Social Interaction Dynamics Modulates Collective Creativity

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Abstract

In an experimental study, we investigated how social interaction dynamics affect collective creativity. Pairs of participants collaborated in a computer game, creating "beautiful and interesting" shapes by moving tiles on a large touchscreen. We identified naturally emerging interaction styles by applying k-means clustering on participants' tile moves. The game allowed us to quantify the unfolding creative process in a well-defined search space. Pairs characterized by a single dominating member tended to visit fewer areas of the solution space, stay there longer and created on average more (but less original) shapes. In contrast, pairs that took turns with every tile move tended to explore more, stayed in each area of the solution space for less time and created fewer (but more original) shapes. While previous literature found conflicting effects of 'creating with another', the current paper suggests naturally emerging interaction styles as a differentiating factor underlying how collective creativity unfolds.

Keywords: Collective creativity; divergent thinking; social interaction; turn-taking; originality

Introduction

Many creative practices, for instance in research, design, and art, unfold in collaborative contexts where several individuals jointly search for novel, useful or interesting solutions (John-Steiner, 2006). While many studies investigate the cognitive processes involved in individual creative search (Kaufman & Sternberg, 2010) and the effect of external factors such as instructions and incentives on collective creativity (Baruah & Paulus, 2009; Toubia, 2006), the effect of naturally emerging social interactions is less clear. In an attempt to unravel previous conflicting observations, this study investigates how different naturally emerging styles of social interaction affect the underlying dynamics of collective creativity.

Individual and Joint Creativity

In cognitive/experimental approaches, creativity is often equated with *divergent thinking*, that is the ability to come up with multiple solutions to a prompt (Runco, 2010). A creative process is thus thought to be characterized by *fluency* (the number of solutions provided within a set time frame), *flexibility* (how different the solutions are), and *originality* (how original the solutions are), and a creative individual is one that is capable of producing many, different, and original solutions.

The impact of social interaction on creative processes is controversial. On the one hand, many studies of collective problem-solving show how groups working together often outperform individuals solving the task on their own (Bahrami et al., 2010; Larey & Paulus, 1999; Taylor et al., 1958; Wahn et al., 2017; Woolley & Fuchs, 2011). This happens when group members successfully integrate their diverse perspectives, contribute different strategies, or push each other out of cognitive fixation. However, another set of studies find that group members can exert an inhibiting effect on each other's creative processes, dampening their group productivity. In these cases, social interaction seems to disrupt or bias group members' search processes making them unable to realize their full creative potential (Diehl & Stroebe, 1987; Kohn & Smith, 2011; Lencioni, 2002; Pauhus et al., 1993). While these studies have mostly focused on fluency, it is not clear if interaction can have similar detrimental effects on flexibility and originality (but see also Larey & Paulus, 1999).

It is a scientific puzzle why social interaction seems to positively stimulate creativity in some contexts while inhibiting it in other contexts. Research on social interaction and coordination, however, points to the fact that interaction dynamics can vary from group to group and context to context, and that these differences can have profound effects on the outcomes of the social activity (Dideriksen et al., 2020; Fusaroli et al., 2012; Fusaroli & Tylén, 2016). For instance, joint performance on perceptual, categorization, and problem-solving tasks has been shown to be contingent on the extent to which group members coordinate their dialogical turns and other aspects of their interactions. In a study by Bjørndahl et al (Bjørndahl et al., 2015), utilizing an open-ended LEGO construction task, it was found that depending on the interaction style of the group, properties of creative products would either be constituted by a mere concatenation of individual group members' ideas, or presenting a single integrated group idea. It is, in other words, not unlikely that properties of social interaction impact the unfolding of collective cognitive search processes.

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The 'Solution Space' Metaphor

Creative search is often portrayed using a spatial metaphor: The search for novel and useful solutions is depicted as the movement through an imaginative 'space of solutions' analogous to the navigation of a physical landscape (Spivey, 2008). Some creative ideas appear immediately accessible, that is, "close" in space, while others are hard to find since they are located "further away". The distance between solutions is thus constituted by their associative strength with very related solutions occupying clusters of the space (Baronchelli & Radicchi, 2013).

