Physiological Signals for Teamwork: User-Centered Design of a Brain-Computer Interface to Enhance Creative Collaboration

Christopher Micek[1,*], Erin T. Solovey[1]

[1]Worcester Polytechnic Institute (WPI), 100 Institute Road, Worcester, Massachusetts, USA, 01609-2280

Abstract

The success of people engaging in creative tasks has the potential to be amplified by collaboration, allowing them to achieve greater efficiency and output than those working individually. However, teams are also vulnerable to process loss, where suboptimal working environments, member decisions, or group dynamics lead to inefficiencies that prevent them from reaching their full potential. Recent work has shown that brain signals recorded using functional near-infrared spectroscopy (fNIRS) hyperscanning are able to reliably and non-invasively detect levels of team processes in team members engaged in collaborative problem-solving, which are crucial for determining whether a team is functioning effectively. However, to date there are no existing interventions that leverage this ability to facilitate effective teamwork in creative contexts. To avoid the risk of creating a tool that will not provide the intended value to users, or give rise to unanticipated privacy and ethical issues, we instead first assess the perspective and needs of potential users rather than proceeding directly to technical development. Here we outline a preliminary user-centered design study we are currently running that assesses the needs and concerns of various stakeholders (potential users and team leaders) to explore how brain data could be used to enhance collaboration.

Keywords

teams, brain sensing, hyperscanning, creativity support tool

1. Introduction

Creativity is key for developing novel art and ideas, tackling complex challenges, and generally driving innovation. Several convergent factors—individuals' backgrounds, behaviors, and personalities; their cognitive processes; and the environment and broader social context in which they operate—influence creative thinking and output [1]. Thus, properly accounting for and manipulating these variables is necessary in order to maximize creative production [2, 3]. Additionally, prior work has shown that collaboration between individuals has the potential to fuel creative synergy, where new cognitive inputs, the combinations of personality characteristics, or interaction dynamics can yield a volume, breadth, and fluency of creativity greater than what would be possible from working alone [1].

However, an increase in creative output as a result of collaboration is not guaranteed; indeed, several studies have shown that creative collaboration can result in *decreased* output, despite the potential gains. Such process loss can be caused by a number of mechanisms, including groupthink (the tendency of group members to adopt the majority perspective), social anxiety or apprehension toward sharing ideas, downward comparison with others, cognitive load, or distraction by other group members [1, 4, 5, 6, 7]. Thus, while it is possible to have high-performing creative teams, the appropriate environment, resources, and workflow must be fostered for creative synergy to occur.

Monitoring and supporting effective cognitive states and team processes can enable support systems to maximize team potential and mitigate process loss. Such systems work best when they are unobtrusive and do not impair the team processes of team members, instead monitoring team dynamics in real-time to facilitate the social and cognitive processes necessary for successful collaboration (coordinating, persuading, planning, etc.) [8, 9]. In addition to containing information about relevant individual cognitive states such as mind wandering [10] and workload [11], recent work has shown that brain signals recorded using functional near-infrared spectroscopy (fNIRS) can be used to reliably detect levels these team processes in team members engaged in collaborative problem-solving [4]. fNIRS recording is non-invasive and robust to motion-induced artifacts, making it useful as input for a brain-computer interface (BCI) that could serve as a creative support system.

While some existing systems from prior work have been introduced that use BCIs to enable creative output or provide support for design and ideation [12, 13, 14, 15, 16], the vast majority have focused on assisting *individual* users. Very little work has been done employing brain

CHI '24, May 11–16, 2024, Honolulu, HI, USA

*Corresponding author.

cjmicek@wpi.edu (C. Micek); esolovey@wpi.edu (E. T. Solovey)

https://christophermicek.wixsite.com/homepage (C. Micek); https://users.wpi.edu/~esolovey/ (E. T. Solovey)

0000-0002-4606-3598 (C. Micek); 0000-0003-2423-4963 (E. T. Solovey)

sensing specifically in the context of *group collaboration*, and even less has employed *hyperscanning* to leverage data from multiple users simultaneously (see [17] for one example). To date, no general-purpose BCI support tools for collaborative creativity exist that leverage the relevant phenomena they can sense to assist real-world users, and the perspectives of relevant stakeholders have not been assessed to inform the development of one.

However, proceeding directly with the design and implementation of a system incorporating user physiological data has several potential risks. There is a chance of creating a system that users do not find useful, and thus will not want to use; or that the system would rely on measuring or displaying physiological markers that users may not feel comfortable sharing with others, such as their level of engagement or workload during team meetings. It is possible to develop a system both team members and leaders find useful, but has potentially harmful downstream consequences, such as enabling new forms of discrimination based on brain activity, or allowing employers to tie cognitive metrics to employee performance reviews. In order to mitigate these issues and concerns, it is necessary to integrate user perspectives in the earliest stages of designing the system, before any prototyping takes place.

Therefore, in this paper we outline an exploratory study in progress evaluating the needs and concerns of stakeholder groups that would be impacted by the introduction of a BCI support system for collaborative creativity. Specifically, we employ the user-centered approach used by Holstein, McLaren, & Alaven [18] to assess user needs and develop design requirements for emerging technologies, entailing a series of design interviews and brainstorming exercises with the members and leaders of various creative teams.

2. Background and Related Work

Here we present relevant literature and prior work across the domains of social psychology, human-computer interaction, and neuroergonomics to provide a foundation for our studies. First we discuss the nature of teams and creative collaboration, how creative synergy can arise, and pitfalls that can result in process loss. Then we briefly discuss the existing work on creativity support tools and BCIs for creative applications, and how BCIs can be used to support creative collaboration. Finally, we summarize prior studies that assessed perceptions of BCIs and other emerging technologies.

2.1. Teams and Creativity

In sociology and social psychology, a group is typically defined as a collection of two or more individuals connected by and within social relationships [19]. Likewise, a team is a particular type of group whose members work together in pursuit of a shared goal [19]. Teams work together as an organizational unit—failure or success occurs at the group level, rather than for members individually. Beyond this, however, teams can vary considerably in size, composition, or structure [9], with global trends such as digitalization and globalization increasingly challenging the traditional notion of what teams are and how they function [20]. Team composition can be selected by members (e.g., for a school project), or by organizational leadership (e.g., for a company division); members can be co-located, or dispersed to various degrees technologically and geographically [21]; and have varying distributions of skills, knowledge, and expertise [20]. The bounded and stable membership of classical teams has frequently given way to teams in which membership changes frequently, and members taking on multiple roles, or even roles in multiple interdependent teams. Organizations have in some instances encouraged the formation of self-organizing and self-governing teams, in addition to (or in lieu of) traditional top-down leadership structures.

