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The Interpersonal Neural Coupling in Group Creative Ideation

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Group creative ideation, the capacity of group to produce novel and useful ideas, is essential for navigating challenges and embracing opportunities. Despite its significance, research to decode its neurocognitive underpinnings utilizing interpersonal neuroscience paradigm has just commenced, linking group creative ideation to interpersonal neural coupling. In this perspective, we propose an interpersonal neural coupling in group creative ideation framework, which suggests that group creative ideation is supported by interpersonal neural coupling within three interrelated systems: cognitive, affective, and physical alignments. The cognitive alignment system is considered as the core system that determines the outcome of group creative ideation. Variations in cognitive alignment spanning shared intention, joint attention, shared comprehension, and idea convergence interact with an individual decision making in selecting any of three creative ideation pathways, including flexibility, persistence, and convergence, which collectively determine the final creative performance. The interpersonal neural coupling in group creative ideation framework enhances our understanding of the neurocognitive underpinnings of group creative ideation and outlines promising avenues for future research.

Keywords: creativity, group creative ideation, neural coupling, hyperscanning, interpersonal neuroscience

"Logic will get you from A to B. Imagination will take you everywhere," said Albert Einstein. This statement highlights the importance of human imagination, particularly creative ideation, in driving innovation and progress by pushing the boundaries of what is known and possible. Throughout human history, group creative ideation has been a key driver of scientific discovery, technological advancement, and artistic expression, contributing significantly to cultural enrichment and societal progress. Group creative ideation refers to the collaborative process through which multiple (two or more) individuals generate novel and useful ideas or solutions for problems (Paulus & Brown, 2007; Paulus & Nijstad, 2003; Runco & Jaeger, 2012). This process involves the interaction, exchange, and integration of diverse perspectives and knowledge bases, which together enhance the creative output beyond what individuals can achieve alone. Although group creative ideation is prevalent and significant, the scientific journey to unravel its neurocognitive underpinnings has just commenced.

In the early 2010s, researchers attempted to indirectly uncover the neurocognitive basis of group creative ideation using conventional single-brain neuroscience paradigms (Fink et al., 2010, 2012). Two functional magnetic resonance imaging studies were conducted to simulate group creative ideation using a single-person cognitive stimulation paradigm and to investigate its neurocognitive underpinnings. Fink et al. (2010) reported that creative ideation can be enhanced through exposure to others' ideas, and this improvement in performance was linked to heightened activity in areas such as the right-hemispheric temporoparietal, medial frontal, and posterior cingulate gyrus. Fink et al. (2012) further confirmed that the temporoparietal brain regions, primarily right hemisphere, were particularly sensitive to others' common or moderately creative ideas.

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The research mentioned above provided valuable insights, yet faces two main limitations in elucidating the neurocognitive underpinnings of group creative ideation. Group creative ideas are not just a collection of individual creative efforts. Neuroscientific techniques and evidence that focus solely on individual creativity are insufficient to fully uncover the neurocognitive underpinnings of group creative ideation. The conventional paradigm of stimulating individual cognition fails to mimic real-life group creative ideation because it overlooks critical elements such as interpersonal interaction. Given this, it is reasonable to conclude that current neuroimaging findings may not match the neural underpinnings underlying group creative ideation. This urges the pursuit of more ecologically valid paradigms for group creative ideation. Taking inspiration from the interpersonal neuroscience perspective on social interaction (Hamilton, 2021; Hasson et al., 2012; Pan et al., 2022; Redcay & Schilbach, 2019), it is likely that group creative ideation can be better understood by examining both intrapersonal and interpersonal neural responses. This highlights the importance of using an interpersonal neuroscience approach, such as hyperscanning, to simultaneously record neural signals from multiple brains during group creative ideation. This approach may help to uncover the complex neural mechanisms underlying these processes, which might otherwise remain obscured.

In this study, we aim to integrate the burgeoning hyperscanning research in the neuroscience of group creative ideation within a comprehensive theoretical framework. First, we briefly review important new perspectives on group creative ideation, hyperscanning, and interpersonal neural coupling. We argue that the role of interpersonal neural coupling in group creative ideation (IncGC) is more extensive than previously assumed and that a coherent framework tailored specifically to group creative ideation is required. Second, we present the IncGC framework. This framework conceptualizes the neural basis of group creative ideation as multilayered interpersonal neural coupling involving cognitive, affective, and physical alignments. In addition, we consolidate current research on the neurocognitive basis of group creative ideation into the proposed framework, presenting it as supporting evidence. Last, we highlight how the IncGC framework enhances our understanding of the neurocognitive underpinnings of group creative ideation and outline promising avenues for future research.

Group Creative Ideation

Group creative ideation indeed builds upon the personal creative ideation processes of each individual within the group. Mednick's (1962) associative theory of creativity highlights the important roles of semantic memory structure and associative thinking in individual creative ideation. The search for ideas in associative memory model further assumes that idea generation involves reduplicative idea searching in associative memory and manifests itself in two stages: encompassing knowledge activation and idea production (Nijstad & Stroebe, 2006). Benedek et al. (2023) proposed the memory in creative ideation framework to describe the four stages of creative ideation: memory search, candidate idea construction, novelty evaluation, and effective evaluation. The framework highlights the role of semantic and episodic memory in each stage of creative ideation. For example, the process of generating ideas involves searching for relevant semantic and episodic information to retrieve concepts or specific details. Candidate ideas are then formulated by establishing connections between unrelated concepts or reconstructing information into a mental representation (Benedek et al., 2023). The aforementioned perspectives emphasize the role of memory as the foundation for creative ideation.

The dual pathway to creativity model offers additional insights into the processes that underlie individual creative ideation (Nijstad et al., 2010). According to this model, the origin of creative ideation is based on cognitive flexibility and persistence pathways or a combination of both. The flexibility pathway involves the use of various cognitive categories and perspectives, resulting in the generation of ideas across different domains. Conversely, the persistence pathway is evident in producing numerous ideas within limited categories or dedicating extended time to a task, focusing on knowledge and ideas relevant to a singular category.

Although group creative ideation is based on individual creative ideation, it is not simply a collection of individual creativity. For example, turn-taking behaviors, cognitive stimulation/interference (i.e., individual idea generation is affected by group interaction), and cognitive failures (i.e., a failure to generate a new idea, which may consist of either generating no idea at all or generating an idea that has already been mentioned) in intragroup communication can significantly affect the process of individual idea generation (Nijstad & Stroebe, 2006). The cognitive–social–motivational model of group ideation proposes that the group creative ideation process involves cognitive, motivational, and social factors. Cognitive factors include idea generation, memory retrieval, attending to others, and integrating previous ideas. Motivational factors include intrinsic motivation, competition, task goals, social facilitation, and matching. Social factors include information sharing and exchange, disputes, social comparison (i.e., members evaluate their ideas based on others' contributions), and conflict management. This model highlights how social–motivational factors influence individual creative ideation by affecting the amount of attention paid to group partners' ideas (Paulus & Brown, 2007; Paulus & Kenworthy, 2021). For instance, social comparison, which is a social factor, can impact an individual's motivation to share their own opinions or pay attention to others' viewpoints. This, in turn, can influence the process of individual creative ideation. Furthermore, the creative synthesis model emphasizes the importance of knowledge integration, proposing that group creativity stems from leveraging the group's diverse resources to develop a synthesized understanding of the problem, as opposed to promoting divergent views among individuals (Harvey, 2014). This synthesis generates specific exemplars that further evolve the synthesis.

These two models suggest that cognitive stimulation within groups prompts individuals to explore ideas that they would not have conceived independently, highlighting the unique advantages of group creative ideation over individual creative ideation. Therefore, in group creation, a group scenario may yield an additional pathway, which we refer to as the "convergence pathway." This pathway is evident in the development of ideas that combine one's own perspectives with those of others and has been faintly captured in recent research (Lu, Qiao, Yun, et al., 2021; Lu, Yu, & Hao, 2020). The scope of this notion is not as broad as that of the "information elaboration," which is defined as the exchange, individual-level processing, discussion, and integration of different perspectives and information (Hoever et al., 2012; van Knippenberg et al., 2004). It involves a sequence of interrelated processes, where higher order

processes depend on the completion of lower order processes. In contrast, the proposed "convergence pathway" focuses solely on the highest order component—integration of others' perspectives—without including the lower order processes. Although these subprocesses lay the groundwork for the integration of others' perspectives during group creative ideation, they do not guarantee it. Thus, we propose distinguishing these subprocesses from the "convergence pathway" and identifying the integration of others' perspectives as a distinct pathway for creative ideation, namely combining one's own ideas with those of others to generate new ideas.

In summary, these studies make a significant contribution to our understanding of group creative ideation. They show that this process goes beyond the cognitive mechanisms of individual creative ideation, which involve flexibility and persistence pathways, by introducing a potentially unique component: the "convergence pathway." This pathway, specific to group interaction, highlights the intricate interplay between individual and interpersonal cognitive processes in fostering group creativity. It is proposed that a triple-pathway perspective can clarify the dynamics of group creative ideation and provide a more insightful understanding of its neurocognitive underpinnings. In addition, it is suggested that all contributing factors shape group creative ideation through these three distinct pathways.

Given the differences between individual and group creative ideation, it is reasonable to assume that the traditional single-person brain imaging paradigm may not fully unravel the neural underpinnings of group creative ideation. This further underscores the necessity of introducing a novel neuroscience paradigm, such as hyperscanning, which can simultaneously record neural signals from multiple brains in the research of group creative ideation.

Hyperscanning and Interpersonal Neural Coupling

Hyperscanning involves simultaneously recording brain activity from multiple individuals during naturalistic or pseudonaturalistic social interactions (Cui et al., 2012; Piazza et al., 2020) using neuroimaging methods such as functional near-infrared spectroscopy, functional magnetic resonance imaging, electroencephalography, and magnetoencephalography. This technique has been applied in various fields, including intergroup conflict resolution (H. Zhang, Yang, et al., 2023), learning behavior (Davidesco et al., 2023; Pan et al., 2023), and information and emotional exchange (Balters et al., 2023; Dai et al., 2018; Ellingsen et al., 2023; Z. Liu, Lu, et al., 2023). Redcay and Schilbach (2019) highlighted the unique opportunities presented by transitioning from single- to multibrain neuroscience approaches for understanding the neurocognitive underpinnings of social interactions. Through quantifying interpersonal neural coupling—the synchronization of brain signals during social exchanges—which is expected to intensify especially during cognitive, affective, or behavioral interactions (Pan et al., 2022), researchers can gain deeper insights into the interplay of brains in social scenarios.

With the proliferation of hyperscanning research, attempts have been made to integrate these findings into theoretical frameworks. Interpersonal neural coupling involving diverse brain regions is linked to various facets of social alignment during social interactions (Pan et al., 2022; Shamay-Tsoory et al., 2019). Shamay-Tsoory et al. (2019) proposed three interconnected levels of social alignment: motor synchrony, emotional contagion, and cognitive conformity. Pan et al. (2023) viewed interpersonal neural coupling as the phase alignment of neural activities across individuals, which may also associate with interpersonal cognitive, emotional, and motor alignments and facilitate efficient interbrain information transfer. Shamay-Tsoory et al. (2019) further developed a multisystem neurofunctional model of social alignment with a feedback-loop structure. The gap-monitoring system (dorsomedial prefrontal cortex [PFC], dorsal anterior cingulate cortex, and anterior insula) assesses the level of approach or avoidance behaviors required for group alignment. The alignment system (inferior frontal gyrus, inferior parietal lobule, premotor cortex, and superior temporal sulcus) executes social alignment. The reward system (ventral striatum, orbitofrontal cortex, and ventromedial PFC) activates upon achieving alignment (Gvirts & Perlmutter, 2020; Shamay-Tsoory et al., 2019).

