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Beyond togetherness: interactional dissensus fosters creativity and tension in freely improvised musical duos

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Abstract

While coordination in joint-music making is often associated with synchronized and converging behaviors, research on group creativity routinely emphasizes the importance of dissensus and individual autonomy in collective creative endeavors. When musicians perform together, there might thus be a tension between the demands of coordination and that of creativity, which could lead them to inject some degree of dissensus in their interactions to foster the creativity of their musical output. In this paper, we investigate in two listening experiments the possibility that dissensual interactions between musicians might increase the perceived creativity of the musical output, using collective free improvisation as a paradigm for creative joint action. Relying on a recorded corpus of forty tracks in which improvisers annotated their performances in terms of the various interactional intents they had towards one another (playing “with”, “against”, or “without” the other), we show, first, that musical snippets exhibiting interactional dissensus were rated as more creative by expert third-party listeners than consensual snippets, and second, that the degree of interactional dissensus between the performers predicts the tension perceived within the music by expert third-party listeners. Taken together, our results provide additional empirical ground to the idea that dissensus might play a key role in enabling group creativity, and extend its relevance to artistic situations relying on non-verbal communication.

1. Introduction

Creativity and innovation studies often emphasize the role of dissensus in collective creative endeavors (see Nemeth & O'Connor, 2019, for a recent overview). According to this literature, allowing for the expression of dissenting opinions is a way to mitigate the effects of “group think” (Janis, 1972) and/or conformity pressure, that tend to make groups less creative. Indeed, disagreement between group members is supposed to favor the emergence of divergent thinking (Guilford, 1967) at the individual level, thus directly stimulating the overall group creativity. In this perspective, dissensus plays a key role in the ability of groups “to come up with ideas or artefacts that are new, surprising and valuable”, to quote Margaret Boden’s classic definition of creativity (Boden, 2004, p. 1).

However, most of the empirical literature supporting this idea focuses on a very limited range of creative situations – the paradigm of which being team brainstorming. Such creative situations have three specific features. First, they mainly focus on ideation processes. Second, they generally obey a sequential structure, with each group member presenting her own ideas or opinions one after another. This only requires loose forms of coordination and interaction within the group, since it involves profoundly scripted communicational habits of turn-taking and conversational argumentation. Third, they are typically “problem-solving” situations, in which the group members have to come up with specific solutions *tailored* to a given situation or set of constraints.

This contrasts strongly with the kind of creative situations that are typically found in improvised performing artforms, such as dance, theatre, or music (Davies, 2011). Such collective performances typically involve both ideation and effectuation; they rely on simultaneous actions from the group members¹, thus requiring tight interaction and coordination within the group, most often in the absence of direct verbal communication; and they follow a “problem-finding” structure, in which group members “are not faced with a specific problem to solve” but rather are looking for unexpected goals and problems “that they create for themselves” (Sawyer, 2003, p. 169). Given how deeply such collective artistic performances differ from team brainstorming, the question remains as to whether and how dissensus may influence and support group creativity in these creative contexts.

¹ Even in the case of improvised theater, actors will often improvise gestures or motions during their partners’ turns (on the polyphonic nature of improv comedy, see Canonne, 2021).

Collective music-making provides a particularly apt paradigm for addressing this question. Not only does it clearly exemplify the aforementioned dimensions of artistic group performances, but music is often taken as an ideal setting to empirically investigate issues related to joint action or social interactions, allowing to easily balance ecological validity and experimental control (D'Ausilio et al., 2015; Michael, 2017). The creative processes underlying collective music-making have already been the subject of numerous studies – whether looking at the performance of pre-existing compositions (e.g., Rink, 2002; Cook, 2013), improvisation (e.g., Monson, 1996 on jazz; Tilley, 2020 on Balinese gamelan), or collaborative composition (e.g., Bennett, 2011 on collaborative song-writing; Clarke & Doffman, 2018 on composer/performer collaborations within contemporary Western art music). However, the extant literature on collective music-making does not allow firm conclusions regarding the role of dissensus for musical creativity.

On the one hand, within the psychology of collective musical performances, the emphasis is on the strategies used by musicians to achieve synchronization, shared plans, and convergent decisions (e.g., Bishop, 2018). Here, desynchronization or incongruent decisions are most often equated with coordination failures, simply preventing the group to achieve a well-formed result, let alone a creative one. However, this may simply be due to the fact that such literature typically focuses on scripted musical performances (i.e., chamber music ensembles performing well-rehearsed composed pieces) that require performers to be true to the work (Dodd, 2020), rather than creative in a stricter sense (i.e., performers do not typically have to generate new musical material on the fly).

On the other hand, within the musicology of creative processes (e.g., Clarke & Doffman, 2018), numerous ethnographical case studies have shown that collective, multi-authorial creative processes often display numerous artistic tensions or negotiations between the project members. Yet, such tensions and negotiations are generally taken as an intrinsic component of collective creativity, which is trivially present in most collective creative endeavors. With dissensus being considered an integral part of such processes, the potential stimulating (or inhibiting) effects of dissensus on the actual creativity of the participants are typically not discussed. Besides, because of their very nature, these case studies are not able to provide more than circumstantial evidence that tension and negotiations between co-creators could directly influence the creativity of the outcome, and how such dissensual cases might differ in comparison with cases of perfectly harmonious and convergent collaborations. Moreover, as Margaret Barrett et al. (2021)'s recent review paper illustrates, most of the studies done in this area typically focus on *verbal* interactions taking place in between performances (e.g., during

rehearsals) rather than on the *musical* interactions grounding the performances themselves. In our view, a finer understanding of the mechanisms underlying musical creativity in group performances would require: 1) moving away from the comfort of studying only post-performances verbal interactions – that reflect both genuine features of the performances, but also necessarily musicians’ re-interpretations of their performances – to delve into the complexities of the actual musical interactions, and 2) embracing a more systematic or comparative approach allowing to collect direct evidence that dissensual interactions can foster collective creativity. With these objectives in mind, we designed two studies to systematically investigate whether dissensus in musical interactions can impact group creativity within a musical setting. To design these studies, we relied on a corpus of 40 freely improvised duos recorded for a previous experiment, and introduced in Golvet et al. (2021). This corpus is highly relevant for our purpose for two reasons.

