Camcorders) and audio recorded with high quality microphones. Once Partner A finished, Partner B was called to the lab and the procedure was repeated, with A waiting outside.

Phase 2: Mirroring Task

After Partner B finished their solo improvisation, Partner A returned to the lab. Participants were given instructions about the mirroring task (Phase 2). Each pair was assigned to one of three different mirroring tasks. The participants engaged in the mirroring task for a period of eight minutes. Each pair was allowed a one-minute practice following the instructions, before beginning the mirroring task. The participants were videotaped during this task.

In each task the participants were given instructions and examples on the target mirroring behavior for their assigned condition. In all conditions, participants were instructed to move from the waist up while standing within a pre-marked box (around 2 by 3 feet) on the floor. Movements were defined as simple gestures or movements of the upper body. Participants

were instructed to create smooth and continuous movements, while avoiding stops between movements.

For the Hierarchical mirroring and turn taking mirroring conditions, the follower (Partner B) was instructed to duplicate the leader's (Partner A) movements exactly as if the leader were looking into a mirror. The goal was to mirror the leader perfectly. The leader was instructed to move carefully so the follower wouldn't fall behind, with simple, smooth, and continuous movements. The leader was instructed to avoid trying to trick the follower, and instead to try to create movements that would allow the follower to follow with ease.

The only difference between the Hierarchical and the turn taking conditions was that for the Turn-Taking condition, mid-way through the mirroring phase (after 4 minutes of Partner A serving as the leader and Partner B as the follower), the instructions were given again, with Partner B being asked to serve as the leader and Partner A as the follower for another 4 minutes.

For the Egalitarian mirroring condition, the participants were instructed to make simple, smooth, and continuous movements from the waist up, with no designated leader or follower. Participants were instructed to move carefully so that they can co-create smooth continuous movement with their partner. They were instructed to avoid trying to trick their partner by initiating a movement for their partner to follow; instead, they will be instructed to try to create movements together as a team.

Phase 3: Music improvisation

Participants engaged in music improvisation using two identical percussion instruments (cajóns) for a period of four total minutes. Participants were told to create rhythms as a cohesive musical ensemble. They could alternate in who's playing, while the other person is providing rhythmic support. They were instructed that they no longer needed to mirror each other, they

could play the same rhythms or contrasting rhythms. Lastly, they could also play at different volumes to create even more combinations. The music improvisation sessions were videotaped and audiotaped.

Finally, the participants completed the post-improvisation subjective measures questionnaire, were debriefed about the purpose of the study, and compensated for their time.

CHAPTER 4: RESULTS

We used the audio recordings of the music improvisation phase (Phase 3) to extract signatures of alignment in the performance between the two partners. We examined the effect of the type of mirroring task on the degree of alignment in the acoustic performance of the two partners. In exploratory analyses, we also controlled for the effects of individual differences in music sophistication, beat perception, prosocial motivation, and personality. Finally, in additional exploratory analyses, we examined the extent to which mirroring condition and the degree of alignment predicted ratings of subjective task outcomes (perceptions of the performance and their partner's contribution).

Processing of Audio Recordings

First, audio files were gated using the GarageBand gate plugin. Gating the individual audio files from the joint music improvisation sessions made it so frequencies below the threshold of -30 dB were removed (within GarageBand 0 represents the maximum threshold before sound becomes distorted in general, -30 dB is 30 decibels below this threshold and was determined to be the optimum level for reducing unwanted sounds consistently across pairs). This was done in order to minimize the overlapping sound from the other participant in the microphone recording (i.e. participant A's sound being in the recording from participant B's microphone). The resulting audio signals were then downsampled, from the original 44.1 kHz to 11.025 kHz. Audio signals were converted into amplitude envelopes using the Hilbert envelope, which is a standard technique for audio signals (Falk & Kello, 2017).

Measures of Alignment Derived from Cross-Correlation

Our main measure of alignment was based on correlating the amplitude envelopes of the two partners, during their performance. Cross-correlation was applied to the two-time series of

each pair's music output. Cross-correlation is an extension of autocorrelation and examines the dependence between future and past values of different time series. Cross-correlation is a common measure in interaction research, capturing time-aligned covariation in music output here. Compared to alternatives (e.g., cross-Recurrence Quantification Analysis), cross-correlation is computationally more transparent and permits a relatively clear interpretation of the output (Dale et al, 2020). Because it permits examining the correlation between time series at time lags other than zero, it can be used to determine if one behavior leads or follows another at some specific time lag. For each pair we computed cross-correlations at lags up to 12000 data points (around 4 seconds) and identified two measures of interest: the mean and the maximum cross-correlation for the shared performance. The time of four seconds was selected because this time was slightly over one complete measure (4 beats) of the accompanying track. Ideally, one measure should be the first point where individuals may begin to show recurring patterns that could be observed through cross-correlation.

Measures of Individual Difference (covariates)

Individual differences served as covariates to control for their contribution to alignment. The following individual ability measures were examined: the scores on the General Music Sophistication, Music Training index, and accuracy on the Beat Perception Task quantified musical aptitude and training; the scores on the extraversion and openness subscales of the 10-item Big-5 inventory quantified personality; and the score on the Prosocial Behavior and Intention scale quantified prosocial behavior.

Statistical Analyses

Main analyses. Ordinary least squares (OLS) linear regressions were built with the cross-correlation measures (mean and max cross-correlation) as the dependent variables to assess

whether the type of mirroring condition in Phase 1 predicted interpersonal coordination in music improvisation in Phase 2. In these models, the mirroring condition was a fixed effect.

