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Demystifying Collaborative Ideation

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Résumé

L'idéation collaborative est un processus très répandu qui génère de bonnes retombées économiques pour les entreprises qui l'utilisent. Toutefois, son efficacité est encore débattue dans le milieu scientifique. En examinant la portée de la littérature sur l'idéation collaborative nous avons identifié deux méthodes d'idéations collaborative qui pourraient être au cœur de ce débat. Le Brainstorm Énergétique et l'Approche à Angles Multiples sont deux techniques prédominantes utilisées par des équipes de design. L'étude de la littérature a aussi permis d'établir une définition de l'idéation collaborative (comprenant trois vecteurs : moments de structurations, la phase de conception et la phase d'illustration) ainsi qu'une définition des facteurs étudiés qui impactent la séquence et la performance d'une équipe créative.

Il est identifié dans la littérature et confirmer par nos observations que l'écoute active et la rétroaction sont deux facteurs sociaux qui semblent avoir des impacts distincts sur l'approche choisie par l'équipe et leur performance. De plus, l'expérience individuelle dans un contexte créatif impacte aussi la séquence d'idéation collaborative.

Utilisant une approche exploratoire-déductive pour analyser nos observations, ce mémoire examine ces phénomènes avec huit équipes d'innovateurs. Les résultats démontrent que les facteurs sociaux et les expériences vécues des participants non-seulement joue un rôle important sur la méthode d'idéation collaborative utilisée, mais aussi sur la performance de l'équipe. Nos résultats indiquent que les équipes avec de meilleures performances créatives ont un effort cognitif et un niveau d'excitation plus élevé que les autres. L'écoute active semble avoir un impact positif significatif sur la conception de proposition de design, la performance des équipes et la valence des différents membres d'une équipe. Ceci illustre que cette action empathique aide la pensé divergente et donc à étoffer une idée en réduisant l'effort des participants dans l'équipe. Nos résultats démontrent aussi que la rétroaction à un impact complexe sur l'idéation collaborative. En effet, nos résultats indiquent qu'aucun effet n'a été mesuré sur la performance des équipes, toutefois une rétroaction perçue comme plus ou moins négative entraîne un impact négatif sur la phase générative d'idées et l'expérience vécue par les

participants. Ceci illustre un moment de combinaisons et de façonnages d'idées plutôt qu'un moment d'expansion. Les moments de structurations eux semblent aussi jouer un rôle important sur la performance des équipes étudiées. Nous pensons donc que d'adopter une méthode consensuelle (l'Approche à Angles Multiples) pour développer des idées est important pour la performance d'équipes créatives dans un contexte d'innovation.

Réaliser en deux temps, ce mémoire vise à comprendre les facteurs psychosociaux qui affecte les membres d'une équipe de design, leur processus collaboratif et leur performance dans un contexte créatif. En premier lieu, un examen de la portée de la littérature sur l'idéation collaborative a été menée pour définir ce sujet, déterminer les différentes méthodes utilisées et les facteurs clés qui l'impact. Les facteurs psychosociaux des participants dans un contexte créatif semblent être la raison des choix de méthode des équipes de design ainsi que la variation de leur performance. Ensuite, le processus d'idéation collaboratif a été observé en laboratoire sur huit des équipes de trois dans une étude expérimentale. Nous avons observé les facteurs comportementaux et la séquence d'idéation collaborative de ces huit équipes. De plus, nous avons collecté des données physiologique et cognitive en continue pour comprendre leur expérience vécue. Ceci nous a permis non-seulement de dresser un portrait complet de l'idéation collaborative pour des équipes dans un contexte créatif mais aussi d'établir une méthode de recherche qui permet de trouver des résultats qui ont une haute validité écologique.

Jumeler à notre approche exploratoire et déductive pour l'analyse de nos données, nos résultats sont donc adaptés pour un contexte industriel. En effet, notre but est de comprendre comment les facteurs comportementaux des participants de notre étude impactent l'expérience vécue et l'idéation collaborative de ceux-ci pour promouvoir une façon de faire propice à développer des performances créatives exceptionnelles.

Mots clés : Idéation Collaborative, Facteurs Psychosociaux, Expérience Individuelle dans un Contexte Créatif, Innovation, Méthodes de Co-Design, Créativité

Abstract

Generating positive economic outcomes for organizations who use it, collaborative ideation is no longer just a design-focused practice. Having gained popularity in industry, nonetheless, the effectiveness of this widespread process is still debated today's in the scientific community. To address this tension between scholars and practice, this thesis will research with a scoping review of the literature and observe in an experiment Collaborative Ideation (CI). The goal is to understand how participatory behavioural factors impact participants' lived experiences and the collaborative ideation sequence of the team. This will uncover and promote an approach conducive to developing high creative performances for creative groups.

Conducted in two phases, this research aimed to understand how psychosocial patterns impact the individual experiences of participants, the collaborative ideation sequence and the performance of creative teams.

First, a scoping review of the literature was conducted to develop a theoretical understanding of CI and identify its practical methods and factors that influence its sequence and performance. Two collaborative ideation methods have been identified: the 'Energetic Brainstorm' and the 'Multiple Angles'. This review also has allowed for a definition of CI to be illustrated. CI is a sequence comprised of three dimensions: structuring moments, a conceiving phase and an illustrating phase. The literature review also provides the definitions of the studied social factors that impact the sequence and performance of creative teams. Active listening and feedback cues appear to have discernible impacts on the team's approach and performance in CI. Additionally, the individual experience, within a creative context, also plays a role in shaping CI's sequence.

Second, the eight three-member teams involved in collaborative ideation were observed in an experimental setting. During these experiments participants' actions, their ideation sequence, physiological data, and affective-cognitive measures were collected continuously for the eight teams involved in collaborative ideation. The psychosocial data

collected during those sessions were then analyzed using the deductive-exploratory research method. The results demonstrate that social factors and participants' lived experiences not only play a significant role in shaping CI's sequence but also its performance. This facilitated the construction of a comprehensive portrayal of this phenomenon with high ecological validity which is highly relevant in an industrial context.

For example, teams with high creative performance perceived higher cognitive effort and arousal levels than others. Active listening cues appear to have a significant positive impact on idea generation, the valence of team members, and team performance. This illustrates that these empathic actions aid divergent thinking and, therefore, idea elaboration by enhancing the participants' affective state in the team.

Furthermore, feedback cues seem to have a more complex impact on collaborative ideation. Their negative effect on idea generation and the lived experience of participants when they are proportionally more negative illustrates moments of combination and shaping of ideas rather than expansion. Furthermore, structuring moments also seem to play a crucial role in the performance of the studied teams. Therefore, it is believed that adopting a consensual method (the Multiple Angles method) to develop ideas is important for the performance of creative teams in an innovation context.

Keywords: Collaborative Ideation, Psychosocial Patterns, Individual Experiences in a Creative Context, Co-Design Methods Innovation, Creativity

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List of abbreviations and acronyms

CI: Collaborative Ideation

Con_SEC: Conceiving phase

ConvThink: Convergent thinking

DivThink: Divergent Thinking

EDA: Electrodermal Activity

Ill_SEC: Illustrating phase

Struct_SEC: Structuring moments

TTCT Test: Torrance Test of Creative Thinking

UX: User Experience

Foreword

This research was completed as part of a master of science thesis in User Experience in a Business Context at HEC Montreal. The thesis has been approved by the administrative management of the M.Sc. program. Further authorization was given to write this thesis in the form of articles by the program director. The inclusion of each article within this thesis has been approved by all co-authors. Article 1 (Chapter 2), was written in preparation for being submitted to the Design Science Journal. Article 2 (Chapter 3), was written in preparation for being submitted to the Journal Technovation.

This research project included in this thesis was approved by the Research Ethics Board of HEC Montreal on February 25th, 2022, under the project number: ***2022-4887***. Accordingly, the research project involving humans as participants was completed ethically.

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During the preparation of this work, the author used ChatGPT (2023-24) version 3 and 3.5 from from May 2023 to April 2024 to improve readability and language. After

using this tool/service, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

Chapter 1: Introduction

"Great things in business are never done by one person. They're done by a team of people." - Steve Jobs (2003, 60 Minutes Interview)

1. Unveiling the Crux of Creativity in a Collaborative Context

Amabile's (1983) dismantling of the creative genius myth in the 80s has ushered in a new understanding of creative collaboration in the business world. Her findings have introduced the 'designerly' process, as delineated by influential designers like Cross (1982; 2004), Shneiderman (2000), and Dorst (2015), into the business realm. This process serves as a blueprint for individuals involved in the creative process. In this context, individuals employ their subjectivity and expertise to collaboratively explore problems from different angles with open propositions. This cyclical process is finalized when consensual 'satisfycing' about the outcome is reached by the team (Buchanan, 2019; Simon, 1978) and the final product or service can be gifted back to the users (Shneiderman, 2000). This working methodology is now widely used and employed by the likes of Apple, IBM and Coca-Cola. However, this profitable resource for organizations (Naiman, 2019) remains a topic of controversy within the scientific community. The variability in creative outputs observed among teams utilizing these design-born techniques contributes to ongoing debate on their effectiveness (Cash et al., 2023; Davis & Eisenhardt, 2011; Stroebe et al., 2010).

To elucidate this issue, scholars have observed and charted the co-ideation process in their study (Cross and Cross, 1995). Co-design uses three different loops: Collaborative Ideation Loops, Collaborative Conversations and Collaborative Moving. All three of these loops must be used for effective CI (Dorta et al. 2011). Consensual decision-making techniques in creative groups are beneficial to the creative output of teams (Convertino, 2008). These studies, consistently highlight the beneficial effect of consciously grounding the collective comprehension of the design process to generate optimal performance. Nevertheless, the psychosocial patterns through which teams autonomously organize and

ground their collaborators into the ideation scheme, which significantly influences team creative output, remain inadequately addressed.

Building from collective ideation frameworks

Two types of autonomously determined CI methods are found to occur in creative groups: The “energetic brainstorm” and the “multiple angles” (Dorst, 2015 and Stempfle and Badke-Schaub, 2002). Both employ varying degrees of consensus-reaching in ideation and are perceived differently in the literature. This thesis aims to examine if these perceptions are fundamental to the effectiveness of collaborative ideation, helping prove the usefulness of CI within the scientific community.

1.1 *Refining our Understanding of Collaborative Ideation (Article 1, Chapter 2)*

Collaborative ideation (CI) is a complex phenomenon with a multitude of factors. To be able to make effective observations and diagnostics about the impact of psychosocial patterns within it and on its performance requires a streamlined framework. The breakdown of CI were both used to develop three main areas of focus which are believed to be key factors in CI performance development (Dorta et al. 2011 and Stempfle and Badke-Schaub, 2002). As described in more detail in Chapter 2 of this thesis, CI is understood as a sequence which is comprised of three dimentions: Structuring moments, a Conceiving phase and an Illustrating phase. In their analyses, both research teams suggest that social factors among group participants may influence collaborative ideation (CI) development and performance. This, paired with the recognized impact of various cognitive and affective factors on creativity when studied at the individual level (Baas et al., 2008; Sadler-Smith, 2015), has led to the identification of a gap in the literature. To fill this gap the following research question is asked:

What are the drivers of creativity in collaborative ideation?

Using a scoping review to examine relevant literature allowed for the integration of different scientific perspectives on collaborative ideation. The reviewed domains include design, human-computer interaction (HCI), neuroscience, and creative psychology. This approach is beneficial for explaining the complex dynamics by which creative groups collectively organize, synthesize, and construct novel ideas to yield innovative outputs.

Conducting this multifield review permitted, the examination of both individual and collective requirements for generating novel and innovative ideas and a refined understanding of CI.

1.1.1 Insightful Findings

Our literature review revealed that the individual experience, the social factors, and the elements of the collaborative ideation sequence are all interrelated key creativity drivers in collaborative ideation. To produce an effective creative output an individual must balance the use of divergent and convergent thinking (Cropley, 2006). The interrelated relationship between cognitive and affective states in the generation of individual ideas (Akbari, Chermahini & Hommel, 2012) requires their effective management by co-participants during CI. This is where social cues come into play. For example, Active listening cues, by providing visible nonverbal support, enhance positively co-participants affective state (Weger Jr et al., 2010). This cue could be conducive for moments where divergent thinking is required. Feedback cues, according to the literature have a focusing/evaluative role (Barr & Conlon, 1994; Hattie & Timperley, 2007; Turner & Schober, 2007). This cue could be appropriate for convergent moments. However, when poorly managed, this cue leads to a diminished affective state, leading to a lack of motivation and participation in CI (Turner & Schober, 2007). Administering a varied degree of positive feedback by the group is essential for maintaining positive states in co-participants (Turner & Schober, 2007). To achieve high creative performance the strategic placement and quantity of these different factors are crucial for the creative output of teams. Consequently, proficient ideation processes require the appropriate placement and quantity of social cues for collective groups to govern the affective states of co-participants, guaranteeing optimal cognitive functionality in ideational development and effective creative output.

1.2 *Applied Exploration of Collaborative Ideation (CI) (Article 2, Chapter 3)*

The theoretical foundation established in Article 1 serves as the basis for the investigation into the phenomena in collaborative ideation (CI). Promising insights from different studies heightened our anticipation for potential findings (Dow et al. 2011 and

Cash and Maier, 2016). It is demonstrated that sharing multiple designs not only enhances team creativity but also helps collective divergent thinking (Dow et al. 2011). Furthermore different types of gestures influence different aspects of CI (Cash and Maier, 2016). These studies emphasize the impact of both cognitive input and social factors on creative development and team performance. Thus, our study aims to explore not only the co-generativity of ideas but also the influence of psychosocial patterns on CI and its performance. To achieve this, we observed the social factors, the collaborative ideation (CI) sequence, and individual cognitive-affective states of eight creative teams across different levels of creativity. This allowed for the examination of psychosocial patterns and their influence on the CI sequences and the overall performance of teams. The guiding research question is as follows:

How do social dynamics among team members, through the communication of verbal and non-verbal cues impact the different elements of collaborative ideation and team performance?