First, on a theoretical level, collective free improvisation (CFI for short) provides a paradigmatic example of group creativity (Cook, 2018). CFI is both a case of emergent creativity (Sawyer, 2003), in which the performance emerges entirely from the musicians’ interactional dynamics, and a case of distributed creativity (Sawyer & DeZutter, 2009), in which individual roles and creative contributions to the overall output are constantly shifting and renegotiated over the course of the performance. Second, on a practical level, the corpus provides us with fine-grained annotations of the evolution of the musicians’ relations towards one another over the course of their performance. In their study, Golvet et al. asked improvisers to annotate their own performances immediately after playing. As they were listening back to their performances, improvisers used a digital interface that took the form of a triangle (see Figure 1) to continuously indicate whether they were intending to play “with” their co-improviser (i.e., intending to converge with what the other musician was doing), “against” their co-improviser (i.e., intending to diverge from what the other musician was doing), or “without” their co-improviser (i.e., intending to ignore what the other musician is doing). Importantly, musicians were able to indicate the intensity to which they conformed to each interactional mode by varying the distance to the corresponding vertex. The resulting corpus thus provides two complementary ways of assessing the amount of interactional dissensus present at any given time. One way is simply to look, for any given time, at how distant musicians were from the “with” vertex, indicating the extent to which they were actually avoiding to converge with one another. This provides a metrics for what we will refer as *first-order dissensus*. Another way is to look, for any given time, at how distant the musicians’ annotations were from each other. This *second-order dissensus* reflects the extent

to which musicians intended to endorse distinct relations towards one another. Note that this is distinct from first-order dissensus. For example, the two musicians might be both distant from the “with” vertex (thus exhibiting a high degree of first-order dissensus), but close from one another near the “against” vertex, “agreeing to disagree” so to speak (and thus exhibiting a low degree of second-order dissensus).

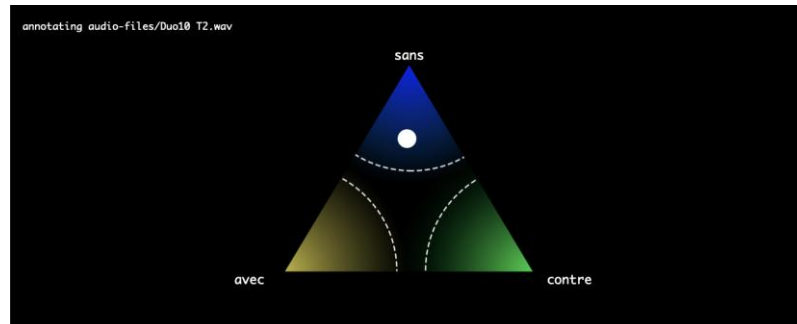


Figure 1. Interface used by the participants for the annotation task in Golvet et al. (2021). The improvisers could navigate continuously within the triangle to indicate the intensity with which they conformed with a given relational intent, with white dashed lines delineating the limits of each area. The black area in the center corresponds to an area of interactional indeterminacy. Here, “without” in on top of the triangle, “with” on the bottom left, and “against” on the bottom right.

Golvet et al. (2021) showed that non-cooperating (playing “against”) or non-interacting (playing “without”) behaviors were no stranger to CFI, amounting to roughly one quarter of the total playing time. This is in line with observations often found in the literature on CFI, such as Corbett (2016): “improvisation is social music. The shape it takes and the methods used to make it are collective in nature, often gregarious, interactional. But there are anti-social elements in the music, too, solitary, uncommunicative moments, times when the collective is shunned in favor of the individual. The antisocial impulse helps keep the music from growing predictable” (Corbett, 2016, p. 56-57). What remains unknown, however, is whether these “anti-social elements” really foster group creativity.

Our first study directly addresses this issue. By pseudo-randomly selecting musical snippets from Golvet et al. (2021)’s corpus exhibiting various degrees of first-order interactional dissensus, we were able to directly investigate whether third-party listeners (both experts and non-experts) found the musicians in snippets with a higher degree of interactional dissensus to be more musically creative.

Our second study addresses a closely related question, by investigating whether interactional dissensus fosters musical tension. On the one hand, musical creativity in performances is often cashed out in terms of expressivity (Clarke, 2012, p. 18), and an important aspect of expressivity in performance is precisely the ability to successfully convey a sense of tension – to produce a performance that play with the listeners’ expectations while still making sense

within the broader sonic world and aesthetic context to which it belongs (Farbood & Upham, 2013). On the other hand, musical creativity is often associated with unpredictability (van der Schyff et al., 2018). Here, musical tension has been shown to be connected to structural unpredictability and melodic surprise in musical performances (Gingras et al., 2016), and, in line with Leonard Meyer's pioneering contribution on the perception of musical emotion (Meyer, 1956), to violations of expectations (Sun et al., 2020; You et al., 2021) and ruptures of tonal stability (Bigand, 1997; Bharuca & Krumhansl, 1983), thus providing a perceptual link between unpredictability and musical creativity. For both these reasons, we believe that musical tension provides a good indicator of creativity in musical performances. Our second study thus looks at the effects of interactional dissensus on the perception of musical tension. Here, we investigated the extent to which the evolution of the interactional dissensus between the improvisers (both first-order and second-order) correlated with the evolution of the musical tension perceived by third-party listeners, as indicated through a continuous annotation task using a digital slider (for a similar setup, see Goodchild et al., 2016 or Fredrickson, 2001). Taken together, our studies should thus allow to provide a comprehensive picture of the role of interactional dissensus in the creativity of freely improvised musical performances.

2. Experiment 1

2.1. Methods

2.1.1. Participants

As specified in the pre-registration (<https://osf.io/kcesh>), we recruited two groups of participants for this study, one group of 24 non-musicians (mean years of musical training = 0.2 years, SD = 0.6 years, mean years of improvisation experience = 0 years, SD = 0.1 years, 7 women, 12 men, 5 not specified, mean age = 24.3 years, SD = 4.0 years) and one group of 24 expert musical improvisers (mean years of musical training = 26.3 years, SD = 7.3 years, mean years of improvisation experience = 13 years, SD = 8.7 years, 4 women, 15 men, 5 not specified, mean age = 35.3 years, SD = 7.9 years). Note that expert free improvisers were on average older than the non-musicians because free improvisation is a musical practice that musicians typically start engaging with later in life, generally, once they have first acquired a high level of proficiency in their instrument (see Savouret, 2010). Group size was determined based on a power analysis that relied on a previous listening experiment on free

improvisation, which indicated that we should test 23 participants to have a power of 80% at the 0.05 alpha level (see Goupil et al., 2021 for details). This power analysis was done using the R package ‘pwr’, which is based on Cohen’s book on power analysis for the behavioral sciences (1988). In order to have a complete randomization we needed an even number of participants and therefore decided to recruit 24 participants in each group. Non-musician participants were recruited through the [INSEAD](#) recruitment procedure. Participants for the expert improvisers group were recruited from students attending improvisation graduate studies in Paris Conservatory, as well as through personal contacts with musicians from the French CFI scene. Each participant received 10 euros as compensation. Data for the non-musicians were collected in October 2021. Data for the expert improvisers were collected from October 2021 to March 2022.