Dyads in the Egalitarian condition had numerically the highest maximum cross-correlation (M = .23, SD = .03), followed by dyads in the Hierarchical condition (M = .20, SD = .10), and with dyads in the Turn-Taking condition having the lowest maximum cross-correlation (M = .15, SD = .05). These patterns are also reflected in the boxplots of Figure 2. In the linear regression with mirroring condition as the predictor variable, there were no significant effects of the mirroring condition contrasts (Egalitarian vs. Hierarchical, and Egalitarian vs. Turn-Taking) on maximum cross-correlation. As shown in Table 1, neither contrast was statistically significant, although the Egalitarian vs. Turn-Taking predictor indicated a marginal effect (p = .058). The coefficient for the Egalitarian vs. Turn-Taking contrast was negative, suggesting that Turn-Taking involved a lower maximum cross-correlation compared to the Egalitarian condition, consistent with the descriptive statistics.

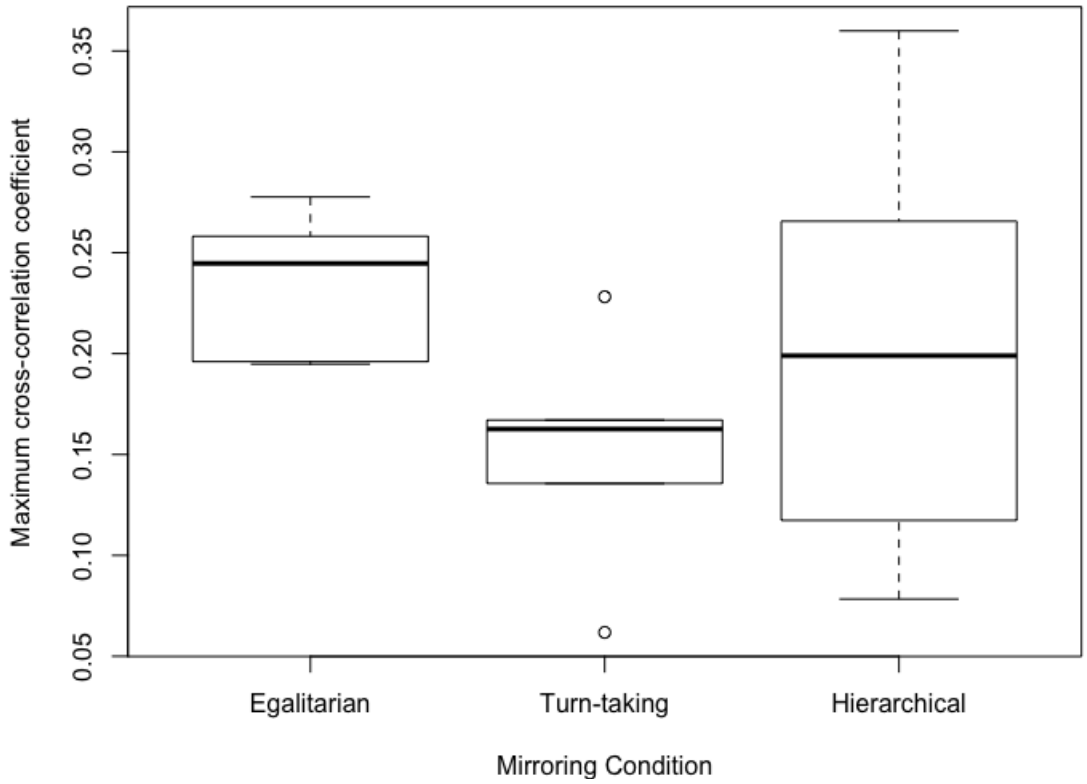
Table 1.

Regression with Maximum Cross-Correlation as Outcome Measure
R^2 = .22

Predictor	*B*	*SE*	95% CI [LL, UL]	*p*-value
Intercept	0.246	.029	[0.18, 0.30]	.000
Egalitarian vs. Hierarchical	-0.032	.040	[-0.12, 0.05]	.430
Egalitarian vs. Turn-Taking	-0.083	.040	[-0.17, 0.00]	.058

Figure 2

Boxplot of Maximum Cross-Correlation Values Separated by Mirroring Condition



Note. Boxplot represents the maximum cross correlation for the joint music improvisation performances based on the three mirroring conditions with the bold line representing median of the max cross-correlation. Whiskers represent the minimum and maximum values. The open circles represent outliers which are ± 1.5times the interquartile range.

The mean cross-correlation followed a similar pattern as the maximum cross-correlation with the Egalitarian (M = .013, SD = .015) condition having the highest mean numerically, followed by Hierarchical (M = .013, SD = .023), and then the Turn-Taking (M = .008, SD = .054) condition (see also the distributions in their boxplots of Figure 3).

A linear regression with mirroring condition as the predictor and mean cross-correlation as the outcome measure revealed no significant differences across conditions. As shown in Table 2, the contrast terms for Hierarchical vs. Egalitarian conditions and the Turn-Taking vs. Egalitarian conditions were not significant.