As illustrated above, teams are complex dynamical systems, and their success is a function of the social and environmental context in which they are operating as well as team composition (demographics, cultural background, expertise, leadership and pacing styles, etc.) [22, 23]. These in turn give rise to affective states, cognitive states, and behavioral processes, which can evolve over time as team composition changes, conflicts occur, or trust grows between team members. Such states are emergent both at the individual level (e.g., the valence, arousal, cognitive load, and trust of individual team members) and at the team level (in the case of team processes such as coordination, strategy formulation, affect management, etc.) [24, 25]. Work by Woolley et al. [26] has shown that the contribution of these processes toward task performance can be summarized by a collective intelligence (CI) factor, which is predictive of success across a variety of group tasks [27, 28]. Teams with high CI tend to have members with greater social perceptiveness, and a greater proportion of women. In general, gender and ethnic diversity is associated with greater CI in teams [29]; however, the level of group and individual processes of team members is a greater predictor of CI than team composition [27]. Interpersonal emotion regulation (IER), when individuals engage in actions motivated to modify emotional expressions or experiences, may also impact the quality of relationships between team members. IER strategies that are appropriate for the given context may positively impact the affect, well-being, and interpersonal closeness of team members [30], with engagement-oriented strategies, such as resolving conflicts and seeking emotional support, predictive of lower feelings of loneliness and greater feelings of connection and relationship satisfaction [31].

Creativity is defined by Paulus, Dzindolet, & Kohn [9] as "the generation or production of novel products or ideas." While much of the early research on creativity focused on creativity of individuals [1, 32, 33, 34], more recent work has investigated creativity at the team level. Teams engaging in creative tasks are in many respects equivalent to other teams, and the goal of collaboration broadly remains the same: that of realizing synergy, whereby team performance is enhanced relative to that of individuals. Thus, supporting teamwork in general can be advantageous to team creativity as well. However, there are several factors that can have an outsized influence on a team's creative potential. One model of high-performing creative teams (e.g., interdisciplinary teams at Pixar) suggests that teams formed from subgroups from different disconnected disciplines (e.g., art and technology) with different skillsets and expertise, rather than merely just a large array of diverse viewpoints and perspectives, are most successful [35]. Thus, a team that has a membership with diverse perspectives (experiences, expertise, problem-solving strategies) that are task-relevant can draw on them to explore a greater number of ideas, provided the work environment facilitates integrating and exchanging these perspectives [7, 36]. Fostering a work environment where team members feel psychologically safe enough to share their ideas without fear of discouraging and harsh feedback, while also allowing some amount of conflict and constructive criticism, is likewise necessary for maximizing creative potential [1]. Furthermore, the generation of novel ideas relies upon lateral or associative thinking (in which thoughts leap from category to category via semantic associations) and divergent thinking (i.e., free-flowing, non-linear thinking where ideas are generated in an emergent fashion) [37, 8, 38, 39]. The degree to which team members can successfully employ lateral and divergent modes of thinking is dependent on the dynamic interplay of cognitive states and processes active during ideation [14, 40]. Cognitive flexibility (the ability to update goals and actions in response to changing contexts and task demands) may also play a role [41, 42].

Despite their potential for creative synergy, there are several challenges creative teams face that can lead to process loss. Behaviors such as social loafing (when some group members put forth less due to the presumption that others will contribute more) or social comparisons with other team members, as well as lack of internal or external motivation (e.g., due to lack of trust between team members or incompatibilities between team members and leaders) hinder creative output [1, 43, 44]. Verbally expressing ideas can lead to production blocking, where participants forget their ideas while waiting for a turn to speak, or choose not to share them because they feel they are less relevant after time has passed, and eventually become discouraged from sharing future ideas [45]. Alternatively, rehearsing ideas internally can prevent group members from being attentive to the ideas of others. While asynchronous, remote collaboration has the potential to alleviate these issues by allowing team members to record their ideas in real time [7], remote collaboration has been shown to curb idea generation by narrowing the cognitive focus of communicators to screens [46]. The potential for remote collaboration technology to be misused for surveillance, coupled with the always-on nature of digital communication channels, can also impede collaboration by reducing the time available for cognitive and social processes required for divergent thinking and the integration of others' perspectives [47]. The consensus in the literature seems to be that teams need balance among several qualities to avoid process loss and maximize synergy [9]. Teams should have some amount of cohesion and trust, but not so much that interpersonal bonds between team members are prioritized over commitment to the creative task at hand. Teams should have some amount of diversity in task-relevant expertise and experiences, but teams that are too diverse may have difficulty integrating knowledge across domains. Team members require both intrinsic motivation and external support (e.g., a work environment that facilitates creative thinking and collaboration, where members feel safe to share their ideas [48, 3], as well as tasks and goals set by team leaders). Teams can also benefit from workflows that integrate remote and in-person collaboration, to mitigate the pitfalls of each. These approaches to enhance creative synergy ultimately aim to benefit the affective states, cognitive states, and behavioral processes that belie collaboration.

2.2. Artistic BCIs and Creativity Support Tools

Given that the affective states, cognitive states, and behavioral processes of team members are indicative (and sometimes predictive ([27, 28]) of successful collaboration, measuring these states and processes in real-time as teams are working could provide useful input to a tool or interface designed to aid teams in achieving synergy during collaboration. While prior work has demonstrated that affective states, such as valence and arousal [49, 50, 51], and cognitive states such as mind wandering [52], multitasking [53, 54], and workload [55, 11, 56] can be measured and integrated into online systems via continuous non-invasive physiological sensing, determining the presence and magnitude of team processes has generally relied on administering periodic surveys and behavioral assessments [25, 57], which can disrupt team workflow and only provide sporadic indicators of how well they are collaborating. However, some work employing hyperscanning (simultaneous recording) using electroencephalography (EEG) [58] and fNIRS [59] has demonstrated differences in neurophysiological signals between participants working individually versus as a team, and between expert and novice teams.

Eloy and colleagues [4] demonstrated that fNIRS can be used to measure levels of team processes in real-time. Similar to fMRI, fNIRS measures hemodynamic responses that occur in the brain following neuronal activation. Instead of relying on an expensive and non-portable MRI scanner, fNIRS employs emitters and detectors of near-infrared light placed on the scalp to determine the concentrations of oxygenated and deoxygenated hemoglobin in the brain. fNIRS has temporal resolution that is comparable to fMRI and boasts greater spatial resolution than electroencephalography (EEG) [60]. Additionally, fNIRS devices are low-cost, portable, and require little advance preparation, making them a good choice for real-world scenarios. By employing fNIRS hyperscanning (simultaneous recording) while pairs of users collaborated with an artificial agent during a realistic resource allocation task, Eloy and colleagues were able to reliably model the levels of different team processes (coordination, strategy formation, and affect management) using a technique called multidimensional recurrence quantification analysis (MdRQA). MdRQA can identify patterns in multidimensional data without a priori assumptions or model tuning beyond a single parameter, making it an ideal technique to employ for quantifying the levels of team processes across a variety of contexts.