2.1.2. Stimuli

Golvet et al. (2021) had their participants improvise in two different conditions: either in the same room (“Co-present” condition) or in two separated studio booths (“Isolated” condition), hearing each other through headphones but not being able to see each other. For this first experiment, we only used tracks that were recorded in the Co-present condition, i.e., 19 tracks. This allowed us to preserve the tracks recorded in the “Isolated” condition for our second experiment, so that there would be no overlap in musical stimuli between the two experiments.

As shown in Figure 1 above, the triangular interface used by the musicians to annotate their performances included white dashed lines, that delineated various areas within the interface. In order to test for the effects of dissensus in a direct and efficient way, we treated Golvet et al. (2021)’s annotation data in a binomial way, separating between times in which a musician was intending to play “with” her partner (and was thus in the “with” area of the triangle interface) and times in which she was not (and was thus anywhere else in the triangle interface, i.e., in the “against” area, in the “without’ area, or in the “center” area). Dissensus was thus conceived in a rather broad way, as encompassing all the behaviors that were not clearly aiming at converging with one’s improvisation partner. In that perspective, playing “against” or playing “without” are both seen as ways to introduce dissensus between the improvisation partners, albeit in two different ways (i.e., either by actively diverging from one’s partner or by simply ignoring her contribution).

By aggregating the annotation data from the two musicians, we were then able to create three blocks of stimuli, each with an increasing level of relational dissensus. This resulted in the

three following experimental conditions: “with-with” (both musicians were in the “with” area for the whole duration of the stimulus); “with-else” (one musician was in the “with” area and the other musician was elsewhere in the triangle for the whole duration of the stimulus); and “else-else” (neither musicians were in the “with” area for the whole duration of the stimulus). In order to obtain the stimuli, we pseudo-randomly selected three snippets for each track: one in which the two musicians were intending to play “with” each other (“with-with”); one in which one of the musicians was intending to play with the other, but the other musician was not (“with-else”); and one in which none of two musicians were intending to play “with” the other (“else-else”). We first parsed our corpus to identify, in each track, every snippet in which the musicians were in one of the previously mentioned relational states (with-with; with-else; else-else) for at least 20 seconds. We then eliminated snippets in which one of the musicians was not playing for more than 10 seconds. If more than two snippets of each condition were available for a given track, we selected the one that was closer in time to snippets of the two other conditions. If there was no difference, this was done randomly. Finally, each remaining snippet was randomly cut to a duration of 20 seconds, with a short fade-in/fade-out. This yielded 16 triplets of snippets (with-with; with-else; else-else), corresponding to 16 different tracks of our initial corpus (the three remaining tracks did not contain at least one 20-second sample for each one of our conditions).

2.1.3. Procedure

Our experiment followed a 2-AFC procedure. Participants had to listen to pairs of snippets (taken each time from the same track of the initial corpus, in order to present participants with pairs of stimuli that would be maximally close to one another in terms of their instrumentation, timbral material, and overall aesthetics) and select with the keyboard arrows the snippet in which they found the musicians to be more creative. For each trial, the two snippets were played one after the other, with a 5 second silence between them. A graphical interface showed in green which snippet was playing at each time (see Figure 2). Over the course of the experiment, participants were presented with all the possible pairs of snippets for each one of our original tracks (i.e., comparing “with-with” and “with-else”; “with-with” and “else-else”; and “with-else” and “else-else”), resulting in a total of 48 trials. These trials were separated into three blocks and semi-randomized in such a way that snippets from the same track were only heard once per block. Additionally, we ensured that the snippets presented at the end of one block would not be from the same take as the snippets presented at the beginning of the next block.

The graphical interface, together with the stimuli used in the experiment, is available as a standalone Max/MSP application at <https://researchbox.org/1287> (under “Study 2”).

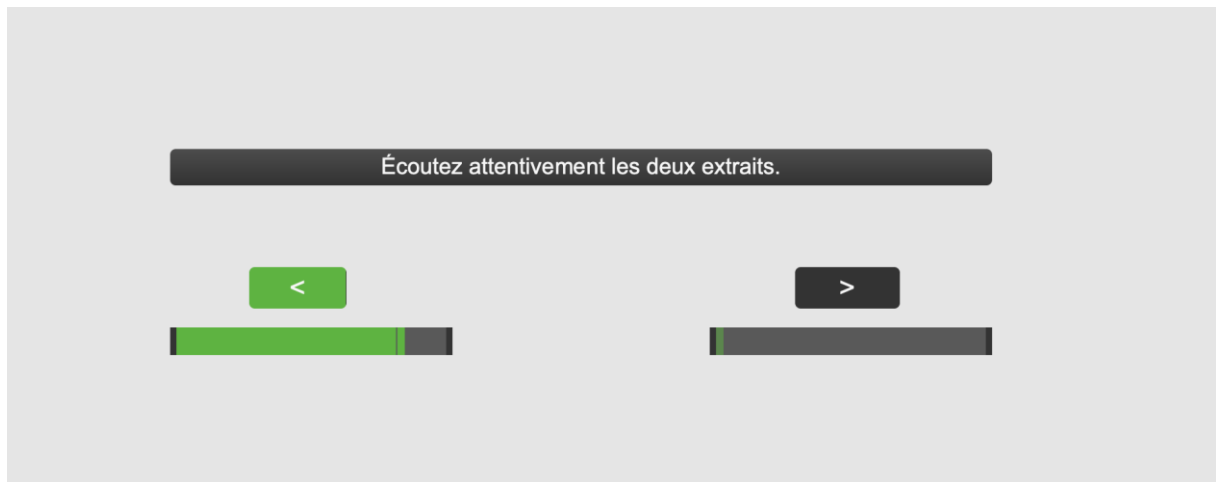


Figure 2. Participant interface for Experiment 1. In the upper box, participants are asked to “listen carefully to both excerpts”.

2.1.4. Variables

On top of categorizing the snippets into one of three relational categories (with-with, with-else and else-else) as described above, our corpus also allows us to define two continuous variables that reflect relational dissensus in a more graded fashion. For each snippet, we calculated the mean first-order dissensus, which was defined as the mean of the Euclidean distance at each time between the mean position of the two improvisers within the annotation interface used in Golvet et al. 2021 (see Figure 1 above) and the “with” vertex. This first-order measure reflects the extent to which both musicians were attempting to play with one another at all times. For example, Figure 3a and 3b below show respectively a case in which musicians are exhibiting a lower degree of first-order dissensus and a case in which musicians are exhibiting a higher degree of first-order dissensus.

For each snippet we also calculated the mean second-order dissensus, which was defined as the mean of the Euclidean distance at each time between the two improvisers’ position within the annotation interface. This second-order measure thus reflects the convergence (or divergence) between the two musicians’ intentions at all times. For example, Figures 3c and 3d below show respectively a case in which musicians are exhibiting a lower degree of second-order dissensus and a case in which musicians are exhibiting a higher degree of second-order dissensus.