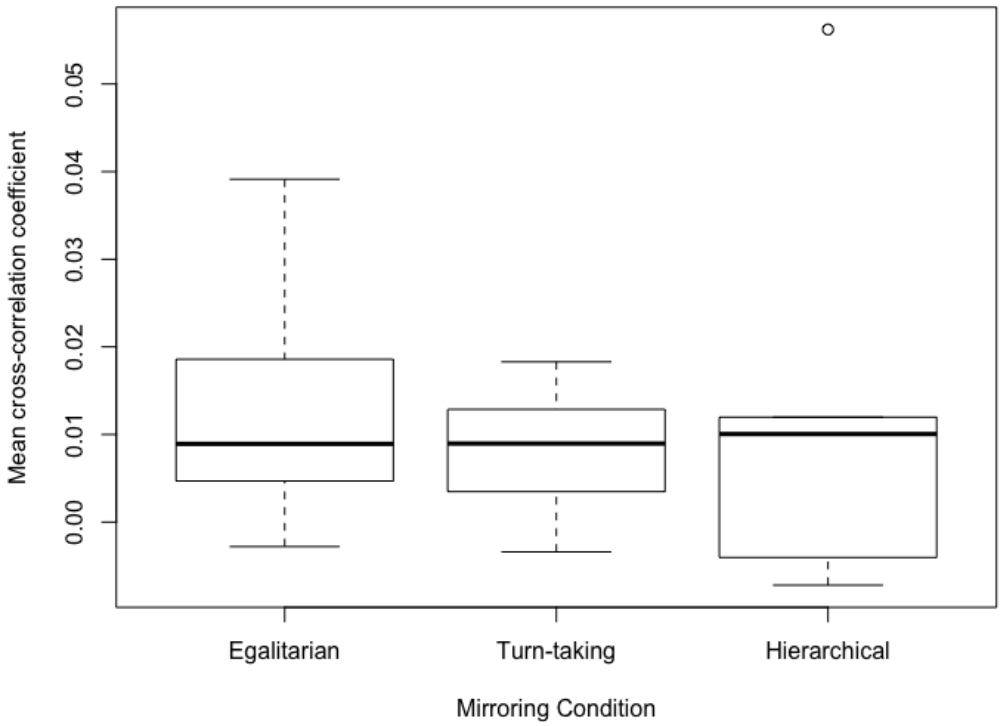
Table 2

Regression with Mean Cross-Correlation as Outcome Measure
R^2 = .02

Predictor	*b*	*SE*	95% CI LL, UL	*p*-value
Intercept	0.065	.014	0.04, 0.09	.000
Egalitarian vs. Hierarchical	-0.019	.019	-0.06, 0.02	.334
Egalitarian vs. Turn-Taking	-0.021	.019	-0.06, 0.02	.278

Figure 3

Boxplot of Mean Cross-Correlation Values Separated by Mirroring Condition



Note. Boxplot represents the mean cross correlation for the joint music improvisation performances based on the three mirroring conditions with the bold line representing median of the mean cross-correlations.

Exploratory analyses: Individual differences. In separate linear regression models, we explored the effect of individual differences on coordination. For each model, the individual difference measure of interest, for partner A and for partner B's scores, were both entered as covariates, along with the interaction of these two terms.

A series of regression analyses were performed with mirroring condition as the predictor, mean or maximum cross-correlation as outcome measures, and individual differences variables (of Partner A, Partner B, and their interaction) as covariates. Appendix E includes the output of these models with covariates for beat alignment (Table E.1, E.2), for the general music sophistication index (GMSI; Table E.3, E.4) and music training index scores (MTI, E.5, E.6),

extraversion (E.7. E.8), openness (E.9, E.10) and prosocial behavior measured from the PBIS (E.11, E.12). In none of these models was there a significant effect of individual difference or an effect of condition, with one exception. For the model predicting mean cross-correlation with extraversion measures as covariates, partner B's extraversion was a significant predictor of the dyad's mean cross-correlation (p = .04; see Table B. 7 or 8) and the interaction of the extraversion of the two partners (A and B) had a marginal effect (p = .09).

Models that took musical ability into account (with beat accuracy, GMSI, and MTI as covariates) suggested consistently that partner A's ability might have influenced the dyad's coordination in music improvisation. The beat accuracy and music training index score (MTI) of partner A was a significant predictor of maximum cross-correlation (p = .046 in both models, see Table B.1 and B5). Additionally, the general music sophistication index (GMSI) of partner A was a marginally significant predictor of maximum cross correlation (p = .055, see Table B3). In all cases, the better the partner A's musical ability, the higher the dyad's maximum cross-correlation. Still, all these patterns should be interpreted with caution.

Exploratory analyses: subjective task outcomes. In another set of linear regression models, we examined whether the type of mirroring task and the degree of interpersonal alignment (mean and maximum cross-correlation) predicted subjective ratings of task performance. Mirroring condition, the dyad's cross-correlation, and their interaction was entered as fixed effects. Six different models were evaluated, one for each of the subjective aspects of performance during improvisation shown in Appendix D (fun, difficulty, effort, cooperation, relative contribution, improvisation quality). For fun, difficulty, effort, cooperation, and improvisation quality, the responses of A and B of each dyad were averaged. For the "relative contribution" item, we computed an absolute difference score of A and B, with larger differences

indicating more agreement on perceived relative contribution and smaller differences indicating less agreement on perceived relative contribution (e.g., when both partners each said that they directed the improvisation).

The regression models (presented in Appendix F) indicate that the mirroring condition and degree of interpersonal alignment did not predict subjective ratings of task performance for fun (Table F.1, F.2), effort (Table F.5, F.6), cooperation (Table F.7, F.8), and relative contribution (Table F.9, F.10).

However, the models predicting improvisation difficulty with both the mean and maximum cross-correlation as predictors (Table F.3, F.4) revealed some interesting patterns. Participants in the Turn-Taking condition rated improvisation as more difficult than in the Egalitarian condition. For both the model with the mean and the maximum cross-correlation as predictors, the contrast term for the Turn-Taking vs. Egalitarian condition was marginally significant in predicting difficulty.

The model predicting improvisation quality with the maximum cross-correlation as a predictor (Table, F.12) also indicated some interesting patterns. Maximum cross-correlation predicted perceived improvisation quality: the higher the perceived improvisation quality the lower the dyad's maximum cross-correlation ($p = .05$). Moreover, this pattern differed across the Egalitarian and Hierarchical conditions as indicated by a significant interaction between this contrast term and maximum cross-correlation ($p = .04$). Again, all these models should be interpreted with caution due to the small number of participants in the three mirroring conditions and the number of models run in our exploratory analyses.