To answer this question an exploratory-deductive approach was used to analyze the continuous multifactorial observations. In a controlled environment, behavioural actions, physiological states, and self-perceived cognitive and affective measures were continuously accounted for to capture the complexity of collaborative ideation (CI). The use of the median split method created two creative groups for pattern identification and statistical tests. Our results below further the empirical knowledge of CI and confirm scientific findings.

1.2.1 Insightful Findings

High-creativity teams demonstrated higher levels of structuring moments. Monitoring and adjusting the collaborative ideation process in alignment with idea development seems to establish optimal conditions for high creative performance. Playing a vital role in achieving high creative output by inducing positive affective states and extending conceiving phases, active listening cues contribute to ideational expansion in creative teams. Our results however demonstrate the complexity of feedback cues. The absence of their impact on creative performance, coupled with a positive effect on cognitive load and a negative influence on the conceiving phase and participants' affective states, indicates that feedback cues adversely affect idea expansion, inducing a state of

ideational focus in co-participants. Its limited impact on CI, lack of effect on performance, and its focusing role during CI suggest either the presence of another variable or could require its pairing with structuring moments. Therefore, empathetic actions and CI management in creative teams foster a consensus-driven creative process and improve group creativity. Our research validates once more the use of the "multiple angles" approach as a valid method for achieving collective high creative output.

2. Goal and Expected Contribution of this Work

Shedding light on the intricate production required to achieve high creative outputs in teams provides theoretical, methodological, and practical implications.

While creativity has been extensively studied at the individual level, its dynamics in a collective settings still pose intriguing questions for the scientific community. Integrating scientific literature from design, human-computer interaction (HCI), neuroscience, and creative psychology provides a comprehensive understanding of Collaborative Ideation (CI). This research procedure enabled the construction of questions and hypotheses which were subsequently validated through empirical experimentation. This research technique contributes to the theoretical comprehension of CI by multifactorial validation.

Constructing and validating a three-dimensional data structure based on established frameworks provides a codifying structure for collaborative ideation (CI) and offers a rigorous template for observing the impact of social factors in the context of CI. This methodological contribution presents a simple and effective approach for conducting continuous observations for subsequent thorough analysis.

Practical implications for achieving effective creative consensus in collaborative ideation are illustrated in this thesis. By unveiling the intricacy of collaborative ideation, we identify key social factors that can be taught to be applied at specific moments during CI. These observations can be employed during CI in organizations to choreograph the perfect ideational dance, ultimately leading to enhanced team creative performance.

3. Thesis Structure

Segmented into four chapters, the structure of this memoir is as follows:

Chapter 1 introduces and situates the research in the larger context of empirical studies on creativity & design practices in the business world. It underlines its importance for both the scientific community and the industry.

Chapters 2 and 3, both written in the form of articles, constitute the main body of this research. Article 1 (chapter 2) is a scoping review of the literature. Its purpose is to define CI for its examination and make an argument for the factors that are believed to impact it. Article 2 (chapter 3) presents rigorous qualitative observational research on CI. To ensure the ecological validity of our results, eight creative teams are observed in a controlled environment to collect continuous behavioural, physiological and self-observed cognitive-affective measures. The goal of this experiment is to elucidate the fluctuation of creative performance in innovation teams and provide tangible recommendations to organizations for the management of their teams in an innovation context.

Chapter 4 concludes this research by summarizing our key findings and discussing the limitations of our empirical analysis. This examination establishes the theoretical, methodological and practical implications of this study and provides new opportunities for further investigations on collaborative ideation.

Please note that ChatGPT 3 and 3.5 have been used throughout by the student to correct grammar and improve readability/language. After using this tool/service, the content was reviewed and edited as needed.

4. Author's Role in Completing this Thesis

This research was conducted as part of the student's master's thesis, under the guidance of two co-directors. Their valuable input and guidance were instrumental in each step of the process. The study took place at the Tech3lab, with precious assistance from its research team. Table 1 outlines the student's contributions and responsibilities at each stage of this process.

Table 1. *Author's Contribution to the Research Process and Writing of the Articles*

Research Process	Student Contribution
Research Questions	Identifying the gaps in the current literature for charting the data and a qualitative assessment of the research problem. **–70%** - In partnership with co-authors, this process involves determining the challenges of the studied issue and its implications for both the industry and research community.
Literature Review (Chapter 2, Article 1)	Conducting relevant research, and reading scientific articles related to the topic. **–100%** Constructions of complex visualization of key concepts and methodologies. **–33%** - Help was provided to the student for the conception and illustration of those figures by co-authors.
Conception and Experimental Design	Designing and development of the experimental protocol. **–75%** Determining unintrusive measurements and continuous recording of key factors in the experiment. **–30%** - These measures were designed and conceptualized with the assistance of the co-authors and the Tech3lab research team. Applying to CER. **–90%** - Prepared the documentation related to the submission of the application to the CER.
Recruitment of participants	Recruiting the participants for the study. **–80%** - Determining the inclusion and exclusion criteria for the participants of the study. - Recruitment logistics: managing scheduling and communication with the participants accordingly. - Help was provided to the student for the recruitment of participants from the second co-author.
Pre-Test & Data Collection	Pre-testing the experimental design and collecting the data. **–75%** - In collaboration with the research team and co-authors, the student oversaw the collection of the data for all participants in the study.
Data Analysis	Charting the data for visualization. **–70%** - With the help and supervision from second co-author, the student first conducted case studies of the observed teams and systematically coded participants actions according to the literature and provided coding scheme by this co-author. Analysis of the Data. **–50%** - Formatting of the data for easy analysis was performed by the student and the statistical analysis of the data was performed by the Tech3lab statistician with the statistical tool SAS 9.4.

Empirical Study (Chapter 3, Article 2)	Conducting relevant research, and reading scientific articles related to the topic. **–100%** Synthesizing results in a clear and concise argument. **–100%** Constructions of complex visualization of key concepts and methodologies. **–50%** - Help was provided to the student for the conception and illustration of those figures by the second co-author.
Thesis	Writing Thesis/First & Second Articles **–100%** - Guidance and feedback were provided by co-directors throughout this process. - Co-directors/co-authors edited and reviewed the articles submitted to the journals.

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Chapter 2: Literature Review: Examining the Human Experience in Collaborative Ideation

A multidisciplinary scoping review of collaborative ideation to understand the factors that impact its process, content, and performance.

Highlights:

- Describes the interconnectivity of social-cognitive-affective factors in collaborative ideation and their impact on creative performance.
- Demonstrates consensus reaching as an effective management methodology for collaborative ideation.
- Emphasizes the role of empathetic cues in collaborative ideation for optimal creative performance.
- Sets the groundwork for empirical testing on collaborative ideation.

Abstract:

The development and implementation of effective design strategies for idea development have become significant across various industries, extending beyond design-focused practices. Collaborative ideation, influenced by agile working methodologies, plays a crucial role in optimizing the outcomes of those design strategies. This multidisciplinary scoping review explores the evolving landscape of collaborative ideation to provide a comprehensive understanding of this complex subject. To guide this research the following question was formulated: *What are the key drivers of creativity in collaborative ideation?* Here, the role of social, affective, and cognitive factors on collective performance is emphasized. Scholars and practitioners can use this review as a valuable resource to enhance their understanding and optimize collaborative ideation processes for collective innovation.

Keywords:

Collaborative ideation, Collaborative design, Design practice, Design studies, Research methods

1. Introduction

Design methods are no longer the sole domain of a design-focused practice and have become commonplace across multiple industries (Dorst, 2015a; Kolko, 2015). The creative process is an iterative, cyclical process (Cash & Maier, 2016; Dorta et al., 2011a) that serves as a blueprint for multiple design processes such as future thinking and design thinking found in collaborative ideation (CI). These now widely used design processes embrace open problem definition and follow an iterative ideation structure (Dorst, 2015a; Kolko, 2015). These techniques aim to enhance problem comprehension, generate ideas, and facilitate their selection into a cohesive and structured outcome during collective ideation (Dorst, 2015b; Shneiderman, 2000). Such design techniques are great for providing designers and knowledge workers with an outline for conducting research and producing innovative site-specific solutions (Dorst, 2015b).

The prevalence of collaborative ideation (CI) is seen in multiple high-performing companies such as Coca-Cola and Apple (Naiman, 2019). However, the efficiency and validity of CI have long been subjects of debate among the scientific community (Davis & Eisenhardt, 2011; Stroebe et al., 2010), with perspectives suggesting that individual brainstorming is significantly more productive than its collective counterpart. A first step in understanding the dichotomy between the widespread use of CI in industry and its disputed benefits among the scientific community begins with a survey of 208 creativity-centered studies (Frich et al., 2018). It reported on the surprising discovery that only 7.21% of those studies addressed the interplay between individual and collaborative creativity (Frich et al., 2018). Expanding on this notion, design research, as well as cognitive research on CI, tend to focus on task-based interactions (e.g. pointing to concept, proposing or questioning seen in Dorta, et al. (2011a); questioning and analysis seen in Stempfle and Badke-Schaub (2002)) or exclusively on the creative performance (e.g. variations on Guilford (1956); Torrance (1990) tests; Amabile (1982) *Consensual Assessment Technique*) without considering the lived and expressed experience of the participants during CI. This strong understanding of task-based actions and creative output affords only a partial understanding of the cognitive processes and overlooks the social and affective factors during CI. A closer look at the interplay of individual and

group lived and expressed experiences might shed light on the disputed effectiveness of CI.

2. Literature Review

This literature review will look at the role of socio-cognitive-affective factors, present in participants' lived and expressed experiences during collaborative ideation (CI), to explain the varying levels of creative outputs noticed by the scientific community for creative teams. To give structure and some guidelines to this review, the following research question is used:

What are the drivers of creativity in collaborative ideation?

To understand the drivers of creativity in CI the article will be divided into six sections. First, the methodology used to construct this argument will be reviewed. Second, the progression of CI will be defined. Third the psychosocial factors that influence its sequence and performance will be outlined. Fourth these findings will be contextualized and discussed. Finally, the fifth and sixth sections of this article serve to establish a framework for researching CI and culminate in a conclusive summary.

2.1 *Methodology for Literature Review*

The influence of the lived and expressed experience emphasizes the intricate nature of CI and highlights the importance of gaining a broader understanding of the social, cognitive, and affective experiences of individuals participating in CI. This review aims to integrate different perspectives from design, human-computer interaction (HCI), neuroscience, and creative psychology, to provide a deeper understanding of how creative groups collectively organize, synthesize, and construct novel ideas to create innovative results. Exploring these interdisciplinary insights will uncover the collaborative processes employed by these groups in effectively addressing complex challenges and in doing so shedding light on the human experience of CI.

To do so, a thorough scoping review of multiple interdisciplinary fields was conducted to explore literature (Arksey & O'Malley, 2005). The following five steps were respected:

“identifying (i) the research question, (ii) relevant studies, [from] study selection, [then (iii)] charting the data, (iv) collating, summarizing and (v) reporting the results” (Arksey & O'Malley, 2005, p. 22).

For this review, 180 articles were first assessed from conference papers (29) and journal articles (161), 65 articles (8 conference papers and 57 journal articles) were selected. The selection of relevant studies was carried out in three phases: (i) reviewing and selecting a definition of creativity to be used in the study; (ii) reviewing how social, cognitive, and affective interactions affect creativity and problem-solving in a group or a team. Lastly, (iii) articles were selected that: 1) Reflect our understanding of creativity; 2) Are supported by many other sources in the literature; and 3) Are useful for research teams and managerial bodies in charge of creative and complex problem-solving teams (Long & Magerko, 2020).

Once the selection of our material was finalized, each chosen document was rigorously reviewed and the data presented in it was archived in an Excel spreadsheet by: Name of the article, Author, Year/Study location, Population, Aim of the Study, Methodology, Results and Contribution. From this literature review coding process and the interpretation that followed, a subsequent critical understanding of effective collaborative ideation (CI) is presented further below.

2.2 *Review of the progression of collaborative ideation*

Given that creativity constitutes the cornerstone of CI, it is valuable to begin by defining this fundamental process. This will pave the way for a comprehensive exploration of the multitude of factors involved in CI. A long-lasting definition in psychology sees creativity as *“any new, unprecedented, and effective method of solving problems*” (Guilford, 1956, p. 233). At the individual level, in this field, this process involves the ability to establish associative connections between various concepts, thereby generating novel meanings (Mednick, 1962). Creative cognition is defined by two generative phases: generation (where an idea is proposed) and exploration (where this same idea goes through an explorative and generative loop) (Ward, 2007). While the common definition of creativity provides a useful foundation, it fails to fully encompass

the crucial role of social dynamics in collective endeavors and overlooks the broader objectives beyond problem-solving inherent in CI. Subsequent research acknowledges that individuals in CI use the aforementioned creative process within a social framework to generate novel and beneficial outcomes (Hennessey & Amabile, 2010; Osborn, 1953; Warr & O'Neill, 2005). The research on CI has shown that an individual's creativity is influenced not only by their perception of their environment but also by the group's context, including the personality and expertise of its members, its ability to organize and synthesize ideas, and its effectiveness in applying these ideas to problem-solve (Amabile, 1983; Frich et al., 2018). In other words, an individual's open-mindedness, willingness to participate and ability to synthesize complex issues with others are all crucial steps for optimal CI sessions. Drawing on Warr and O'Neill (2005) extensive research, creativity in a collective setting is therefore defined as follows:

> *"Creativity is the generation of ideas, which are a combination of two or more matrices of thought, which are considered unusual or new to the mind in which the ideas arose and are appropriate to the characteristics of a desired solution defined during the problem definition and preparation stage of the creative process." p.122*

This understanding has led to the argument that cognitive flexibility, crucial for producing novel creative outputs, is essential in collaborative ideation (CI) (De Dreu et al., 2008; Grawitch et al., 2003). While this individual trait holds significance in collaborative ideation (CI), investigating the interplay between individual and group experiences and its impact on ideational sequence and team performance could provide valuable insights and potentially alter this perspective.