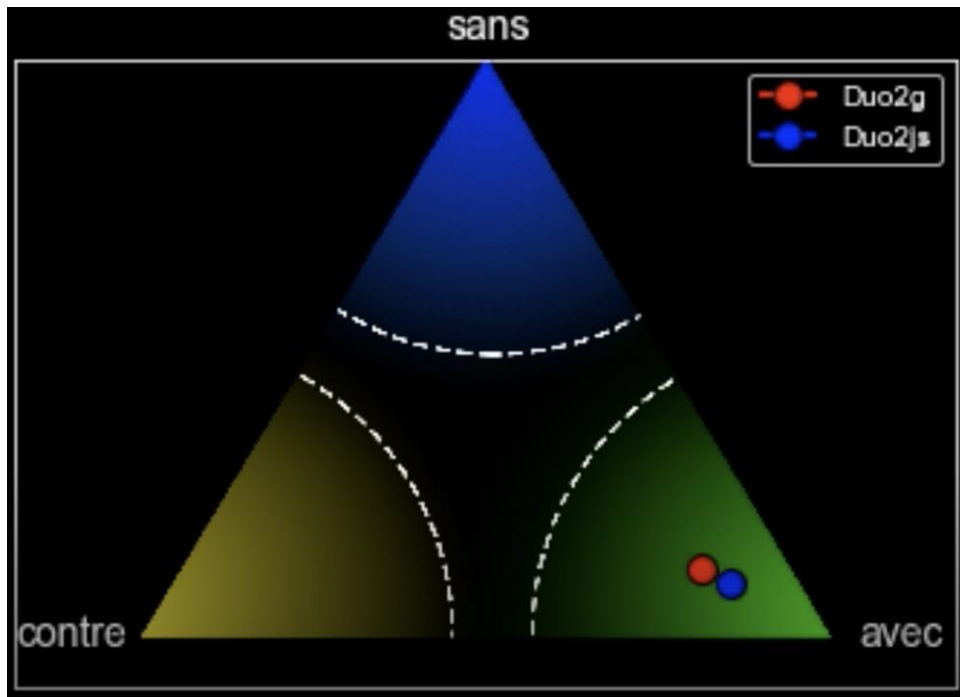


Figure 3a. Example of low first-order dissensus: both musicians are close from the “with” (“avec”, in French) vertex.

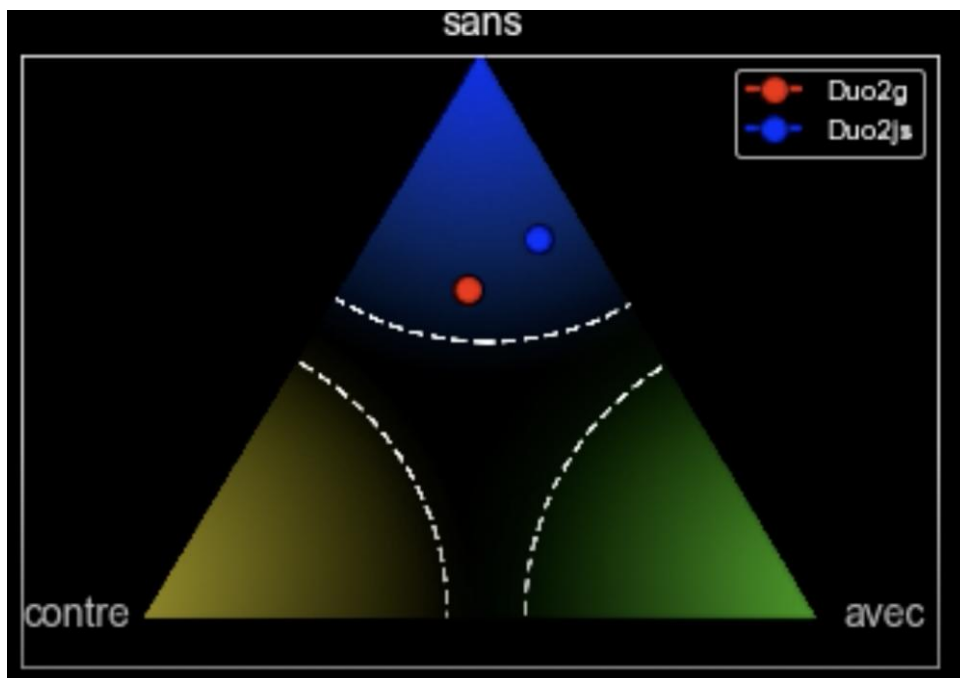


Figure 3b. Example of high first-order dissensus: both musicians are far from the “with” (“avec”, in French) vertex.

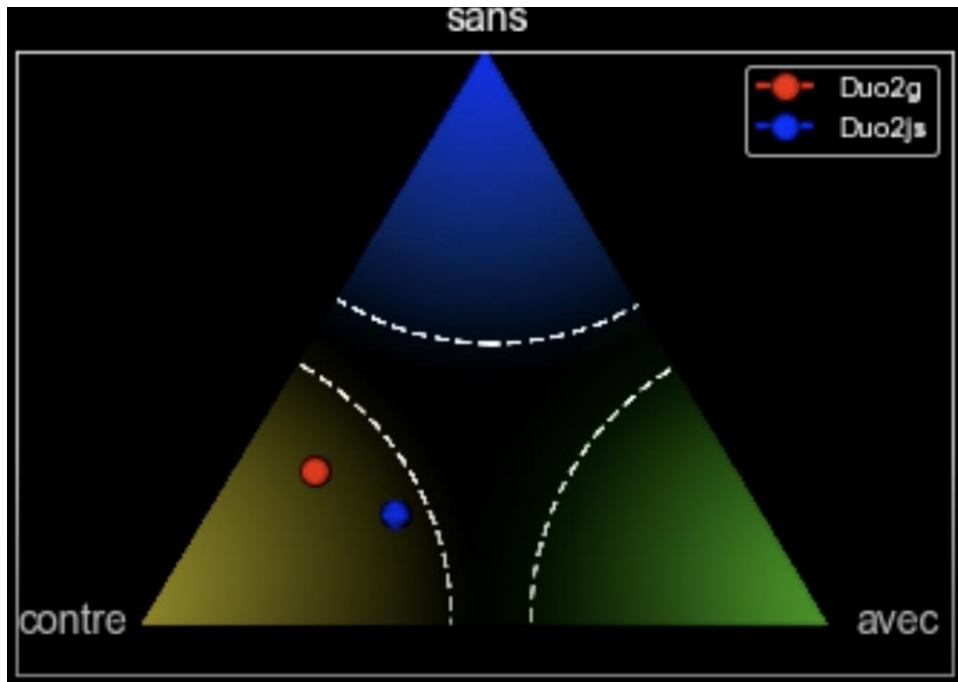


Figure 3c. Example of low second-order dissensus: both musicians are close from one another within the triangular interface.