Creative professionals have historically been quick to experiment with and adopt novel technologies to augment art and ideation [61]. From recording devices such as the phonograph or camera, to graphic design software and generative artificial intelligence programs, technology has shaped the ways artists are able to create emotionally engaging and thought-provoking experiences for audiences. Artists have been using physiological sensing and brain-computer interfaces to shape such experiences for decades. The first use of a BCI for artistic exploration was in 1934, where alpha waves recorded via EEG were converted to sound. American composer Alvin Lucier later used the technique in concert in 1965 [62]. Since then, BCIs and recordings of physiological signals have—via passive or active control by users—been used to create music [17], generate lighting/sound effects during performances in response to audience engagement [63], alter the narrative flow of movies [64, 65], provide visual or auditory representations of users' cognitive or affective states, play games, and more [66].

In addition to being integrated with art exhibits and experiences directly, researchers have also demonstrated how BCIs can serve as creativity support tools, which are digital systems that can enhance creativity by assisting users of varying levels of expertise in one or more phases of the creative process (e.g., planning, ideation, implementation, evaluation, and iteration) [67]. A wide variety of such tools have been developed both for individuals [68] and groups [69], including tools which help define problem scope of prior to brainstorming [70], allow users to map the semantic connections between ideas [71], iteratively generate new graphics based on initial user input [72], and more [68]. BCI-based support tools are additionally able to respond to the cognitive and affective states of users. Botrel, Holz, & Kübler [13] and Todd et al. [12] developed hands-free, brain-powered graphic design tools which used the P300 event-related potential, a response to conscious decision making. Other tools include an artificial agent that provides design suggestions for architectural designers based on their affective state [16], neurocognitive feedback to enhance creative problem solving [15], and a brainstorming assistant that can alter the semantic distance between suggested ideas in response to a user's level of cognitive effort [14]. However, while these tools are able to leverage brain activity to provide novel forms of assistance, thus far the BCI-based tools in the literature collect data from and provide assistance to individual users. No existing BCI-based creative support tools have simultaneously recorded and processed the brain data of multiple users to assist with creative collaboration.

2.3. Evaluating Public Perceptions of BCIs and Emerging Technologies

As a BCI support system for creative collaboration does not currently exist, we look to existing work examining perceptions of BCIs and other emerging technologies to inform our user-centered design approach and study design. Studies generally choose either of two main approaches: conducting surveys of large samples representative of the general public or demographics of interest, or semi-structured interviews of smaller, targeted groups of participants (usually with a design probe to stimulate thinking and discussion).

An example of a relevant larger-scale study is work by Sample et al. [73], who conducted a large ($N = 1,403$) web-based transnational survey of the public in Germany, Canada, and Spain assessing attitudes toward ethical issues related to BCIs (they found participants had moderate concern for agent-related issues (changing self-perception, stigma, autonomy) and consequence-related issues (new forms of hacking, privacy concerns, moral/legal accountability), with women and those who were religious slightly more likely to have stronger concerns). A related study by Sattler & Pietralla [74] used a nationally representative sample of German adults ($N = 1,089$) asking about their willingness to use BCIs and whether they were morally acceptable. In a $2 \times 2 \times 2$ factorial experiment, the authors varied purpose (treatment vs.

enhancement), invasiveness (invasive vs. non-invasive) and framing (i.e., the order questions assessing moral acceptability vs. willingness were presented) in vignettes that introduced BCI technology to participants, and moderate moral acceptability and willingness to use, with a preference for treatment over enhancement use cases and non-invasive over invasive devices. Finally, Tindale et al. [75] surveyed 344 people (employers and employees) about the use of brain and body signals in the workplace across a wide variety of occupations (construction, healthcare, government, education, etc.) in British Columbia, Canada. While 95% of participants did not use brain or body signals in their workplace, benefits for it they envisioned included uses for health monitoring, wellness, and safety, while potential risks included stress, a lack of privacy, and excessive oversight of employees by employers. Interestingly, brain sensors were more likely to be seen as inconvenient and having no benefit compared to body sensors, and a majority of participants said employees should own the info recorded from them (with employers more likely than employees themselves to say this). However, while these larger studies can gauge the perspectives of the public and get a clearer picture of trends for specific sub-populations, these studies miss the chance to ask probing questions to further explore perspectives of individual participants and could miss out on unexpected insight.

In contrast with the larger studies above, studies that recruited smaller, more targeted cohorts of participants were better able to engage with particular groups of interest in greater depth. Merrill & Chuang [76] wanted to assess software developers' narratives and anxieties around BCIs and explore their visions of the future for these devices—how do their ideas about the mind and how it relates to the brain and body inform and constrain beliefs about what BCIs can (and should) do? The authors conducted semi-structured interviews with 8 Silicon Valley software engineers who did not have prior experience working with BCIs, using a user authentication BCI built with a Muse EEG headset as a design probe to inspire thoughts and questions from interviewees. Participants voiced different positions on what the mind was (e.g., the brain acting like a computer; "conscious awareness" separate from unconscious phenomena that affect the mind; embodied cognition arising from the connection between brain, body, and the environment), but all believed BCIs could "read" and decode it. The probe caused participants to speculate on the future of BCI technology generally. Similar to the Tindale et al. study above, the chief concerns participants had related to privacy and security, with several wary of BCIs being able to "leak their thoughts." The consensus among participants was that BCIs would become pervasive (one said we would have to "come to terms with [them]") whether we wanted them to or not, rather than individuals having agency about using them.

Devendorf et al. [77] were interested in examining the future of technology and fashion, and explored an emerging technology altogether different from BCIs: computationally responsive clothing. The authors used Ebb, a textile display made from conductive thread coated with thermochromatic paint, as a design probe in semi-structured interviews where 12 potential wearers and 5 designers compare it to existing similar technologies (e.g., fiber optic or flexible LED screens). The interviews elicited several novel use cases in real-world contexts—Ebb could be used to connect physical and digital lives, display physiological data, show time or transit info, have many-in-one garments, and more.

Merrill & Chuang [76] and Devendorf et al. [77] both used design probes in their studies, but what if a prototype is not available, or has not adequately considered the needs of users? Holstein, McLaren, & Aleven [18] conducted interviews with 10 middle school teachers to explore their needs for intelligent tutoring systems (ITSs) with the goal of designing a real-time ITS. Instead of using a design probe to facilitate this exploration, the researchers relied on a combination of other techniques, so the assessment of needs would inform the development of a prototype, and not the other way around. First, the researchers conducted design interviews using superpowers as a probe, asking the teachers, "If you could have any superpowers you wanted, to help you do your job, what would they be?" The teachers wrote responses on index cards and were asked to prioritize them. This allowed the researchers to get a sense for teachers' needs in the classroom, where breakdowns in current practices occurred, without feeling constrained by solutions offered by existing technology. To inquire about the teachers' needs more directly, the researchers conducted semi-structured interviews asking about their experiences with ITSs, and how they could be improved. Many teachers were concerned that ITSs were *replacing* their roles rather than *supporting* them, and desired analytics that could provide more valuable insights about either their teaching or their students learning. Finally, participants "speed dated" several possible futures based on their superpowers depicted with storyboards in quick succession. Researchers used this to probe boundaries of what participants considered acceptable system behavior, and discovered that while teachers appreciated designs that presented them with information that could help them prioritize their time, they disliked alert systems with direct recommendations because they were perceived as threatening their autonomy in the classroom.