2.1.1 Two Common Collaborative Ideation Practices

The analytical best practice of considering the "multiple angles" to develop an idea by constructing a matrix of thoughts (Dorst, 2015b) is not consistently followed by designers despite being vastly recognized for optimal performance (Badke-Schaub & Stempfle, 2003; 2002). Instead, as illustrated in Figure 1, two types of ideational sequences are thought to occur in teams:

- Proposal (generation) followed by immediate evaluation (focused implementation) (Badke-Schaub & Stempfle, 2003; 2002) or the "energetic brainstorm".

- Proposal (generation) followed by analysis (exploration, generation and focused implementation) (Badke-Schaub & Stempfle, 2003; 2002 and Ward et al. 2007) or the "multiple angles" strategy (Dorst, 2015b).

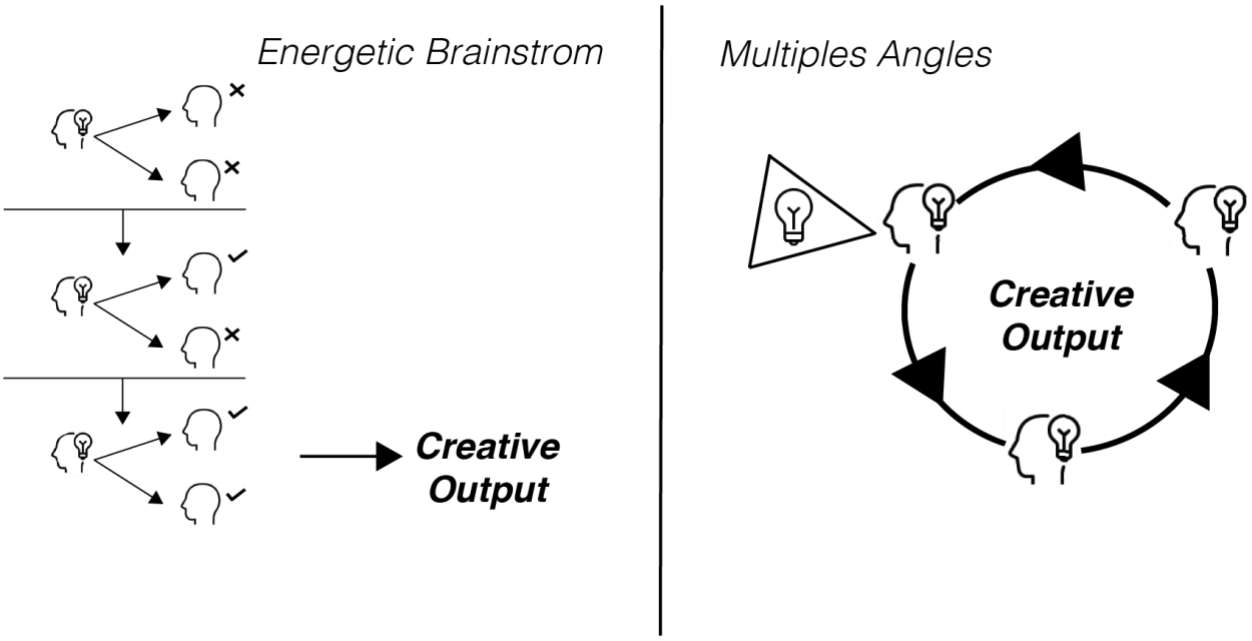

Figure 1. *Prominent Collaborative Ideation Sequences: The "Energetic Brainstorm" and the "Multiple Angles" Strategy*

The distinction between these two sequences is the absence or presence of iteration. In the "energetic brainstorm" sequence, the iterative loop is cut by the immediate evaluation from fellow teammates (Badke-Schaub & Stempfle, 2003; 2002). This quicker process is susceptible to misleading outcomes and lower levels of creative performance (Dow et al., 2011; Stempfle & Badke-Schaub, 2002). Here participants accept or reject ideas along with the group without expanding on the idea or considering its entirety through open angles (Dorst, 2015b; Dow et al., 2011; Stempfle & Badke-Schaub, 2002). Therefore, the insufficient qualitative assessment of a proposal with one's or a teammate's worldview during an analysis phase can lead to the implementation of "quasicreative" ideation output, negatively impacting the team's creative performance (Cropley, 2006). In contrast,

teams that follow the “multiple angles” approach, engage in design actions that form an ideation loop which facilitates the iterative process (Dorta et al., 2011a). Here, proposed ideas are analyzed through peer qualitative assessments and are then assimilated into the collective creative output (Jansson & Smith, 1991). Studies found that teams who were able to identify and address their “knowledge gaps” through qualitative assessment of ideas were more successful in producing higher levels of creative performance (Dow et al., 2011; Turner & Schober, 2007). Going through the iterative process of reframing/analysis and reflecting the perspective of others, allows for a conceptual blending of ideas to update the collective memory of the group (Turner & Schober, 2007). Considering an issue as being full of open angles by sharing and exchanging multiple points of view/concepts (Dorst, 2015b) and reaching a *consensus* in the implementation phase (Dow et al., 2011) is therefore essential for avoiding “quasicreative” creative performances (Cropley, 2006).

As described in Figure 1 and above, the iterative process of building upon others' ideas leads to higher levels of creative output (Dow et al., 2011; Turner & Schober, 2007).

In collaborative ideation, the iterative process of reaching *consensus* enables group members to gather inspirational material for expanding and refining collective ideas, resulting in joint actions where participants shape and expand each other’s ideas to create a mutually agreed-upon collective output (Dow et al., 2011; Dorta et al., 2011b). Improving our understanding of participants' socio-cognitive-affective states and their influence on idea development during CI would help organizations and researchers comprehend why teams tend to sometimes follow the “energetic brainstorm” as opposed to the “multiple angles” strategy to generate ideas in collaborative work.

2.3 *The Ideational Sequence (Collaborative Ideation Content and Process)*

The complexity of CI requires a definition of its multiple elements to allow for the visualization and illustration of the impact of social, cognitive, and affective factors on its processes and performance. During the generative phase team members explore the problem at hand by generating and analyzing the proposed ideational cues from fellow participants (Stempfle & Badke-Schaub, 2002). This process is followed by the

implementation phase where a configuration of those ideas occurs (Jansson & Smith, 1991). To achieve this dynamic interplay, teams oscillate organically between *content* and *process* actions to construct creative outputs (Convertino et al., 2008; Stempfle & Badke-Schaub, 2002). *Content* actions are referred to as information on the working topic of discussion or "know-that" and require the teammates to share an understanding of the problem at hand (Convertino et al., 2008). *Process* actions or the "know-how" are there to organize and structure the CI and need to be constantly implemented for the well-functioning of a team (Convertino et al., 2008; Stempfle & Badke-Schaub, 2002). Table 1, showcases how researchers exemplify the oscillation of CI within a team, as it iteratively alternates between opening and narrowing the problem space. This cycle of generative and implementation phases ultimately contributes to the overall creative performance of the team (Dorst & Cross, 2001; Dorta et al., 2011a; Jansson & Smith, 1991; Stempfle & Badke-Schaub, 2002).

Table 1. *Collaborative Ideation Sequence as expressed by Authors and Phases*

<table>
<tr><td rowspan="2">MODEL</td><td colspan="10">GENERATIVE PHASE</td><td colspan="3">IMPLEMENTATION PHASE</td></tr>
<tr><td colspan="13">Iterative Interplay between these two phases: (Feedback Loop)</td></tr>
<tr><td>JANSSON & SMITH, (1991)</td><td colspan="10">Concepts</td><td colspan="3">Configuration</td></tr>
<tr><td>WARD ET AL., (1999)</td><td colspan="6">Generate</td><td colspan="7">Explore</td><td colspan="3"></td></tr>
<tr><td rowspan="2">DORST & CROSS, (2001)</td><td colspan="10">Problem Space</td><td colspan="3">Solution Space</td></tr>
<tr><td colspan="4">Analysis</td><td colspan="3">Synthesis</td><td colspan="3">Evaluation</td><td>Analysis</td><td>Synthesis</td><td>Evaluation</td></tr>
<tr><td rowspan="2">STEMPFLE & BADKE-SCHAUB, (2002)</td><td colspan="10">Opening the Problem Space</td><td colspan="3">Narrowing the Problem Space</td></tr>
<tr><td colspan="6">Generation</td><td colspan="4">Exploration</td><td colspan="2">Comparison</td><td>Selection</td></tr>
<tr><td rowspan="2">DORTA ET AL,. (2011A, 2011B)</td><td colspan="13">Collaborative Ideation Loop</td></tr>
<tr><td>Naming</td><td>Constraining</td><td colspan="3">Negotiation</td><td colspan="3">Moving</td><td colspan="2">Decision Making</td><td colspan="2">Illustrating</td></tr>
<tr><td></td><td></td><td>Questioning</td><td>Proposing</td><td>Explaining</td><td>Pointing</td><td>Gesturing</td><td>Sketching</td><td></td><td></td><td></td><td></td></tr>
</table>

The overview provided by Table 1 is useful for observing creative *content* and *process* development in a group setting as seen by different researchers. It also provides a visual evolution of CI in the literature. Considering the complexity of both the described ideational sequence and the socio-cognitive-affective factors that mediate it, we have

developed a streamlined version of collaborative ideation (CI). This simplified version of CI will facilitate a clearer understanding of the influence of lived and expressed experiences of participants on CI. The following subsection will offer a comprehensive explanation of this simplified segmentation of a CI sequence comprising three attributes: Structuring moments (constant organizational indicators), and the Conceiving phase, and Illustrating phase.

2.3.1 Structuring moments (organizational indicators):

The structuring moments contain actions which offer directionality and structure to the team. To achieve optimal CI andperformance, team members must alternate between a generative/exploratory phase (Ward, 2007) for broad problem exploration and a focused implementation phase (Stempfle & Badke-Schaub, 2002). To achieve this cycle in a social setting, teams require constant organizational indicators. During this progression, *content* and organizational actions are interwoven and continuous (Stempfle & Badke-Schaub, 2002).

Design teams need a *process* (organization of a design project) (Badke-Schaub & Stempfle, 2003) and a frame to structure and adjust their ideational development for the creation of effective outputs (Kozlowski & Ilgen, 2006). The structuring moments in this review are defined by using two observational tags in the literature.

The first observational tag: “Naming” (Dorta et al., 2011a) is defined as the action of verbalizing the desired impact of the design project and is usually found to happen at the beginning of the CI or in pair with the action of pointing to start the selection process in the “problem space” of CI. It is therefore a marker of structure that frames and influences ideational development or *content* by dividing CI into two consecutive spaces: the Generative Implementation phases as seen in Table 1.

The second observational tag: “Goal clarification”, is the process of dividing and structuring tasks during the CI such as instructing another team member to take notes or sketch (Badke-Schaub & Stempfle, 2003). Unlike “Naming” the precise placement of “Goal clarification” during CI for achieving high levels of creative output is still unclear.

Structuring moments are therefore injected into the ideational content development to offer structure and keep the team on the right trajectory. From the research above two hypotheses can be explored:

- The markers discussed ("Naming" and "Goal clarification"), play a crucial and indispensable role in facilitating the effective functioning of collaborative ideation (CI). They contribute to the establishment of a shared understanding of the design brief and the development of a cohesive creative output.
- These "process-directed activit[ies]" are a catalyst for social, cognitive, and affective dynamics within the group.

Furthering this understanding will allow for an effective study of socio-cognitive-affective interplay within CI development and the production of creative outputs.

2.3.2 Conceiving phase:

As seen before in this review, *consensus*-driven teams which explore "multiple angles" (Dorst, 2015b) by sharing multiple perspectives, iterating and focusing them into a comprehensive ideational output demonstrate higher creative performance (Dow et al., 2011). The study demonstrated that designers who received multiple perspectives and iterated on their ads achieved higher performance indicator scores and better expert assessments (Dow et al., 2011). This consensual process underscores the significance of iterative behaviors and the sharing of perspectives to facilitate successful outcomes in CI. Therefore, an optimal conceiving phase has iterative cycles where participants open and then narrow the problem space (Stempfle & Badke-Schaub, 2002) to expand collectively the ideas proposed by fellow participants (Dow et al., 2011) until the resolve reaches "good, just, useful, and satisfying" levels (Buchanan, 2019, p. 101).