CHAPTER 5: DISCUSSION

Understanding how early interpersonal coordination interactions can influence the dynamics of later interactions is relevant to joint action theory. Based on Wallot and colleagues (2016) where dyads in Egalitarian and Turn-Taking roles had lower levels of synchronization compared to dyads in Hierarchical roles, we had predicted that the joint improvised performances for the Egalitarian and Turn-Taking mirroring conditions would have lower levels of alignment compared to the Hierarchical condition. However, this is not what we found. In fact, we did not find any significant differences across mirroring conditions.

Consistent with our predictions, improvising after Turn-Taking was involved numerically with lower levels of alignment (lower mean and maximum cross-correlation) compared to after Hierarchical mirroring. However, contrary to our predictions, the mean and maximum cross-correlations in the Egalitarian condition were numerically higher than for the Hierarchical condition. One reason for this numerical pattern could be due to our design decision to have a separate task induce differences in dynamics of coordination according to role asymmetry compared to previous studies. The present study examined the potential downstream effects of one interpersonal task (mirroring) on another interpersonal task (music improvisation), whereas Wallot and colleagues (2016) examined the effects of role asymmetry on alignment within a single task. Furthermore, there was tentative evidence for a difference between the Egalitarian and the Turn-Taking conditions in terms of maximum cross-correlation, with the Egalitarian condition having higher levels of max cross-correlation. This could be because individuals in the Egalitarian mirroring condition were told to work together as one unit during the mirroring phase and this may have transferred to the improvisation phase in terms of higher alignment. Conversely, the Turn-Taking condition allowed each individual to develop separate ideas, with

this dynamic transferring to the following task (music improvisation). Regardless of the possible reasons for these numerical patterns, the differences between the Egalitarian and the other conditions were not significant.

There could be multiple reasons for these null effects. The first is the small sample size. Previous research (Wallot et al., 2016) that found differences across role dynamics (Turn-Taking, Hierarchical, and Egalitarian) had a sample of 37 dyads and used a within-subjects design. Although the current study differs from the research of Wallot and colleagues (2016) in a number of ways (including our focus on music improvisation as opposed to designing and building model cars, and the fact that the role dynamics were manipulated in a separate mirroring task), the difference in sample size is still an important one. With a larger sample size, we can establish whether the current trend is robust or misleading. Toward this end, we plan to continue data collection and reach the planned sample size of 48 dyads (16 dyads within each condition).

Another factor that may have contributed to the lack of an effect of mirroring condition on interpersonal coordination (mean and max cross-correlation) was the time length of the mirroring task. Previous research (Hart et al., 2014) that used a mirroring task to examine improvisation allowed for multiple mirroring trials during which participants could coordinate. In the research by Hart and colleagues (2014) participants completed three separate mirroring trials for three minutes each. Perhaps increasing the amount of mirroring and improvisation trials (such as a round of mirroring followed by a round music improvisation and then repeating this cycle) could allow dyads to settle into more stable coordination dynamics. The coordination dynamics as a result of these rounds could lead to detectable differences during improvisation. Furthermore, Richardson and colleagues (2014) explain how phase transitions occur when an individual has a critical number of positive experiences. Perhaps, it could be that more time and

repetition is needed to establish a critical number of experiences that can lead to a change in the system (in this case a system is joint music improvisation).

The exploratory analyses of the effect of the task partners' individual differences indicated some intriguing tentative results. One consistent pattern was that the musical ability of partner A predicted coordination: when partner A had higher musical ability (better beat perception, higher music sophistication, and greater music training) pairs tended to have greater improvisation alignment in terms of maximum cross-correlation. This outcome is interesting because the identity of partners A and B were arbitrary in the Turn-Taking and Egalitarian conditions, in the sense that their two roles were symmetrical. In the Turn-Taking condition, both partners took the lead at different time points; in the Egalitarian condition, they shared responsibility leading and following. It could be that leading the mirroring task first (as partner A did in the Hierarchical and Turn-Taking conditions) influenced the dynamics of music improvisation, such that A's musical ability mattered. Moreover, partner B being extroverted also had an impact on music improvisation: pairs with a more extroverted partner B exhibited a higher mean cross-correlation. It is difficult to interpret these patterns in the current preliminary dataset, as they may not be robust. Currently, these findings merely suggest that individual differences in the partners' musical ability and personality could influence the dynamics of joint improvisation.

The findings of interpersonal alignment and perceived improvisation performance provide evidence of trends consistent with previous literature. As noted in the introduction, Chartrand and Bargh (1999) found that individuals who were more aligned through conversational mannerism reported better social rapport. We found that the Turn-Taking condition was associated with higher levels of perceived improvisation difficulty (compared to

the Egalitarian condition). It could be that being forced to switch roles and experiencing both leading and following increased perceived difficulty during improvisation. Individuals from the Turn-Taking condition may have tried to take on both roles (leading and following) during improvisation, which could have presented a greater challenge compared to pairs who engaged in mirroring without a designated leader and follower in the Egalitarian condition. This possibility is highly speculative. Nevertheless, the finding that pairs in this "difficult" Turn-Taking condition experienced the lowest levels of alignment numerically is broadly consistent with prior work that lower levels of alignment are associated with lower rapport.

In order to establish other baselines of coordination, we would like to examine the patterns of correlation between solo music improvisation performance of true pairs. We would also like to compare improvisation performances within mirroring conditions of true pairs and fake, surrogate pairs. In future analyses, we will examine the cross-correlation between the solo performance of partner A, and partner B and we expect that there will be lower levels of cross-correlation compared to the joint music improvisation performance. Surrogate pairs will be built using opposite role partners from different pairs within the same condition. If there is an effect of mirroring condition on interpersonal coordination, we should expect surrogate pairs to produce different levels of mean and max cross-correlation compared to true pairs.