In summary, while their results may not generalize to larger populations, the studies with smaller cohorts above demonstrate several advantages over studies with larger pools of participants. Smaller studies allow researchers to target specific populations more easily, and it is easier to try a variety of different approaches with the same participants or ask probing questions to further explore ideas that arise in discussion. Additionally, meeting with participants in person allows researchers to present tangible artifacts to participants that they can interact with, which can elicit perspectives that may be difficult to attain otherwise. All these advantages make adopting the methodological approaches they used appealing for our present studies.

3. Methods

The study design used by Holstein et al. [18] assessed the needs and concerns of a small, targeted cohort of participants (middle school teachers) regarding an emerging technology (real-time ITSs) *without* the use of a design probe. The stated rationale for this choice was to ensure that any future prototype would adequately meet the needs of eventual users, rather than potentially biasing participant responses with a probe that did not do so. As we also wish to examine the needs of users for a currently nonexistent emerging technology (a BCI support tool for collaborative creativity), we adopted the user-centered approach of Holstein et al. to assess user needs.

The ongoing study seeks answers to the following research questions:

1. What unmet (or under-met) needs do stakeholders (team members and team leaders) have over the course of collaborating?
2. In what ways could a BCI help fulfill these needs?
3. What concerns do stakeholders have about a BCI being used for this purpose, and what risks do they foresee?
4. How could such risks and adverse impacts be minimized over the course of design and development?

3.1. Participants

We recruited 11 participants (7 female) that were either members or leaders of teams engaging in creative collaboration. To avoid unnecessarily restricting perspectives that may ultimately prove insightful, we use the definition of creativity from Amabile & Pratt [78]: "the production of novel and useful ideas by an individual or small group of individuals working together." This is contrasted with *innovation*, which is "the successful implementation of creative ideas within an organization." Thus, for the purposes of our study, a team engaging in creative collaboration is one engaging in any form of creative problem solving; our cohort includes educators, software engineers, a marketing professional, healthcare professionals, student researchers, a sports coordinator, members of sports teams, a game developer, and a construction estimator. Recruitment was be conducted via email outreach to potentially eligible participants.

3.2. Study Design and Proposed Analysis

The study consists of three different types of design interviews, conducted remotely over the course of two Zoom sessions. At the time of writing, all members of our participant cohort have recently completed the first session of the experiment. While the data has yet to be analyzed and synthesized for the second session, we hope to present preliminary results during the workshop. The procedure for each session is outlined below.

Prior to the first Zoom session, participants complete the Process Model of Emotion Regulation Questionnaire (PMERQ; [31]), to assess individual differences in the emotion regulation strategies between participants. Then the first Zoom session consists of:

1. **Generative card-sorting with "superpowers" (Part 1):** Participants were asked to consider their roles on any creative teams that they typically engage with, and to think about the sorts of challenges they face. They were then asked, "If you could have any superpowers you wanted, to help you accomplish your goals when working as part of these teams, what would they be?" Participants were instructed to create sticky notes with their desired superpowers using Miro, an online platform for visual collaboration, and then sort them based on their relative priority. If this process inspired new ideas, participants were encouraged to add new cards.
2. **Semi-structured interviews:** After ranking their superpowers, we conducted semi-structured interviews with participants in order to better assess their needs for support and to investigate the role supportive technology could play in providing this support. Participants were be asked to reflect on their experiences on the teams they were a part of, any challenges they have faced, whether they had used any technologies to overcome these challenges, and to imagine how a technology that could detect how well teams were working together could improve their team interactions, assuming it had no limitations. We also asked participants whether they had experience using any generative AI tools, and what role if any they play in the workflow for their teams.

Audio transcripts from interviews will be analyzed using two techniques from Contextual Design [79]. First, the transcripts will be examined through the lens of interpretation sessions, through which quotes representing key issues and insights will be extracted. Then, affinity diagrams using the extracted quotes will be created. An affinity diagram is a multi-level hierarchical clustering method whereby higher-level categories gradually emerge from bottom-up clustering. First, quotes will be grouped into unnamed level-1 categories based on their perceived level of similarity, and then labeled. These categories will then be grouped into level-2 categories, and the process repeats iteratively until categories representing more abstract, high-level themes are reached.

Once the semi-structured interviews have been analyzed, the final design interview will take place for each participant in a second Zoom session:

3. **Generative card-sorting with "superpowers" (Part 2):** Following the initial sorting, participants will be presented with the cards generated by all previous participants and asked to include them in the ranking as well. If any of these new superpowers is redundant with one of the powers they had generated, they will be encouraged to align them horizontally to indicate a tie. If the participant does not desire any of the new superpowers, they can be omitted from the ranking.

Once the study is complete, the relative rankings of the superpowers will be compared between each of the participants to explore any trends.

4. **Speed-dating possible futures:** To explore potential concerns and design tensions arising from the prior session and further probe and evaluate user needs, we will present storyboards of futuristic scenarios based on the ideas presented during card sorting and semi-structured interviews. These scenarios will be presented to participants in quick succession in "speed dating," a design method for rapidly exploring new technology concepts. The scenarios will be designed to probe potential concerns or ethical issues relating to the use of technology to provide support in creative collaboration that may become evident from the earlier session.

The transcripts for the speed sessions will be analyzed via inductive open coding to uncover any common themes.

Participants will be paid $10 upon the completion of each Zoom session (up to $20 total).

4. Conclusion

By conducting our user-centered design study and examining the needs, challenges, and perspectives of different stakeholders, we hope to gain insight into how (or whether) brain sensing could be used to support teams in a future workplace. Responses from our interviews and brainstorming exercises will enable us to answer key questions about the goals and experiences of leaders and members of various types of teams, and allow us to imagine a possible future where a brain sensing technology able to detect and convey how well teams are working together exists and is useful.

In synthesizing themes from participant responses, there are several aspects that are necessary to consider: Are there any challenges that are shared by different types of teams, or are unique to specific fields? What qualities do teams that are high performing share? What information would be useful for different types of teams? Of the information that is useful, which states/indicators can be measured with brain sensing? In what ways should this information be interpreted and delivered to users? Finally, what are ways we can overcome ethical and security concerns related to user privacy and autonomy?

Answers to all of these questions will inform the development of a BCI support tool able to provide the greatest utility to teams working in different contexts, while mitigating the potential for adverse outcomes.