These insights highlight the association between enhanced interpersonal neural coupling and social alignment facets, such as cognitive, motor, and emotional alignments. Enhanced interpersonal neural coupling, which may indicate a state of social alignment, is believed to improve most social outcomes such as group cohesion (Yang et al., 2020; H. Zhang, Yang, et al., 2023), empathy between patients and clinicians (Ellingsen et al., 2023), social learning (Pan et al., 2023), and parent–child interaction (Davidesco et al., 2023).

Recent efforts have increasingly incorporated functional near-infrared spectroscopy-based hyperscanning paradigms into the group creative ideation process as well (Balters et al., 2023; Liang et al., 2022; Lu, Xue, Nozawa, et al., 2019; Mayseless et al., 2019; Müller et al., 2013; Müller & Lindenberger, 2019; H. Xue et al., 2018). These studies provided preliminary insights into the neurocognitive underpinnings of group creative ideation by linking it to interpersonal neural coupling. This intriguing phenomenon was observed not only in group creative ideation contexts involving generating alternative uses for common objects or solving knotty problems (He et al., 2023; Lu, Xue, Nozawa, et al., 2019; Mayseless et al., 2019) but also in those involving musical improvisation (Cheng et al., 2024; Gugnowska et al., 2022; Müller et al., 2013; Müller & Lindenberger, 2019, 2022; Ramírez-Moreno et al., 2023). Research shows a complex relationship between group creative ideation and interpersonal neural coupling, with some scenarios showing a positive correlation (Cheng et al., 2024; He et al., 2023; Lu, Yu, & Hao, 2020; Müller & Lindenberger, 2022) and others showing a negative correlation (Liang et al., 2022; Lu et al., 2021). Group creative ideation also involves interpersonal neural coupling in multiple brain areas, such as the bilateral frontal, parietal, and temporal cortex. A comprehensive theoretical framework is needed to integrate the growing literature and fully understand these complex findings.

As group creative ideation is a form of social interaction, it may also involve interpersonal cognitive, affective, and physical alignments, which accounts for the observed interpersonal neural coupling during group creative ideation. However, while social alignment such as cognitive alignment can foster creative responses by allowing individuals to attend to each other's diverging ideas and share a mutual understanding of those ideas, deviating from the "herding mode" is also crucial for group creative ideation. This deviation, crucial for thinking outside the box, refers to breaking away from groupthink and contributing individual unique insights to the group, catalyzing the emergence of more creative ideas. Accordingly, integrating theoretical frameworks of group creative ideation with insights into interpersonal neural coupling and social

alignments is essential for reinforcing and expanding our current understanding of the neurocognitive underpinnings of group creative ideation.

The IncGC Framework

Based on the aforementioned insights, the IncGC framework proposes that group creative ideation is also supported by interpersonal neural coupling within three interrelated systems: cognitive alignment (i.e., the alignment of one's cognitive processes such as intention, attention, thinking with those around), affective alignment (i.e., the alignment of one's emotions with the emotions expressed by those around), and physical alignment (i.e., the alignment in time of the behavior of two or more interacting individuals). The cognitive alignment system is considered as the core system that determines the outcome of group creative ideation. A reciprocal relationship between the interpersonal neural coupling within the cognitive alignment system and various levels of cognitive alignment encompassing intention, attention, comprehension, and convergence of ideas is suggested. Research has shown that collective commitment to a shared vision (i.e., shared intention) can significantly influence group creativity (Hülsheger et al., 2009; Lu, Xue, Nozawa, et al., 2019). To pursue the shared intention of group creative ideation — generating a wealth of creative ideas, group members must not only need to generate their own ideas but also pay attention to and comprehend each other's shared ideas (Kohn et al., 2011; Lu, Yu, & Hao, 2020; Paulus & Brown, 2007). This shared comprehension enables individuals to integrate their partners' ideas, foster creative ideas that they might not have conceived independently, and eventually contribute to group creative performance (Hoever et al., 2012; Kohn et al., 2011; Lu et al., 2021; Santos et al., 2015). During both creative and noncreative social activities, these cognitive alignment processes evoked different patterns of interpersonal neural coupling (Dai et al., 2018; Hirsch et al., 2017; Koike et al., 2016; J. Liu, Zhang, et al., 2023; Lu, Qiao, & Hao, 2019; Lu, Qiao, Yun, et al., 2021; Lu, Xue, Nozawa, et al., 2019). Despite the fact that interpersonal neural coupling underlying these cognitive alignment processes may, to some extent, also play a role in noncreative social activities, we should not underestimate their unique significance in harnessing the collective creativity of multiple individuals in group creative ideation.

During group creative ideation, members are also likely to engage in reciprocal affective and physical alignments. Regarding the emotional or affective aspects, emotion is closely linked to creative performance, with positive emotions enhance creativity through stimulating cognitive flexibility and negative emotions enhance creativity through cognitive persistence (De Dreu et al., 2008). Positive emotions such as joy, interest, contentment, and love can increase variety-seeking behaviors and broadens cognition, which are essential for creative ideation (Fredrickson, 2013). For instance, Duan et al. (2022) found that the lover dyads outperformed the stranger dyads in group creative ideation. Research also found that positive group emotion (collectively experienced emotion) contributed to group creative performance relative to neutral group emotion (Grawitch et al., 2003). They also reported that groups in which group members were induced to share a positive affective experience outperformed groups in other mood conditions on a creativity task (Tsai et al., 2012). Further research indicated that both positive and negative shared/group emotions impact group creative performance (Tsai et al., 2012).

Concerning the physical aspects, research indicated that physical gestures or movements can affect creative performance. For instance, individuals walking freely outperformed those walking in a fixed route on creativity tasks (Slepian & Ambady, 2012). The behavior of tracing fluid drawings or breaking the wall in virtual reality facilitated creative ideation (Leung et al., 2012; X. Wang et al., 2019). A nonsedentary work configuration, encouraging standing rather than sitting in the course of work, led to better information elaboration and better creative performance (Knight & Baer, 2014). Moreover, acting in synchrony with others could serve as a solution to motivate group members, especially for those in free-rider problem-facing groups, to contribute toward the collective goals (Wiltermuth & Heath, 2009). Research showed that male–male dyads exhibited greater creativity after experiencing sensorimotor coordination, whereas female–female and mixed-gender pairs exhibited greater creativity after the solo condition (Gaggioli et al., 2019). Nonverbal information, such as physical gestures and interpersonal spatial distance could be exchanged among members during group creative ideation (X. Wang, Lu, et al., 2022). A closer interpersonal spatial distance and more direct eye contact could foster greater group creativity (X. Wang, Lu, et al., 2022). The lack of in-person communication also impacted the neurocognitive process of group creative ideation (Balters et al., 2023; Lu, Yu, & Hao, 2020).

The current knowledge indicates that affective and physical alignments are related to interpersonal neural coupling in various regions (Z. Liu, Lu, et al., 2023; Nozawa et al., 2019; Pan et al., 2023; X. Wang, Lu, et al., 2022). Therefore, during group creative ideation, the interpersonal neural coupling may also support affective and physical alignments between members. These two aspects of social alignment will jointly influence the interpersonal neural coupling within the cognitive alignment system and further cognitive processes and creative performance. We suggest a reciprocal relationship between the cognitive, affective, and physical alignment systems (Pan et al., 2022; Shamay-Tsoory et al., 2019). Increases in affective or physical alignment typically enhance cognitive alignment, and vice versa, which has been supported by a substantial body of evidence (Barsade, 2002; Hawk et al., 2012; Kaplan et al., 2009; Leander et al., 2011; Páez et al., 2015). For instance, physical alignment boosts cognitive alignment and vice versa (Kaplan et al., 2009; Leander et al., 2011).

Based on the abovementioned research, we underscore the crucial roles of cognitive, affective, and physical alignment systems and their underlying IncGC. By focusing on these alignments within the context of group creative ideation, this model can contribute to a deeper understanding of the neurocognitive mechanisms that drive group creative ideation and provide practical insights for enhancing group creative performance. However, given that the cognitive alignment system is central to the IncGC framework and to simplify the model content to increase readability, we aim to focus on the cognitive alignment system and its role in interpersonal neural coupling during group creative ideation.

We further propose that there are three ideation pathways (flexibility, persistence, and convergence pathways) in group creative ideation, which collectively determine the group's creative performance. There may be a reciprocal interaction between the cognitive alignment system and the individual decision making related to the selection of ideation pathways. The cognitive alignment system also feeds into the individual execution of these ideation pathways,

especially for the convergence pathway. Following the endeavors in ideation pathways, the experience of generating an idea in mind or not and exposure to others' ideas may, in turn, influence the individual decision of ideation pathway, the relevant cognitive alignment, and the individual execution of ideation pathways, thereby affecting subsequent group creative performance (see Figure 1). We suggest that this model does not end with whether a group member generates an idea in his/her mind. Once an idea emerges, the group member may evaluate its originality and usefulness before deciding whether to share it with their group members.

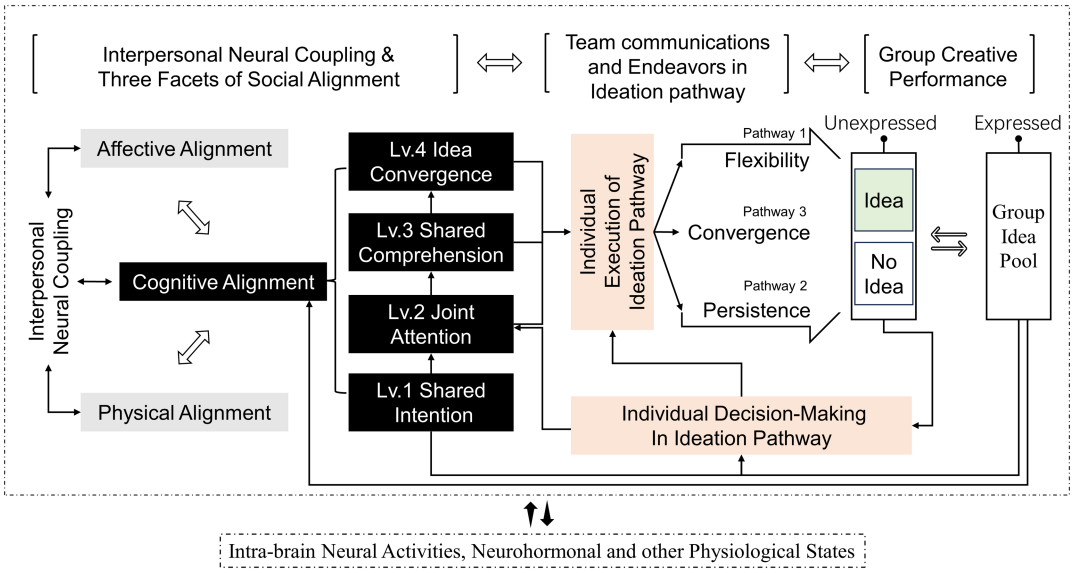
We also underscore the potential role of the neurohormonal modulation of creative ideation and interpersonal alignment within the IncGC framework. Mounting evidence indicates that the frontal and striatal dopaminergic pathways modulate human creative ideation via regulating cognitive flexibility and persistence, respectively (Beversdorf, 2019; Boot et al., 2017; W. Zhang et al., 2020). The norepinephrine was also assumed to play a role in modulating human creative ideation (Beversdorf, 2019; Lin & Vartanian, 2018). Moreover, previous research suggested that interpersonal neural coupling possibly interacts with neurohormones and other physiological states (Gvirts & Perlmutter, 2020; Pan et al., 2022). The administration of oxytocin stimulated interpersonal coordination behaviors and interpersonal neural coupling amid social coordination (Arueti et al., 2013; Launay et al., 2016; Mu et al., 2016). Accordingly, it is reasonable to assume the potential impacts of neurohormones on relative interpersonal neural coupling, creative ideation process, and interpersonal interaction amid group creative ideation.