While conceiving, teammates verbalize and undertake design actions to collaboratively generate creative outputs (Dorta et al., 2011a) as shown in Table 1. By looking at the issue through multiple angles (Dorst, 2015b) the team analyzes, synthesizes and evaluates ideation inputs proposed by co-participants in both the problem and solution space (Dorst & Cross, 2001). The conceiving phase is where items such as "ideas,

relationships, or other abstractions" are generated and analyzed (Jansson & Smith, 1991, p. 3). These items can then become implemented or not into the larger context of the collective creative output in the later solution or "configuration space" shown in Table 1 (Jansson & Smith, 1991, p. 3). The iterative interaction between the generative/explorative phase (Ward, 2007) and the focused implementation phase (Stempfle & Badke-Schaub, 2002) is vital as it allows for the sharing and comparison of ideas from participants, promoting a shared understanding and collaborative generation of solutions to complex problems and innovation (Stempfle & Badke-Schaub, 2002). Members of a team are able to clarify, analyze and evaluate the idea by reinterpreting ideational input from their co-participants (Dow et al., 2011; Stempfle & Badke-Schaub, 2002). This cyclical process is ideal for ideational growth and produces better creative output (Dow et al., 2011; Stempfle & Badke-Schaub, 2002).

Next, the conceiving phase is defined by two observational tags and a modified understanding from an existing tag in the literature.:

Developed by Dorta and colleagues (2011a), the first existing two tags are "Negotiation" (proposing, explaining, questioning) and "Moving" (pointing, gesturing, sketching). These tags encapsulate key individual actions which are part of the ideational development within design teams. These gestures as seen in Figure 2 below, represent the verbalizations and actions of idea conception, instrumental in observing and comprehending the progression of the conceiving phase.

The third tag, "Decision-Making" developed by the same research team, is modified, and replaced by "Consensus" for a clearer grasp of the decision-making process in collaborative ideation (CI). As demonstrated earlier, to conceive rich creative outputs a team must use a consensual iterative process. The items in "Negotiation" and "Moving" have the dual purpose of selection and expansion in the conceiving phase. They can serve as explaining, showcasing, or abstracting the issue allowing for the expansion and selection of ideas (Cardoso et al., 2009; Cash & Maier, 2016; Härkki et al., 2018). The descriptive elements found in "Moving" helps the team understand the proposed issue (Cash & Maier, 2016) whereas the abstractions found in these same gestures allow for

associative thoughts to occur (Ward, 2007). Thus, this process allows for addressing and resolving the team's "knowledge gaps" (Dow et al., 2011). Therefore, the verbalization of conceiving an idea or "Negotiating" with "Moving" allows individuals involved in CI to visualize, examine, and give feedback on the idea (Dorta et al., 2011a). This process will expand or select the creative output (Härkki et al., 2018) which leads to reaching a "Consensus". Therefore, the constant iterative feedback loop leads to better creative performance. Decision-making is therefore accomplished by expanding and discussing the preferred concept through an iterative loop (Cash & Maier, 2016) and stops when consensual "satisfying" is reached (Buchanan, 2019; Eris et al., 2014).

Hence these codes help visualize and mark where the conceiving phase occurs in CI. They serve as markers for the explorative and dynamic evolution of opening and narrowing the problem space iteratively, leading to a transient bridge that identifies potential pairings of individual ideas into a larger collective resolve. Teammates can then endorse or reject these pairings during the selection process of constructing the creative output (Dorst & Cross, 2001).

2.3.3 Illustrating phase:

The illustrating phase is seen as the last step taken by the creative team to cement the established ideational output created by the team (Dorta et al., 2011b). It serves as a stabilization of the ideational process. The illustrative phase of CI is when ideational outputs become cemented in the collective minds (Jansson & Smith, 1991). In this stage, designers and innovators transform their concepts into diagrams and renderings, which they later present to individuals outside the collaborative ideation (CI) process. This tangible representation enables them to visualize the proposed ideas effectively (Jansson & Smith, 1991).

The illustrating phase in this review is defined by one observational tag in the literature. Also taken from the model developed by Dorta and colleagues (2011b) the illustrating phase is an observed action where individuals in collaborative ideation (CI) summarize the concepts developed by the group for later presentation. This process is instrumental for stopping the feedback loop and realizing the participatory ideational

input into a cohesive detailed collective creative output. However, swift implementation, with the adoption/rejection of ideational input, will negatively impact the creative output (Jansson & Smith, 1991). Early adoption/rejection of ideational input can prove adequate for the "task structure of the group" p.128 but inadequate for the problem-solving and innovation as a whole (Badke-Schaub & Stempfle, 2003).

Figure 2 below, presents a visualization of the above explained simplified version of the CI sequence. This streamlined understanding of the collaborative ideation (CI) can be used to observe the relationship between ideational sequences and the larger socio-cognitive-affective context of collaborative ideation (CI). The establishment of these simplified phases will enable researchers to observe the preceding socio-cognitive-affective factors that impact each phase, leading to a better understanding of how to effectively manage participants for optimal creative output.

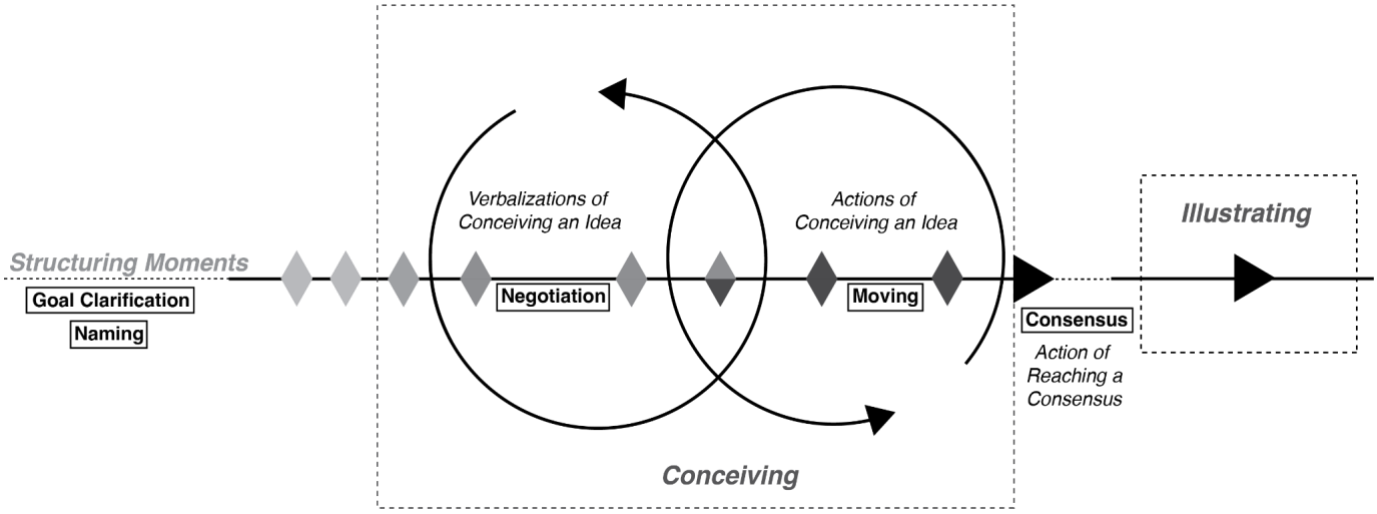

Figure 2. *Visualization of the simplified Collaborative Ideation Sequence*

3. Results: Examining the socio-cognitive-affective impact on the Collaborative Ideation

Social inputs from fellow participants significantly influence the cognitive and affective states of individuals, impacting their ability to generate ideas and effectively communicate within a group (Bierhals et al., 2007; Dow et al., 2011; Stroebe et al., 2010). Individuals involved in CI need to go through different cognitive and affective states to

be able to generate an ideational output (Akbari Chermahini & Hommel, 2012; Cropley, 2006; Ward, 2007). To achieve this process, individuals in CI use divergent thinking (DivThink) and convergent thinking (ConvThink) (Akbari Chermahini & Hommel, 2012) modulated by proposals, generative questions and the re-framing of the proposal by fellow participants (Eris, 2003) until the resolution of the ideation responds to the collective vision of "good, just, useful, and satisfying" design (Badke-Schaub & Stempfle, 2003; Buchanan, 2019). The transformative and modulative influence of social factors on information distribution and ideation building in collaborative ideation (CI) will be explored in further detail below.

3.1 *Cognitive Processes and Cognitive States of a Collaborative Ideation Participant*

To gain a comprehensive understanding of the cognitive processes and states involved in divergent and convergent thinking, it is essential to delve into the mechanisms underlying these thinking phases. Amabile's (1983) collaborative ideation (CI) model suggests that individuals engaged in CI undergo multiple cognitive stages during both DivThink and ConvThink. These stages can be compared to Wallas (1926) dimensions of the creative process seen in Sadler-Smith (2015): preparation, incubation, intimation, illumination and verification. As described by Ward et al. (1999) with their *Geneplore* model, it is thought that individuals involved in conceiving an idea oscillate between a "*generative*" state (consisting of the generation of pre-inventive structures) and an "*exploratory*" state (consisting of the exploration and interpretation pre-inventive structures). The conceived ideas are then subjected to conscious and subconscious evaluative stages (Sadler-Smith, 2015) found in the convergent thinking (ConvThink) phase (Cropley, 2006). Here, an idea undergoes two stages of assessment: firstly, it is individually evaluated on a subconscious level by a participant, involving the dimensions of incubation and intimation (Sadler-Smith, 2015); secondly, the idea is subjected to collective conscious examination by the rest of the team, involving the verification dimension (Cropley, 2006; Sadler-Smith, 2015). In simpler terms, to move an idea forward, individuals engage in two phases: the generative/exploratory stage known as DivThink, which involves cognitive flexibility, and the evaluative stage (Cropley, 2006; Ward, 2007). The evaluative stage known as ConvThink occurs subconsciously prior to

verbalizing the idea and then requires conscious cognitive perseverance once the idea is verbalized to the rest of the group (Cropley, 2006; Sadler-Smith, 2015; Ward, 2007).

As seen earlier, if not critically analyzed within the context of individual or team perspectives, there is a possibility of producing "quasicreative" ideation output (Cropley, 2006) where the creative outputs do not reach "good, just, useful, and satisfying" levels (Buchanan, 2019). This emphasizes the need for the collective and meticulous pursuit of the conscious verification dimension of the ConvThink process, while also allowing sufficient time for its subconscious counterpart to evolve in individuals (Sadler-Smith, 2015), thereby ensuring the success of the creative performance and fostering a productive DivThink process in CI (Cropley, 2006). Therefore, it could be argued that effective group mobilization of DivThink) and ConvThink within CI is imperative. How this process is expressed and affected by others within the group requires further exploration and will be described in the next sections of this literature review.

3.1.1 The Management of Individuals' Cognitive Process

An ideation process entails two phases: DivThink and ConvThink. In this process, an idea is generated, expressed and developed by members of the group through iterative ideation loops (Dorst & Cross, 2001; Dorta et al., 2011a; Jansson & Smith, 1991; Stempfle & Badke-Schaub, 2002). Participant idea generation in a CI session is, thus, motivated by the idea generation of others within the team and is stunted by cognitive failure such as "Production-Blocking" (the act of taking turns to state an idea in CI) (Stroebe et al., 2010), "Functional Fixedness" (the fixation on a small aspect of the issue), (Abraham & Windmann, 2007) and "Path-Of-Least Resistance" (accessing readily available information) (Ward et al., 1999). Here, it will be stated and argued further below that these impediments if properly managed can in fact help the collective development of ideas.

The input of fellow participants can sometimes hinder the ideation process of a participant and is described as "Production-Blocking" (Stroebe et al., 2010). As previously described the subconscious or intuitive, focused selection process of convergent thinking (ConvThink), which leads to the "Ah Ha" moment or expression of an idea, is so rapid and natural that turn-taking in expressing ideas can sometimes cause

“Production-Blocking” which thwarts the ideation process of fellow participants in CI (Stroebe et al., 2010). Having been extensively researched, it is found that common note-taking (writing one’s idea when others are verbalizing their idea) or having generative computational tools during CI (Jenkin et al., 2020) helps avoid this cognitive failure. It is therefore conceivable to claim that the expression of an idea from a fellow participant interferes with the ConvThink process of others in the CI session and comprehensively observing the CI process might provide more answers to this predicament.

The free association process found in DivThink requires an individual to diffuse their attention by expanding and exploring pre-inventive structures (Ward et al., 1999). This requires a low cognitive effort (Ward, 2007). During this process, individuals have a tendency to use easily accessible knowledge cues to generate ideas which can trigger the “Path-of-Least Resistance” if not managed properly by the group with early adoption of subpart, incomplete, and unoriginal ideas (Abraham & Windmann, 2007; Stempfle & Badke-Schaub, 2002; Ward et al., 1999).

Focused tasks, which are more goal-oriented, rely on top-down structural activation patterns in the brain located where our worldview is stored (Abraham & Windmann, 2007). This helps individuals understand and relate the ideas proposed by their team to their own understanding of the world (Abraham & Windmann, 2007). If unchallenged by the rest of the team or if provided early on in the collaborative ideation (CI) with detailed visual stimuli, the limitation of an individual's own worldview and the influence of the detailed image can engender a prolonged state of fixation, giving rise to the occurrence of “Functional Fixedness” within the collaborative group (Cardoso et al., 2009). However, fixation can also elicit beneficial effects, with collective sketching of a complex issue. Sketching is conducive to breaking down complex concepts into manageable pieces for effective problem-solving (Cardoso et al., 2009; Härkki et al., 2018). This visual segmentation of ideas enables a collective understanding and allows for knowledge transfer (Cardoso et al., 2009; Härkki et al., 2018). Fixation on a specific element of the issue with sketches and detailed explanations can help explain certain elements and create a shared understanding of an issue (Goldschmidt, 1990; Härkki et al., 2018). This tool can also be used for ideational abstraction, expansion and creative output building (Eris et al.,

2014; Ward, 2007). This interaction between sketching and ideational input through abstraction and gesturing provides a widening of the idea proposed by an individual in the group (Härkki et al., 2018). On the other hand, if mismanaged, its prolonged state can have the opposite effect on the group's process and performance as it can stunt associative thinking found in DivThink and hinder the group's process of creating a comprehensive creative output (Cardoso et al., 2009; Stroebe et al., 2010).