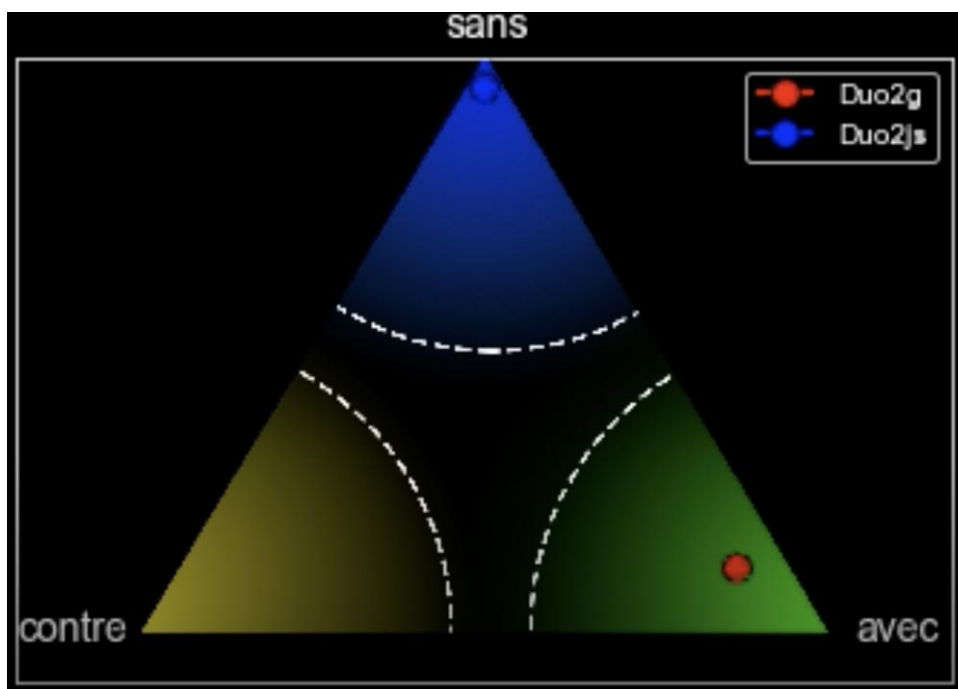


Figure 3d. Example of high second-order dissensus: both musicians are far from one another within the triangular interface.

2.1.5. Analysis

In order to test for the effect of Condition (with-with, with-else, else-else) on whether a snippet was chosen to be more creative than the comparison snippet, and also to test for possible differences between the groups (musicians and non-musicians), we built a mixed binomial regression model with Condition and Group as predictors and participants' choice (creative: yes/no) to be predicted. This model also included the interaction term between Condition and Group. In the random structure we included the random slope for each listener. The model was calculated with the "lme4" package in R.

We also calculated binomial regression models with the continuous variables first-order dissensus and second-order dissensus (both averaged per snippet) as predictors of choice, both for musicians and non-musicians.

2.2. Results

First, we will present the results from the binomial regressions model with Condition and Group as categorical predictors.

The base level for the comparisons was the Group musician and Condition else-else. For the full model output see Table 1. The condition with-with showed a significant negative effect on the probability of a snippet being chosen as more creative ($\beta = -0.22$, $z = -2.19$, $p = 0.03$). The interaction between the condition with-with and Group was also significant ($\beta = 0.36$, $z = 2.53$, $p = .012$). The main effects of the Condition with-else ($\beta = -0.07$, $z = 0.72$, $p = .47$) and Group ($\beta = -0.19$, $z = -1.84$, $p = .07$) were not significant. The interaction between condition with-else and Group was also not significant ($\beta = 0.20$, $z = 1.37$, $p = .17$). This means that musicians perceived with-with condition snippets to be less creative ($M = 0.47$, $SD = 0.10$) than else-else snippets ($M = 0.53$, $SD = 0.13$), but for non-musicians there was no difference in judgements between with-with ($M = 0.51$, $SD = 0.10$) and else-else snippets ($M = 0.48$, $SD = 0.13$). This can also be seen in Figure 4.

Second, we will present the results from the binomial regressions in which we calculated whether any of the two continuous predictors (first-order dissensus and second-order dissensus) predicted participants' choice. In musicians, neither first-order dissensus ($\beta = 0.213$, $z = 1.605$, $p = .11$) nor second-order dissensus ($\beta = 0.060$, $z = 0.445$, $p = .656$) significantly predicted choices. Similarly, in non-musicians, neither first-order dissensus ($\beta = 0.048$, $z = 0.360$, $p = .72$) nor second-order dissensus ($\beta = 0.017$, $z = 0.126$, $p = .90$) were significant.

In short, expert listeners found the performers to be more creative when they were not aiming at playing “with” one another than when they were actually both trying to play “with” one another. However, no such difference was observed in the group of non-experts.