Cognitive Alignment and Interpersonal Neural Coupling

This framework is centered around the cognitive alignment system and presumes a hierarchical structure encompassing various levels of cognitive alignment: shared intention, joint attention, shared comprehension, and idea convergence (see Figure 2). The cognitive alignment system emphasizes interpersonal coordination through shared intention (here, collaborative creative ideation). Shared intention drives individuals to focus on shared information, forming joint attention. In other words, shared intention guides attention, leading to joint attention. Only with joint attention can group members establish shared comprehension and achieve idea convergence. Therefore, we arranged shared intention, joint attention, shared comprehension, and idea convergence from Level I to Level IV, respectively. The following contents will elucidate this hierarchical cognitive alignment structure and showcase relevant research on interpersonal neural coupling during group creative ideation as supporting evidence.

Figure 1

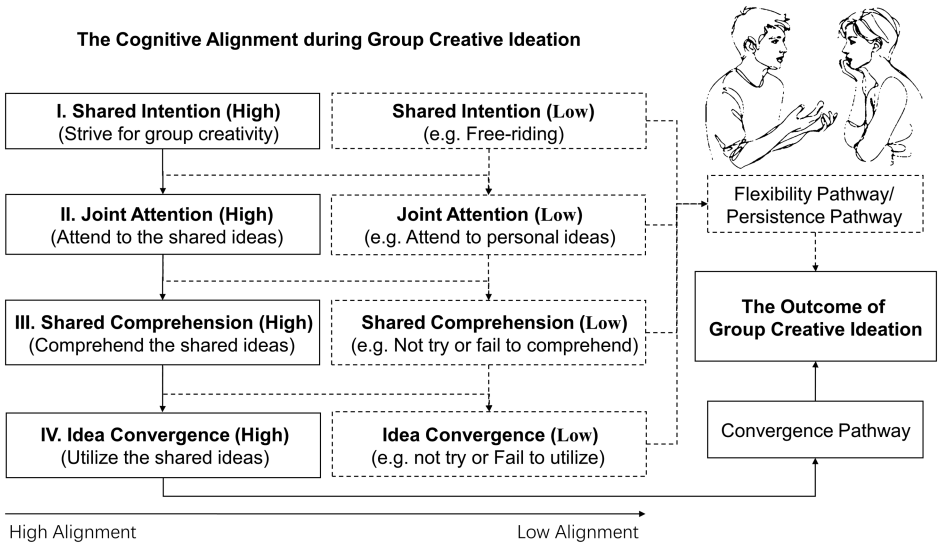
The Interpersonal Neural Coupling in Group Creative Ideation Framework



Note. The interpersonal neural coupling in group creative ideation framework suggests that group creative ideation is supported by interpersonal neural coupling within three interrelated systems: cognitive, affective, and physical alignments. Central to this is cognitive alignment, compassing various levels such as intention, attention, comprehension, and convergence of ideas, each associated with specific interpersonal neural coupling. The cognitive alignment processes interacted with an individual's decision making in selecting three creative ideation pathways, which collectively determine the final outcome of group creative performance. Individual experience of generating an idea in mind or not and exposure to others' ideas when the partners report their ideas may, in turn, influence the cognitive alignment system (which may further influence the affective and physical alignment systems), individual decision making in selecting ideation pathways, and following individual execution of ideation pathways, thereby affecting the subsequent group creative performance. Furthermore, the intrabrain neural activities, neurohormonal, and other physiological states may influence the association between interpersonal neural coupling and group creative performance. Lv. = level. See the online article for the color version of this figure.

Figure 2

The Hierarchical Structure of Cognitive Alignment During Group Creative Ideation



Note. This hierarchical structure consists of four levels: shared intention, joint attention, shared comprehension, and idea convergence. The achievement of these four levels, as illustrated in the solid line box, indicates a higher degree of cognitive alignment and contributes to group creative performance through the convergence pathway. Higher levels of alignment build upon the lower ones. If alignment is not achieved, as illustrated in the dotted line box, interpersonal cognitive alignment would be low. In this case, group members can also contribute to group creative performance through the ideation pathway of flexibility or persistence.

Level I: Shared Intention

The cognitive alignment hierarchy is structured on the interpersonal shared intention or intention alignment. During group creative ideation, group members are required to establish a shared intention—focusing on generating as many creative ideas as possible together—to achieve a high level of group creative performance. A shared intention for group creative performance elicited a higher level of interpersonal neural coupling in the dorsolateral PFC (r-DLPFC) between group members, compared to a condition where they strive for personal superiority during creative ideation (Lu, Xue, Nozawa, et al., 2019; Yin et al., 2023). Research utilizing a three-person hyperscanning paradigm, where one member was a confederate pretending to undertake the creative ideation task, also confirmed the relation between shared intention and interpersonal neural coupling in the DLPFC (Lu & Hao, 2019). When both the real participants and the confederate present in the same room and nominally interacting, an increase in interpersonal neural coupling was observed only between the bilateral DLPFC of two real participants who shared the intention to generate creative ideas.

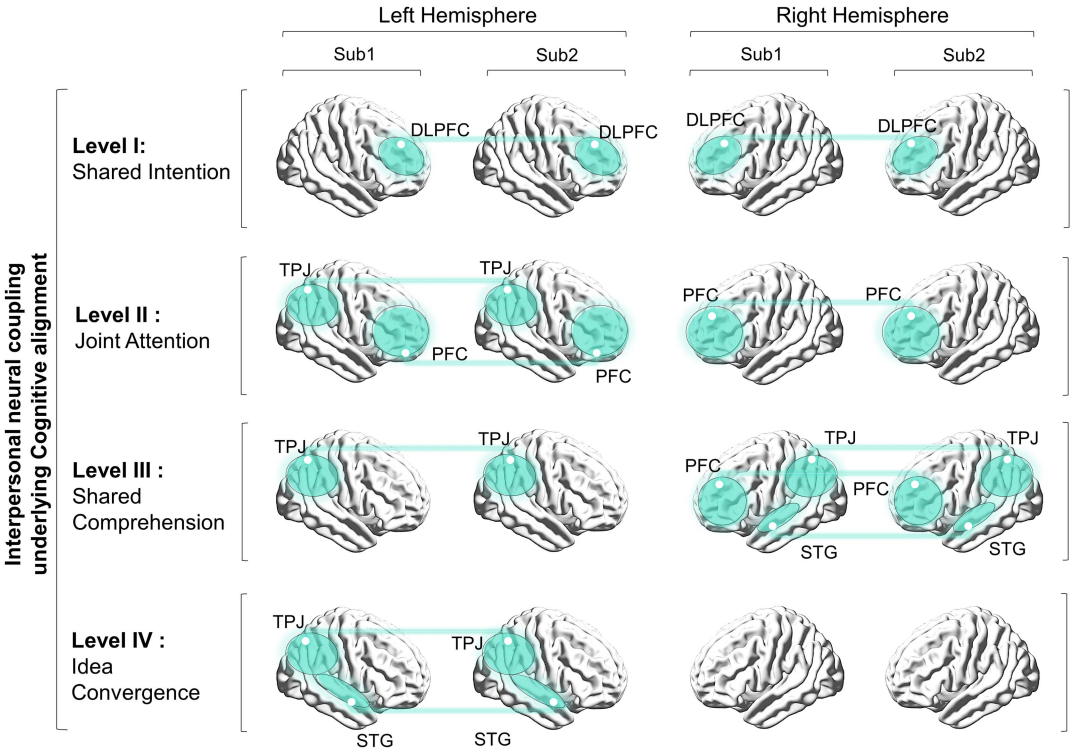
The PFC, especially the DLPFC, is linked to top-down control processes, usually guided by an intention or internal states (Miller & Cohen, 2001). Stimulating the DLPFC could selectively enhance intention-based decisions (Nihonsugi et al., 2015). A shared intention between individuals was linked to an increase in interpersonal neural coupling of the DLPFC, which was absent when individuals performed identical tasks independently, reflecting a similar but not shared intention (Fishburn et al., 2018). Accordingly, we suggest that interpersonal neural coupling in the DLPFC may underpin the establishment of the shared intention between group members during group creative ideation (see Figure 3). This interpersonal neural coupling assists in the establishment and maintaining of the interpersonal shared intention, thereby laying a foundation for group creative ideation.

Level II: Joint Attention

After establishing the shared intention, group members must focus on the creative ideation task and utilize diverse resources and information to generate creative ideas. Group members can attend to both the information shared by their partners (joint attention) and their own memory repositories (self/internal attention). Here, we used the term "joint attention" to indicate that individuals attend to their partners' ideas or perspectives, which reflects a higher level of cognitive alignment than the internal attention. Research has, to some extent, shown that joint attention is related to enhanced interpersonal neural coupling between group members. During group creative ideation, female dyads exhibited more joint attention between group members and a higher level of interpersonal neural coupling in the right temporal–parietal junction (TPJ) compared to male or opposite-sex dyads (Lu, Teng, & Hao, 2020). Lover dyads attended more frequently to their partner's ideas and also exhibited higher interpersonal neural coupling in the PFC and right TPJ compared to stranger opposite-sex dyads (Duan et al., 2022). Moreover, expressing praise during group creative ideation focused more group members' attention on the ideas being praised and increased interpersonal neural coupling in the PFC (Lu, Qiao, & Hao, 2019). The PFC is linked to the executive control of attention (Miller & Cohen, 2001; Rossi et al., 2009). The right TPJ has

Figure 3

Interpersonal Neural Coupling That Underlies the Hierarchical Structure of Cognitive Alignment During Group Creative Ideation



Note. It shows the interpersonal neural coupling that underlies different levels of cognitive alignment between two individuals. Four levels of interpersonal cognitive alignment are proposed to be supported by specific interpersonal neural coupling. Here, this figure only demonstrates the interpersonal neural coupling between the same brain regions of individuals. Sub1 and Sub2 represent two individuals. DLPFC = dorsolateral prefrontal cortex; TPJ = temporal–parietal junction; PFC = prefrontal cortex; STG = superior temporal gyrus; sub = subject. See the online article for the color version of this figure.

also been repeatedly reported to relate to attentional reorienting (Mitchell, 2008). Koike et al. (2016) also found that joint attention fosters interpersonal neural coupling in the PFC during eye contact, especially after joint work.

During group creative ideation, aligning the group members' attention on shared information or ideas may be supported by the enhanced interpersonal neural coupling in the bilateral PFC and right TPJ (see Figure 3). Note that task performance of noncreative interpersonal interaction activities such as cooperative button pressing (Cui et al., 2012), drumming (T. Liu et al., 2021), or lectures (Silbert et al., 2014), usually relies on interpersonal joint attention. However, group creative ideation requires not only joint attention to integrate diverse perspectives from multiple individuals but also self/internal attention to access personal memory repositories, independently explore ideas, and share unique insights with partners. Group members have to alternate between the states of joint attention and internal attention, intermittently engaging in and disengaging from joint attention. Therefore, we highlight the importance of joint attention and its underlying IncGC, though a linear relationship between the interpersonal neural coupling underlying joint attention and better group creative performance cannot be assumed.

Level III: Shared Comprehension

Only when individuals had access to joint attention, they were able to process and subsequently comprehend their partner's shared ideas. It is suggested that the ability of individuals to comprehend each other's ideas depends on the clarity of those ideas. When ideas are straightforward, particularly those with low or moderate creativity, achieving shared comprehension between individuals becomes simple. Individuals may be exposed to complex or abstract ideas that can be challenging to comprehend or interpret, particularly for those with high creativity, making the achievement of shared comprehension challenging (Johnson & Proudfoot, 2024). In this case, individuals may require a certain level of knowledge or information to understand these ideas (Lu et al., 2021; H. Xue et al., 2018). Otherwise, gaps in understanding are likely to arise and hinder the mutual comprehension between group partners.