References

[1] T. R. Kurtzberg, T. M. Amabile, From Guilford to Creative Synergy: Opening the Black Box of Team-Level Creativity, Creativity Research Journal 13 (2001) 285–294. URL: https://doi.org/10.1207/S15326934CRJ1334_06. doi:10.1207/S15326934CRJ1334_06.

[2] A. Bhagwatwar, A. Massey, A. R. Dennis, Creative Virtual Environments: Effect of Supraliminal Priming on Team Brainstorming, in: 2013 46th Hawaii International Conference on System Sciences, 2013, pp. 215–224. doi:10.1109/HICSS.2013.152, iSSN: 1530-1605.

[3] J. M. McCoy, G. W. Evans, The Potential Role of the Physical Environment in Fostering Creativity, Creativity Research Journal 14 (2002) 409–426. URL: https://www.tandfonline.com/doi/abs/10.1207/S15326934CRJ1434_11. doi:10.1207/S15326934CRJ1434_11.

[4] L. Eloy, C. Spencer, E. Doherty, L. Hirshfield, Capturing the Dynamics of Trust and Team Processes in Human-Human-Agent Teams via Multidimensional Neural Recurrence Analyses, Proceedings of the ACM on Human-Computer Interaction 7 (2023) 122:1–122:23. URL: https://dl.acm.org/doi/10.1145/3579598. doi:10.1145/3579598.

[5] A. H. DeCostanza, A. R. Marathe, A. Bohannon, A. W. Evans, E. T. Palazzolo, J. S. Metcalfe, K. McDowell, Enhancing humanagent teaming with in-

dividualized, adaptive technologies: A discussion of critical scientific questions, Technical Report, US Army Research Laboratory Aberdeen Proving Ground United States, 2018.

[6] P. Paulus, Groups, Teams, and Creativity: The Creative Potential of Idea-generating Groups, Applied Psychology 49 (2000) 237–262. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/1464-0597.00013. doi:10.1111/1464-0597.00013.

[7] P. B. Paulus, J. B. Kenworthy, Research Findings on Ideational Creativity in Groups, in: S. Doboli, J. B. Kenworthy, A. A. Minai, P. B. Paulus (Eds.), Creativity and Innovation: Cognitive, Social, and Computational Approaches, Understanding Complex Systems, Springer International Publishing, Cham, 2021, pp. 47–67. URL: https://doi.org/10.1007/978-3-030-77198-0_3. doi:10.1007/978-3-030-77198-0_3.

[8] A. L. Thayer, A. Petruzzelli, C. E. McClurg, Addressing the paradox of the team innovation process: A review and practical considerations, American Psychologist 73 (2018) 363–375. doi:10.1037/amp0000310.

[9] P. B. Paulus, M. Dzindolet, N. W. Kohn, Chapter 14 - Collaborative Creativity—Group Creativity and Team Innovation, in: M. D. Mumford (Ed.), Handbook of Organizational Creativity, Academic Press, San Diego, 2012, pp. 327–357. URL: https://www.sciencedirect.com/science/article/pii/B9780123747143000148. doi:10.1016/B978-0-12-374714-3.00014-8.

[10] R. Liu, E. Walker, L. Friedman, C. M. Arrington, E. T. Solovey, fNIRS-based classification of mind-wandering with personalized window selection for multimodal learning interfaces, Journal on Multimodal User Interfaces 15 (2021) 257–272. URL: https://doi.org/10.1007/s12193-020-00325-z. doi:10.1007/s12193-020-00325-z.

[11] U. Asgher, K. Khalil, M. J. Khan, R. Ahmad, S. I. Butt, Y. Ayaz, N. Naseer, S. Nazir, Enhanced Accuracy for Multiclass Mental Workload Detection Using Long Short-Term Memory for Brain–Computer Interface, Frontiers in Neuroscience 14 (2020). URL: https://www.frontiersin.org/articles/10.3389/fnins.2020.00584. doi:10.3389/fnins.2020.00584.

[12] D. A. Todd, P. J. McCullagh, M. D. Mulvenna, G. Lightbody, Investigating the use of brain-computer interaction to facilitate creativity, in: Proceedings of the 3rd Augmented Human International Conference, AH '12, Association for Computing Machinery, New York, NY, USA, 2012, pp. 1–8. URL: https://dl.acm.org/doi/10.1145/2160125.2160144. doi:10.1145/2160125.2160144.

[13] L. Botrel, E. Holz, A. Kübler, Brain Painting V2: evaluation of P300-based brain-computer interface for creative expression by an end-user following the user-centered design, Brain-Computer Interfaces 2 (2015) 135–149. URL: https://doi.org/10.1080/2326263X.2015.1100038. doi:10.1080/2326263X.2015.1100038.

[14] J. Chan, P. Siangliulue, D. Qori McDonald, R. Liu, R. Moradinezhad, S. Aman, E. T. Solovey, K. Z. Gajos, S. P. Dow, Semantically Far Inspirations Considered Harmful? Accounting for Cognitive States in Collaborative Ideation, in: Proceedings of the 2017 ACM SIGCHI Conference on Creativity and Cognition, C&C '17, Association for Computing Machinery, New York, NY, USA, 2017, pp. 93–105. URL: https://dl.acm.org/doi/10.1145/3059454.3059455. doi:10.1145/3059454.3059455.

[15] M. Hu, T. Shealy, J. Milovanovic, J. Gero, Neurocognitive feedback: a prospective approach to sustain idea generation during design brainstorming, International Journal of Design Creativity and Innovation 10 (2022) 31–50. URL: https://doi.org/10.1080/21650349.2021.1976678. doi:10.1080/21650349.2021.1976678.

[16] Q. Yang, S. Feng, T. Zhao, S. Kalantari, Co-Design with Myself: A Brain-Computer Interface Design Tool that Predicts Live Emotion to Enhance Metacognitive Monitoring of Designers, in: Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems, CHI EA '23, Association for Computing Machinery, New York, NY, USA, 2023, pp. 1–8. URL: https://dl.acm.org/doi/10.1145/3544549.3585701. doi:10.1145/3544549.3585701.

[17] E. Morgan, H. Gunes, N. Bryan-Kinns, Using affective and behavioural sensors to explore aspects of collaborative music making, International Journal of Human-Computer Studies 82 (2015) 31–47. URL: https://www.sciencedirect.com/science/article/pii/S1071581915000853. doi:10.1016/j.ijhcs.2015.05.002.

[18] K. Holstein, B. M. McLaren, V. Aleven, Intelligent tutors as teachers' aides: exploring teacher needs for real-time analytics in blended classrooms, in: Proceedings of the Seventh International Learning Analytics & Knowledge Conference, LAK '17, Association for Computing Machinery, New York, NY, USA, 2017, pp. 257–266. URL: https://dl.acm.org/doi/10.1145/3027385.3027451. doi:10.1145/3027385.3027451.