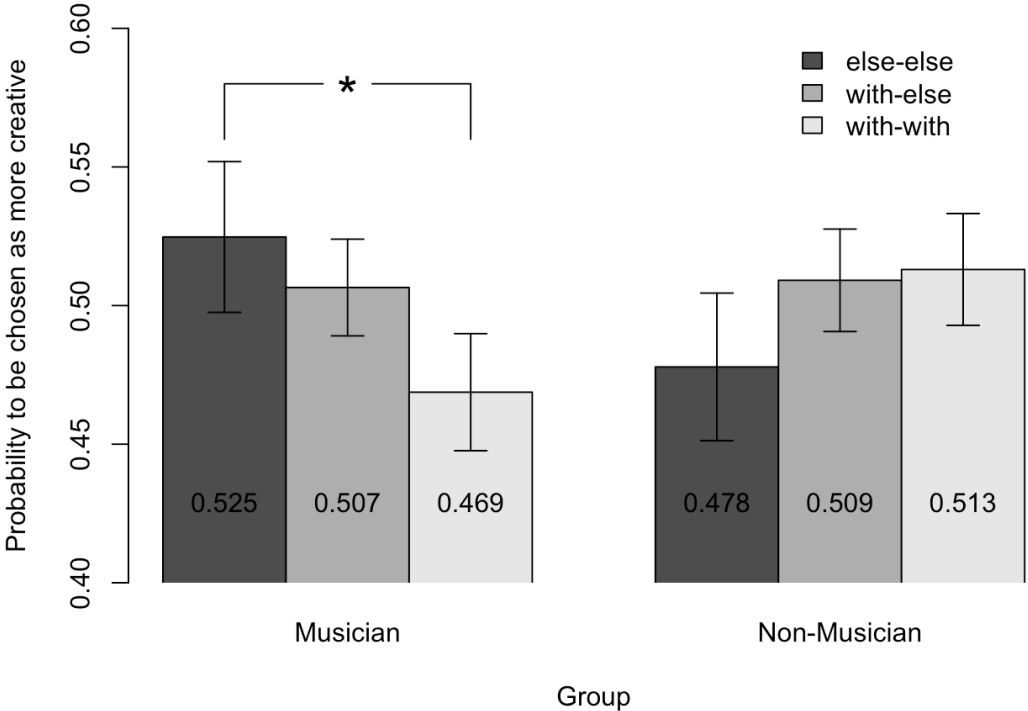


Figure 4. Results for Experiment 1. Bars represent the probability of a snippet from a certain Condition (else-else, with-else or with-with) to be chosen as more creative than the comparison snippet. There were 32 datapoints for each participant and condition ($32 * 3 = 96$ datapoints per participant), which were averaged per participant ($N = 48$, 24 musicians and 24 non-musicians) and Condition before they were used in the plot. Error bars show standard error, and the black asterisk shows a significant difference between conditions else-else and with-else in musicians ($p < 0.05$). All other comparisons were not significant ($p > 0.1$).

Table 1: Full model output of the binomial regression model. * indicates significance with $p < 0.05$, ** $p < 0.01$; *** $p < 0.001$. In the table the base level for all comparisons is the else-else condition for the musician group (other intercepts for the musician group were also non-significant (all $p > .05$). All intercepts for the non-musicians were non-significant (all $p > .20$).

Effect	Estimate	SE	z	p
Intercept (Group: musician, Condition: else-else)	0.099	0.072	1.371	0.170
Condition: with-with	-0.224	0.102	-2.194	0.028*
Condition: with-else	-0.073	0.102	-0.715	0.475
Group	-0.188	0.102	-1.837	0.066
Interaction: Group * with-with	0.365	0.144	2.526	0.012*
Interaction: Group * with-else	0.198	0.144	1.372	0.170

3. Experiment 2

3.1. Methods

3.1.1. Participants

As for experiment 1, we collected data from both musicians and non-musicians as specified in a pre-registration (<https://osf.io/9a6zu>). As for experiment 1, we based the sample size we aimed for on a power analysis that relied on a previous listening experiment on free improvisation (Goupil et al., 2021) which indicated that we should test 23 participants to have a power of 80% at the 0.05 alpha level. However, due to difficulty in recruiting expert improvisers, we only managed to gather 20 musicians (musical practice > 10 years, 4 women, 16 men, mean age = 28.1 years, SD = 9 years). Because of a technical error that prevented us from recording slider data for one non-musician participant, our final sample size for the group of non-musicians was 22 (musical practice < 2 years, 11 women, 11 men, mean age = 25.3 years, SD = 3.7 years). Non-musicians were recruited through the [INSEAD](#) recruitment procedure. Expert improvisers were students attending improvisation graduate studies in Paris Conservatory, or were recruited through personal contacts with musicians from the French CFI scene. Each participant received 8 euros as compensation. Data for the non-musician group were collected in October 2021. Data for the expert improvisers group were collected from October 2021 to December 2021.

3.1.2. Stimuli

For experiment 2, we used the 18 tracks from Golvet et al. (2021)' corpus that were recorded in the Isolated condition, so that they would not be any overlap with the track used in Experiment 1. For each track, we cut a 90-second snippet starting from the first sound actually played, with a short fade-in/fade-out. This resulted in a total of 18 snippets. The snippets used in this second study are available at <https://researchbox.org/1287> (under “Study 1”).

3.1.3. Procedure

Participants listened to the 18 snippets in random order. Participants were provided with a touch-screen iPod and asked, for each snippet, to continuously rate the amount of tension they perceived in the music by using a digital slider (from “No tension” to “Highly tensed”) (see Figure 5). The interface was developed with the *soundworks* architecture (Matuszewski, 2019). We sampled the data from the digital slider at a rate of 4 Hz.



Figure 5. Participant interface for Experiment 2.

3.1.4. Variables

As in experiment 1, relational dissensus between the improvisers was assessed through two continuous variables. For each snippet, first-order dissensus was defined as the Euclidean distance at each time between the two improvisers' mean position within the annotation interface used in Golvet et al. 2021 (see Figure 1 above) and the “with” vertex. For each snippet, second-order dissensus was defined as the Euclidean distance at each time between the two improvisers' position within the annotation interface.

3.1.5. Analysis

We examined the relationship between perceived musical tension and first-order relational dissensus in a linear mixed regression including listeners' IDs as random intercept, musical tension as a dependent variable and first-order relational dissensus as well as Group

(musician, non-musician) as independent variables. We also included the interaction term between first-order relational dissensus and Group in the model. Our dependent variable was a time-series of ratings provided by listeners with an incompressible inertia (since they had to move the cursor continuously within the interface), so we also specified the auto-correlation structure of our time-series data in the model. This was done using the R package ‘nlme’. Similarly, we examined the relationship between perceived musical tension and second-order relational dissensus in a separate model.

3.2. Results

First, we will present the results from the linear mixed model that includes first-order relational dissensus as a predictor of musical tension (see Table 2 for the full model output). There was no significant effect of Group ($\beta = 0.04$, $t = 1.02$, $p = .313$), but there was a significant interaction between Group and First-order dissensus ($\beta = -0.07$, $t = -11.76$, $p < .001$). For the participants in the musician group, first-order relational dissensus significantly predicted listeners’ ratings ($\beta = 0.01$, $t = 2.22$, $p = .026$). The positive beta estimate here means that there was a positive relationship between first-order relational dissensus and tension ratings. First-order relational dissensus also significantly predicted non-musicians’ ratings ($\beta = -0.06$, $t = -14.77$, $p < .001$). However, in non-musicians this relationship was negative.

Second, calculating the linear mixed model that includes second-order relational dissensus revealed that second-order relational dissensus was a significant predictor of musical tension, both for musicians ($\beta = 0.03$, $t = 10.69$, $p < .001$) and for non-musicians ($\beta = 0.04$, $t = 13.44$, $p < .001$). There was neither a significant main effect of Group ($\beta = -0.03$, $t = -0.70$, $p = .49$), nor a significant interaction between Group and Second-order relational dissensus ($\beta = 0.01$, $t = 1.53$, $p = .13$). Thus, in both groups of listeners, the perceived level of musical tension increased with the amount of second-order relational dissensus between the performers.

Table 2: Full model output of the linear mixed regression models which test for effects of first-order and second-order relational dissensus on musical tension ratings. * indicates significance with $p < 0.05$, ** $p < 0.01$; *** $p < 0.001$.