In conclusion, even though we don't have robust evidence of the type of mirroring condition having an effect on music improvisation, it still could be the case that there are downstream effects from mirroring to music improvisation, or more broadly from an earlier phase of interaction to a subsequent one. We have found evidence of a marginal difference between the Egalitarian and Turn-Taking conditions in predicting maximum cross-correlation during improvised performances. Moreover, by investigating the role of individual differences,

we found the possibility of musical ability and extraversion may influence the dynamics of improvisation. By examining subjective reports of the performance, we found the possibility that improvisation difficulty and ideal improvisation performance was predicted by interpersonal coordination. Collecting more data will allow for the current study to achieve greater statistical power. Moreover, future research examining multiple mirroring and improvisation trials within the same study may also help to determine the capability of one coordinated task having downstream influence on a subsequent task. The findings obtained from our final analyses, with a larger sample, will not only allow us to better understand how the dynamics of improvisation may be influenced by early tasks, but also how later interpersonal coordination can be influenced by prior interactions. Through this, we will better inform the current theories of joint improvisation and interpersonal coordination.

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Appendix A

Subset of items from Gold-MSI (Mullensiefen et al., 2014)
We indicate the item number from the Gold-MSI scale in parenthesis (e.g., Q1).
Items 14, 27, 32, 33, 35, 36, 37 (based on the original item numbers in parenthesis) comprise the Musical Training subscale.
R indicates reversed-scored items.
All items are rated on a 1-7 agreement scale, unless indicated otherwise.

General Factor - Musical Sophistication

1. I spend a lot of my free time doing music-related activities. (Q1)
2. I enjoy writing about music, for example on blogs and forums. (Q3)
3. If somebody starts singing a song I don't know, I can usually join in. (Q4)
4. I can sing or play music from memory. (Q7)
5. I am able to hit the right notes when I sing along with a recording. (Q10)
6. I can compare and discuss differences between two performances or versions of the same piece of music. (Q12)
7. I have never been complimented for my talents as a musical performer. (Q14) R
8. I often read or search the internet for things related to music. (Q15)
9. I am not able to sing in harmony when somebody is singing a familiar tune. (Q17) R
10. I am able to identify what is special about a given musical piece. (Q19)
11. When I sing, I have no idea whether I'm in tune or not. (Q23) R
12. Music is kind of an addiction for me - I couldn't live without it. (Q24)
13. I don't like singing in public because I'm afraid that I would sing wrong notes. (Q25) R
14. I would not consider myself a musician. (Q27) R
15. After hearing a new song two or three times, I can usually sing it by myself. (Q29)
16. I engaged in regular, daily practice of a musical instrument (including voice) for ___ years. (Q32) [Response options: 0, 1, 2, 3, 4-5, 6-7, 10+]
17. At the peak of my interest, I practiced ___ hours per day on my primary instrument. (Q33) [Response options: 0, .5, 1, 1.5, 2, 3-4, 5+]
18. I can play ___ musical instruments. (Q37) [Response options: 0, 1, 2, 3, 4, 5, 6+]

Additional items from Musical Training subscale

19. I have had formal training in music theory for __ years. (Q35) [Response option: 0, .5, 1, 2, 3, 4-6, 7+]
20. I have had __ years of formal training on a musical instrument (including voice) during my lifetime. (Q36) [Response options: 0, ,5, 1, 2, 3-4, 6-9, 10+]

Categorical question

1. The instrument I play best (including voice) is ____. (Q39) [Response options: NA; voice; piano; guitar; drums; xylophone; flute; oboe; clarinet; bassoon; trumpet; trombone]

Appendix B

Prosocial Behavior Intentions Scale (Baumsteiger and Siegel, 2018)

	Definitely would not do this (1)	Probably would not do this	Possibly would not do this	Neither agree nor disagree	Possibly would do this	Probably would do this	Definitely would do this (7)
Comfort someone I know after they experience a hardship	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Help care for a sick friend or relative	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Assist a stranger with a small task (e.g. help them carry groceries, watch their things while they use the restroom)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Help a stranger find something they lost, like a key or a pet	(1)	(2)	(3)	(4)	(5)	(6)	(7)

Appendix C

The four items on Extraversion and Openness retained from the Big Five Inventory-10 (BFI-10). The first and third item measure extraversion, and the second and fourth item measure openness. (R) indicates reverse coded items.

Instruction: How well do the following statements describe your personality?

I see myself as someone who…	Disagree strongly	Disagree a little	Neither agree nor disagree	Agree a little	Agree strongly
…Is reserved (R)	(1)	(2)	(3)	(4)	(5)
…Has few artistic interests (R)	(1)	(2)	(3)	(4)	(5)
…Is outgoing, sociable	(1)	(2)	(3)	(4)	(5)
…Has an active imagination	(1)	(2)	(3)	(4)	(5)

Scoring the BFI-10 Scales:
Extraversion: 1R, 6; Agreeableness: 2, 7R; Conscientiousness: 3R, 8; Neuroticism: 4R, 9; Openness: 5R; 10 (R=Reversed-Scored)

Appendix D

Subjective Perceptions Questionnaire adapted from Wallot et al (2016) targeting participants' perceptions of their task partner, the interaction, and the task outcomes.

Instructions: Please take a minute to reflect on the music improvisation task. Read the following questions and use the slider scale to indicate your response according to your agreement with the conditions at either end.