From the previously discussed cognitive process in ideation, it can be argued that cognitive failures are a result of mismanaged cognitive states. Not permitting ideas to be properly developed by fellow participants – either by the inappropriate amount of time spent or stimuli given in the different sections of the collaborative ideation (CI) process – negatively impacts the creative performance of the group.

3.2 *Affective States and Cognitive Relationships of a Collaborative Ideation Participant:*

The interplay of cognitive and affective states plays a decisive role in idea generation during collaborative ideation (CI). It is found that activating affective states with high levels of arousal which are promotion-focused, will yield higher creative performance in individuals during collaborative ideation (CI) (Baas et al., 2008; Funke et al., 2012; Knight et al., 2019) whereas deactivating affective states with low levels of arousal will yield lower creative performance in individuals (Baas et al., 2008; Funke et al., 2012; Knight et al., 2019). A positive affective state "signal[s to the brain] a problem-free environment and leads to flexible processing which broadens the attentional focus, whereas [a negative affective state]…signal[s] a problematic environment and leads to systematic processing and a narrow attentional focus" (Stroebe et al., 2010, p. 193). In order to have access to "distributed" information for associative thinking or being in a state of DivThink) one needs to be in a positive affective state (Akbari Chermahini & Hommel, 2012). However, to transform and focus this information or be in a state of ConvThink one needs to be in a negative affective state (Akbari Chermahini & Hommel, 2012). Hence, the ability to self-regulate an affective state in anticipation of the task at hand would put forward the idea that cognitive and affective states are not only associated

but interdependent variables of the creative process (Akbari Chermahini & Hommel, 2012). This would mean that because the DivThink phase requires a positive affective state to be effective, and promote our ability to access the associative process, the body in anticipation would place the participant in a positive mood. ConvThink, on the other hand, requires a negative affective state to be optimal for us to access a focused goal-oriented process which means that here too the body of the participant would regulate to lower the affective state. This understanding of affective states in relationships to DivThink and ConvThink allows for interesting observations of individuals during CI. First, DivThink and ConvThink are in opposition when it comes to the affective state of participants during CI. Second, by monitoring the fluctuations in the lived experience of participants, researchers can determine if participants are in a generative (DivThink) or evaluative (CivThink) state during a CI session. Exploring how these states manifest in a group setting can reveal new insights into the CI process and identify the optimal balance of generative and evaluative phases to enhance the performance of the group.

3.3 *Social Behaviors in Verbalization and Action of Conceiving an Idea:*

Many social factors are thought to impact the creative performance of a team during ideation such as work diversity in terms of education, personality, and functional background or interpersonal relationships between team members (Hennessey & Amabile, 2010). Furthermore, management is also thought of having an impact on the creative performance of teams throughout an organization (Keum & See, 2017). For example, organizations that encourage risk-taking and give a sense of empowerment to employees foster better creative work than those who monitor closely and give negative evaluation (Hennessey & Amabile, 2010). The focus of this section of the literature review is the social factors during collaborative ideation (CI) which directly impact the modelling of ideas through cognitive and affective changes in participants. Therefore, external social factors such as trust or diversity within the group are not factored in this research, but communicative support and interaction between participants through different types of expressed communication during CI are considered in its stead and will be explored below.

3.3.1 Social Experience of Participants During Ideational Contribution (Input) from Co-Participants:

Two socio-communicator elements (*active listening* and *feedback*) are believed to have an effect on group ideation (Dow et al., 2011; Stempfle & Badke-Schaub, 2002). These different types of expressed communications seem to play different roles in CI development (Hattie & Timperley, 2007; Shalley & Zhou, 2008; Weger Jr et al., 2010). Their strategic usage would seem to influence the group toward one of the two seen earlier ideation sequences ("energetic brainstorm" and "multiple angles") (Dow et al., 2011; Stempfle & Badke-Schaub, 2002). These two types of social markers will be explored to understand how they affect the individual creative sequence in a group. This exploration aims to provide insights that can inform strategic implementation of the "multiple angles" sequence or *consensus*-based CI, empowering innovators with a better understanding of this process.

3.3.1.1 Active Listening:

Empathic or active listening are actions provided by the listener to demonstrate their attentiveness to the generated ideational contribution or input from fellow participant (Weger Jr et al., 2010). To do so, the listener supports with attention signifiers and reflects their teammates' ideas by using the same tone, language and wording (Weger Jr et al., 2010).

Active listening contains multiple verbal and non-verbal items such as reflective language, nodding and verbal utterance (Kohpeima Jahromi et al., 2016). Effective *active listening* technique uses verbal techniques like paraphrasing and non-verbal cues that demonstrate attentiveness as well as empathetic understanding of a teammates verbal input (Weger Jr et al., 2014). Non-verbal communication cues are thought to be great vectors of content communication (Hans & Hans, 2015). For example, verbal-utterance and nodding which are non-verbal gestures, showcase approval and encourage co-participant in the verbalization of an idea without causing any interruption (Davitz & Davitz, 1961). On the other hand, verbal techniques, such as paraphrasing, are utilized in the iterative confirmatory process. This involves the listener to use the same words

previously proposed by their fellow teammate to endorse and demonstrate their understanding of the proposed concept (Weger Jr et al., 2010). The action of paraphrasing or using reflecting language to reiterate the communicated idea by a co-participant in collaborative ideation (CI) not only shows interest but also demonstrates non-judgmental approval of a generated ideational input (Weger Jr et al., 2014). This process is seen as reducing friction between teammates and offering a positive environment conducive to CI (Kohpeima Jahromi et al., 2016). *Active listening* thus facilitates the building of a common understanding among teammates and the expansion of ideas during CI (Weger Jr et al., 2010).

3.3.1.2 Feedback:

Feedback provides informational and evaluative statements on the ideational performance of a co-participant (Hattie & Timperley, 2007; Shalley & Zhou, 2008). Its aim is to assess peer solutional vision for CI (Hattie & Timperley, 2007). Its nature can be encouraging (positive) or preventive (negative), both these values seem to have benefits and setbacks for building an understanding and concept growth during the CI (Barr & Conlon, 1994; Hattie & Timperley, 2007; Turner & Schober, 2007). The comparison of Hattie and Timperley (2007), Turner and Schober (2007) and Barr and Conlon (1994) research, demonstrates contradicting findings on this matter. Similar to Osborn's (1953) findings, Barr and Conlon (1994) comparative study on collaborative work groups, indicated that preventive *feedback* triggered withdrawal from the CI, lowered motivation, and found that this hindered the group's effectiveness to create collaborative outputs. On the other hand, both Turner and Schober's (2007) observational study on product design teams and Hattie and Timperley's (2007) conceptual analysis suggest that negative *feedback* enhances the creative outputs more than positive *feedback* and fear of judgement did not play a role in idea generation. In the observational study, however, it is thought that this relationship can only be viable to a certain extent, and it is determined that participants in creative teams still require some form of positive *feedback* (Turner & Schober, 2007). Positive affective states of co-participants are conducive to effective generation of ideas, as they increase receptivity to negative feedback and willingness to continue participating in CI (Turner & Schober, 2007). Therefore, to ensure

positive states in co-participants, a varying degree of positive *feedback* need to be administered by the rest of the group (Turner & Schober, 2007). The varying outcomes of the above studies could be related to multiple factors such as context, population studied and measurement differences. However, these studies all suggest the importance of managing the affective states of co-participants for the ideal ideational generation and Turner & Schober (2007) seem to indicate the importance of a balanced ratio of positive to negative *feedback* cues for effective CI (Barr & Conlon, 1994; Hattie & Timperley, 2007; Turner & Schober, 2007). The preferred level of positive to negative feedback is still unclear and will be further explored in the paragraph below.

The overall and the individual affective state is positively correlated to participation and leads to "prosocial behaviours" whereas the negative affective state leads to withdrawal from group social activities (Kozlowski & Ilgen, 2006). The positive and negative *feedback* tone, therefore, influences the social demonstrations within the group, and can affect group dynamics/cohesion (Badke-Schaub & Stempfle, 2003). For example, a study on design groups provides a significant finding that accounts for a drop in "group rapport" after the *feedback* phase (Dow et al., 2011). Therefore, whether positive or negative the verbalization of *feedback* seems to have a negative impact on the affective state in CI (Dow et al., 2011) which helps the cognitive process of idea selection by placing the individual in a state of ConvThink (Akbari Chermahini & Hommel, 2012). Expanding on this narrative, giving immediate feedback hinders ideation development or DivThink, but its focused process enhances the ideation selection or ConvThink (Keum & See, 2017). This is an interesting insight into the types of social dynamics that should be used to foster DivThink and CvonThink. It seems that *feedback* is beneficial to CI when it occurs at the end of a fully formed idea proposal. However, it also appears that *feedback* cues given at an inappropriate time during the individual creative process have the potential to disrupt idea presentation by fellow teammates and negatively affect the creative performance of the group.

Gestures in a social context are important non-verbal communicators that are thought to impact the cohesiveness of communication within a group and the selection of co-participant ideational input. Kinesics, like pointing, for example, are physical gestures

that impact communications (Bekker et al., 1995; Dorta et al., 2011; Hans & Hans, 2015). Pointing is a repeated physical gesture that impacts communication by drawing attention to a specific point/area and verbalizing what is seen (Bekker et al., 1995; Dorta et al., 2011; Hans & Hans, 2015). Defined as a part of "moving gestures" in Dorta and colleagues (2011a) study this non-verbal communication can become the visual signifier of ideational adoption. In the context of CI, pointing can become a signifier of "ideas, space or person"(Bekker et al., 1995, p. 162) and can signify an evaluation of said signifiers by having a member of the group point to portions or full visually represented concepts (Cash & Maier, 2016; Dorta et al., 2011a). Therefore a link is found between pointing and the ConvThink phase (Cash & Maier, 2016; Visser & Maher, 2011) as it helps the selection of ideational input. This link mediates the process of CI and is foundational to constructing a shared understanding and idea adoption (Cash & Maier, 2016) by conveying and building communal "haptic and kinesthetic knowledge" (Härkki et al., 2018, p. 23).

Therefore, these informational evaluative cues allow for the review and assessment of the different anticipated outcomes and have the ability to ratify, build upon or change the collective understanding in the ideation sequence of CI (Hattie & Timperley, 2007; Mory, 2004). *Feedback* is therefore seen as assisting peers in collaborative ideation (CI) to detect inconsistency in the group's understanding of the goal (Hattie & Timperley, 2007) and achieve a *consensus* (Dow et al., 2011). It also helps to control and constrain the parameters for the project (Hattie & Timperley, 2007).

4. Discussion: Unveiling Insightful Findings

Teams of designers during CI can be seen as "open systems" where the structure of the group is organic, unplanned and a dynamic reflection of its environment (Keum & See, 2017; Stempfle et al., 2001). However, after this thorough review, it could be argued that this socially complex, "nonlinear", iterative process is intuitively optimized to allow individuals in the group to have the appropriate state for the phase of the ideational sequence they are in. For example, when an individual seeks to expand an idea within a group, *active listening* cues from fellow participants play a crucial role. Strong ideational communicators such as gestures are thought to impact the social making of the group

(Davitz & Davitz, 1961; Hans & Hans, 2015; Phutela, 2015). For example, gestures contained in *active listening* cues such as verbal utterances and nodding serve as conversation modulators, indicating focused attention, interest, attentiveness, and the need for a verbal or nonverbal response from co-participants (Bekker et al., 1995; Eris, 2003; Hans & Hans, 2015). These non-verbal cues influence the cohesion of a group (Phutela, 2015) and signify an implicit validation of the ideational input (Weger Jr et al., 2010). The problem-free environment created by *active listening* cues thus allows for a more expansive exploration of the initial concept (Härkki et al., 2018; Stroebe et al., 2010). This environment provides an optimal condition for idea generation and expansion, as it promotes a positive mood in the proposer, enabling access to a state of DivThink with a reduced cognitive load (Akbari Chermahini & Hommel, 2012). On the other hand, to transform and narrow the ideas into an effective concept the group needs to foster a negative affective state in individuals to help ConvThink which requires a higher cognitive load (Akbari Chermahini & Hommel, 2012). To do so teammates give positive or negative *feedback* cues through selective gestures or language to focus the ideation, create a shared understanding and trigger a negative affective state (Dorta et al., 2011; Dow et al., 2011; Hattie & Timperley, 2007; Mory, 2004). *Feedback* cues therefore fosters precision and enhances the group's comprehension of individual ideational input, thereby facilitating consensus reaching and the creation of collective ideational output (Cash & Maier, 2016). Therefore, being able to recognize when fellow participants are either in DivThink or ConvThink state will help other members of the team give the appropriate type of social cues. Expressed communications within a creative team seem to have an important impact on creative performance by influencing the cognitive and affective states of fellow participants for better mobilization of the creative process (Cash & Maier, 2016). Consequently, the seemingly chaotic process of CI seems to intuitively enhance the creative process and aids the design team to develop a resolve which responds to the collective vision of "good, just, useful, and satisfying" design (Badke-Schaub & Stempfle, 2003; Buchanan, 2019).