	Effect	Estimate	SE	t	DF	p
First-order relational dissensus	Intercept (Group: musician)	0.468	0.026	17.909	76570	< 0.001***
	First-order relational dissensus	0.010	0.005	2.222	76570	0.026*
	Group	0.037	0.036	1.022	40	0.313
	Interaction	-0.073	0.036	-11.761	76570	< 0.001***
Second-order relational dissensus	Intercept (Group: musician)	0.454	0.026	17.493	76570	< 0.001***
	Second-order relational dissensus	0.032	0.003	10.690	76570	< 0.001***
	Group	-0.025	0.036	-0.704	40	0.486
	Interaction	0.006	0.004	1.526	76570	0.127

4. Discussion

Our two experiments systematically investigated the relation between perceived creativity and group dissensus in musical performances, using collective free improvisation (CFI) as a paradigm for collective musical creativity. First, in experiment 1, we found that musical snippets of CFI duos exhibiting interactional dissensus (i.e., snippets in which neither improviser was intending to play “with” the other) were perceived by expert listeners as being more creative than snippets in which both improvisers were intending to play “with” one another, which was consistent with our hypothesis. By contrast, non-expert listeners’ judgements were not related to interactional dissensus. Second, in experiment 2, we found that interactional dissensus (both first-order and second-order) within CFI duos was perceived by expert listeners as a source of musical tension, again, consistent with our hypothesis. Non-expert listeners, by contrast, perceived second-order dissensus snippets to be more tensed, but unexpectedly, the reverse pattern was observed for first-order dissensus. Taken together, our results provide additional empirical ground to the idea that dissensus might play a key role in enabling group creativity, and show that it can fuel creativity even in situations that strongly

contrast with the “brainstorming paradigm” in terms of modality, temporal structure, and goals. Yet, the data also revealed peculiar differences between experts and non-experts’ perception of interactional dissensus in CFI performances, an issue to which we return below. Our results also highlight the active and intentional nature of interactional dissensus. Taken together with the findings reported in Golvet et al., (2021), the present experiments establish that improvisers can flexibly manipulate such dissensus – in the same way that they manipulate pitches or dynamics – to convey tension or to create moments that are maybe more original, surprising or challenging. In that sense, interactional dissensus should be distinguished from both divergent understandings and aesthetic disagreements within the group – two features often encountered in CFI (and, beyond CFI, probably in most collective artistic endeavors). On the one hand, because of the highly underspecified semantic nature of the musical medium and the relative absence of stylistic constraints, free improvisers do not necessarily have a shared understanding of the ongoing performance, and can sometimes experience a given passage in strikingly divergent ways (Pras et al., 2017; Wilson & MacDonald, 2017). On the other hand, CFI groups often gather musicians with distinct aesthetic backgrounds and stylistic preferences (Watson, 2013; Canonne, 2012). While it might well be the case that such misunderstandings between group members and diversity of individual backgrounds also stimulate creativity (Paulus et al., 2019; Levine et al., 2019), an important difference with interactional dissensus is that they are either unintentional properties of the interactions, or fixed properties of the group structure. Misunderstandings and group composition cannot be actively and willingly manipulated by the improvisers (at least not in the course of the performance), contrary to the degree of dissensus they allow in their interactions. In other words, interactional dissensus is not just a given feature of CFI: it is a full-fledged resource available to the musicians to maximize the creativity of their joint output. This is in line with recent research showing that the very nature of the interactions between group members (e.g., egalitarian or hierarchical) can affect group creativity (see Rosenberg et al., 2022).

This being said, our results also raise the question of how such interactional dissensus might coexist with the requirement of tight coordination between group members that underlie most musical performances. Three remarks should be made here. First, CFI’s coordination criteria are clearly looser than for other types of musical practices: most often, the music collectively produced is not based on a regular pulse (so musicians do not have to precisely synchronize on it) and virtually all types of harmonic or timbral relationships can be tolerated (Corbett, 2016). This does not mean that there are no coordination criteria in CFI, but simply that such

criteria are mostly contextual, depending on the specific sonic configurations emerging from the musicians' interactions. In any case, such flexible coordination criteria certainly allow musicians to explore more diverse modes of relations – including dissensual relations (Aucouturier & Canonne, 2017; Golvet et al., 2021) – without putting at risk the unfolding of the collective performance nor its adherence to a pre-defined aesthetic or stylistic framework. Second, music-making is a highly multi-dimensional affair: when musicians play “against” one another, it does not necessarily mean that they oppose on every musical dimension. Most often, they might oppose on one salient dimension (e.g., timbre) but be highly coordinated on other dimensions (e.g., phrase boundaries, dynamics, etc.). In other words, dissensus and coordination are not necessarily contradictory: they might well coexist at different levels. Third, even when improvisers engage in a dissensual relational mode (by avoiding playing “with” their partners to prefer playing “against” or “without” them), they are still agreeing to make music together, which means that they still have to coordinate on some basic goals. Indeed, musicians' individual goals being not compatible anymore is likely to result in strong discoordination, ultimately disrupting the very process of collective music-making (Canonne & Garnier, 2012; Saint-Germier & Canonne, 2020). The kind of dissensus we investigated here through the improvisers' own annotations is thus relatively partial: it is more likely to describe something happening at the sonic surface of the musical interactions than something happening at the basic underlying coordination structure.

One might then wonder whether our results could extend to other, non-improvised collective musical performances. In which sense can performers of a composed work of chamber music from the common practice period be said to oppose each other while performing? Is there room for conflict and disruption in the course of scripted performances themselves, between the performers' own sonic actions? And if so, can this result in a more expressive or creative performance? Chamber music performances are generally well-rehearsed, and the goal of these rehearsals is often precisely for the performers to reach a consensus on the main interpretive choices, so that there is no dissensus left when reaching the actual (public) performance. Of course, performers can also “simulate” dissensus when the various voices of a polyphonic composition – and their underlying musical personae – conflict with one another in a kind of musical drama (see Maus, 1988); but in such cases, the dissensus lies in the musical “fiction” orchestrated by the composer, and not between the performers themselves. However, this does not mean that dissensus is necessarily absent from the performance of chamber music. But it is more likely to emerge in the performance of works that do not clearly ascribe fixed socio-musical roles and functions to the various musicians, but rather

allow them to explore a variety of playing relationships, as in Ravel's *Sonata for Violin and Cello* (see Heyde, 2022). In any case, one would probably need to calibrate the very notion of interactional dissensus at a fine-grained level to make sense of it, and to study slightly incongruent actions in terms of intonation, timbre or micro-timing not necessarily as coordination failures, but as potentially creating a space for expressivity and flexibility (see Terepin, 2021, for a study on how asynchronies might contribute to specific forms of expressivity in string quartet playing). These remain largely open questions, and answering them would require more detailed studies of actual performance practices.