1. How much fun was the music improvisation task?

1	2	3	4	5
Not fun at all	A little fun	Moderately fun	Significantly fun	Extremely fun

2. How difficult was the music improvisation task?

1	2	3	4	5
Very easy	Somewhat easy	Neither easy nor difficult	Somewhat difficult	Very difficult

3. How effortful was the music improvisation task?

1	2	3	4	5
Not effortful	Little effort	Moderately effortful	Significantly effortful	Very effortful

4. How much fun was the mirroring task?

1	2	3	4	5
Not fun at all	A little fun	Moderately fun	Significantly fun	Extremely fun

5. How difficult was the mirroring task?

1	2	3	4	5
Very easy	Somewhat easy	Neither easy nor difficult	Somewhat difficult	Very difficult

6. How effortful was the mirroring task?

1	2	3	4	5
Not effortful	Little effort	Moderately effortful	Significantly effortful	Very effortful

7. How well did you and your partner cooperate during music improvisation?

1	2	3	4	5
Not well at all	Slightly well	Moderately well	Well	Very well

8. Did you or your partner direct the music improvisation more than the other?

1	2	3	4	5
Completely my partner	Mostly my partner	Both directed equally	Mostly me	Completely me

9. How much did your music performance reflect your ideas about what good music improvisation should be like

1	2	3	4	5
Not at all	Slightly	A moderate amount	A significant amount	A lot

Appendix E

Tables of Regression Models with Individual Difference Measures as Covariates

Table E1

Regression results of mean cross-correlation with the Beat Perception accuracy of each Partner (and their interaction) as covariates

R^2 = .076

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept	-0.01	.03	[-0.08, 0.07]	.87
Egalitarian vs. Hierarchical	-0.00	.01	[-0.02, 0.02]	.97
Egalitarian vs. Turn-Taking	-0.00	.01	[-0.03, 0.03]	.97
Beat Perception of A	0.01	.01	[-0.01, 0.02]	.52
Beat Perception of B	0.00	.01	[-0.01, 0.02]	.71
Beat Perception of A x B	-0.00	.00	[-0.00, 0.00]	.69

Table E2

Regression results of max cross-correlation with Beat Perception accuracy of each Partner (and their interaction) as covariates

R^2 = .598

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept	0.08	.10	[-0.14, 0.31]	.43
Egalitarian vs. Hierarchical	-0.04	.03	[-0.11, 0.03]	.28
Egalitarian vs. Turn-Taking	-0.05	.04	[-0.14, 0.04]	.21
Beat Perception A	0.06*	.03	[0.00, 0.12]	.05
Beat Perception B	0.01	.20	[-0.03, 0.06]	.47
Beat Perception of A x B	-0.01	.01	[-0.02, 0.00]	.20

Table E3

Regression results of mean cross-correlation with GMSI of each Partner (and their interaction) as covariates.

R^2 = .087

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept	.06	.110	[-0.30, 0.18]	.59
Egalitarian vs. Hierarchical	-0.00	.011	[-0.02, 0.02]	.97
Egalitarian vs. Turn-Taking	0.00	.128	[-0.03, 0.03]	.96
GMSI A	0.02	.024	[-0.04, 0.07]	.50
GMSI B	0.01	.021	[-0.03, 0.06]	.59
GMSI A x B	-0.00	.005	[-0.01, 0.01]	.59

Table E4

Regression results of max cross-correlation with GMSI of each Partner (and their interaction) as covariates

R^2 = .650

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept	.083	.103	[-1.04, 0.39]	.44
Egalitarian vs. Hierarchical	- .038	.033	[-0.12, 0.03]	.28
Egalitarian vs. Turn-Taking	.053	.040	[-0.14, 0.03]	.22
GMSI A	.058*	.026	[-0.00, 0.31]	.05
GMSI B	.015	.020	[-0.06, 0.22]	.47
GMSI A x B	-.008	.006	[-0.05, 0.01]	.20

Table E5

Regression results of mean cross-correlation with MTI of each Partner (and their interaction) as covariates

R^2 = .076

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept	-0.01	.03	[-0.08, 0.07]	.87
Egalitarian vs. Hierarchical	-0.00	.01	[-0.02, 0.02]	.97
Egalitarian vs. Turn-Taking	-0.00	.01	[-0.03, 0.03]	.97
MTI A	0.01	.01	[-0.01, 0.02]	.52
MTI B	0.00	.01	[-0.01, 0.02]	.71
MTI A x B	-0.00	.00	[-0.00, 0.00]	.69

Table E6

Regression results of max cross-correlation with MTI of each Partner (and their interaction) as covariates

R^2 = .598

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept	0.08	.10	[-0.14, 0.31]	.44
Egalitarian vs. Hierarchical	-0.04	.03	[-0.11, 0.03]	.28
Egalitarian vs. Turn-Taking	-0.05	.04	[-0.14, 0.04]	.22
MTI A	0.06*	.03	[0.00, 0.12]	.05
MTI B	0.01	.20	[-0.03, 0.06]	.47
MTI A x B	-0.01	.01	[-0.02, 0.00]	.20

Table E7

Regression results of mean cross-correlation with Extraversion of each Partner (and their interaction) as covariates

R^2 = .366

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept	-0.08	.04	[-0.17, 0.01]	.09
Egalitarian vs. Hierarchical	-0.00	.01	[-0.02, 0.02]	.89
Egalitarian vs. Turn-Taking	0.01	.01	[-0.01, 0.03]	.41
Extraversion A	0.02	.01	[-0.01, 0.06]	.11
Extraversion B	0.03*	.01	[0.00, 0.06]	.04
Extraversion A x B	-0.01	.00	[-0.02, 0.00]	.09

Table E8

Regression results of max cross-correlation with Extraversion of each Partner (and their interaction) as covariates

R^2 = .342

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept	0.04	.21	[-0.41, 0.50]	.84
Egalitarian vs. Hierarchical	-0.04	.04	[-0.13, 0.06]	.42
Egalitarian vs. Turn-Taking	-0.04	.05	[-0.15, 0.08]	.49
Extraversion A	0.04	.07	[-0.12, 0.19]	.63
Extraversion B	0.07	.02	[-0.08, 0.21]	.35
Extraversion A x B	-0.01	.21	[-0.07, 0.04]	.57