Previous research has provided evidence supporting the relationship between shared comprehension and interpersonal neural coupling during group creative ideation. Dyads engaging in designing a product, during which achieving shared comprehension regarding the product is crucial, exhibited increased interpersonal neural coupling between the left PFC, TPJ, and superior temporal

gyrus (Mayseless et al., 2019). H. Xue et al. (2018) found that dyads comprising one high-creative individual and one low-creative individual exhibited less idea convergence behavior and lower interpersonal neural coupling in the PFC and right TPJ during group creative ideation compared to dyads of two low-creative individuals. The difference in creativity in the high–low dyads makes it difficult for the less-creative member to understand the ideas of the highly creative member (H. Xue et al., 2018). Another research found that dyads comprising individuals with different educational backgrounds exhibited less interpersonal neural coupling in the right TPJ amid group creative ideation compared to dyads consisting of individuals with similar educational backgrounds (Lu et al., 2021). Moreover, conflict of views emerging during group creative ideation was observed to relate to a reduction in the interpersonal neural coupling in the left PFC and right TPJ (Liang et al., 2022). They suggested that such a decrease in interpersonal neural coupling during group creative ideation might be due to factors such as the difficulty in understanding creative ideas, which could be improved via bridging the knowledge gap (Liang et al., 2022).

The neural basis of auditory language comprehension may involve brain regions such as the left PFC (especially the left inferior frontal gyrus) and left superior temporal gyrus (Friederici, 2011). The left inferior frontal gyrus was reported to be associated with evaluating the idea originality (Kleinmintz et al., 2018). The lateral PFC (especially DLPFC) contributed to retrieving schema-incongruent information, highlighting its role in facilitating the modulation of personal schemas (Brod et al., 2015). This may assist in processing others' information incongruent with personal schemas, supporting the achievement of interpersonal shared comprehension. The angular gyrus (part of the TPJ) functions as a cross-modal hub, integrating converging multisensory information to comprehend and give sense to events, manipulate mental representations, and reorient attention to relevant information (Seghier, 2013). These findings suggest that interpersonal neural coupling involving regions such as the left PFC, superior temporal gyrus, and bilateral TPJ may play a crucial role in facilitating shared comprehension between individuals during group creative ideation (see Figure 3).

Level IV: Idea Convergence

Given that the primary goal of group creative ideation is to integrate diverse perspectives from different individuals, we propose that idea convergence represents the highest level of cognitive alignment. Idea convergence is a process where different ideas are blended into a more comprehensive or improved idea. Building upon shared comprehension, group members are capable of leveraging idea convergence to facilitate their own creative ideation process. Although it is possible that "one may misunderstand someone else's idea entirely but still be cognitively stimulated by it and build on the idea in further idea generation," we suggest that, in most cases, shared comprehension is necessary for idea convergence. Previous research has shown a connection between idea convergence and interpersonal neural coupling in the right TPJ (Duan et al., 2022; Lu, Xue, et al., 2019; Lu, Qiao, Yun, et al., 2021; Lu, Yu, & Hao, 2020; H. Xue et al., 2018) and right superior temporal gyrus (Lu et al., 2023). The right TPJ (especially the angular gyrus) is critical for divergent thinking and serves as a core hub in the default network, which involves the automatic generation of candidate responses during creative thinking (Beaty et al., 2016; Pick & Lavidor, 2019). Research reported that the creative ideation process activated the right TPJ, and this activation was further enhanced when individuals engaged in creative ideation following being exposed to others' ideas (Fink et al., 2010). The right superior temporal gyrus is responsible for selectively accessing and integrating conceptual representations (Shen et al., 2017). Accordingly, we assume that the interpersonal idea convergence during group creative ideation may be underpinned by the interpersonal neural coupling involving the right TPJ and superior temporal gyrus (see Figure 3).

It is imperative to acknowledge that endeavors in idea convergence do not invariably result in the generation of creative ideas. For one thing, in the pursuit of creative ideas through idea convergence, individuals may struggle with obstacles such as difficulty in utilizing others' ideas, creative exhaustion (i.e., an inability to continue generating creative solutions on one's own), or cognitive fixation, which can hinder the generation of new creative ideas. For another, even when such an endeavor yields an idea, one may still consider this idea uncreative, which may discourage him/her from sharing it. This may account for the absence of correlation between idea convergence and relative interpersonal neural coupling, as noted in previous research (Lu, Qiao, & Hao, 2019; Lu, Teng, & Hao, 2020; Lu & Hao, 2019).

It should be noted that the underlying interpersonal neural coupling of these four levels of cognitive alignments requires some overlapping brain regions. For instance, the interpersonal neural coupling in the right superior temporal gyrus is linked to both interpersonal shared comprehension and idea convergence. We suggest that although such interpersonal neural coupling involves an identical area, it may play diverse roles in different levels of interpersonal cognitive alignments due to its multifunctionality. Therefore, the right superior temporal gyrus can be involved in higher level interpersonal idea convergence as well as lower level interpersonal shared comprehension.

Triple Pathways to Group Creativity

To elucidate the complex associations between interpersonal neural coupling and group creative performance, we also proposed a triple-pathway model for group creative ideation (see Figure 1). We assume that there are three ideation pathways in group creative ideation, which collectively determine the group creative performance. Group members can generate creative ideas through any of these three ideation pathways: the flexibility pathway, which involves generating ideas from multiple conceptual categories; the persistence pathway, which involves generating ideas through in-depth explorations within a few conceptual categories; and the convergence pathway, which involves combining one's own ideas with those of others to generate new ideas. The flexibility and persistence pathways refer to individual ideation pathways, whereas the convergence pathway refers to a collective ideation pathway.

There has been a few neuroscientific evidence and models to speculate how processes related to the flexibility and persistence pathways are grounded in the brain. The left inferior frontal gyrus has been found related to divergent thinking and other tasks that demand cognitive flexibility (Chávez-Eakle et al., 2007; Mayseless & Shamay-Tsoory, 2015). The left DLPFC is linked to persistence-processing processes (W. Zhang et al., 2020). The posterior inferior parietal brain regions are proposed to support spontaneous thought processes such as mind wandering, which are thought to reflect a

more flexible state (Beaty et al., 2019; Golchert et al., 2017). W. Zhang et al. (2020) suggested that the strong activation of left inferior frontal gyrus along with weak activation of the left DLPFC and right posterior parietal cortex (e.g., the angular gyrus) or right superior temporal gyrus contributes to cognitive flexibility, whereas the neural pattern, which consists of weak activation of the left inferior frontal gyrus along with strong activation of both left DLPFC and right-hemispheric structures, is associated with persistence. Accordingly, the flexibility and persistence pathways may be grounded in the interplay between the left PFC and right temporal–parietal regions. As for the convergence pathway, given that it heavily depends on interpersonal shared comprehension and idea convergence, we suggest that this collective ideation pathway should be mainly grounded in the interpersonal neural coupling underlying these two types of cognitive alignments.

Moreover, evidence links individual decisions on selecting the flexibility pathway or persistence pathway for generating creative ideas with activation in the fronto-striatal circuitry, which consists of several interconnected brain areas. Among these areas, two are particularly linked to creativity: the striatum and the PFC (Boot et al., 2017). The subcortical striatum is involved in flexibility-supporting processes such as updating goal representations and shifting strategies (Ikemoto, 2007; Kehagia et al., 2010). The PFC is involved in persistence-supporting processes such as controlled manipulation of information and executive functioning (Benedek et al., 2014; Metuki et al., 2012). We suggest that this fronto-striatal circuitry may also underlie individual decision process of selecting a specific ideation pathway to generate creative ideas during group creative ideation. Nevertheless, the precise neural underpinnings of this decision making in selecting ideation pathways and specific ideation pathways remain to be further elucidated.

Several factors such as personal preference for ideation pathway, evaluation of others' ideas, prior experience with ideation pathways, creative exhaustion, and others can also influence this decision. Obviously, individuals are more likely to select a specific ideation pathway based on their personal preferences. In terms of the evaluation of others' ideas, if group members judge the quality of their partners' shared ideas negatively, they may prefer individual ideation pathways (flexibility and persistence) over the convergence pathway (Zhou et al., 2019). Prior experience with ideation pathways, success or failure in producing ideas through a specific ideation pathway may influence an individual's expectation of the likelihood of generating ideas through this pathway, thereby influencing his/her inclination to further utilize this pathway provisionally (G. Xue et al., 2010; Yechiam & Busemeyer, 2005). Concerning creative exhaustion, research suggests that when individuals experience this state, the use of examples to enhance creative ideation becomes more pronounced (Yuan et al., 2021, 2022). This may indicate that individuals are more willing to seek out others' perspectives for creative ideation when they are incapable of generating creative ideas on their own provisionally. From this perspective, group members are more likely to select the flexibility or persistence pathway during the early phase of group creative ideation and the convergence pathway during the later phase. Other factors like personal traits such as openness to experience and preference for teamwork may also shape individual selection of ideation pathways (Homan et al., 2008; Shaw et al., 2000; H. Wang, Rispens, & Demerouti, 2022). In addition, given that positive and negative emotions enhance creativity through stimulating cognitive flexibility and persistence, respectively (De Dreu et al., 2008), the hedonic tone (whether positive or negative) of individually experienced or shared emotion may also affect the selection of ideation pathways.

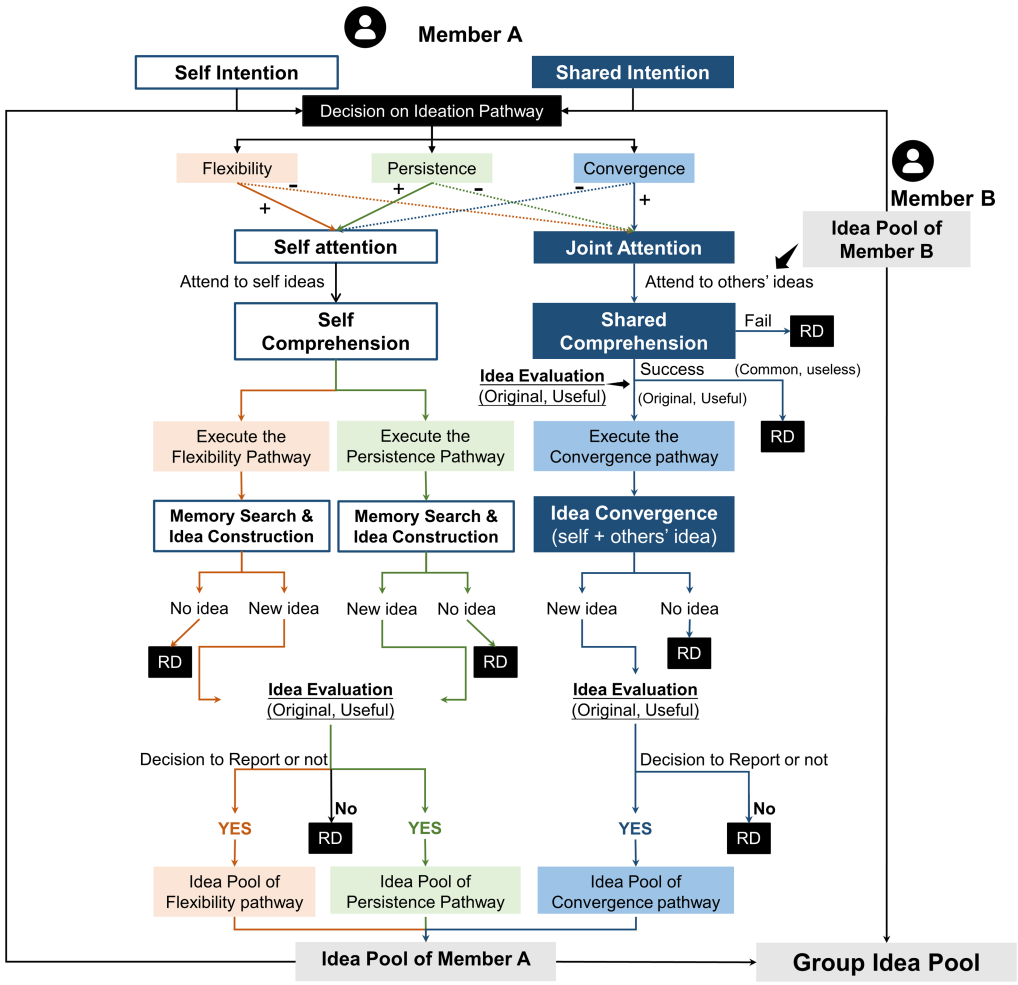
We also suggest that there may be a reciprocal interaction between the cognitive alignment system and individual decision making in selecting ideation pathways (see Figure 4). Specifically, the establishment of a shared intention may drive group members to generate their own ideas while also considering how to effectively utilize their partners' shared ideas. This makes it more likely for group members to select the convergence pathway, though they are not bound to select it. Conversely, if group members only aim to gain a competitive advantage by surpassing others, or are even not interested in the partners' shared idea, they are more likely to avoid referencing others' ideas, thereby reducing the use of the convergence pathway (Lu, Xue, et al., 2019). Following the decision, individual attentional resources will be allocated to self attention and joint attention. These two types of attention are always present during the group creative ideation process, albeit in varying degrees. Once group members select the flexibility or persistence pathway, more attentional resources will be allocated to self attention. If the convergence pathway is selected, more attentional resources will be allocated to joint attention. This further determines whether group member will take time to comprehend (shared comprehension) and even incorporate others' ideas (idea convergence).