This overall review seems to align with Bierhals et al. (2007) observational analysis which demonstrates the high impact of *consensus* and *groupthink* social patterns on the communal conception of ideas during collaborative ideation (CI). *Consensus* or the ability

to analyze the multiple angles of an issue allows for the iterative expansion of an idea and to focus it into an ideational sequence whereas *groupthink* is following along with the group and the listing of ideas with minimal expansion (Bierhals et al., 2007; Dow et al., 2011). In order to collectively develop highly creative ideas, it is important to explore the issue from multiple angles and merge the team's perspectives into a *consensus*. Design team leads and managers need to take careful consideration of this described phenomenon to know how to use and organize creative tools and give appropriate cues to allow for the CI process to be optimal (Härkki et al., 2018).

5.1 *Future research:*

The importance and appropriate management of social, cognitive and affective factors are demonstrated through the above-discussed literature. It should be noted that the studies examined above focus on how social factors, conveyed through expressed communications, independently impact the performance of CI, distinct from the cognitive-affective processes experienced by participants during this progression (Grawitch et al., 2003). Furthermore, cognitive-affective studies tend to focus on participants' overall cognitive-affective state during a session and compare it to their creative performance (Akbari Chermahini & Hommel, 2012; Baas et al., 2008; Bierhals et al., 2007). While these approaches provide insights into the optimal social-cognitive-affective conditions for CI and creativity, they lack a nuanced understanding of the interplay of lived and expressed factors that influence its development and performance. Visualizing and testing different key moments in this collective design approach will give insights to team members for achieving higher levels of creative performance. Bringing attention to the fluctuation and interplay of lived and expressed factors in participants during different key moments of CI will allow for recommendations to be made on the type of management styles required for professionals using this method. For that reason, it would be valuable to further this research with empirical testing to consider the intricate nuances involved in CI. This will allow the furthering of the research and the understanding of socio-cognitive-affective process in CI and its significance in an individual's creative development during CI.

The exemplified novel insight above allows for a rigorous in-depth depiction of the social, cognitive, and affective interaction and their impact on creative development and performance of a team. It also provides some great guidelines for managers of innovation development teams and design team leads. Below are some potential areas for further research, aimed at investigating the impact of the described phenomena on the different phases and performances of CI. These areas represent gaps in the existing literature and offer opportunities for future exploration:

- Exploring the combined effects of social interactions such as *Feedback*/*Active listening* on the CI sequence and participants' cognitive and affective states to allow for a more granular understanding of this method.
- Investigating the role and the strategic implementation of *feedback* cues in discerning the structuring of effective collaborative ideation (CI).
- Examining the impact of *active listening* cues on the expansion and development of ideas during collaborative ideation (CI).

From this enhanced perspective, future studies can then focus on addressing these broader issues:

- Analyzing the management of cognitive and affective states within the different phases of CI to grasp its impact on the creative process and performance.
- Reviewing the social dynamics inherent in verbal and non-verbal communication cues to provide insight on the substantial influence on participants' cognitive and affective states, thereby discerning its significant impact on the CI sequence and performance.

Observing the CI process in a controlled context with our developed understanding can prove useful for the analysis and empirical development of CI and recommendations for best practices. Gaining insight into the social interactions involved in structuring, conceptualizing, and illustrating an idea can be advantageous to understand the impact of verbal and nonverbal communications on CI development and performance. These points of inquiry could validate our conceptual examination and postulations, help identify ways to improve creative performance, and make recommendations accordingly.

5. Conclusion:

With the use of this extensive exploration of scholarly works, this literature review has shed light on the dynamic nature of collaborative ideation (CI). The primary objective of this paper was to gain a comprehensive understanding of this intricate procedure by conducting a rigorous literature review centered around the question: ***What are the drivers of creativity in collaborative ideation?***

Throughout this review, particular emphasis has been placed on the crucial role that social factors played on participants' cognitive and affective states during collaborative ideation (CI). Improper management of these factors, without empathetic cues and well-timed feedback, can hinder the individual and collective ideation procedure. By leveraging the insights in this review, organizations, scholars, and practitioners can refine their understanding and optimize the collaborative ideation processes to foster collective innovation. This review serves as a valuable resource, providing a foundation for further research, and enabling the implementation of effective innovative strategies. The hope is that the insights above will also allow fellow researchers to engage in empirical studies on CI.

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Chapter 3: Team Dynamics Unveiled: How Social Markers Shape Collaborative Ideation Sequence and Performance

Team Dynamics Unveiled: How Social Markers Shape Collaborative Ideation Sequence and Performance

Highlights:

- Social factors during collaborative ideation among three-member teams led to performance fluctuation in creative teams.
- Three-member teams that spontaneously monitored and continuously adapted their collaborative ideation process to the development process of ideas seemed to create optimal environments for creative performance.
- Empathetic social cues by triggering specific cognitive-affective states linked to divergent thinking seem to aid the ideational expansion of co-participants.
- Evaluative social cues by triggering specific cognitive-affective states linked to convergent thinking seem to aid teams in merging and focusing their ideas.
- Providing guidelines for the empirical study of social factors the collaborative ideation sequence and team performance for future research on the effects of psychosocial factors during collaborative ideation.

Abstract:

Design methods have become commonplace for achieving effective strategic planning and foresight in many organizations. Breaking down silos through multi-expert teams, these ideation techniques facilitate the development of forward-thinking solutions. Prompted by the well-known fluctuation in team performance, this research investigates how social dynamics affect the creative performance of teams when involved in Future Thinking sessions. The objective of this study is to offer distinct strategies for professionals and researchers to attain innovation. For this purpose, eight teams were observed and the social interactions and the cognitive-affective state of participants with the different phases of collaborative ideation (CI) were continuously collected. The gathered data was first sorted and conceptualized into patterns using grounded theory

methodologies and then analyzed using a deductive-exploratory approach. Our research findings reveal that delineating constraints (structuring) and utilizing active listening cues have a positive influence on idea conception (conceiving) in the creative output of teams. However, the detrimental effects of feedback cues on this process underscore the significance of managing emotional states and responses among team members for optimal performance. These granular findings offer valuable insights for professionals seeking to optimize co-creative environments and provide informed insights for organizational changes for improved innovation. These conclusions seem to underscore the significant role of social and experiential dynamics in shaping CI sequence and outcomes. This analysis yields both theoretical and practical implications for achieving effective creative consensus in a CI context.

Words:

Collaborative Ideation (CI), Participatory decision, Consensus Reaching, Active listening cues, Feedback cues, Structuring (constraint delineation)

1. Introduction

Design operationally integrated companies who use diverse design ideation techniques, such as IBM and Pepsi seem to be outperforming others by a significant 211%, showcasing the effectiveness of these proven design methods (Naiman, 2019). Widely used, and extending across entire organizations for service and product development (Dorst, 2015; Kolko, 2015), these techniques serve as valuable procedural frameworks for teams to design successful innovation (Cash et al., 2023; Ferreira et al., 2020; Kolko, 2015). However, the sustained performance of these skillful professionals is not always guaranteed (Ferreira et al., 2020). Company-specific dimensions such as innovation culture, strategy, knowledge and competence, organizational structure, R&D development and financial support for innovation are key factors for the development of innovative products or solutions (Dziallas & Blind, 2019). Here, for example, it is found that leading experts and cutting-edge technology are important tools for effective innovation (Amabile, 1983). While effective in outlining necessary organizational elements for success, these measures fall short when pivotal industry indicators are in place and yet the team fails to translate CI practices into sound innovative services or products for production (Ferreira et al., 2020). Consequently, the efficacy of CI remains the subject of ongoing debate within the scientific community and industry alike (Cash et al., 2023; Davis & Eisenhardt, 2011; Stroebe et al., 2010).

CI is a collective endeavour and requires participants involved in it to mobilize cognitive and affective states to produce a collective creative performance (Akbari Chermahini & Hommel, 2012; Baas et al., 2008). Well researched on an individual level, these idea-generation techniques seem to not be as well understood in a collaborative context, by organizations and designers alike. However, in thirty percent of cases, this approach is used collectively with people throughout the firm (Birkhofer & Jlinsch in Lindemann (2003)). This initial phase of the innovation process (CI) can prove to be complex to assess (Dziallas & Blind, 2019). Modulated by idea proposals, questions and feedback from fellow participants, the group uses divergent and convergent thinking to create a collaborative creative output (Akbari Chermahini & Hommel, 2012; Eris, 2003; Ward, 2007). Therefore, understanding the interplay of psychosocial patterns during CI

by meticulously examining CI may shed light on how social factors which modulate the ideation process toward a collectively perceived effective and 'satisfycing' design (Badke-Schaub & Stempfle, 2003; Buchanan, 2019; Simon, 1978). This analytical process holds the potential to construct a meticulous understanding of CI and give some answers to the earlier described dilemma. This study aims to determine the optimal individual experience and social factors (or psychosocial patterns) for ideal CI sequence and creative performance. To give structure and some guidelines to this empirical study, the following research question is used:

How do social dynamics among team members, through the communication of verbal and non-verbal cues impact the different elements of collaborative ideation and team performance?

This formulation was assessed in three ways: first, at the individual level through cognitive load and affective states of co-participants; second, through the impact of social factors on the collaborative ideation (CI) sequence; and third, on determining optimal processes for high creative output. By employing data conceptualization, and comparative analysis of patterns and trends, the research team was able to comprehensively assess the influence of social factors on individual experiences and creative sequences, thereby revealing their impact on group performance. The hope is that this comprehension will help organizations improve their product and service development tactics and bridge the gap between CI and innovation.

2. Literature Review

The early phase of innovation has attracted interest from many fields and is contextualized in many studies. These understandings are often complementary and have a myriad of different emphases, models, and vocabulary. For instance, co-creation, co-design, creative problem-solving or collaborative generativity are all qualifying descriptors of what is referred to here as CI. In a nutshell, during CI, teams collaboratively employ design methodologies to generate, develop, and select ideas that eventually evolve into products or services (Chen et al., 2023).

To achieve optimal performance, innovation teams should use consensual ideation building through the *Multiple Angles* method to explore the issue at hand. To do so, team members must use the expertise of all participants involved in idea generativity and consolidate it into a consensual collection (Amabile 1983; Badke-Schaub & Stempfle, 2003; Dorst, 2015; Dow et al., 2011; Stempfle & Badke-Schaub, 2002). Accordingly, this process requires an iterative collaborative sequence to be used. To do so, team members need to oscillate between a generative/explorative phase (Ward, 2007) and a focussed implementation phase (Stempfle & Badke-Schaub, 2002). Here the mental models of participants are externalized and merged by talking, gesturing and sketching (Birkhofer & Jlinsch in Lindemann (2003)). The diverse interpretations of ideas during CI, are understood to enhance the quality of the creative output and emphasize the importance of the iterative cycle in this procedure (Marsh et al., 1996; Ward, 2007). For example, the *shared multipl*e strategy, provides evidence that teams generate higher-quality outcomes and foster stronger social cohesion when multiple concepts are proposed (Dow et al., 2011). In other words, CI is achieved by reaching a consensus where participants select and modify teammates' ideational inputs through different kinds of selective loops or iterative patterns to create a creative output (Cash & Maier, 2016). Consequently, to create innovative results teams need to mobilize and weave together expert ideational input into a collaborative creative output. The elements of this procedure are repeated until consensual "satisfycing" (a compromise between the perfect and the realistic solution) is reached (Buchanan, 2019; Eris et al., 2014).

To measure this collaborative procedure two frameworks are used: Dorta and colleagues (2011a) and Badke-Schaub and Stempfle (2003). These frameworks allow for a detailed account of the collaborative ideation (CI) procedure. Badke-Schaub and Stempfle (2003) segment CI into *content* and *process*. *Content* pertains to the development and expansion of ideas, while *process* relates to the organization of the ideation and the group. Here these components illustrate the relationship between collective ideational content development and its structure. Dorta and colleagues (2011a) framework allows for an elaboration of this analysis. Here, CI is divided into three components: Collaborative Ideation Loops, Collaborative Conversations and Collaborative Moving. They consist of descriptive tags for key stages of the CI procedure,

including *naming, proposing, questioning, iterating, sketching, and illustrating*. These examinations of CI allowed for the development of the Collaborative Ideation Sequence. It contains three dimensions: structuring moments (composed of organizational indicators), the conceiving phase (composed of generation, exploration, and implementation indicators) and the illustrating phase (composed of concept summarization indicators). In the structuring moments, two types of actions occur: Naming a content task which consists of establishing the constraints of the project (Dorta et al., 2011b) and Goal Clarification process task which consists of giving directions to the rest of the team (Badke-Schaub & Stempfle, 2003). The conceiving phase consists of multiple actions relating to the content creation of the ideas in CI. The actions are proposing, questioning, iterating, and sketching (Dorta et al., 2011b). Finally, the illustrating phase consists of the action of documenting or cementing the idea by writing or drawing and is the last development phase of a creative output (Dorta et al., 2011b). The interplay between these three dimensions is crucial for creative teams as it enables the expansion and comparison of teammate's ideational input. This procedure facilitates the development of a shared understanding and the participatory generation of solutions to complex problems (Stempfle & Badke-Schaub, 2002). Investigating creative development during the initial stages of the innovation process becomes imperative for understanding how to maintain consistently high creative performance for teams across an organization or in research and development labs (Ferreira et al., 2020).

2.1 *Design Ideation Tool & Team Patterns*

As seen above, the CI sequence is a multifactorial process. It unfolds when two or more people collaborate to find creative solutions to problems by using different design thinking techniques. In this study, the future thinking design method was used. It is a technique that provides structure to brainstorming sessions and helps the development of ideas (Hornecker, 2010). It contains key organizational processes such as strategic planning, foresight, and design thinking (Buehring & Liedtka, 2018). This technique has proven to better the "effectiveness of Strategic Planning processes" for businesses (Buehring & Liedtka, 2018, p. 139). Here participants from diverse backgrounds first reflect on their past and present to predict a future using methodologies from the design

practice such as brainstorming, journey mapping or scenario building (Buehring & Liedtka, 2018). This allows team members to collectively ideate on possible futures for different business sectors (Buehring & Liedtka, 2018). This process was chosen because it allows for better idea development by leveraging users' and designers' insights for design conversations and experimentation, aiming to align achievable, desirable futures with both the organization and users (Buehring & Liedtka, 2018).