Table E9

Regression results of mean cross-correlation with Openness of each Partner (and their interaction) as covariates

R^2 = .122

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept	-0.09	.17	[-0.46, 0.28]	.61
Egalitarian vs. Hierarchical	0.00	.01	[-0.02, 0.03]	.78
Egalitarian vs. Turn-Taking	0.00	.02	[-0.03, 0.04]	.87
Openness A	0.03	.04	[-0.07, 0.12]	.55
Openness B	0.02	.04	[-0.06, 0.10]	.66
Openness A x B	-0.00	.01	[-0.03, 0.02]	.63

Table E10

Regression results of max cross-correlation with Openness of each Partner (and their interaction) as covariates

R^2 = .365

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept	0.25	.70	[-1.26, 1.77]	.72
Egalitarian vs. Hierarchical	-0.03	.05	[-0.13, 0.07]	.52
Egalitarian vs. Turn-Taking	-0.08	.06	[-0.22, 0.05]	.21
Openness A	0.01	.18	[-0.39, 0.40]	.97
Openness B	-0.04	.15	[-0.37, 0.29]	.82
Openness A x B	0.01	.04	[-0.08, 0.09]	.88

Table E11

Regression results of mean cross-correlation with PBIS of each Partner (and their interaction) as covariates

R^2 = .342

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept	-0.38	.57	[-1.63, 0.88]	.52
Egalitarian vs. Hierarchical	0.00	.01	[-0.02, 0.02]	.94
Egalitarian vs. Turn-Taking	-0.00	.01	[-0.02, 0.02]	.95
PBIS A	0.05	.09	[-0.14, 0.24]	.57
PBIS B	0.07	.09	[-0.13, 0.28]	.44
PBIS A x B	-0.01	.01	[-0.04, 0.02]	.49

Table E12

Regression results of max cross-correlation with PBIS of each Partner (and their interaction) as covariates

R^2 = .477

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept	1.07	.70	[-4.32, 6.45]	.72
Egalitarian vs. Hierarchical	-0.02	.05	[-0.11, 0.06]	.52
Egalitarian vs. Turn-Taking	-0.06	.06	[-0.14, 0.03]	.21
PBIS A	-0.18	.18	[-0.99, 0.63]	.97
PBIS B	-0.09	.15	[-0.96, 0.77]	.81
PBIS A x B	0.02	.04	[-0.11, 0.15]	.88

Appendix F

Tables of Regression Models with Subjective Task Perceptions as Outcome Measures

Table F1

Regression results of Fun subjective measure with mirroring condition and mean cross-correlation (and their interaction) as predictors

R^2 =.082

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept (Egalitarian)	4.01	.37	[3.20, 4.82]	.00
Egalitarian vs Turn-Taking	0.14	.55	[-1.07, 1.35]	.81
Egalitarian vs Hierarchical	0.37	.49	[-0.70, 1.43]	.47
Mean Cross-Correlation	5.56	19.91	[-37.83, 48.94]	.79
Egalitarian vs Turn-Taking x Mean Cross- Correlation	16.77	42.96	[-76.82, 110.37]	.70
Egalitarian vs Hierarchical x Mean Cross- Correlation	-8.93	23.72	[-60.61, 42.76]	.71

Table F2

Regression results of Fun subjective measure with mirroring condition and max cross-correlation (and their interaction) as predictors

R^2 =.192

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept (Egalitarian)	2.49	1.94	[-1.74, 6.72]	.22
Egalitarian vs Turn-Taking	2.12	2.11	[-2.47, 6.71]	.33
Egalitarian vs Hierarchical	2.48	2.03	[-1.94, 6.91]	.25
Max Cross-Correlation	6.76	8.16	[-11.01, 24.53]	.42
Egalitarian vs Turn-Taking x Max Cross- Correlation	-8.56	9.61	[-29.50, 12.38]	.39
Egalitarian vs Hierarchical x Max Cross- Correlation	-9.89	8.58	[-28.59, 8.80]	.27

Table F3

Regression results of Difficulty subjective measure with mirroring condition and mean cross-correlation (and their interaction) as predictors

R^2 =.535

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept (Egalitarian)	2.81	.32	[2.12, 3.50]	.00
Turn-Taking	1.01	.47	[-0.02, 2.04]	.05
Hierarchical	-0.55	.42	[-1.45, 0.36]	.21
Mean Cross- Correlation	-11.11	17.01	[-48.17, 25.95]	.53
Turn-Taking Mean Cross-Correlation	-68.65	36.70	[-148.61, 11.30]	.09
Hierarchical Mean Cross-Correlation	29.48	20.26	[-14.67, 73.63]	.17

Table F4

Regression results of Difficulty subjective measure with mirroring condition and max cross-correlation (and their interaction) as predictors

R^2 =.448

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept (Egalitarian)	-0.49	1.93	[-4.69, 3.70]	.80
Egalitarian vs Turn-Taking	4.65*	2.09	[0.10, 9.20]	.05
Egalitarian vs Hierarchical	2.33	2.01	[-2.05, 6.72]	.27
Max Cross-Correlation	13.39	8.09	[-4.24, 31.02]	.12
Egalitarian vs Turn-Taking x Max Cross- Correlation	-19.85	9.53	[-40.62, 0.93]	.06
Egalitarian vs Hierarchical x Max Cross- Correlation	-10.15	8.51	[-28.69, 8.40]	.26

Table F5

Regression results of Effort subjective measure with mirroring condition and mean cross-correlation (and their interaction) as predictors