In addition, the components of cognitive alignment system, especially joint attention, shared comprehension, and idea convergence, also feed into the individual execution of these ideation pathways. Both joint attention and shared comprehension subserve all three ideation pathways during group creative ideation. For the flexibility or persistence pathway, although group members do not need to fully focus on and thoroughly comprehend others' ideas for further interpersonal idea convergence, they still need to expend some cognitive resources to attend to and comprehend others' ideas, helping them avoid duplicating reported ideas. For the convergence pathway, joint attention, shared comprehension, and idea convergence all lay the foundation for group members to integrate others' ideas with their own.

Following the endeavors in ideation pathways, group members either succeed in generating nonredundant creative ideas or not. We propose that factors such as cognitive exhaustion, fixation, cognitive load, time pressure, and self-efficacy significantly influence the ability of group members to generate creative ideas (Camarda et al., 2018; Lucas & Nordgren, 2020; Redifer et al., 2021; Yuan et al., 2022; Y. Zhang, Qu, et al., 2023). For instance, as the task progresses, cognitive exhaustion intensifies, making it progressively more challenging for individuals to generate new creative ideas (Yuan et al., 2022). We suggest that this model does not end with whether a group member generates an idea in his/her mind. Once a new idea emerges, the group member will evaluate its originality and usefulness before deciding whether to share it with their group members. For instance, one may consider the emerged idea uncreative, which may discourage him/her from sharing it. In addition, the very act of sharing ideas makes individuals feel self-disclosing (Goncalo & Katz, 2020). In this case, even if the emerged idea is highly novel, individuals may hesitate to share it out of concern that revealing such thoughts may make them appear odd or "rock the boat."

Figure 4

The Simulation of the Individual Creative Ideation Process During Group Creative Ideation



Note. It shows the interaction between the interpersonal cognitive alignment system, individual decision and execution ideation pathways, and group creative performance. We assume that the ideation processes of different members are generally similar, thereby only presenting the ideation process of Member A as an example. To simplify the simulation process, we assume that individual intention remains stable throughout the task. Whether a shared intention established between Members A and B may drive them to select different ideation pathways, which further influence the allocation of attentional resources (self attention vs. joint attention). In the case of the convergence pathway, a high level of joint attention allows Member A to comprehend and evaluate the ideas of Member B. If Member A successfully comprehends the ideas of Member B and evaluates them as highly creative, Member A will execute the convergence pathway to pursue idea convergence. Otherwise, Member A will return to the decision-making process in selecting ideation pathways. In the case of the flexibility or persistence pathway, Member A will pay more attention to their own mind, search relative memory, and construct candidate ideas. Note that a certain level of joint attention and shared comprehension is necessary for Member A to avoid duplicate Member B's shared ideas. Following the endeavors in any of these ideation pathways, Member A either succeeds in generating nonredundant creative ideas or not. Once a new idea emerges, Member A will evaluate its originality and usefulness before deciding whether to share it with their group members. If Member A fails to generate a nonredundant creative idea or decides not to report the emerged idea, Member A will return back to the decision process. Otherwise, the reported idea of Member A will affect the creative ideation process of both Members B and A. RD in the black rectangle denotes redeciding the selection of ideation pathways. Note that in our effort to succinctly describe the individual creative ideation process within group creative ideation, we presented the stages in a clear sequential order with boundaries. However, this structured approach may not fully capture the complexity of real-life group creative ideation, where the process is often more fluid and dynamic. See the online article for the color version of this figure.

Eventually, individual experience of generating an idea in mind or not and exposure to others' ideas when the partners report their ideas may, in turn, influence the cognitive alignment system (which may further influence the affective and physical alignment systems), individual decision making in selecting ideation pathways, and following individual execution of ideation pathways, thereby affecting the subsequent group creative performance (see Figure 1).

Conclusion

The IncGC framework presents an intricate understanding of the group creative ideation. This framework suggests that the process is supported by three interconnected systems of interpersonal neural coupling: cognitive, affective, and physical alignments. Each system has a unique function in the group creative ideation. Cognitive alignment, which is regarded as the central system, is influenced by various levels of shared intention, joint attention, shared comprehension, and idea convergence. Empirical studies have shown that these cognitive processes evoke distinct patterns of interpersonal neural coupling during group creative ideation. Shared intention may be underpinned by interpersonal neural coupling in DLPFC. Joint attention may be relative to interpersonal neural coupling in the bilateral PFC and right TPJ. Shared comprehension also involves interpersonal neural coupling in the left PFC, superior temporal gyrus, and bilateral TPJ. Idea convergence involves regions such as the right TPJ and superior temporal gyrus. In addition, the IncGC framework proposes a triple-pathway model for group creativity: the flexibility pathway, persistence pathway, and convergence pathway. We propose a reciprocal interaction between the cognitive alignment system, individual decision making in selecting ideation pathways (also influenced by other various factors), and individual execution of ideation pathways. Individual experience of generating an idea in mind or not and exposure to others' ideas when the partners report their ideas will, in turn, influence the cognitive alignment system and the selection and execution of ideation pathways, thereby affecting the subsequent group creative performance.

This framework aims to provide explanations for the complex findings of hyperscanning studies of group creative ideation. It specifically addresses the interrelations among interpersonal neural coupling, ideation pathways, and group creative performance. Furthermore, it highlights the necessity of linking different cases of interpersonal neural coupling to cognitive alignments and ideation pathways, assisting in uncovering the neurobehavioral underpinnings that support group creative ideation. For instance, according to this framework, the emergence of conflict of views or difficulty in comprehending partners' ideas may motivate group members to neglect partners' ideas and rely on flexibility or persistent ideation pathways to generate creative ideas. This will result in a low level of cognitive alignment such as joint attention and shared comprehension, which can be reflected by a decrease in interpersonal neural coupling in the PFC and TPJ. This is in line with the observation of a reduction in the interpersonal neural coupling in the left PFC and right TPJ between group members encountering conflict of views (Liang et al., 2022) or difficulty in comprehending partners' ideas during group creative ideation (Lu et al., 2021). In contrast, when group members had a higher level of cognitive alignment such as joint attention and shared comprehension, increases in interpersonal neural coupling were observed (Cheng et al., 2024; Lu, Qiao, & Hao, 2019; Lu, Yu, & Hao, 2020; Müller & Lindenberger, 2022). It is important to note that it was situations like emerging conflicts of views or difficulties in understanding partners' ideas, rather than the task itself, that influenced the degree of interpersonal neural coupling and cognitive alignment during group creative ideation.

The framework can also provide some explanation for the findings of Gaggioli et al. (2019). Previous research observed that while females were more likely to attend to others' ideas and integrate them with their own (reflecting a high level of cognitive alignment and more endeavors in convergence pathway), males intended to generate creative ideas by themselves (reflecting a low level of cognitive alignment and less endeavors in convergence pathway; Lu, Teng, & Hao, 2020). The experience of sensorimotor coordination may enhance interpersonal cognitive alignment via the physical alignment, motivating the male dyads to explore the convergence pathway for creative ideation more, which is reflected by enhanced flow of ideas between partners (Gaggioli et al., 2019). Similarly, the experience of solo condition may decrease interpersonal alignment, thereby motivating the female and mixed-gender dyads to explore the flexibility or persistence pathway more. In this case, expending more effort to explore the unpreferred and thus underdeveloped pathways may help group members to generate more creative ideas, thereby enhancing the creative performance of the male dyads and female/mixed-gender dyads (Gaggioli et al., 2019).

The IncGC framework may also offer some implications for understanding classic group creativity phenomena. The emphasis on the social alignment and underlying interpersonal neural coupling in this framework explains the important beneficial roles of cohesion, vision, participative safety, and internal communication in group creativity (Hülsheger et al., 2009). These factors may contribute to the interpersonal cognitive alignment and enhance information elaboration between group members, thereby assisting them in utilizing three ideation pathways to generate creative ideas efficiently. Another interesting phenomenon is the potential benefits of dissent or diversity in perspectives/knowledge for group creativity (De Dreu & West, 2001; Hoever et al., 2012). We propose that diverging perspectives contribute to group creative performance via two mechanisms. On one side, the presence of diverging perspectives directly contributes to group creative performance (i.e., the flexibility pathway). On the other side, diverging perspectives can serve as cognitive stimuli, prompting group members to explore previously unconsidered ideas (e.g., the convergence pathway). The latter mechanism requires interpersonal cognitive alignment, which enables joint attention and shared comprehension, allowing individuals to fully leverage diverse perspectives to generate more creative ideas (Hoever et al., 2012). Overall, such diversity indeed brings more varied perspectives, but to fully leverage the advantages of these perspectives, the convergence pathway is essential, along with the underlying interpersonal neural coupling of the interpersonal cognitive alignment.

Multiple unanswered questions remain unknown in this field, which open up new avenues for exploring the complexities of group creative ideation. First, it is essential to determine whether interpersonal neural coupling has a real impact on cognitive activity during group creative ideation, or whether it is just a serendipitous occurrence. To achieve this, future research should go beyond hyperscanning and include multibrain stimulation methods such as transcranial alternating current stimulation and rhythmic sensory stimulation in future research (Novembre & Iannetti, 2021) to clarify

the actual impact of interpersonal neural coupling. These two techniques involve the application of a low electrical current (transcranial alternating current stimulation) and acoustic stimulation causing neural entrainment outlasting the stimulation offset (rhythmic sensory stimulation) to exogenously modulate interpersonal neural coupling and relevant cognitive functions.