[19] D. R. Forsyth, Group Dynamics, Cengage Learning, 2018. Google-Books-ID: vg9EDwAAQBAJ.

[20] R. Wageman, H. Gardner, M. Mortensen, The changing ecology of teams: New directions for teams research, Journal of Organizational Behavior 33 (2012) 301–315. URL: https://onlinelibrary.wiley.com/doi/abs/10.1002/job.1775. doi:10.1002/job.1775.

[21] J. V. Hacker, M. Johnson, C. Saunders, A. L. Thayer, Trust in Virtual Teams: A Multidisciplinary Review and Integration, Australasian Journal of Information Systems 23 (2019). URL: https://journal.acs.org.au/index.php/ajis/article/view/1757. doi:10.3127/ajis.v23i0.1757.

[22] J. E. Driskell, G. F. Goodwin, E. Salas, P. G. O'Shea, What makes a good team player? Personality and team effectiveness, Group Dynamics: Theory, Research, and Practice 10 (2006) 249–271. doi:10.1037/1089-2699.10.4.249.

[23] S. T. Bell, S. G. Brown, A. Colaneri, N. Outland, Team composition and the ABCs of teamwork., American Psychologist 73 (2018) 349–362. URL: https://psycnet.apa.org/fulltext/2018-23205-005.pdf. doi:10.1037/amp0000305.

[24] P. Bobko, L. Hirshfield, L. Eloy, C. Spencer, E. Doherty, J. Driscoll, H. Obolsky, Human-agent teaming and trust calibration: a theoretical framework, configurable testbed, empirical illustration, and implications for the development of adaptive systems, Theoretical Issues in Ergonomics Science 0 (2022) 1–25. URL: https://doi.org/10.1080/1463922X.2022.2086644. doi:10.1080/1463922X.2022.2086644.

[25] M. A. Marks, J. E. Mathieu, S. J. Zaccaro, A Temporally Based Framework and Taxonomy of Team Processes, The Academy of Management Review 26 (2001) 356–376. URL: https://www.jstor.org/stable/259182. doi:10.2307/259182.

[26] A. W. Woolley, C. F. Chabris, A. Pentland, N. Hashmi, T. W. Malone, Evidence for a Collective Intelligence Factor in the Performance of Human Groups, Science 330 (2010) 686–688. URL: https://www.science.org/doi/full/10.1126/science.1193147. doi:10.1126/science.1193147.

[27] C. Riedl, Y. J. Kim, P. Gupta, T. W. Malone, A. W. Woolley, Quantifying collective intelligence in human groups, Proceedings of the National Academy of Sciences 118 (2021) e2005737118. URL: https://www.pnas.org/doi/full/10.1073/pnas.2005737118. doi:10.1073/pnas.2005737118.

[28] Y. J. Kim, D. Engel, A. W. Woolley, J. Y.-T. Lin, N. McArthur, T. W. Malone, What Makes a Strong Team? Using Collective Intelligence to Predict Team Performance in League of Legends, in: Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing, CSCW '17, Association for Computing Machinery, New York, NY, USA, 2017, pp. 2316–2329. URL: https://dl.acm.org/doi/10.1145/2998181.2998185. doi:10.1145/2998181.2998185.

[29] P. Chikersal, M. Tomprou, Y. J. Kim, A. W. Woolley, L. Dabbish, Deep structures of collaboration: Physiological correlates of collective intelligence and group satisfaction, in: Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing, CSCW '17, Association for Computing Machinery, New York, NY, USA, 2017, p. 873–888. URL: https://doi.org/10.1145/2998181.2998250. doi:10.1145/2998181.2998250.

[30] K. L. Dixon-Gordon, S. L. Bernecker, K. Christensen, Recent innovations in the field of interpersonal emotion regulation, Current Opinion in Psychology 3 (2015) 36–42. URL: https://www.sciencedirect.com/science/article/pii/S2352250X15000925. doi:10.1016/j.copsyc.2015.02.001.

[31] S. Olderbak, A. Uusberg, C. MacCann, K. M. Pollak, J. J. Gross, The Process Model of Emotion Regulation Questionnaire: Assessing Individual Differences in Strategy Stage and Orientation, Assessment (2022) 10731911221134601. URL: https://doi.org/10.1177/10731911221134601. doi:10.1177/10731911221134601.

[32] J. P. Guilford, Creativity, American Psychologist 5 (1950) 444–454. doi:10.1037/h0063487.

[33] R. J. Sternberg, Creating a vision of creativity: The first 25 years, Psychology of Aesthetics, Creativity, and the Arts S (2006) 2–12. doi:10.1037/1931-3896.S.1.2.

[34] R. J. Sternberg, A triangular theory of creativity, Psychology of Aesthetics, Creativity, and the Arts 12 (2018) 50–67. doi:10.1037/aca0000095.

[35] S. Harvey, Creative Synthesis: Exploring the Process of Extraordinary Group Creativity, Academy of Management Review 39 (2014) 324–343. URL: https://journals.aom.org/doi/abs/10.5465/amr.2012.0224. doi:10.5465/amr.2012.0224.

[36] P. B. Paulus, M. Dzindolet, Social influence, creativity and innovation, Social Influence 3 (2008) 228–247. URL: https://doi.org/10.1080/15534510802341082. doi:10.1080/15534510802341082.

[37] A. P. Walton, The impact of interpersonal factors on creativity, International Journal of Entrepreneurial Behavior & Research 9 (2003) 146–162. URL: https://doi.org/10.1108/13552550310485120. doi:10.1108/13552550310485120.

[38] A. Warr, E. O'Neill, The effect of group composition on divergent thinking in an interaction design activity, in: Proceedings of the 6th conference on Designing Interactive systems, DIS '06, Association for Computing Machinery, New York, NY, USA, 2006, pp. 122–131. URL: https://dl.acm.org/doi/10.1145/1142405.1142427. doi:10.1145/1142405.1142427.

[39] S. W. J. Kozlowski, G. T. Chao, J. A. Grand, M. T. Braun, G. Kuljanin, Advancing Multilevel Research Design: Capturing the Dynamics of Emergence, Organizational Research Methods 16 (2013) 581–615. URL: https://doi.org/10.1177/1094428113493119. doi:10.1177/

1094428113493119.

[40] E. Volle, Associative and Controlled Cognition in Divergent Thinking: Theoretical, Experimental, Neuroimaging Evidence, and New Directions, in: O. Vartanian, R. E. Jung (Eds.), The Cambridge Handbook of the Neuroscience of Creativity, Cambridge Handbooks in Psychology, Cambridge University Press, Cambridge, 2018, pp. 333–360. doi:10.1017/9781316556238.020.

[41] G. Dreisbach, K. Fröber, On How to Be Flexible (or Not): Modulation of the Stability-Flexibility Balance, Current Directions in Psychological Science 28 (2019) 3–9. URL: https://doi.org/10.1177/0963721418800030. doi:10.1177/0963721418800030.