Scholarly discourse highlights the prevalence of two distinct collaborative ideation patterns in team settings. As seen in Table 1, teams, either propose and concurrently evaluate ideas or iteratively evaluate and focus ideas by exploring and relating them to the design brief until a consensual resolution is reached (Badke-Schaub & Stempfle, 2003; Dorst, 2015; Dow et al., 2011; Turner & Schober, 2007). These two types of sequences are described in this paper as the *Energetic Brainstorm* or *Multiple Angles*.

Table 1. *Collaborative Ideation Practices*

Energetic Brainstorm	***Multiple Angles***
Teams propose and concurrently evaluate ideas until a consensual resolution is reached. This can be described as a yes/no pattern, an idea is proposed, and participants vote on the validity of it.	Teams iteratively evaluate and focus ideas by exploring and relating them to the design brief until a consensual resolution is reached. This can be described as *"the try it for size"* pattern, an idea is proposed, contextualized, exemplified within in the design brief and its validity is determined by scenarios and sensemaking.
Exemplified in research by:	Exemplified in research by:
Badke-Schaub & Stempfle, 2003, Dow et al., 2011 and Turner & Schober, 2007	Badke-Schaub & Stempfle, 2003; Dorst, 2015; Dow et al., 2011; Turner & Schober, 2007

During the *Energetic Brainstorm* designers are constantly proposing ideas to the teams. These ideas are then accepted or rejected without thorough discussion and consideration to the design brief by fellow designers. This favoured piecemeal ideation process, although efficient, can lead to misleading outcomes and a lower creative performance due to its swift acceptance/rejection process (Cropley, 2006; Stempfle & Badke-Schaub, 2002). The *Multiple Angles* method involves consensual ideation building through iterative loops and qualitative idea assessment in association with the larger project, fostering higher creative performance (Dow et al., 2011; Turner & Schober, 2007). The influence of individual experiences on collaborative ideation practices is evident in CI

conversations. Participants by sharing their expert perspectives, shape the central dynamics of a co-design team (Dorta et al. 2011). As such the first analytical questions to guide this study can be posed:

Q.A: How does the collaborative ideation sequence impact the creative performance of teams?

2.2 *Social Factors that Contribute to Collaborative Ideation (CI)*

It is understood that social factors are thought to be a connective bond between participants. They are synchronized and adaptive actions aimed at collectively constructing a shared understanding of the topic at hand (Convertino et al., 2008). Communication through social factors is a *multimodal process* comprising verbal, non-verbal and focused evaluative task-idea-based interactions (Convertino et al., 2008). It is understood that communication between members of a team may derive from formal and informal social ties and affect the symbiotic decision-making process during collaborative ideation (CI) (Sáenz-Royo & Lozano-Rojo, 2023). The level of expertise in a subject matter also influences communicative responses in CI (Hennessey & Amabile, 2010). However, this research does not consider external social factors such as trust dictated by individual proficiency or group interrelationships. Instead, it focuses on participants' communicative support and interaction during CI. The research team specifically examined the influence of social factors during CI, isolating them from external variables. For this study, the recruited team members had no prior collaborative experience and had the same level of proficiency in the subject at hand.

Communicated social factors during the CI both help fellow participants' ideation process and create a shared understanding of the discussed issue (Cash & Maier, 2016). CI is an iterative process that requires maintaining mutual assumptions to construct a shared cognitive understanding among teammates during CI (Convertino et al., 2008). Here, participants foster mutual understanding and openness to the contributions of others. In a collaborative context, teammates value inputs that redefine the problem-solving process and focus its perspective (Leshed et al., 2007). In one study, participants gave higher scores to teammates who actively contributed to group decision-making than

those who were passive (Leshed et al., 2007). Furthermore, participants who mostly do not reflect or build on their fellow participants' ideational inputs are negatively perceived by others in the same group (Dow et al., 2011; Leshed et al., 2007). This demonstrates that social factors or teammate reactions to creative input during CI impacts team motivation and cohesion which could then influence the performance of the group. It is therefore imperative to develop an understanding of key social factors that mediate the development of creative outputs in the context of CI.

Social factors are viewed as positive to the collaborative ideation process (Leshed et al., 2007) because they help build a mutual grasp of the ideas presented within collaborative ideation (CI) (Visser & Maher, 2011). Resulting in a longer conceiving phase (Badke-Schaub & Stempfle, 2003; 2002), teams, through in-depth iteration moments, can achieve consensus. Here the different ideational inputs are iteratively focused into a comprehensive ideation output (Dow et al., 2011). Consequently, the conceiving phase is periodically punctuated with structuring moments to help the team focus their ideation in a specific direction (Stempfle & Badke-Schaub, 2002) and achieve *consensus* (Dow et al., 2011). *Consensus*-driven teams thus demonstrate higher creative performance (Dow et al., 2011). This *consensus* is achieved through the demonstration of implicit approval and verbalized review of developed ideas. Due to their effect on interrelated conversations, two socio-communicators (*active listening* and *feedback*) are believed to exert distinct influences on collaborative ideation (CI).

Active listening cues, demonstrating acceptance and attentiveness, are thought of as facilitating the building of a common understanding among teammates and the expansion of the conceiving phase during CI (Weger Jr et al., 2010). Although they appear to be a minute portion of the collaborative ideation (CI) development (Cash & Maier, 2016) their impact seems significant on the CI sequence. By signifying "focused attention on some piece of information" (Bekker et al., 1995, p. 163) and "interest and attentiveness" (Hans & Hans, 2015, p. 48) active listening has a significant impact on the conceiving phase. As articulated by Kohpeima Jahromi et al. (2016) "creative managers are good listeners" p.2124. Empathetic or active listening cues provided by fellow participants allow for proposed ideas to be received and approved without any interference (Cash & Maier,

2016; Weger Jr et al., 2010). *Active Listening* cues are social factors that are thought of as creating social cohesion (Weger Jr et al., 2010). To support a proposed idea or concept, fellow participants use verbal utterances, nodding and a reflective tone or language. This tone/language mimics or paraphrases a co-participants idea as a sign of reflective acceptance (Groh, 2022). This process creates an environment for idea expansion during CI (Akbari Chermahini & Hommel, 2012; Weger Jr et al., 2010).

Feedback cues, on the other hand, are a type of communication cues introduced by a fellow participant to assess an idea. Evaluative or feedback cues provide an assessment of the proposed concepts (Hattie & Timperley, 2007). Their nature can be positive or negative and help fellow participants detect inconsistencies or flaws with the projected understanding of the project at hand (Barr & Conlon, 1994; Hattie & Timperley, 2007; Turner & Schober, 2007). This phenomenon often leads to the revisions of a co-participant ideational input (Shalley & Zhou, 2008). They can either hurt social cohesion and cause individuals to withdraw from group participation in favour of an introspective state (Dow et al., 2011; Kozlowski & Ilgen, 2006) or their challenging aspect can allow for a more thorough idea development (Badke-Schaub & Stempfle, 2003). These cues when used to assist the elaboration of co-participants' input are key to facilitating decision-making (Keum & See, 2017). In this context, feedback cues serve to assist peers in detecting inconsistency in the group's understanding of the goal and aid in the decision-making in collaborative ideation (CI) (Hattie & Timperley, 2007). They are key confirmatory indicators where participants demonstrate their understanding of a task by substantiating, overwriting or reorganizing memorial information cues or knowledge structure (Hattie & Timperley, 2007, p. 5740). Therefore using one's knowledge structure to shape and frame the ideas into a shared understanding helps control and constrain the parameters for problem-solving and solution-finding (Hattie & Timperley, 2007; Mory, 2004). As such a second analytical can be posed:

Q.B: To what extent does the quality of feedback cues have an impact on creative performance of teams?

The described above findings seem to point to a strategical sharing of *active listening* and *feedback* cues amongst participants during CI to ensure their beneficial effect on the teams' creative performance (Cash & Maier, 2016; Härkki et al., 2018; Weger Jr et al., 2010). As such a third analytical question can be posed:

Q.C: What is the impact of social factors on the collaborative ideation sequence and creative performance of team?

2.3 *Cognitive-Affective States of Participants During Collaborative Ideation*

Given that collaborative ideation (CI) inherently involves social dynamics, co-participant inputs during CI are likely to influence the ideation process by evoking different cognitive and affective states through communicative exchanges among team members (Convertino et al., 2008). For example, affective states such as frustration can cause poor decision-making in the context of CI (Groh et al., 2022). To remedy this issue, it is found that affective mimicry such as short verbal utterances and perspective-taking or reflecting language can enhance cognitive performance and mitigate the effect of frustration in participants during CI (Groh et al., 2022). Considered at the individual level, these individual descriptive instances of CI suggest that cognitive-affective states play a significant role in the creative development. As seen in creative cognitive research, the communicative transfer of ideas can affect the cognitive-affective states of participants and the sequence of collaborative ideation (CI) (Bierhals et al., 2007; Dow et al., 2011; Stempfle & Badke-Schaub, 2002; Stroebe et al., 2010) resulting in variation in the performance of a team (Birkhofer & Jlinsch in Lindemann (2003). Thus, it is reasonable to infer that social cues may induce variations in a participant's cognitive-affective state, influencing the establishment of an ideational *consensus*, and consequently impacting the group's performance.

In creative cognitive-affective research studies, it is recognized that provoking promotion-focused affective states (e.g. happiness or frustration), enhances creative performance in individuals (Baas et al., 2008; Funke et al., 2012; Knight et al., 2019). However, prevention-focused affective states (e.g. fear, anxiety, sadness, and relaxation), will decrease creative performance (Baas et al., 2008; Funke et al., 2012; Knight et al.,

2019). Although valuable in illustrating the ideal cognitive-affective conditions for creativity and their significance in idea development (Akbari Chermahini & Hommel, 2012; Baas et al., 2008; Cropley, 2006), this approach lacks the detailed analysis required to fully understand the evolution of cognitive-affective states during the collaborative ideation (CI) sequence and its impact on team creative performance. To create fruitful outputs teams need to open and narrow their ideation based on their design brief (Stempfle & Badke-Schaub, 2002). To do so the team goes through a "generative/ exploratory" stage using cognitive flexibility and an "evaluative" stage using cognitive perseverance (Cropley, 2006; Ward, 2007). In this context, individuals will initially engage in divergent thinking followed by convergent thinking processes to generate ideas (Cropley, 2006). To achieve the first one needs to have a positive affective state which allows for associative thinking (Akbari Chermahini & Hommel, 2012) and to then transform the idea into a focused cohesive thought one needs to be in a negative affective state (Akbari Chermahini & Hommel, 2012). Therefore, it could be argued that group mobilization of these two cognitive-affective states within CI is imperative. The mentioned above studies, (1) tend to compare the overall cognitive-affective states of participants during ideation to the overall creative performance and (2) separate the study of divergent and convergent thinking (Akbari Chermahini & Hommel, 2012; Baas et al., 2008; Cropley, 2006). The intrinsic significance of cognitive-affective states for the development of ideas during CI (Akbari Chermahini & Hommel, 2012) requires a comprehensive understanding of this collective development. As such a fourth analytical question can be posed:

Q.D: What is the Impact of Collaborative Ideation Sequence and Social Factors on Participant's Cognitive and Affective States?

3. Methodology

To comprehend the natural tendency of teams' preferred ideation process, it would be valuable to unfold the impact of psychosocial patterns on collaborative ideation (CI). This exploration will help grasp why the *Energetic Brainstorm* strategy is sometimes favoured and assist researchers and organizations in enhancing the creative performance of their innovation teams (Dow et al., 2011).

In the first phase of this research and by referencing Figure 1, eight factors within three categories were continuously measured during this experiment: 1-Individual experience (*Cognitive load*, *Arousal*, *Valence*), 2-Social Factors (*Active listening cues*, *Feedback cues*), 3-Collaborative Ideation Sequence (*Structuring Moments*, *Conceiving phase*, *Illustration phase*). To do so, eight groups of three professionally diverse innovators were formed and tasked with determining possible futures for the dissemination, content, and format of audio-visual products in ten years. The actions and cognitive-affective states of participants in the teams were systematically recorded and coded with the use of unobtrusive data collection. During the eight CI sessions, the teams used the design method of Future Thinking. This enables participants to reflect on their past and present experiences with audio-visual products, allowing for strategic collective prediction for their future. The behavioural actions and psychosocial data of each individual involved in the eight teams were collected during and after the collaborative ideation (CI) sessions. This data was subsequently structured and conceptualized in the first phase of this research using grounded theory (Corbin & Strauss, 1990) and then analyzed using the *deductive-exploratory* research method (Casula et al., 2021). From the continuous observations, patterns were identified and CI sequence for high and low creative output teams were identified. In the second phase of this research, the defined factors within teams' psychosocial patterns in collaborative ideation (CI) were analyzed and their impact and significance on the development of collaborative ideation output were elucidated.