Applying this metaphor, it can be suggested that our mental search for creative products unfolds as an 'information foraging' process (Hart et al., 2017), similar to other mental search tasks (Hills et al., 2008, 2010, 2012; Wilke et al., 2009), and to actual spatial foraging done by humans (Kalff, 2010) and a variety of animals (Perry & Pianka, 1997; Scharf et al., 2011). Such a foraging process is characterized by a succession of alternating phases of *scavenging* and *exploration* phases.

In this context, a scavenging phase is characterized by a series of short paths traveled through space to collect multiple closely related solutions, often belonging to the same category, or area of the solution space. An exploration phase, on the other hand, is characterized by a longer path traveled in search for new categories or ideas. Different contexts of cognitive search often present relatively stable patterns of exploration and scavenging phases, captured for example in the model of Levy flights (Baronchelli & Radicchi, 2013; Szary & Dale, 2014). However, a specific creative process can lean either toward more scavenging or more exploration. A creative process leaning towards scavenging would yield multiple solutions belonging to the same few categories. In contrast, a creative process leaning towards exploration will present solutions from a wider range of areas in the solution space while possibly staying for a shorter time in each area, demonstrating more cognitive flexibility.

Experimental tools that are usually applied to study creative processes, such as the Alternative Uses Test (AUT) (Gilhooly et al., 2007) focus on offline measures of the creative products, in particular the fluency, originality and flexibility of the collected solutions. In order to measure the possible effect of naturally emerging social interaction on both the creative products and the unfolding dynamic process (the succession and distribution of scavenging and exploration phases), we rely on a recently developed paradigm, the *Creative Foraging Game* (CFG).

The Creative Foraging Game

The Creative Foraging Game (Hart et al., 2017; Noy et al., 2012) investigates open-ended creative processes in a well-defined space of geometric shapes, composed of ten connected square tiles making up ~36k possible configurations (see Figure 1 and 2). Starting from a common starting point - a horizontal line - participants are instructed to "create beautiful and interesting" shapes by moving around the tiles on a computer screen, and to save shapes they find beautiful and interesting to a "gallery" for later collection and appreciation. Notice that the task is open-ended with no 'right' or 'wrong' solutions, and thus attempts to capture the creative exploration process - albeit in a simplified and controlled environment - by which artists or designers explore a space of possibilities in a particular medium (Jennings et al., 2011; Simonton, 2003).

Figure 1: The Dyadic Creative Foraging Game. Two participants were placed in front of a large touchscreen and instructed to move 10 tiles around in order to create shapes that are "interesting and beautiful" and save them to their "gallery".

Importantly, beyond relevant properties of the creative products, the CFG makes it possible to record a number of measures capturing the dynamics of the unfolding creative process. Every move of a tile is recorded in spatial and temporal coordinates making it possible to track how participants search the solution space through phases of exploration and scavenging (see Figure 2). This enables the CFG to detect subtle effects of creative search, for example, the first report on a placebo effect on open-ended creative search: Participants who smelled a 'creativity inducing' odorant explored more relative to control participants (Rozenkrantz et al., 2017).

In this study, we utilize a slightly modified version of the CFG. In order to accommodate creative collaboration, the game was presented on an 80-inch touchscreen allowing pairs of participants to directly manipulate tiles to create and save shapes. Participants did not receive instruction on how to structure their collaboration but were left to self-organize. This allows us to study how variability in naturally emerging social coordination patterns impacts properties of collective creative search and the resulting products.

Studies on collective creativity mostly fall to either the *input-output approach*, where the focus is what happened before and after the group interaction, or the *process*

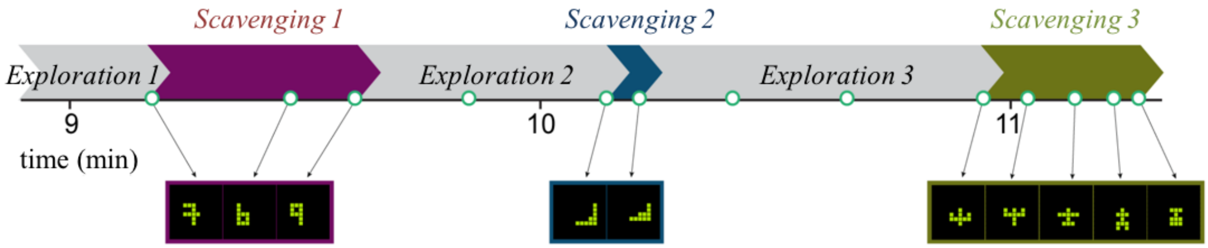

Figure 2: Investigating the creative process. An illustration of the process by which participants alternate between phases of exploration (with few, unrelated gallery saves, depicted as small green circles on the timeline), and scavenging phases (with a burst of similar gallery saves). Shapes in a scavenging phase often belong to semantic categories (e.g., "digits" as in Scavenging 1 or "airplanes" as in Scavenging 3) but can also be abstract forms (as in Scavenging 2).

approach where the focus is what happened during the interaction (Sawyer, 2012). Our approach can be seen as a combination of both approaches as it gives quantitative data both on process and product variables.