[42] B. Hommel, Chapter Two - Between Persistence and Flexibility: The Yin and Yang of Action Control, in: A. J. Elliot (Ed.), Advances in Motivation Science, volume 2, Elsevier, 2015, pp. 33–67. URL: https://www.sciencedirect.com/science/article/pii/S2215091915000048. doi:10.1016/bs.adms.2015.04.003.

[43] R. C. Mayer, M. B. Gavin, Trust in Management and Performance: Who Minds the Shop While the Employees Watch the Boss?, Academy of Management Journal 48 (2005) 874–888. URL: https://journals.aom.org/doi/abs/10.5465/amj.2005.18803928. doi:10.5465/amj.2005.18803928.

[44] S. Chowdhury, The Role of Affect- and Cognition-based Trust in Complex Knowledge Sharing, Journal of Managerial Issues 17 (2005) 310–326. URL: https://www.jstor.org/stable/40604504.

[45] B. A. Nijstad, W. Stroebe, How the Group Affects the Mind: A Cognitive Model of Idea Generation in Groups, Personality and Social Psychology Review 10 (2006) 186–213. URL: https://doi.org/10.1207/s15327957pspr1003_1. doi:10.1207/s15327957pspr1003_1.

[46] M. S. Brucks, J. Levav, Virtual communication curbs creative idea generation, Nature 605 (2022) 108–112. URL: https://www.nature.com/articles/s41586-022-04643-y. doi:10.1038/s41586-022-04643-y.

[47] S. L. Jarvenpaa, L. Välikangas, Advanced Technology and End-Time in Organizations: A Doomsday for Collaborative Creativity?, Academy of Management Perspectives 34 (2020) 566–584. URL: https://journals.aom.org/doi/abs/10.5465/amp.2019.0040. doi:10.5465/amp.2019.0040.

[48] D. Vyas, D. Heylen, A. Nijholt, G. van der Veer, Collaborative Practices that Support Creativity in Design, in: I. Wagner, H. Tellioğlu, E. Balka, C. Simone, L. Ciolfi (Eds.), ECSCW 2009, Springer, London, 2009, pp. 151–170. doi:10.1007/978-1-84882-854-4_9.

[49] H. Huang, Q. Xie, J. Pan, Y. He, Z. Wen, R. Yu, Y. Li, An EEG-Based Brain Computer Interface for Emotion Recognition and Its Application in Patients with Disorder of Consciousness, IEEE Transactions on Affective Computing 12 (2021) 832–842. doi:10.1109/TAFFC.2019.2901456.

[50] S. K. Ehrlich, K. R. Agres, C. Guan, G. Cheng, A closed-loop, music-based brain-computer interface for emotion mediation, PLOS ONE 14 (2019) e0213516. URL: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0213516. doi:10.1371/journal.pone.0213516.

[51] I. Daly, D. Williams, A. Kirke, J. Weaver, A. Malik, F. Hwang, E. Miranda, S. J. Nasuto, Affective brain–computer music interfacing, Journal of Neural Engineering 13 (2016) 046022. URL: https://dx.doi.org/10.1088/1741-2560/13/4/046022. doi:10.1088/1741-2560/13/4/046022.

[52] S. D'Mello, K. Kopp, R. E. Bixler, N. Bosch, Attending to Attention: Detecting and Combating Mind Wandering during Computerized Reading, in: Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems, CHI EA '16, Association for Computing Machinery, New York, NY, USA, 2016, pp. 1661–1669. URL: https://dl.acm.org/doi/10.1145/2851581.2892329. doi:10.1145/2851581.2892329.

[53] E. Solovey, P. Schermerhorn, M. Scheutz, A. Sassaroli, S. Fantini, R. Jacob, Brainput: enhancing interactive systems with streaming fnirs brain input, in: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI '12, Association for Computing Machinery, New York, NY, USA, 2012, pp. 2193–2202. URL: https://dl.acm.org/doi/10.1145/2207676.2208372. doi:10.1145/2207676.2208372.

[54] D. Afergan, T. Shibata, S. W. Hincks, E. M. Peck, B. F. Yuksel, R. Chang, R. J. Jacob, Brain-based target expansion, in: Proceedings of the 27th annual ACM symposium on User interface software and technology, UIST '14, Association for Computing Machinery, New York, NY, USA, 2014, pp. 583–593. URL: https://dl.acm.org/doi/10.1145/2642918.2647414. doi:10.1145/2642918.2647414.

[55] F. Putze, T. Schultz, Investigating Intrusiveness of Workload Adaptation, in: Proceedings of the 16th International Conference on Multimodal Interaction, ICMI '14, Association for Computing Machinery, New York, NY, USA, 2014, pp. 275–281. URL: https://doi.org/10.1145/2663204.2663279. doi:10.1145/2663204.2663279.

[56] M. Spüler, T. Krumpe, C. Walter, C. Scharinger, W. Rosenstiel, P. Gerjets, Brain-Computer Interfaces for Educational Applications, in: J. Buder, F. W. Hesse (Eds.), Informational Environments

: Effects of Use, Effective Designs, Springer International Publishing, Cham, 2017, pp. 177–201. URL: https://doi.org/10.1007/978-3-319-64274-1_8. doi:10.1007/978-3-319-64274-1_8.

[57] D. J. McAllister, Affect- and Cognition-Based Trust as Foundations for Interpersonal Cooperation in Organizations, The Academy of Management Journal 38 (1995) 24–59. URL: https://www.jstor.org/stable/256727. doi:10.2307/256727.

[58] S. Dodel, J. Cohn, J. Mersmann, P. Luu, C. Forsythe, V. Jirsa, Brain Signatures of Team Performance, in: D. D. Schmorrow, C. M. Fidopiastis (Eds.), Foundations of Augmented Cognition. Directing the Future of Adaptive Systems, Lecture Notes in Computer Science, Springer, Berlin, Heidelberg, 2011, pp. 288–297. doi:10.1007/978-3-642-21852-1_35.

[59] A. Czeszumski, S. H.-Y. Liang, S. Dikker, P. König, C.-P. Lee, S. L. Koole, B. Kelsen, Cooperative Behavior Evokes Interbrain Synchrony in the Prefrontal and Temporoparietal Cortex: A Systematic Review and Meta-Analysis of fNIRS Hyperscanning Studies, eNeuro 9 (2022) ENEURO.0268–21.2022. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9014979/. doi:10.1523/ENEURO.0268-21.2022.

[60] N. R. C. U. C. o. M. a. I. M. f. E. N. a. C. R. i. t. N. T. D. , Emerging Cognitive Neuroscience and Related Technologies, National Academies Press, 2008. Google-Books-ID: K6icAgAAQBAJ.