Second, while current hyperscanning research of group creative ideation is ecologically valid, it lacks precise experimental control. This complicates the issue of directly connecting interpersonal neural coupling to distinct cognitive processes in group creative ideation. Researchers should make trade-offs between rigorous experimental design and high ecological validity based on their research objectives. Furthermore, recent research (Balters et al., 2023; Li et al., 2021; X. Wang, Zhang, et al., 2022) has demonstrated the potential for gaining insights by analyzing dynamic changes in interpersonal neural coupling during group creative ideation. These studies have identified varying patterns of interpersonal neural coupling linked to different phases of group creative ideation, which can affect creative outcomes.

Third, present studies typically focus on small groups of —two to three people due to technological constraints. This differs from real-life group innovation activities that often involve larger numbers (Paulus et al., 2013), posing a challenge in extending these findings to real-world group creative activities. Therefore, it is necessary to utilize hyperscanning technique into a group creative ideation paradigm involving larger groups.

Fourth, present studies use indices such as idea convergence, cognitive flexibility, and viewpoint conflict to describe the process of group creative ideation. However, these alone do not fully represent the complexity of group creative ideation, which encompasses cognitive processes such as idea generation, sharing, attention, evaluation, and selection. Therefore, more precise and appropriate indicators are needed to fully capture these complex cognitive processes. In addition, due to the existing hardware constraints, many studies fail to observe the entire brain cortex and neglect subcortical regions, potentially overlooking vital information and complicating interpretations.

In summary, the progress of hyperscanning research in group creative ideation holds great promise for uncovering the intricate neural mechanisms underlying group creative ideation. This effort can provide a comprehensive understanding of the interpersonal neural underpinnings of creative communication, showcasing how individuals within a group interact and integrate dynamically as a unified system in naturalistic creative settings. Research into the neurocognitive underpinnings of group creative ideation, particularly through the hyperscanning paradigm, presents an exhilarating and rewarding challenge. This endeavor promises a significant and enduring impact, paving the way for groundbreaking discoveries and advancements in our understanding of group creative ideation.

References

Arueti, M., Perach-Barzilay, N., Tsoory, M. M., Berger, B., Getter, N., & Shamay-Tsoory, S. G. (2013). When two become one: The role of oxytocin in interpersonal coordination and cooperation. *Journal of Cognitive Neuroscience*, *25*(9), 1418–1427. https://doi.org/10.1162/jocn_a_00400

Balters, S., Miller, J. G., Li, R., Hawthorne, G., & Reiss, A. L. (2023). Virtual (Zoom) interactions alter conversational behavior and interbrain coherence. *The Journal of Neuroscience*, *43*(14), 2568–2578. https://doi.org/10.1523/JNEUROSCI.1401-22.2023

Barsade, S. G. (2002). The ripple effect: Emotional contagion and its influence on group behavior. *Administrative Science Quarterly*, *47*(4), 644–675. https://doi.org/10.2307/3094912

Beaty, R. E., Benedek, M., Silvia, P. J., & Schacter, D. L. (2016). Creative cognition and brain network dynamics. *Trends in Cognitive Sciences*, *20*(2), 87–95. https://doi.org/10.1016/j.tics.2015.10.004

Beaty, R. E., Seli, P., & Schacter, D. L. (2019). Network neuroscience of creative cognition: Mapping cognitive mechanisms and individual differences in the creative brain. *Current Opinion in Behavioral Sciences*, *27*, 22–30. https://doi.org/10.1016/j.cobeha.2018.08.013

Benedek, M., Beaty, R. E., Schacter, D. L., & Kenett, Y. N. (2023). The role of memory in creative ideation. *Nature Reviews Psychology*, *2*(4), 246–257. https://doi.org/10.1038/s44159-023-00158-z

Benedek, M., Beaty, R., Jauk, E., Koschutnig, K., Fink, A., Silvia, P. J., Dunst, B., & Neubauer, A. C. (2014). Creating metaphors: The neural basis of figurative language production. *NeuroImage*, *90*, 99–106. https://doi.org/10.1016/j.neuroimage.2013.12.046

Beversdorf, D. Q. (2019). Neuropsychopharmacological regulation of performance on creativity-related tasks. *Current Opinion in Behavioral Sciences*, *27*, 55–63. https://doi.org/10.1016/j.cobeha.2018.09.010

Boot, N., Baas, M., van Gaal, S., Cools, R., & De Dreu, C. K. W. (2017). Creative cognition and dopaminergic modulation of fronto-striatal networks: Integrative review and research agenda. *Neuroscience and Biobehavioral Reviews*, *78*, 13–23. https://doi.org/10.1016/j.neubiorev.2017.04.007

Brod, G., Lindenberger, U., Werkle-Bergner, M., & Shing, Y. L. (2015). Differences in the neural signature of remembering schema-congruent and schema-incongruent events. *NeuroImage*, *117*, 358–366. https://doi.org/10.1016/j.neuroimage.2015.05.086

Camarda, A., Salvia, É., Vidal, J., Weil, B., Poirel, N., Houdé, O., Borst, G., & Cassotti, M. (2018). Neural basis of functional fixedness during creative idea generation: An EEG study. *Neuropsychologia*, *118*, 4–12. https://doi.org/10.1016/j.neuropsychologia.2018.03.009

Chávez-Eakle, R. A., Graff-Guerrero, A., García-Reyna, J.-C., Vaugier, V., & Cruz-Fuentes, C. (2007). Cerebral blood flow associated with creative performance: A comparative study. *NeuroImage*, *38*(3), 519–528. https://doi.org/10.1016/j.neuroimage.2007.07.059

Cheng, S., Wang, J., Luo, R., & Hao, N. (2024). Brain to brain musical interaction: A systematic review of neural synchrony in musical activities. *Neuroscience and Biobehavioral Reviews*, *164*, Article 105812. https://doi.org/10.1016/j.neubiorev.2024.105812

Cui, X., Bryant, D. M., & Reiss, A. L. (2012). NIRS-based hyperscanning reveals increased interpersonal coherence in superior frontal cortex during cooperation. *NeuroImage*, *59*(3), 2430–2437. https://doi.org/10.1016/j.neuroimage.2011.09.003

Dai, B., Chen, C., Long, Y., Zheng, L., Zhao, H., Bai, X., Liu, W., Zhang, Y., Liu, L., Guo, T., Ding, G., & Lu, C. (2018). Neural mechanisms for selectively tuning in to the target speaker in a naturalistic noisy situation. *Nature Communications*, *9*(1), Article 2405. https://doi.org/10.1038/s41467-018-04819-z

Davidesco, I., Laurent, E., Valk, H., West, T., Milne, C., Poeppel, D., & Dikker, S. (2023). The temporal dynamics of brain-to-brain synchrony between students and teachers predict learning outcomes. *Psychological Science*, *34*(5), 633–643. https://doi.org/10.1177/09567976231163872

De Dreu, C. K. W., Baas, M., & Nijstad, B. A. (2008). Hedonic tone and activation level in the mood-creativity link: Toward a dual pathway to creativity model. *Journal of Personality and Social Psychology*, *94*(5), 739–756. https://doi.org/10.1037/0022-3514.94.5.739

De Dreu, C. K. W., & West, M. A. (2001). Minority dissent and team innovation: The importance of participation in decision making. *Journal of Applied Psychology*, *86*(6), 1191–1201. https://doi.org/10.1037/0021-9010.86.6.1191

Duan, H., Yang, T., Wang, X., Kan, Y., Zhao, H., Li, Y., & Hu, W. (2022). Is the creativity of lovers better? A behavioral and functional near-infrared spectroscopy hyperscanning study. *Current Psychology*, *41*(1), 41–54. https://doi.org/10.1007/s12144-020-01093-5

Ellingsen, D.-M., Isenburg, K., Jung, C., Lee, J., Gerber, J., Mawla, I., Sclocco, R., Grahl, A., Anzolin, A., Edwards, R. R., Kelley, J. M., Kirsch, I., Kaptchuk, T. J., & Napadow, V. (2023). Brain-to-brain mechanisms underlying pain empathy and social modulation of pain in the patient–clinician interaction. *Proceedings of the National Academy of Sciences of the United States of America*, *120*(26), Article e2212910120. https://doi.org/10.1073/pnas.2212910120

Fink, A., Grabner, R. H., Gebauer, D., Reishofer, G., Koschutnig, K., & Ebner, F. (2010). Enhancing creativity by means of cognitive stimulation: Evidence from an fMRI study. *NeuroImage*, *52*(4), 1687–1695. https://doi.org/10.1016/j.neuroimage.2010.05.072

Fink, A., Koschutnig, K., Benedek, M., Reishofer, G., Ischebeck, A., Weiss, E. M., & Ebner, F. (2012). Stimulating creativity via the exposure to other people's ideas. *Human Brain Mapping*, *33*(11), 2603–2610. https://doi.org/10.1002/hbm.21387

Fishburn, F. A., Murty, V. P., Hlutkowsky, C. O., MacGillivray, C. E., Bemis, L. M., Murphy, M. E., Huppert, T. J., & Perlman, S. B. (2018). Putting our heads together: Interpersonal neural synchronization as a biological mechanism for shared intentionality. *Social Cognitive and Affective Neuroscience*, *13*(8), 841–849. https://doi.org/10.1093/scan/nsy060

Fredrickson, B. L. (2013). Chapter one-positive emotions broaden and build. In P. Devine & A. Plant (Eds.), *Advances in experimental social psychology* (Vol. 47, pp. 1–53). Academic Press.

Friederici, A. D. (2011). The brain basis of language processing: From structure to function. *Physiological Reviews*, *91*(4), 1357–1392. https://doi.org/10.1152/physrev.00006.2011

Gaggioli, A., Falletta, E. M., Ferrise, F., Graziosi, S., Gallace, A., D'Ausilio, A., Cipresso, P., Riva, G., & Chirico, A. (2019). Effects of interpersonal sensorimotor synchronization on dyadic creativity: Gender matters. *Frontiers in Psychology*, *9*, Article 2604. https://doi.org/10.3389/fpsyg.2018.02604

Golchert, J., Smallwood, J., Jefferies, E., Seli, P., Huntenburg, J. M., Liem, F., Lauckner, M. E., Oligschläger, S., Bernhardt, B. C., Villringer, A., & Margulies, D. S. (2017). Individual variation in intentionality in the mind-wandering state is reflected in the integration of the default-mode, fronto-parietal, and limbic networks. *NeuroImage*, *146*, 226–235. https://doi.org/10.1016/j.neuroimage.2016.11.025

Goncalo, J. A., & Katz, J. H. (2020). Your soul spills out: The creative act feels self-disclosing. *Personality and Social Psychology Bulletin*, *46*(5), 679–692. https://doi.org/10.1177/0146167219873480

Grawitch, M. J., Munz, D. C., Elliott, E. K., & Mathis, A. (2003). Promoting creativity in temporary problem-solving groups: The effects of positive mood and autonomy in problem definition on idea-generating performance. *Group Dynamics: Theory, Research, and Practice: Theory, Research, and Practice*, *7*(3), 200–213. https://doi.org/10.1037/1089-2699.7.3.200

Gugnowska, K., Novembre, G., Kohler, N., Villringer, A., Keller, P. E., & Sammler, D. (2022). Endogenous sources of interbrain synchrony in duetting pianists. *Cerebral Cortex*, *32*(18), 4110–4127. https://doi.org/10.1093/cercor/bhab469

Gvirts, H. Z., & Perlmutter, R. (2020). What guides us to neurally and behaviorally align with anyone specific? A neurobiological model based on fNIRS hyperscanning studies. *The Neuroscientist*, *26*(2), 108–116. https://doi.org/10.1177/1073858419861912

Hamilton, A. F. C. (2021). Hyperscanning: Beyond the hype. *Neuron*, *109*(3), 404–407. https://doi.org/10.1016/j.neuron.2020.11.008