In particular, we focus on two process measures and two product measures. The process measures capture the extent to which the creative search is leaning more towards exploration or scavenging, and participants' propensity to stay in a particular phase for longer or shorter time (for more in-depth description to the measures, SER-α and SER-R, see the method section and Figure 3). Notice that these measures relate to the concept of cognitive flexibility in the sense that a high flexibility is characterized by more exploration and overall shorter phases of scavenging. The two product measures are fluency (the number of shapes saved to the gallery) and originality (the relative frequency of shapes).

Social interaction is a multifaceted phenomenon, the richness of which can be difficult to measure. In this context, we rely on video annotation of how pair members coordinate the collective creation of shapes by taking turns in moving around tiles on the screen. Interaction styles are identified using unsupervised dynamical clustering on the transition probabilities of tile-move-by-tile-move between pair members (see the method section and Figure 4). We hypothesize that the naturally emerging interaction styles identified by this approach (e.g., a tendency for pair members to take turns moving the tiles) will affect both the creative search process and creative product measures in the dyadic CFG.

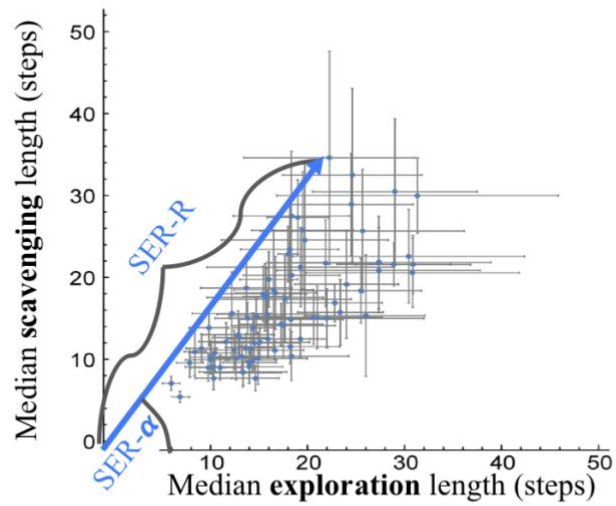

Figure 3: The Scavenging-Exploration-Ratio (SER). In order to derive relevant process measures of creative search, we computed the length (*L*, number of tile moves) of each exploration *Le*(i) and scavenging *Ls*(i) phase respectively. For each game we then computed the vector <median(*Le*(i)), median(*Ls*(i))>, illustrated by the current plot. The polar coordinates (angle and radius) of each vector gives us the Scavenging-Exploration-Ratio (SER), composed of the angle SER-$\boldsymbol{\alpha}$ and the radius SER-R. Higher SER-$\boldsymbol{\alpha}$ values indicates a tilt towards scavenging relative to exploration, and values of SER-R indicates the length of phases of both types (i.e. the propensity to move in/out of a phase).

Methods and Materials

Participants

Fifty-two participants (35 females, 17 males, 0 other), with a mean age 24.31 (std 6.21) took part in the experiment. Participants were recruited from the participant pool of the Cognition and Behavior Lab at Aarhus University and consisted mostly of university students. Participants were randomly assigned to pairs, and did not know each other in advance. All signed informed consent in accordance with the Aarhus University research ethical requirements and received a fixed monetary compensation of DKK 100 (~$15) for their participation.