R^2 =.496

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept (Egalitarian)	3.40	.37	[2.60, 4.21]	.00
Egalitarian vs Turn-Taking	0.02	.55	[-1.18, 1.22]	.98
Egalitarian vs Hierarchical	0.13	.48	[-0.92, 1.19]	.79
Mean Cross-Correlation	0.92	19.80	[-42.22, 44.06]	.96
Egalitarian vs Turn-Taking x Mean Cross- Correlation	39.04	42.72	[-54.03, 132.11]	.38
Egalitarian vs Hierarchical x Mean Cross- Correlation	-36.13	23.59	[-87.52, 15.27]	.15

Table F6

Regression results of Effort subjective measure with mirroring condition and mean cross-correlation (and their interaction) as predictors

R^2 =.392

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept (Egalitarian)	4.00	2.26	[-0.92, 8.92]	.10
Egalitarian vs Turn-Taking	-0.79	2.45	[-6.13, 4.55]	.75
Egalitarian vs Hierarchical	0.45	2.36	[-4.70, 5.60]	.85
Max Cross-Correlation	-2.47	9.49	[-23.15, 18.21]	.80
Egalitarian vs Turn-Taking x Max Cross- Correlation	6.00	11.19	[-18.38, 30.37]	.60
Egalitarian vs Hierarchical x Max Cross- Correlation	-4.26	9.99	[-26.02, 17.50]	.68

Table F7

Regression results of Cooperation subjective measure with mirroring condition and mean cross-correlation (and their interaction) as predictors

R^2 =.149

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept (Egalitarian)	3.81	.32	[3.11, 4.50]	.00
Egalitarian vs Turn-Taking	-0.53	.48	[-1.57, 0.51]	.29
Egalitarian vs Hierarchical	-0.45	.42	[-1.36, 0.46]	.31
Mean Cross-Correlation	-4.46	17.14	[-41.82, 32.89]	.80
Egalitarian vs Turn-Taking x Mean Cross- Correlation	11.56	36.99	[-69.03, 92.15]	.76
Egalitarian vs Hierarchical x Mean Cross- Correlation	-36.13	20.42	[-87.52, 15.27]	.67

Table F8

Regression results of Cooperation subjective measure with mirroring condition and max cross-correlation (and their interaction) as predictors

R^2 =.222

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept (Egalitarian)	4.57	1.70	[0.86, 8.28]	.02
Egalitarian vs Turn-Taking	-1.79	1.85	[-5.82, 2.23]	.35
Egalitarian vs Hierarchical	-0.81	1.78	[-4.70, 3.07]	.65
Max Cross-Correlation	-3.47	7.16	[-19.07, 12.13]	.64
Egalitarian vs Turn-Taking x Max Cross- Correlation	7.12	8.44	[-11.26, 25.50]	.42
Egalitarian vs Hierarchical x Max Cross- Correlation	1.79	7.53	[-14.62, 18.20]	.82

Table F9

Regression results of Relative Contribution subjective measure with mirroring condition and mean cross-correlation (and their interaction) as predictors

R^2 =.362

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept (Egalitarian)	0.99	.34	[0.24, 1.74]	.01
Egalitarian vs Turn-Taking	0.46	.51	[-0.66, 1.58]	.39
Egalitarian vs Hierarchical	0.14	.45	[-0.85, 1.12]	.77
Mean Cross-Correlation	-12.04	18.45	[-52.23, 28.16]	.53
Egalitarian vs Turn-Taking x Mean Cross- Correlation	-42.73	39.80	[-129.44, 43.98]	.30
Egalitarian vs Hierarchical x Mean Cross- Correlation	28.32	21.98	[-19.56, 76.20]	.22

Table F10

Regression results of Relative Contribution subjective measure with mirroring condition and max cross-correlation (and their interaction) as predictors

R^2 =.429

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept (Egalitarian)	-2.08	1.81	[-6.03, 1.87]	.27
Egalitarian vs Turn-Taking	4.14	1.97	[-0.14, 8.43]	.06
Egalitarian vs Hierarchical	2.72	1.90	[-1.41, 6.85]	.18
Max Cross-Correlation	12.36	7.62	[-4.24, 28.96]	.13
Egalitarian vs Turn-Taking x Max Cross- Correlation	-19.29	8.98	[-38.85, 0.27]	.05
Egalitarian vs Hierarchical x Max Cross- Correlation	-8.93	8.02	[-26.39, 8.53]	.29

Table F11

Regression results of Improvisation Quality subjective measure with mirroring condition and mean cross-correlation (and their interaction) as predictors

R^2 =.349

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept (Egalitarian)	2.94	.31	[2.28, 3.61]	.00
Egalitarian vs Turn-Taking	-0.09	.46	[-1.09, 0.91]	.85
Egalitarian vs Hierarchical	0.64	.40	[-0.23, 1.52]	.14
Mean Cross-Correlation	4.33	16.44	[-31.49, 40.14]	.80
Egalitarian vs Turn-Taking x Mean Cross- Correlation	-6.92	35.46	[-84.19, 70.34]	.85
Egalitarian vs Hierarchical x Mean Cross- Correlation	-4.56	19.58	[-47.23, 38.10]	.82

Table F12

Regression results of Improvisation Quality subjective measure with mirroring condition and max cross-correlation (and their interaction) as predictors

R^2 =.549

Predictor	*B*	*SE*	95% CI [LL, UL]	*p-value*
Intercept (Egalitarian)	6.20	1.42	[3.10, 9.30]	.00
Egalitarian vs Turn-Taking	-3.06	1.54	[-6.42, 0.30]	.07
Egalitarian vs Hierarchical	-2.63	1.49	[-5.87, 0.61]	.10
Max Cross-Correlation	-13.56*	=5.97	[-26.57, -0.55]	.04
Egalitarian vs Turn-Taking x Max Cross- Correlation	11.59	7.04	[-3.75, 26.92]	.13
Egalitarian vs Hierarchical x Max Cross- Correlation	13.60	6.82	[-0.08, 27.29]	.05