Harvey, S. (2014). Creative synthesis: Exploring the process of extraordinary group creativity. *Academy of Management Review*, *39*(3), 324–343. https://doi.org/10.5465/amr.2012.0224

Hasson, U., Ghazanfar, A. A., Galantucci, B., Garrod, S., & Keysers, C. (2012). Brain-to-brain coupling: A mechanism for creating and sharing a social world. *Trends in Cognitive Sciences*, *16*(2), 114–121. https://doi.org/10.1016/j.tics.2011.12.007

Hawk, S. T., Fischer, A. H., & Van Kleef, G. A. (2012). Face the noise: Embodied responses to nonverbal vocalizations of discrete emotions. *Journal of Personality and Social Psychology*, *102*(4), 796–814. https://doi.org/10.1037/a0026234

He, Y., Wang, X., Lu, K., & Hao, N. (2023). Letting leaders spontaneously emerge yields better creative outcomes and higher leader-follower interbrain synchrony during creative group communication. *Cerebral Cortex*, *33*(11), 6559–6572. https://doi.org/10.1093/cercor/bhac524

Hirsch, J., Zhang, X., Noah, J. A., & Ono, Y. (2017). Frontal temporal and parietal systems synchronize within and across brains during live eye-to-eye contact. *NeuroImage*, *157*, 314–330. https://doi.org/10.1016/j.neuroimage.2017.06.018

Hoever, I. J., van Knippenberg, D., van Ginkel, W. P., & Barkema, H. G. (2012). Fostering team creativity: Perspective taking as key to unlocking diversity's potential. *Journal of Applied Psychology*, *97*(5), 982–996. https://doi.org/10.1037/a0029159

Homan, A. C., Hollenbeck, J. R., Humphrey, S. E., Knippenberg, D. V., Ilgen, D. R., & Van Kleef, G. A. (2008). Facing differences with an open mind: Openness to experience, salience of intragroup differences, and performance of diverse work groups. *Academy of Management Journal*, *51*(6), 1204–1222. https://doi.org/10.5465/amj.2008.35732995

Hülsheger, U. R., Anderson, N., & Salgado, J. F. (2009). Team-level predictors of innovation at work: A comprehensive meta-analysis spanning three decades of research. *Journal of Applied Psychology*, *94*(5), 1128–1145. https://doi.org/10.1037/a0015978

Ikemoto, S. (2007). Dopamine reward circuitry: Two projection systems from the ventral midbrain to the nucleus accumbens–olfactory tubercle complex. *Brain Research Reviews*, *56*(1), 27–78. https://doi.org/10.1016/j.brainresrev.2007.05.004

Johnson, W., & Proudfoot, D. (2024). Greater variability in judgements of the value of novel ideas. *Nature Human Behaviour*, *8*(3), 471–479. https://doi.org/10.1038/s41562-023-01794-4

Kaplan, S., Brooks-Shesler, L., King, E. B., & Zaccaro, S. (2009). Thinking inside the box: How conformity promotes creativity and innovation. In E. A. Mannix, J. A. Goncalo, & M. A. Neale (Eds.), *Creativity in groups* (Vol. 12, pp. 229–265). Emerald Group Publishing. https://doi.org/10.1108/S1534-0856(2009)0000012012

Kehagia, A. A., Murray, G. K., & Robbins, T. W. (2010). Learning and cognitive flexibility: Frontostriatal function and monoaminergic modulation. *Current Opinion in Neurobiology*, *20*(2), 199–204. https://doi.org/10.1016/j.conb.2010.01.007

Kleinmintz, O. M., Abecasis, D., Tauber, A., Geva, A., Chistyakov, A. V., Kreinin, I., Klein, E., & Shamay-Tsoory, S. G. (2018). Participation of the left inferior frontal gyrus in human originality. *Brain Structure & Function*, *223*(1), 329–341. https://doi.org/10.1007/s00429-017-1500-5

Knight, A. P., & Baer, M. (2014). Get up, stand up: The effects of a non-sedentary workspace on information elaboration and group performance. *Social Psychological and Personality Science*, *5*(8), 910–917. https://doi.org/10.1177/1948550614538463

Kohn, N. W., Paulus, P. B., & Choi, Y. (2011). Building on the ideas of others: An examination of the idea combination process. *Journal of Experimental Social Psychology*, *47*(3), 554–561. https://doi.org/10.1016/j.jesp.2011.01.004

Koike, T., Tanabe, H. C., Okazaki, S., Nakagawa, E., Sasaki, A. T., Shimada, K., Sugawara, S. K., Takahashi, H. K., Yoshihara, K., Bosch-Bayard, J., & Sadato, N. (2016). Neural substrates of shared attention as social memory: A hyperscanning functional magnetic resonance imaging study. *NeuroImage*, *125*, 401–412. https://doi.org/10.1016/j.neuroimage.2015.09.076

Launay, J., Tarr, B., & Dunbar, R. I. M. (2016). Synchrony as an adaptive mechanism for large-scale human social bonding. *Ethology*, *122*(10), 779–789. https://doi.org/10.1111/eth.12528

Leander, N. P., Chartrand, T. L., & Wood, W. (2011). Mind your mannerisms: Behavioral mimicry elicits stereotype conformity. *Journal of Experimental Social Psychology*, *47*(1), 195–201. https://doi.org/10.1016/j.jesp.2010.09.002

Leung, A. K., Kim, S., Polman, E., Ong, L. S., Qiu, L., Goncalo, J. A., & Sanchez-Burks, J. (2012). Embodied metaphors and creative "acts." *Psychological Science*, *23*(5), 502–509. https://doi.org/10.1177/0956797611429801

Li, R., Mayseless, N., Balters, S., & Reiss, A. L. (2021). Dynamic inter-brain synchrony in real-life inter-personal cooperation: A functional near-infrared spectroscopy hyperscanning study. *NeuroImage*, *238*, Article 118263. https://doi.org/10.1016/j.neuroimage.2021.118263

Liang, Z., Li, S., Zhou, S., Chen, S., Li, Y., Chen, Y., Zhao, Q., Huang, F., Lu, C., Yu, Q., & Zhou, Z. (2022). Increased or decreased? Interpersonal neural synchronization in group creation. *NeuroImage*, *260*, Article 119448. https://doi.org/10.1016/j.neuroimage.2022.119448

Lin, H., & Vartanian, O. (2018). A neuroeconomic framework for creative cognition. *Perspectives on Psychological Science*, *13*(6), 655–677. https://doi.org/10.1177/1745691618794945

Liu, J., Zhang, R., Xie, E., Lin, Y., Chen, D., Liu, Y., Li, K., Chen, M., Li, Y., Wang, G., & Li, X. (2023). Shared intentionality modulates interpersonal neural synchronization at the establishment of communication system. *Communications Biology*, *6*(1), Article 832. https://doi.org/10.1038/s42003-023-05197-z

Liu, T., Duan, L., Dai, R., Pelowski, M., & Zhu, C. (2021). Team-work, team-brain: Exploring synchrony and team interdependence in a nine-person drumming task via multiparticipant hyperscanning and inter-brain network topology with fNIRS. *NeuroImage*, *237*, Article 118147. https://doi.org/10.1016/j.neuroimage.2021.118147

Liu, Z., Lu, K., Hao, N., & Wang, Y. (2023). Cognitive reappraisal and expressive suppression evoke distinct neural connections during interpersonal emotion regulation. *The Journal of Neuroscience*, *43*(49), 8456–8471. https://doi.org/10.1523/JNEUROSCI.0954-23.2023

Lu, K., Gao, Z., Wang, X., Qiao, X., He, Y., Zhang, Y., & Hao, N. (2023). The hyper-brain neural couplings distinguishing high-creative group dynamics: An fNIRS hyperscanning study. *Cerebral Cortex*, *33*(5), 1630–1642. https://doi.org/10.1093/cercor/bhac161

Lu, K., & Hao, N. (2019). When do we fall in neural synchrony with others? *Social Cognitive and Affective Neuroscience*, *14*(3), 253–261. https://doi.org/10.1093/scan/nsz012

Lu, K., Qiao, X., & Hao, N. (2019). Praising or keeping silent on partner's ideas: Leading brainstorming in particular ways. *Neuropsychologia*, *124*, 19–30. https://doi.org/10.1016/j.neuropsychologia.2019.01.004

Lu, K., Qiao, X., Yun, Q., & Hao, N. (2021). Educational diversity and group creativity: Evidence from fNIRS hyperscanning. *NeuroImage*, *243*, Article 118564. https://doi.org/10.1016/j.neuroimage.2021.118564

Lu, K., Teng, J., & Hao, N. (2020). Gender of partner affects the interaction pattern during group creative idea generation. *Experimental Brain Research*, *238*(5), 1157–1168. https://doi.org/10.1007/s00221-020-05799-7

Lu, K., Xue, H., Nozawa, T., & Hao, N. (2019). Cooperation makes a group be more creative. *Cerebral Cortex*, *29*(8), 3457–3470. https://doi.org/10.1093/cercor/bhy215

Lu, K., Yu, T., & Hao, N. (2020). Creating while taking turns, the choice to unlocking group creative potential. *NeuroImage*, *219*, Article 117025. https://doi.org/10.1016/j.neuroimage.2020.117025

Lucas, B. J., & Nordgren, L. F. (2020). The creative cliff illusion. *Proceedings of the National Academy of Sciences of the United States of America*, *117*(33), 19830–19836. https://doi.org/10.1073/pnas.2005620117

Mayseless, N., Hawthorne, G., & Reiss, A. L. (2019). Real-life creative problem solving in teams: fNIRS based hyperscanning study. *NeuroImage*, *203*, Article 116161. https://doi.org/10.1016/j.neuroimage.2019.116161

Mayseless, N., & Shamay-Tsoory, S. G. (2015). Enhancing verbal creativity: Modulating creativity by altering the balance between right and left inferior frontal gyrus with tDCS. *Neuroscience*, *291*, 167–176. https://doi.org/10.1016/j.neuroscience.2015.01.061

Mednick, S. (1962). The associative basis of the creative process. *Psychological Review*, *69*(3), 220–232. https://doi.org/10.1037/h0048850

Metuki, N., Sela, T., & Lavidor, M. (2012). Enhancing cognitive control components of insight problems solving by anodal tDCS of the left dorsolateral prefrontal cortex. *Brain Stimulation*, *5*(2), 110–115. https://doi.org/10.1016/j.brs.2012.03.002

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience*, *24*(1), 167–202. https://doi.org/10.1146/annurev.neuro.24.1.167

Mitchell, J. P. (2008). Activity in right temporo-parietal junction is not selective for theory-of-mind. *Cerebral Cortex*, *18*(2), 262–271. https://doi.org/10.1093/cercor/bhm051

Mu, Y., Guo, C., & Han, S. (2016). Oxytocin enhances inter-brain synchrony during social coordination in male adults. *Social Cognitive and Affective Neuroscience*, *11*(12), 1882–1893. https://doi.org/10.1093/scan/nsw106

Müller, V., & Lindenberger, U. (2019). Dynamic orchestration of brains and instruments during free guitar improvisation. *Frontiers in Integrative Neuroscience*, *13*, Article 50. https://doi.org/10.3389/fnint.2019.00050

Müller, V., & Lindenberger, U. (2022). Probing associations between interbrain synchronization and interpersonal action coordination during guitar playing. *Annals of the New York Academy of Sciences*, *1507*(1), 146–161. https://doi.org/10.1111/nyas.14689

Müller, V., Sänger, J., & Lindenberger, U. (2013). Intra- and inter-brain synchronization during musical improvisation on the guitar. *PLOS ONE*, *8*(9), Article e73852. https://doi.org/10.1371/journal.pone.0073852