Procedure

Participants were instructed to perform a collaborative version of the *Creative Foraging Game* (CFG) (Hart et al., 2017; Noy et al., 2012): an open-ended task requiring participants to create shapes by moving around 10 green square tiles on a screen. Built-in constraints in the game script ensured that shapes would snap to allowed positions (with a set distance between tiles), and that shapes were always fully

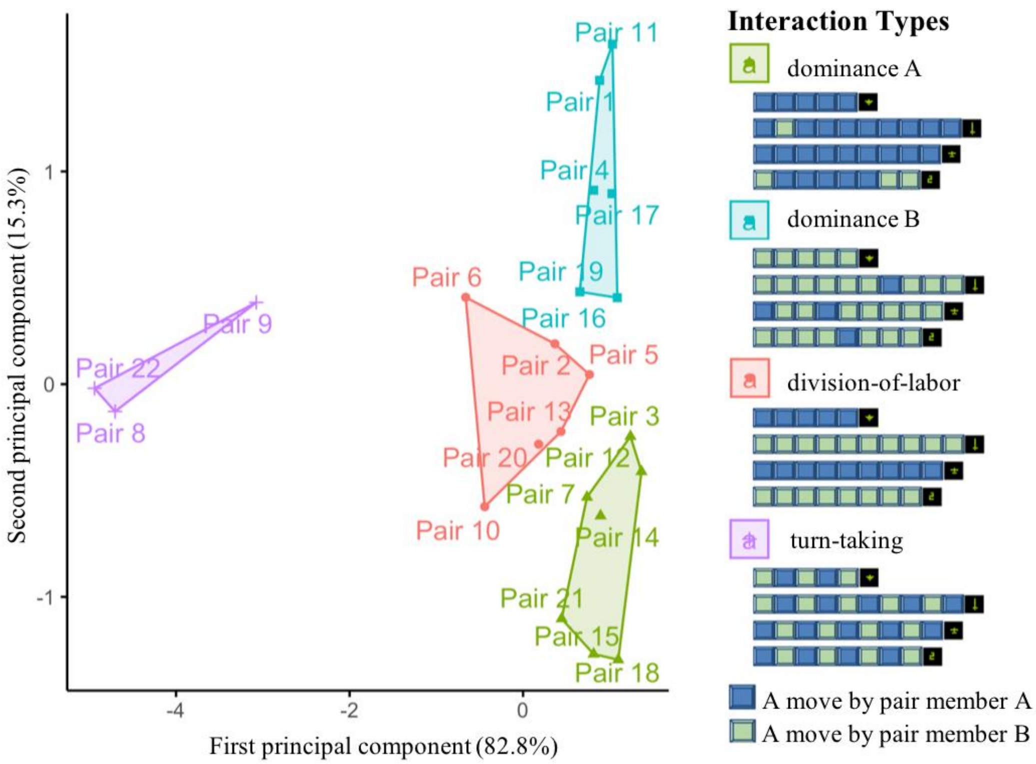

Figure 4: Clustering of interaction styles. Based on the average transition probabilities between moves made by pair members A and B, pairs are divided into four clusters using k-means clustering. Colored polygons represent the cluster convex hulls. The axes represent the first two principal-components with their corresponding loadings. The clusters represent three basic types of interaction: dominance, division-of-labor and turn-taking, illustrated by schematic examples on the right side. Each blue/green square corresponds to a tile move by one of the pair members, and each line is a sequence of moves until a gallery shape is saved (shown at the end of each sequence). From the top: *dominance A* – pair member A did most of the moves, *dominance B* – pair member B did most of the moves, *division-of-labor* - the pair members switched after each gallery shape, and *turn-taking* – the participants switched after each move.

connected (tiles could not be separated to two shapes). All tile positions, movements, and gallery shapes were logged on a Windows computer running a custom Python script.

To accommodate collaboration on the task, the game was presented on an 80-inch touchscreen (see Figure 1). Participants were instructed to jointly create “interesting and beautiful” shapes and save them to their “gallery” by clicking a window in the upper right corner of the screen. There was no expectation or limit to the number of gallery shapes that could be saved. Pairs received no further instruction on how to collaborate, that is, they self-organized with respect to who and how they moved around tiles and submitted resulting shapes to the gallery. No instructions were given regarding allowed communication, with some pairs talking a lot during the session, some less. Interactions were video recorded using a GoPro Hero 4 video camera. The game proceeded through 20 minutes after which it automatically terminated.

Analysis

Video annotation Due to malfunctioning of the video equipment and corrupted files, only footage from 22 pairs entered analysis. Videos were annotated by a research assistant with respect to which of the two pair members (A or B) made which tile move on the screen. That is, for each gallery shape, we would have a time series of the tile moves made by each of the participants to form that shape (see Figure 4, right panel). In order to quantify different styles of interaction, the time series were coded with respect to four possible transitions: a tile move made by a pair member, could be followed by another move by the same or by the partner, giving in all four possible transitions: 1) A⇒A, 2) A⇒B, 3) B⇒B, and 4) B⇒A. Across each pair and each shape, we averaged the probability of each of the four transitions and subjected these scores to dynamic unsupervised clustering using k-means.