[61] E. Edmonds, D. Everitt, M. Macaulay, G. Turner, On physiological computing with an application in interactive art, Interacting with Computers 16 (2004) 897–915. URL: https://www.sciencedirect.com/science/article/pii/S0953543804000918. doi:10.1016/j.intcom.2004.08.003.

[62] M. Prpa, P. Pasquier, Brain-Computer Interfaces in Contemporary Art: A State of the Art and Taxonomy, in: A. Nijholt (Ed.), Brain Art: Brain-Computer Interfaces for Artistic Expression, Springer International Publishing, Cham, 2019, pp. 65–115. URL: https://doi.org/10.1007/978-3-030-14323-7_3. doi:10.1007/978-3-030-14323-7_3.

[63] S. Yan, G. Ding, H. Li, N. Sun, Y. Wu, Z. Guan, L. Zhang, T. Huang, Enhancing Audience Engagement in Performing Arts Through an Adaptive Virtual Environment with a Brain-Computer Interface, in: Proceedings of the 21st International Conference on Intelligent User Interfaces, IUI '16, Association for Computing Machinery, New York, NY, USA, 2016, pp. 306–316. URL: https://dl.acm.org/doi/10.1145/2856767.2856768. doi:10.1145/2856767.2856768.

[64] M. Pike, R. Ramchurn, S. Benford, M. L. Wilson, #Scanners: Exploring the Control of Adaptive Films using Brain-Computer Interaction, in: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, CHI '16, Association for Computing Machinery, New York, NY, USA, 2016, pp. 5385–5396. URL: https://dl.acm.org/doi/10.1145/2858036.2858276. doi:10.1145/2858036.2858276.

[65] R. Ramchurn, S. Martindale, M. L. Wilson, S. Benford, From Director's Cut to User's Cut: to Watch a Brain-Controlled Film is to Edit it, in: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, CHI '19, Association for Computing Machinery, New York, NY, USA, 2019, pp. 1–14. URL: https://dl.acm.org/doi/10.1145/3290605.3300378. doi:10.1145/3290605.3300378.

[66] M. Andujar, C. S. Crawford, A. Nijholt, F. Jackson, J. E. Gilbert, Artistic brain-computer interfaces: the expression and stimulation of the user's affective state, Brain-Computer Interfaces 2 (2015) 60–69. URL: https://doi.org/10.1080/2326263X.2015.1104613. doi:10.1080/2326263X.2015.1104613.

[67] J. Frich, L. MacDonald Vermeulen, C. Remy, M. M. Biskjaer, P. Dalsgaard, Mapping the Landscape of Creativity Support Tools in HCI, in: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, CHI '19, Association for Computing Machinery, New York, NY, USA, 2019, pp. 1–18. URL: https://dl.acm.org/doi/10.1145/3290605.3300619. doi:10.1145/3290605.3300619.

[68] K. Wang, J. V. Nickerson, A literature review on individual creativity support systems, Computers in Human Behavior 74 (2017) 139–151. URL: https://www.sciencedirect.com/science/article/pii/S0747563217302777. doi:10.1016/j.chb.2017.04.035.

[69] A. Gabriel, D. Monticolo, M. Camargo, M. Bourgault, Creativity support systems: A systematic mapping study, Thinking Skills and Creativity 21 (2016) 109–122. URL: https://www.sciencedirect.com/science/article/pii/S1871187116300293. doi:10.1016/j.tsc.2016.05.009.

[70] P. Bao, E. Gerber, D. Gergle, D. Hoffman, Momentum: getting and staying on topic during a brainstorm, in: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI '10, Association for Computing Machinery, New York, NY, USA, 2010, pp. 1233–1236. URL: https://doi.org/10.1145/1753326.1753511. doi:10.1145/1753326.1753511.

[71] P. Siangliulue, J. Chan, S. P. Dow, K. Z. Gajos, IdeaHound: Improving Large-scale Collaborative Ideation with Crowd-Powered Real-time Semantic Modeling, in: Proceedings of the 29th Annual Symposium on User Interface Software and Technology, UIST '16, Association for Computing Machinery, New York, NY, USA, 2016, pp. 609–624. URL: https:

//dl.acm.org/doi/10.1145/2984511.2984578. doi:10.1145/2984511.2984578.

[72] E. C. K. Hung, C. S. T. Choy, Conceptual Recombination: A method for producing exploratory and transformational creativity in creative works, Knowledge-Based Systems 53 (2013) 1–12. URL: https://www.sciencedirect.com/science/article/pii/S0950705113002098. doi:10.1016/j.knosys.2013.07.007.

[73] M. Sample, S. Sattler, S. Blain-Moraes, D. Rodríguez-Arias, E. Racine, Do Publics Share Experts' Concerns about Brain–Computer Interfaces? A Trinational Survey on the Ethics of Neural Technology, Science, Technology, & Human Values 45 (2020) 1242–1270. URL: https://doi.org/10.1177/0162243919879220. doi:10.1177/0162243919879220.

[74] S. Sattler, D. Pietralla, Public attitudes towards neurotechnology: Findings from two experiments concerning Brain Stimulation Devices (BSDs) and Brain-Computer Interfaces (BCIs), PLOS ONE 17 (2022) e0275454. URL: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0275454. doi:10.1371/journal.pone.0275454.

[75] L. C. Tindale, D. Chiu, N. Minielly, V. Hrincu, A. Talhouk, J. Illes, Wearable Biosensors in the Workplace: Perceptions and Perspectives, Frontiers in Digital Health 4 (2022). URL: https://www.frontiersin.org/articles/10.3389/fdgth.2022.800367.

[76] N. Merrill, J. Chuang, From Scanning Brains to Reading Minds: Talking to Engineers about Brain-Computer Interface, in: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, CHI '18, Association for Computing Machinery, New York, NY, USA, 2018, pp. 1–11. URL: https://dl.acm.org/doi/10.1145/3173574.3173897. doi:10.1145/3173574.3173897.

[77] L. Devendorf, J. Lo, N. Howell, J. L. Lee, N.-W. Gong, M. E. Karagozler, S. Fukuhara, I. Poupyrev, E. Paulos, K. Ryokai, "I don't Want to Wear a Screen": Probing Perceptions of and Possibilities for Dynamic Displays on Clothing, in: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, CHI '16, Association for Computing Machinery, New York, NY, USA, 2016, pp. 6028–6039. URL: https://dl.acm.org/doi/10.1145/2858036.2858192. doi:10.1145/2858036.2858192.

[78] T. M. Amabile, M. G. Pratt, The dynamic componential model of creativity and innovation in organizations: Making progress, making meaning, Research in Organizational Behavior 36 (2016) 157–183. URL: https://www.sciencedirect.com/science/article/pii/S0191308516300053. doi:10.1016/j.riob.2016.10.001.

[79] K. Holtzblatt, H. Beyer, Contextual design: defining customer-centered systems, Elsevier, 1997.