Another important aspect of our findings concerns the difference between the two groups of participants, i.e., expert and non-expert listeners. In experiment 1, only experts in CFI perceived significant difference in creativity between the 3 types of snippets. Non-expert listeners (i.e., participants with no previous exposure to the genre of CFI) heard no significant difference whatsoever between the 3 types. It is likely that their lack of familiarity with the artistic domain of free improvisation made them simply unable to register any potentially relevant differences between the various snippets, which were heard as being equally (un)creative. Our results are thus consistent with the theoretical framework of the Consensual Assessment Technique, which is widely used in creativity studies (see Amabile, 1982, and Cseh & Jeffries, 2019, for a discussion). In that perspective, creativity is domain-dependent and can only be inter-subjectively assessed by experts of that domain.

That being said, how exactly to define such “domain” is not obvious. In our study, experts were basically equated with peers – participants who not only had a high level of musical and instrumental expertise, but were also practitioners of free improvisation, making them as close as possible to the musicians whose performance they had to assess. But the “domain” under consideration in this context could also be taken to refer more broadly to “music”, rather than to CFI specifically. As such, it remains an open question whether our results could extend to participants with an expertise in a different musical practice (for example Western classical music or Javanese gamelan). Replicating our study with musician participants from a different background – providing that one ensures that such participants would still recognize the CFI excerpts used in that study as being “music” – would allow to more precisely assess whether the effect of interactional dissensus on the perception of creativity simply reflects the values of a specific community (i.e., CFI practitioners) or whether it is something that can be intersubjectively perceived by the broader community of musicians (if there is such a thing). However, given how widely diverse musical practices actually are, it is likely that such

replications would offer contrasting results, depending on how close the participants' musical background is from that of the improvisers whose performances are evaluated.

Interestingly, such difference in behaviors between the expert and the non-expert listeners was much less clear for experiment 2: while first-interactive dissensus surprisingly correlated with *less* perceived tension for non-expert listeners, non-expert listeners were similarly affected by second-order interactive dissensus in their ratings of musical tension as expert listeners. The fact that our first-order and second-order interactive dissensus had an opposite effect on the perception of musical tension by non-expert listeners is puzzling. This difference might have something to do with how non-musicians reacted to the high amount of dissonance contained in those musical improvisations. Indeed, while first-order dissensus was positively correlated with dissonance in our corpus, second-order dissensus was negatively correlated with dissonance (see supplementary material for detail). In other words, non-experts might have exhibited an aversion to dissonance (already well-documented in musical genres that largely rely on rough sounds, such as noise music or post-serial music, see Ollivier et al., 2019; Popescu et al., 2019) that somehow interfered with their perception of musical tension. Beyond a certain threshold in dissonance (associated with, respectively, high levels of first-order dissensus and low levels of second-order dissensus), non-musicians might have felt that there was no tension anymore – just noise. Such an hypothesis would reasonably explain the observed differences in the effects of our two kinds of dissensus on non-experts. But independently of those differences, the mere fact that non-expert listeners' judgments of musical tension exhibited sensitivity to variations in interactive dissensus suggests that musical tension might be a more basic expressive property of the music – depending on sonic (and, when appropriate, interactive) properties that are widely shared between various musical practices – whereas creativity is more obviously genre-dependent, relying on criteria that can only be picked up by the community of those sufficiently attuned to the genre under consideration, and whose validity might not extend beyond that genre.

Now, if expert listeners found snippets with higher interactive dissensus to be more creative, why improvisers do not stay constantly in such a state when performing? Why, as Golvet et al. (2021) showed, such passages are in fact the minority, with the majority of the performance seeing the musicians displaying more consensual behaviors? A first possibility could be that constant dissensus impairs musicians' empathetic attunement towards one another (Seddon & Biasutti, 2009), leading ultimately to a worst performance, or even to the potential dissolution of the group. Playing “against” or “without” might be beneficial from a purely musical point of view, but it comes with a socio-emotional cost, which can be

detrimental to one's playing. This trade-off appears clearly in the following quote from one of the leading pianists of the French CFI scene, who discusses a performance in which a cellist always stopped playing when she started to play a bit louder: "Musically, it created a tension which was very interesting, but on the other hand, this behavior, it really shocked me, it traumatized me a bit" (quoted in Canonne, 2016). A second possibility could be that the creativity and unpredictability of passages displaying interactional dissensus is even stronger when emerging from a more stable and less surprising context, and thus when artfully balanced with more consensual passages. In any case, such considerations should invite us to resist the temptation to equate "more creative" with "better *simpliciter*", particularly in a task such as the one used for experiment 1, which presented musical snippets in a highly decontextualized way.

Our studies indeed present two important limitations. First, as we just said, they present excerpts disconnected from their broader musical contexts. This was necessary to allow for the actual comparison of excerpts (it is obviously more difficult to remember longer excerpts) and to present a sufficiently high number of excerpts to enable statistical inferences. But given the importance of temporal dynamics in music, further studies should aim at presenting longer excerpts which balance over time at various degrees interactional consensus and dissensus, in order to investigate in more detail the contextual and temporal factors that might lead performers to endorse a dissensual relational mode. Second, our studies do not shed light on how the music's acoustic features might mediate the relationship between interactional dissensus and creativity. The musical excerpts that were presented to our participants were indeed astoundingly diverse in terms of their sonic and aesthetic properties. In that sense, it might be that the effects of dissensus on the listeners' perception were only driven by specific snippets, which displayed certain acoustic features. When running exploratory acoustical analyses (reported in the supplementary material), we saw that interactional dissensus had an effect on tension ratings independently of musical excerpts' respective loudness. In other words, dissensus impacted listeners' perception of musical tension over and beyond the role played by loudness, which is often taken to be a core ingredient in the emergence of musical tension (Farbood & Upham, 2013). However, the results were far less clear cut regarding how dissensus interacted with the excerpts' dissonance (see supplementary material for details). Fully understanding these interactions would require to design new studies with a better control of the sonic variability of the musical performances at hand.

Conclusion.

Because it underlies such diverse activities (from listening to performing, composing or improvising), musical creativity is obviously multi-dimensional (see Schiavo & Benedek, 2020). The results reported here point towards an overlooked dimension of musical creativity, that seem to be relevant for both “process creativity” (i.e., the process of creating) and “product creativity” (i.e., the creative product), to draw on a distinction recently suggested by Julia Langkau (Langkau, forthcoming). Regarding the “process” side of musical creativity, our results suggest that creativity is not only a matter of imagination, planning or adaptation but also a matter of transforming the parameters of the performing situation itself, such as the interactional parameters, as it unfolds. Regarding the “product” side of creativity, our results invite us to consider the music’s social content as an important aspect of its expressivity. We argue that such relational aspects of musical creativity extend well beyond the case of collective improvisation – and even collective musical practices – and could be fruitfully investigated in a wide range of musical activities. The underlying social dimension of music has already been highlighted numerous times (see for example Cook, 2018), but we now suggest to go one step further, by exploring how the many different ways we have to relate to others could fit into the different facets of musical creativity.

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