Since k = 4 gave well-separated and interpretable clusters, we will proceed with these in the later analysis (see Figure 4, left panel). However, the two cluster loading exclusively on A⇒A or B⇒B will be collapsed, yielding three resulting clusters: *Dominance* (n = 13): all moves are made predominantly by one pair member (A or B), *Division-of-labor* (n = 6): A pair member perform a series of moves to create and submit a whole shape before leaving the floor to the partner who does the same, and *Turn-taking* (n = 3): pair members take turns on a move-by-move basis to co-create their shapes (Figure 4, right panel).

Game Measures Four outcome measures are computed from the pairs' game play.

Flexibility is in this context operationalized as the ratio between exploration and scavenging. Based on previous studies relying on the CFG, the analysis builds on the assumption that a game will go through alternating phases of exploration and scavenging. A phase of scavenging follows when participants upon 'discovery' of a category (e.g. animals, airplanes or letters) create and submit multiple shapes from that category. While this can be an effective way of producing many candidate solutions to the task, a prolonged phase of scavenging can also be interpreted as an expression of cognitive fixation. In contrast, a phase of exploration is characterized by free search, that is, when tiles are moved around with no explicit aim to produce a particular shape, and a prolonged phase of exploration could be interpreted as an expression of cognitive flexibility.

An algorithm detected transitions between exploration and exploitation phases based on move-by-move time differences (Hart et al., 2017), and segmented participants' game trajectories to exploration and scavenging phases (see the SI). Based on this segmentation, we computed the median length (measured by number of tiles moves, or steps) of exploration and scavenging phases, and represented each game as a 2D point in this space (see Figure 3). We denote these coordinates as the Scavenging-Exploration-Ratio (SER), with the angle SER-α representing the tendency to scavenge or to explore (with lower values indicative of more exploratory style), and the radius SER-R representing the tendency to have longer or shorter phases overall.

Fluency is operationalized as a count variable expressing the number of shapes saved to the gallery by a pair during the 20 minutes of game play. Notice that pairs were not instructed to save as many shapes as possible - but only to save a shape whenever they found it interesting and beautiful.

Finally, *Originality* is operationalized as the relative frequency of submitted shapes based on a large corpus of 11,000+ shapes collected across a number of games conducted in our lab. Less frequent shapes are considered more original.

To compare flexibility across the detected interaction styles, we build two Bayesian linear regression models (family = gaussian) with SER-α and SER-R (z-scored) as outcomes respectively, and interaction style (based on k-means clustering) as predictor. Similarly, for fluency we build a Bayesian Poisson regression model with the count of gallery shapes as outcome and the interaction style as the predictor. Last, since originality is not an aggregated variable but calculated for each individual shape, we used a multilevel model with shape frequency as outcome, interaction style as predictor, and random intercept by pair. Since the shape frequency data are heavily skewed towards low numbers we modeled it as a negative binomial, which based on prior predictive checks seemed to give the best fit. Full details on predictors and model quality checks are provided in the SI (https://osf.io/6tckf/?view_only=abea2029c2bf4e40a46961ddb8140333).

Differences between interaction styles for each game measure were tested relying on *Evidence Ratio* (ER): the ratio between the number of posterior samples compatible with a hypothesis to that of those incompatible. Usually, values below 3 indicate, at most, anecdotal evidence. Credibility is a complementary measure to ER, indicating the percentage of posterior samples supporting the hypotheses. All analyses and data visualizations were carried out based on the brms, tidyverse, factoextra, and patchwork packages for RStudio (Bürkner, 2018; Kassambara & Mundt, 2020; Pedersen, 2020; RStudio Team, 2020; Wickham et al., 2019).