Nihonsugi, T., Ihara, A., & Haruno, M. (2015). Selective increase of intention-based economic decisions by noninvasive brain stimulation to the dorsolateral prefrontal cortex. *The Journal of Neuroscience*, *35*(8), 3412–3419. https://doi.org/10.1523/JNEUROSCI.3885-14.2015

Nijstad, B. A., De Dreu, C. K. W., Rietzschel, E. F., & Baas, M. (2010). The dual pathway to creativity model: Creative ideation as a function of flexibility and persistence. *European Review of Social Psychology*, *21*(1), 34–77. https://doi.org/10.1080/10463281003765323

Nijstad, B. A., & Stroebe, W. (2006). How the group affects the mind: A cognitive model of idea generation in groups. *Personality and Social Psychology Review*, *10*(3), 186–213. https://doi.org/10.1207/s15327957pspr1003_1

Novembre, G., & Iannetti, G. D. (2021). Hyperscanning alone cannot prove causality. Multibrain stimulation can. *Trends in Cognitive Sciences*, *25*(2), 96–99. https://doi.org/10.1016/j.tics.2020.11.003

Nozawa, T., Sakaki, K., Ikeda, S., Jeong, H., Yamazaki, S., Kawata, K. H. S., Kawata, N. Y. S., Sasaki, Y., Kulason, K., Hirano, K., Miyake, Y., & Kawashima, R. (2019). Prior physical synchrony enhances rapport and inter-brain synchronization during subsequent educational communication. *Scientific Reports*, *9*(1), Article 12747. https://doi.org/10.1038/s41598-019-49257-z

Páez, D., Rimé, B., Basabe, N., Wlodarczyk, A., & Zumeta, L. (2015). Psychosocial effects of perceived emotional synchrony in collective gatherings. *Journal of Personality and Social Psychology*, *108*(5), 711–729. https://doi.org/10.1037/pspi0000014

Pan, Y., Novembre, G., & Olsson, A. (2022). The interpersonal neuroscience of social learning. *Perspectives on Psychological Science*, *17*(3), 680–695. https://doi.org/10.1177/17456916211008429

Pan, Y., Vinding, M. C., Zhang, L., Lundqvist, D., & Olsson, A. (2023). A brain-to-brain mechanism for social transmission of threat learning. *Advanced Science*, *10*(28), Article 2304037. https://doi.org/10.1002/advs.202304037

Paulus, P. B., & Brown, V. R. (2007). Toward more creative and innovative group idea generation: A cognitive-social-motivational perspective of

brainstorming. *Social and Personality Psychology Compass*, *1*(1), 248–265. https://doi.org/10.1111/j.1751-9004.2007.00006.x

Paulus, P. B., & Kenworthy, J. B. (2021). Theoretical models of the cognitive, social, and motivational processes in group idea generation. In S. Doboli, J. B. Kenworthy, A. A. Minai, & P. B. Paulus (Eds.), *Creativity and innovation: Cognitive, social, and computational approaches* (pp. 1–20). Springer. https://doi.org/10.1007/978-3-030-77198-0_1

Paulus, P. B., Kohn, N. W., Arditti, L. E., & Korde, R. M. (2013). Understanding the group size effect in electronic brainstorming. *Small Group Research*, *44*(3), 332–352. https://doi.org/10.1177/1046496413479674

Paulus, P. B., & Nijstad, B. A. (2003). *Group creativity: Innovation through collaboration*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195147308.001.0001

Piazza, E. A., Hasenfratz, L., Hasson, U., & Lew-Williams, C. (2020). Infant and adult brains are coupled to the dynamics of natural communication. *Psychological Science*, *31*(1), 6–17. https://doi.org/10.1177/0956797619878698

Pick, H., & Lavidor, M. (2019). Modulation of automatic and creative features of the remote associates test by angular gyrus stimulation. *Neuropsychologia*, *129*, 348–356. https://doi.org/10.1016/j.neuropsychologia.2019.04.010

Ramírez-Moreno, M. A., Cruz-Garza, J. G., Acharya, A., Chatufale, G., Witt, W., Gelok, D., Reza, G., & Contreras-Vidal, J. L. (2023). Brain-to-brain communication during musical improvisation: A performance case study. *F1000Research*, *11*, Article 989. https://doi.org/10.12688/f1000research.123515.4

Redcay, E., & Schilbach, L. (2019). Using second-person neuroscience to elucidate the mechanisms of social interaction. *Nature Reviews Neuroscience*, *20*(8), 495–505. https://doi.org/10.1038/s41583-019-0179-4

Redifer, J. L., Bae, C. L., & Zhao, Q. (2021). Self-efficacy and performance feedback: Impacts on cognitive load during creative thinking. *Learning and Instruction*, *71*, Article 101395. https://doi.org/10.1016/j.learninstruc.2020.101395

Rossi, A. F., Pessoa, L., Desimone, R., & Ungerleider, L. G. (2009). The prefrontal cortex and the executive control of attention. *Experimental Brain Research*, *192*(3), 489–497. https://doi.org/10.1007/s00221-008-1642-z

Runco, M. A., & Jaeger, G. J. (2012). The standard definition of creativity. *Creativity Research Journal*, *24*(1), 92–96. https://doi.org/10.1080/10400419.2012.650092

Santos, C. M., Uitdewilligen, S., & Passos, A. M. (2015). Why is your team more creative than mine? The influence of shared mental models on intra-group conflict, team creativity and effectiveness. *Creativity and Innovation Management*, *24*(4), 645–658. https://doi.org/10.1111/caim.12129

Seghier, M. L. (2013). The angular gyrus: Multiple functions and multiple subdivisions. *The Neuroscientist*, *19*(1), 43–61. https://doi.org/10.1177/1073858412440596

Shamay-Tsoory, S. G., Saporta, N., Marton-Alper, I. Z., & Gvirts, H. Z. (2019). Herding brains: A core neural mechanism for social alignment. *Trends in Cognitive Sciences*, *23*(3), 174–186. https://doi.org/10.1016/j.tics.2019.01.002

Shaw, J. D., Duffy, M. K., & Stark, E. M. (2000). Interdependence and preference for group work: Main and congruence effects on the satisfaction and performance of group members. *Journal of Management*, *26*(2), 259–279. https://doi.org/10.1177/014920630002600205

Shen, W., Yuan, Y., Liu, C., & Luo, J. (2017). The roles of the temporal lobe in creative insight: An integrated review. *Thinking & Reasoning*, *23*(4), 321–375. https://doi.org/10.1080/13546783.2017.1308885

Silbert, L. J., Honey, C. J., Simony, E., Poeppel, D., & Hasson, U. (2014). Coupled neural systems underlie the production and comprehension of naturalistic narrative speech. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(43), E4687–E4696. https://doi.org/10.1073/pnas.1323812111

Slepian, M. L., & Ambady, N. (2012). Fluid movement and creativity. *Journal of Experimental Psychology: General*, *141*(4), 625–629. https://doi.org/10.1037/a0027395

Tsai, W.-C., Chi, N.-W., Grandey, A. A., & Fung, S.-C. (2012). Positive group affective tone and team creativity: Negative group affective tone and team trust as boundary conditions. *Journal of Organizational Behavior*, *33*(5), 638–656. https://doi.org/10.1002/job.775

van Knippenberg, D., De Dreu, C. K. W., & Homan, A. C. (2004). Work group diversity and group performance: An integrative model and research agenda. *Journal of Applied Psychology*, *89*(6), 1008–1022. https://doi.org/10.1037/0021-9010.89.6.1008

Wang, H., Rispens, S., & Demerouti, E. (2022). Boosting creativity in functional diverse work groups: The importance of help-seeking behavior and openness to experience. *European Journal of Work and Organizational Psychology*, *31*(5), 768–780. https://doi.org/10.1080/1359432X.2022.2047937

Wang, X., He, Y., Lu, K., Deng, C., Qiao, X., & Hao, N. (2019). How does the embodied metaphor affect creative thinking? *NeuroImage*, *202*, Article 116114. https://doi.org/10.1016/j.neuroimage.2019.116114

Wang, X., Lu, K., He, Y., Gao, Z., & Hao, N. (2022). Close spatial distance and direct gaze bring better communication outcomes and more intertwined neural networks. *NeuroImage*, *261*, Article 119515. https://doi.org/10.1016/j.neuroimage.2022.119515

Wang, X., Zhang, Y., He, Y., Lu, K., & Hao, N. (2022). Dynamic inter-brain networks correspond with specific communication behaviors: Using functional near-infrared spectroscopy hyperscanning during creative and non-creative communication. *Frontiers in Human Neuroscience*, *16*, Article 907332. https://doi.org/10.3389/fnhum.2022.907332

Wiltermuth, S. S., & Heath, C. (2009). Synchrony and cooperation. *Psychological Science*, *20*(1), 1–5. https://doi.org/10.1111/j.1467-9280.2008.02253.x

Xue, G., Lu, Z., Levin, I. P., & Bechara, A. (2010). The impact of prior risk experiences on subsequent risky decision-making: The role of the insula. *NeuroImage*, *50*(2), 709–716. https://doi.org/10.1016/j.neuroimage.2009.12.097

Xue, H., Lu, K., & Hao, N. (2018). Cooperation makes two less-creative individuals turn into a highly-creative pair. *NeuroImage*, *172*, 527–537. https://doi.org/10.1016/j.neuroimage.2018.02.007

Yang, J., Zhang, H., Ni, J., De Dreu, C. K. W., & Ma, Y. (2020). Within-group synchronization in the prefrontal cortex associates with intergroup conflict. *Nature Neuroscience*, *23*(6), 754–760. https://doi.org/10.1038/s41593-020-0630-x

Yechiam, E., & Busemeyer, J. R. (2005). Comparison of basic assumptions embedded in learning models for experience-based decision making. *Psychonomic Bulletin & Review*, *12*(3), 387–402. https://doi.org/10.3758/BF03193783

Yin, J., Pan, Y., Zhang, Y., Hu, Y., & Luo, J. (2023). Distinct inter-brain synchronization patterns during group creativity under threats in cooperative and competitive contexts. *Thinking Skills and Creativity*, *49*, Article 101366. https://doi.org/10.1016/j.tsc.2023.101366

Yuan, H., Lu, K., Jing, M., Yang, C., & Hao, N. (2022). Examples in creative exhaustion: The role of example features and individual differences in creativity. *Personality and Individual Differences*, *189*, Article 111473. https://doi.org/10.1016/j.paid.2021.111473

Yuan, H., Lu, K., Yang, C., & Hao, N. (2021). Examples facilitate divergent thinking: The effects of timing and quality. *Consciousness and Cognition*, *93*, Article 103169. https://doi.org/10.1016/j.concog.2021.103169

Zhang, H., Yang, J., Ni, J., De Dreu, C. K. W., & Ma, Y. (2023). Leader–follower behavioural coordination and neural synchronization during intergroup conflict. *Nature Human Behaviour*, *7*(12), 2169–2181. https://doi.org/10.1038/s41562-023-01663-0

Zhang, W., Sjoerds, Z., & Hommel, B. (2020). Metacontrol of human creativity: The neurocognitive mechanisms of convergent and divergent thinking. *NeuroImage*, *210*, Article 116572. https://doi.org/10.1016/j.neuroimage.2020.116572

Zhang, Y., Qu, H., Walter, F., Liu, W., & Wang, M. (2023). A new perspective on time pressure and creativity: Distinguishing employees' radical versus incremental creativity. *Journal of Organizational Behavior*, *44*(9), 1400–1418. https://doi.org/10.1002/job.2742

Zhou, J., Wang, X. M., Bavato, D., Tasselli, S., & Wu, J. (2019). Understanding the receiving side of creativity: A multidisciplinary review and implications for management research. *Journal of Management*, *45*(6), 2570–2595. https://doi.org/10.1177/0149206319827088

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