Results

Flexibility. SER-α differs between conditions, with division-of-labor leaning more towards higher values (that is, more scavenging) (M = 50.91, SD = 9.96), followed by dominance (M = 48.17, SD = 12.55), while turn-taking has the lower angle thus leaning towards exploration (M = 31.84, SD = 12.07). Notice that in the analysis and visualizations, these values are z-scored. The difference between division-of-labor and dominance is moderately credible, β = -0.38, 95% *CI* = -1.09 0.33, *ER* = 4.86, *Credibility* = 0.83, and so is the difference between dominance and turn-taking, β = 0.62, 95%, *CI* = -0.36 1.58, *ER* = 5.6, *Credibility* = 0.85, while the difference between division-of-labor and turn-taking is stronger, β = 1.01, 95% *CI* = 0.01 1.98, *ER* = 19.40, *Credibility* = 0.95 (see Figure 5A).

SER-R also differed between interaction styles with dominance (M = 22.32, SD = 6.27) and division-of-labor (M = 22.60, SD = 6.92) pairs on average staying longer in phases of exploration and scavenging, compared to turn-taking (M = 16.72, SD = 4.56). These values are also z-scored in the visualizations and the analysis. The difference between dominance and division-of-labor is not credible, β = 0.1, 95% *CI* = -0.63 0.84, *ER* = 1.47, *Credibility* = 0.59. Neither is the difference between division-of-labor and turn-taking, β = 0.42, 95% *CI* = -0.64 1.51, *ER* = 2.91, *Credibility* = 0.74. However, the differences between dominance and turn-taking, β = 0.76, 95% *CI* = -0.28 1.80, *ER* = 8.30, *Credibility* = 0.89 is moderately credible (see Figure 5B).

Fluency. The number of gallery shapes also differed as a function of interaction style. Pairs whose interaction style was characterized by dominance had the highest fluency (M = 39.33, SD = 11.82), followed by division-of-labor (M = 34.90, SD = 10.78), and turn-taking (M = 26.33, SD = 9.45). Dominance pairs had credibly higher fluency than division-of-labor pairs, β = 3.79, 95% *CI* = 3.59 3.97, *ER* > 1000, *Credibility* = 1, and turn-taking, β = 4.08, 95% *CI* = 3.82 4.34, *ER* > 1000, *Credibility* = 1, and division-of-labor had credibly higher fluency than turn-taking, β = 0.29, 95% *CI* = 0.08 0.51, *ER* = 67.96, *Credibility* = 0.98 (see Figure 5C).

Originality. The frequency of shapes also differed between interaction types. Dominance pairs created the least original shapes (those with the highest average frequency, M = 19.21, SD = 22), followed by division-of-labor (M = 18.16, SD =

22.53), and turn-taking (*M* = 14.14, *SD* = 20.59). The difference between dominance and division-of-labor was not credible, β = 0.06, 95% *CI* = -0.11 0.24, *ER* = 2.35, *Credibility* = 0.70. However, the differences between dominance and turn-taking, β = 0.34, 95% *CI* = 0.01 0.72, *ER* = 20.50, *Credibility* = 0.95, and between division-of-labor and turn-taking, β = 0.28, 95% *CI* = -0.07 0.64, *ER* = 10.30, *Credibility* = 0.91, are moderately credible (see Figure 5D).

Discussion

We applied the Creative Foraging Game (CFG) to measure open-ended creative search at high-resolution in the context of collective creativity. We identified three naturally emerging social interaction styles when pairs played the CFG together: (1) *dominance* (one player makes most of the moves), (2) *division-of-labor* (participants alternate after each product) and, (3) *turn-taking* (participants alternate in every move). We find that turn-taking pairs behave differently from both dominance and division-of-labor pairs. Turn-taking pairs were more flexible: they showed a tendency to explore more (Figure 4A) and were quicker to exit scavenging or exploration phases (Figure 4B). Turn-taking pairs showed lower fluency (Figure 4C), however, collected more original (less frequent) products (Figure 4D). These results show how variability in naturally emerging social interaction affects unfolding collective creativity, with pairs that converge on a turn-taking interaction style being more flexible and creating more original products than pairs organizing their interaction in other ways.

The differences between dominance and division-of-labor pairs were less clear, with division-of-labor pairs showing a tendency toward more scavenging than dominance pairs, while dominance pairs showed higher fluency than division-of-labor pairs (with no effects on length of phases or originality). Our results contribute to the body of literature investigating how properties of social interaction impact the unfolding of collective creativity (e.g., Horwitz & Horwitz, 2007). A new emphasis of the current results is the possible advantage of turn-taking in collective creativity. Turn-taking is known to be correlated with positive outcomes of conversations (Haan et al., 2021), and other joint actions (Fusaroli et al., 2016). Turn-taking is also an intrinsic feature of known open-ended collective creative practices such as some forms of jazz (Berliner, 1994) and theater improvisation. For example, in theater improvisation actors are trained to build on each other's ideas using the 'Yes! and…' principle, and to add only one new unit of information in every turn (Johnstone, 2007; Spolin, 1999). With analogy to the current task, in theater improvisation actors are encouraged to move *only one tile each time* when they co-create.

A somewhat surprising result of the current paper is that turn-taking pairs show lower fluency. One possible explanation lies with the specifics of the CFG. Participants in the CFG have no lower or upper constraints on the number of shapes they can choose to save to the gallery, and -

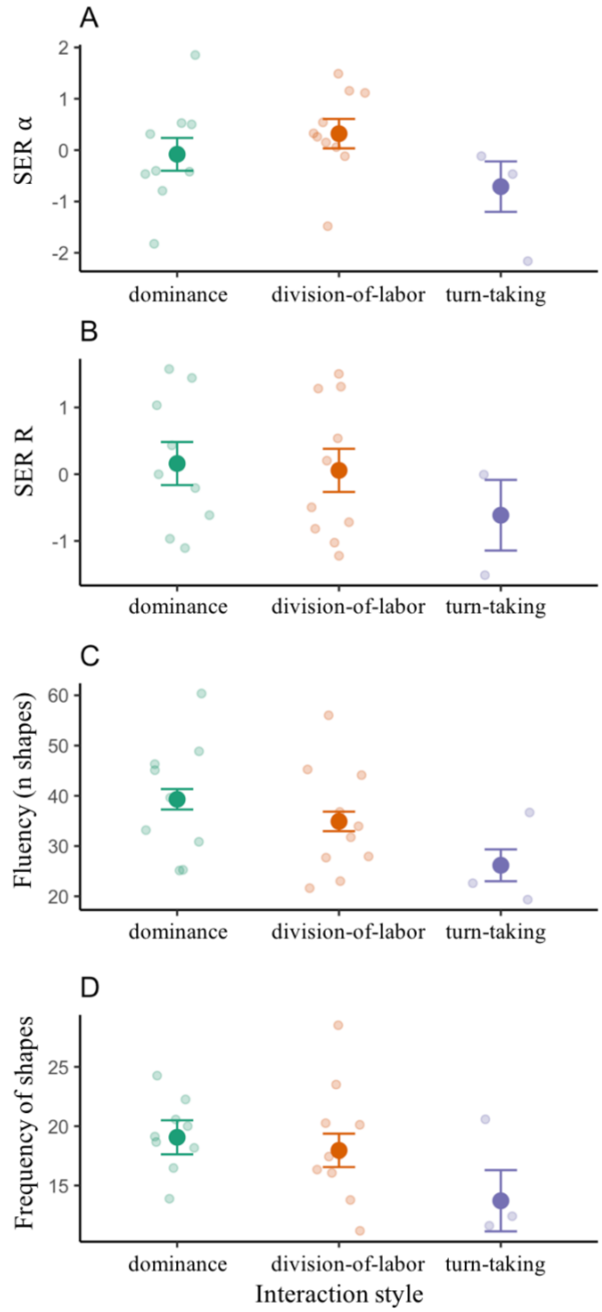

Figure 5: Results. The impact of interaction style on the four game measures. Posterior mean estimates and standard errors (error bars) are superimposed on the raw data each representing one pair/game. A: SER-α (z-scored). Higher values indicate a bias towards scavenging, while lower values indicate a bias towards exploration. B: SER-R (z-scored): Higher values indicate staying longer in exploration and scavenging phases, while lower values indicate quicker exits. C: Fluency (number of gallery shapes saved in each game). D: Originality measured as the average frequency of saved gallery shapes. Lower values (less frequent shapes) represent more original games.

contrary to the AUT - there is no instruction to save as many shapes as possible.

In principle, a participant could save only very few gallery shapes, or save a new gallery shape after every move. In practice, participants tend to save at low frequency in exploration phases, and at high frequency in scavenging phases, where they often rapidly collect a few similar shapes (see Figure 2). In fact, this pattern of behavior constitutes the base for the automatic algorithm that segments games into exploration and scavenging phases (Hart et al., 2017). This suggests a fluency/exploration trade-off in the CFG, and as a consequence, as turn-taking pairs perform more exploration, they collect less gallery shapes than dominance and division-of-labor pairs.

The low fluency of turn-taking pairs might also be explained by *production blocking*, which refers to any aspect of a group's dynamic that leads to a reduction in the number of products generated (Sawyer, 2012). For example, in brainstorming, the fact that only one person can speak at a time can be such a factor (Diehl & Stroebe, 1987). As turn-taking entails more transitions between the pairs, this overhead could be suspected to cause lower fluency.

An interesting aspect of the current results of turn-taking pairs is that despite their lower fluency, they show higher originality scores. This is surprising since existing literature has often found correlations between fluency and originality (Silvia, 2008; Torrance, 2008).

Together, our observations suggest a larger lesson for creativity research: collective creativity is not a 'one-size-fits-all' phenomena. While creativity has often been portrayed as a more or less stable property of an individual, our observations point to creativity as a phenomenon - at least partially - emergent upon the particular social context. Collective creativity can under some scenarios support crucial aspects of the creative process while hindering other aspects. For example, turn-taking seem to stimulate wider exploration leading to more original products, but on the expense of fluency. The reverse pattern (less originality and more fluency) is promoted with other social dynamics, for example dominance. In the current work these interaction styles occurred spontaneously within the activity. Future studies could try to impose specific scenarios, for example, by telling pairs to perform turn-taking or division-of-labor, and to test the effect of this manipulation on the creative process (McGraw et al., 2014).

Another line of inquiry concerns the psychological and dynamical factors that might lead to the emergence of different interaction styles in collective creativity. For instance, it can be speculated that attachment-orientations (the basic internal model of relationship) influence people's tendency to explore together with a partner, since according to the theory, the main function of the attachment system is to provide a safe base for future exploration. People with a secure attachment style should be more easily drawn to a turn-taking interaction style, while people who score high on avoidance attachment often display a strong sense of autonomy and self-reliance (Mikulincer & Shaver, 2016) and should be more attracted to dominance or division-labor interaction styles. A practical advantage of working with attachment tendencies is the existence of established tools for measuring (e.g., the ECR, Brennan et al., 1998), and experimentally manipulating attachment orientations (e.g., 'secure priming', Mikulincer et al., 2011). We speculate that participants' attachment orientation plays an important role in setting the creative products and process in the dyadic CFG, and more generally, in collective creativity.

Our discussion so far has focused on the behavior of pairs in the dyadic CFG, comparing different styles of interaction. Another interesting comparison is with individual participants playing the CFG alone. For example, looking at Figure 5D, we might expect individual participants to perform more similarly to dominance pairs (choosing fewer original shapes), than to turn-taking pairs (choosing more original shapes). However, it is an open question if individuals are more or less original than pairs. A likely answer is neither, that is, they will span the whole range of Figure 5D.

In other words, we believe that some styles of social interaction (e.g. dominance) might push pairs to behave similarly to a subgroup of individuals who tend to scavenge more and be less original, while other social interaction (e.g. turn-taking) will push pairs to behave like individuals who explore more and are more original (but less fluent). As hinted above, our position is that both of these types are important for creativity. At some phases of a creative process, it might be more beneficial to collect a lot of similar and useful solutions, while at other phases exploration and originality are more important. The current paper suggests that collective creativity can be honed to these different 'roles' by pushing the system to specific dynamics of creative interaction.

An important limitation of the current study is the unbalanced number of pairs belonging to the three interaction styles. Only 3/22 pairs were classified to belong to the turn-taking style, which warrants great caution when interpreting the results. Future studies should seek to replicate the setup to ensure that our observations are in fact driven by interaction style and not coincidental group compositions. In addition, the operationalization of interaction styles in this study is possibly only a rough approximation of what actually went on in the creative collaborations. A pair classified as having a "dominant" interaction style could in principle have a very dynamic collaborative style jointly deciding on every move of the tiles, while it is just one pair member that - out of convenience - performs the actual moves on the screen. It could thus be interesting to complement current analyses with measures representing pair members' verbal interactions (Fusaroli et al., 2016).

Last but not least, the CFG is a very open-ended task. Participants are not explicitly instructed to produce many or original shapes. It would thus be interesting to test other versions of the task varying the instructions, to investigate how interaction styles affect creative search also under more explicit constraints or different incentive structures.

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