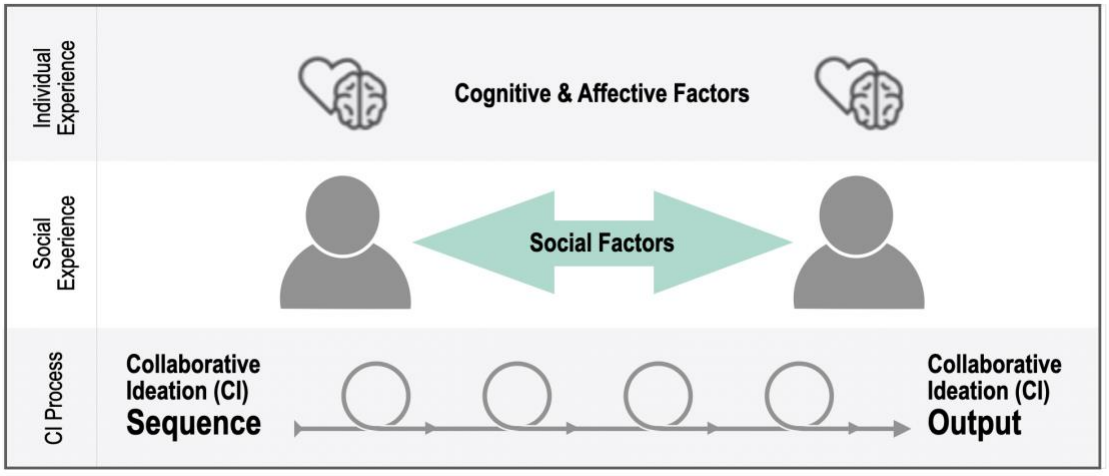

Figure 1. *Team Psychosocial Pattern in Collaborative Ideation (CI)*

3.1 *Theoretical Foundation*

This literature review has allowed us to ask a few questions about what is understood to impact the creative team's performance in a collaborative setting. The need for resources to bolster innovative processes in organizations (Dziallas & Blind, 2019), coupled with the lack of empirical research on the socio-cognitive-affective effect during collaborative ideation (CI), motivated this research team to utilize a two-phase research process anchored in grounded theory (Casula et al., 2021; Corbin & Strauss, 1990; Gioia et al., 2013).

3.2 *Experimental Design*

The research team recorded the social interactions and cognitive-affective states of eight teams, each involved in Future Thinking sessions. Collaborative ideation is a complex social process where behavioural processes and ideational sequences are intertwined. Consequently, it became clear that a controlled environment was an optimal space to observe the CI sequence and socio-cognitive-affective that influence it (Cash et al., 2023). To create an optimal environment to study these dynamics, the selected design and equipment for this experiment were non-intrusive. Here social factors were observed to better understand their impact on the cognitive and affective state of the participants as well as the CI sequence and performance of the teams. To ascertain a comprehensive analysis, *deductive-exploratory* research was performed as it provides an ideal alignment from theory to results and a deductive rigour for the subsequent study of the gathered data (Casula et al., 2021; Gioia et al., 2013; Twining et al., 2017).

3.2.1 Participants & Experimental Set-up

This experiment was conducted in partnership with a media partner of the Tech3Lab at HEC Montreal. This medium-sized broadcasting company tasked us to survey 24 tech-savvy UX graduate students (M:9 and F:15 with a mean age of 26±, *SD*=3.23) from diverse backgrounds through future thinking sessions about audio-visual consumption 10 years from now. From this pool of participants, eight teams were formed through convenient sampling.

A round table was used to better study the exchanges among participants (See Figure 2). On this table, mini keyboards were provided to participants for logging their cognitive load. Additionally, to continuously record the arousal state of participants during CI three Cobalt Bluebox were placed on this table. To collect the various creative outputs of the different teams, paper, post-it and markers were also found on this table. Hence this step-up enabled us to collect participants' socio-communication factors, their cognitive and affective states as well as the collaborative ideation (CI) sequence and performance of Future Thinking sessions concurrently.

Figure 2. *Experimental Set-up*

3.2.2 Experimental procedure

The experimental session lasted 90 minutes, including pre-and-post-task questionnaires as well as, the placing of the sensors on the palms of the non-dominant hand and the chest of the participant for the collection of physiological data. The Future Thinking co-design sessions consisted of two self-reflective ideations of two and five minutes each and one collaborative session of twelve minutes.

In the first part of the experiment, participants were first asked to reflect individually on their audiovisual consumption habits using an empty timetable and grid. Then in teams of three using an ideational prompt (*see Appendix A*) their consumption habits, the students conceptualized and strategically planned for the prospective futures of audio-visual consumption. During the collective phase of the experiment, they were allowed to use shared post-its, markers, and a pad of large sheets. After the experiment, participants were asked to come back to the lab within a 24h window period, to rate their affective

states on a continuum. Here the participants were presented with their teams' recording of the collaborative ideation (CI) and the Russels' emotional circumplex through the software Darma. They used a joystick to perform the required affective annotations (Girard & C. Wright, 2018). Participants were then thanked for their contributions to the experiment and any questions or concerns were also answered at that time. All participants then received a 40$ compensation for their involvement in the experiment. Their creative performance (collective sketches and scripts) was then evaluated using two dimensions originality and creativity. Originality underwent evaluation by design experts using the three-dimensional Guilford (1967) scale, while creativity was assessed by the first author using the TTCT test scale (Torrance, 1990).

3.2.3 Measures

In this multi-factor analysis, four categories were created to comprehensively measure the creative performance of team, as well as, the social experience, and the lived experience during the CI process. Finally, the instruments recording are presented

3.2.3.1 *Measuring creative performance*

The performance of the different teams allowed for the categorization, comparison and analysis of CI sequence and psychosocial patterns between high and low performative teams. This allows for concrete inference to be made for appropriate team regulation leading to effective ideation development. To do so, the creative cognitive approach (derived from cognitive science and psychology) is used to assess the performance of the eight different teams (Ward, 2007). Here, as a consensus, creative performance is seen as the generation of ideas, insights or problem-solving that are both useful, novel and/or unusual (Baas et al., 2008). To measure the creative performance and classify the eight different teams two scales were used the TTCT test (Torrance, 1998) and The Guilford Originality test (Guilford, 1967). Creativity contains three variables measured at the group level: Fluency (absolute number of ideas), Flexibility (number of categories of ideas generated), Elaboration (the number of Elements describing an idea) (Torrance, 1998). Originality contains three variables and was also measured at the group level. Ideas were assessed on a scale from 1 to 7 based on these three criteria: Uncommonness (how

uncommon is the proposed idea while still providing a tangible plan), Remoteness (how did the idea provided by the team further the development of an idea), Cleverness (how insightful and surprising is the idea proposed) (Guilford, 1967). Therefore, this study aims to examine psychosocial patterns among high and low-performing teams to uncover the factors contributing to performance variations in creative teams.

3.2.3.2 *Measuring social experience in collaborative ideation*

As seen in the literature review above two pivotal socio-communicators significantly influence the creative sequence and performance of the teams: Active Listening and Feedback. The coding of active listening cues included the identification of three components: verbal-utterance (short verbal cues like 'mmhmm', 'ok', etc.), nodding (non-verbal affirmations), and reflective language (verbally or gesturally mirroring fellow participants ex: P02 *"I'm seeing a remote with buttons"*, P03 *"A remote with buttons"* [drawing a remote with buttons] OR P02 & P03 [saying these words at the same time] "*in the brain*") (Davitz & Davitz, 1961; Hans & Hans, 2015; Kohpeima Jahromi et al., 2016). The coding of feedback cues also encompassed the identification of three components: accepting language (confirming the input of fellow participants ex: P07: *"I really liked what X said when referring to the first question"* OR P05 *"I like that"*), rejecting language (refuting the input of fellow participants) (Barr & Conlon, 1994; Hattie & Timperley, 2007; Turner & Schober, 2007) and selective pointing (pointing to a segment of the proposed input) (Cash & Maier, 2016; Dorta, et al., 2011a). ObserverTX (version 8, Nodulus, Leesburg, VA, USA) was employed to systematically annotate the observed verbalizations and actions contained in the social factors present in all eight recordings.

3.2.3.3 *Measuring the lived experience during collaborative ideation*

To elucidate the effective processes for generating high creative output, it was crucial to monitor in real-time the fluctuations in the cognitive-affective states of participants during collaborative ideation (CI). The assessment of the mental effort levels and affective states experienced in each dimension of the CI sequence will provide us with the optimal cognitive-affective state for each dimension of CI that contributes to effective creative performance.

With the aim described above, participants' cognitive and affective states were continuously measured during each collaborative ideation session. Here to assess the mental effort of the participants, a cricket sound was used to prompt individuals to assess their mental effort on a scale from 1 to 7 every 90 seconds. To record this measurement during CI, a keyboard tracker software (Macro Recorder version 1, Bartel Media, Germany) which tracks usage over time was used. The scale employed in this study was the 9-point Pass Subjective Rating Likert Scale (Paas et al., 2003) which required participants to rate their mental effort with the use of one item. Upon pre-testing this scale with the mini-keyboards, it was found that the 9-point scale had too many dimensions for the participant to use while in action. Therefore, a condensed 7-point scale was used, as there is no significant improvement in the variance explained via a 9-point scale (Johns, 2010). This method proved to be cost-effective, user-friendly, and non-intrusive for measuring cognitive load during CI. Furthermore, minimal technical expertise was required for the analysis of the data.

To measure the affective state of participants two procedures were used. First, to measure the arousal state of participants during the collaborative ideation sessions, electrodermal (EDA) signals using the palm sweat levels of participants were collected in real-time with the Cobalt Bluebox (Courtemanche et al., 2022; Funke et al., 2012). To record this physiological measurement the EDA sensors were placed on the non-dominant palm of the hand (Courtemanche et al., 2022). This placement was chosen to allow flexibility of movements (Courtemanche et al., 2022). Second, as it proves ideal for unintrusive emotional recall (Sharma et al., 2019), individuals were asked to come back to the lab within a twenty-four-hour period after the experiment and annotate the twelve-minute clip of the collaborative ideation. This annotation was performed after the ideation to not interfere with the flow of the ideation. Participants performed self-observation annotations to rate their affective state to the different dimensions of the creative sequence. This was done with a software called Darma, developed by Girard and C. Wright (2018), which uses Russell's (1980) emotional circumplex for participants to decipher their affective state on a continuum. This allowed us to collect the arousal and valence of individuals for the entire duration of the collaborative ideation (CI).

3.2.3.4 *Measurement instruments and recording equipment*

A recording software (Mediarecorder version 8, Nodulus, Leesburg, VA, USA) was used for different systematic processes. First, for participant affective self-observation, second for coding of movement and actions of participants during the collaborative ideation (CI) sessions, third for expert evaluation, and lastly for triangulation of all data collected. Because of the observational nature of this study, the measurements were collected and recorded systematically and continuously to offer a full portrait of the eight different CI sessions.

The measurement methods described above, allowed for the unobtrusive collection of the cognitive-affective states of participants and provided the best environment for ecological validity in this experiment. Our results thus, shed light on this socially complex, "nonlinear" iterative process (Keum & See, 2017) and can yield optimal findings for understanding collaborative ideation (CI).

3.2.4 Data Analysis

Guided by the hypothesis below, the data was systematically presented and aligned with existing literature to uncover patterns (the inductive phase). Then, a deductive analysis was conducted based on the assumptions derived from these patterns. This process allowed us to understand collaborative ideation (CI) in its entirety.

Hypothesis:

H1: *Social dynamics through the communication of verbal and non-verbal cues will impact the cognitive-affective states of participants which will in turn affect the collaborative ideation (CI) sequence and performance.*

Here are the two phases of this analysis:

1- **Data Conceptualization** to identify occurrences, trends, and phenomena, and formulate guiding analytical questions based on these findings.
2- **Deductive analysis** of the key factors in collaborative ideation using the phase one analytical questions.

Phase one consisted of identifying and understanding the psychosocial trends from the charted data according to the grounded theory method. To aid with this process a data structure model developed in the Gioia Methodology was used (Gioia et al., 2013). To do so the collaborative ideation sessions are categorized according to their creative performances using the median split (Huber et al., 2002). This process ensured that questions were directly derived from the phenomena seen in the data and informed by assumptions derived from the literature review (Gioia et al., 2013). Finally, this categorization proved to be appropriate for later deductive analysis (Huber et al., 2002).

In phase two, comparative analysis and linear regressions were performed to analyze the impact and the degree of interrelation of psychosocial factors and trends on collaborative ideation (CI) socio-cognitive-affective factors, sequence and performance.

3.2.4.1 *Data treatment (sorting the data)*

The observational nature of the data and the diversity of recording instruments, types of equipment and data formats, required a two-stage data categorization and integration process. First, it required a meticulous coding of the individual gestures and actions contained in the trio's Future Thinking sessions using the Gioia Methodology (Casula et al., 2021; Corbin & Strauss, 1990; Gioia et al., 2013). Second, it involved synchronizing various data points according to timestamps specific to each team's collective Future Thinking session. This method established a coherent user flow structure for later visualization and analysis.

The codifying process went as follows: all the data was first tagged into 1st order concepts, then into 2nd order themes and finally into 3rd order dimensions which allows for systematic organization of data and provides the basis for the visualization of psychosocial patterns and trends in the observed collaborative ideation teams (Gioia et al., 2013). Conducted in two stages with multiple iterations the actions and gestures related to the collaborative ideation (CI) sequence using established coding schemes (Dorta, Lesage, et al. (2011); Badke-Schaub and Stempfle (2003)), were first recorded. These schemes served to define the three components involved in the CI Sequence dimension. Second, from the understanding built from the literature, all the social-process

actions and gestures were then tagged. As explained in more detail in the next paragraphs, these annotated individual behaviours were then cross-referenced with the third dimension of CI (Participants Cognitive-Affective States) which involved a set of continuous quantitative physiological data. Figure 3 illustrates this codifying process and construction of the three different dimensions contained in CI (the CI sequence, social factors and the cognitive-affective states).

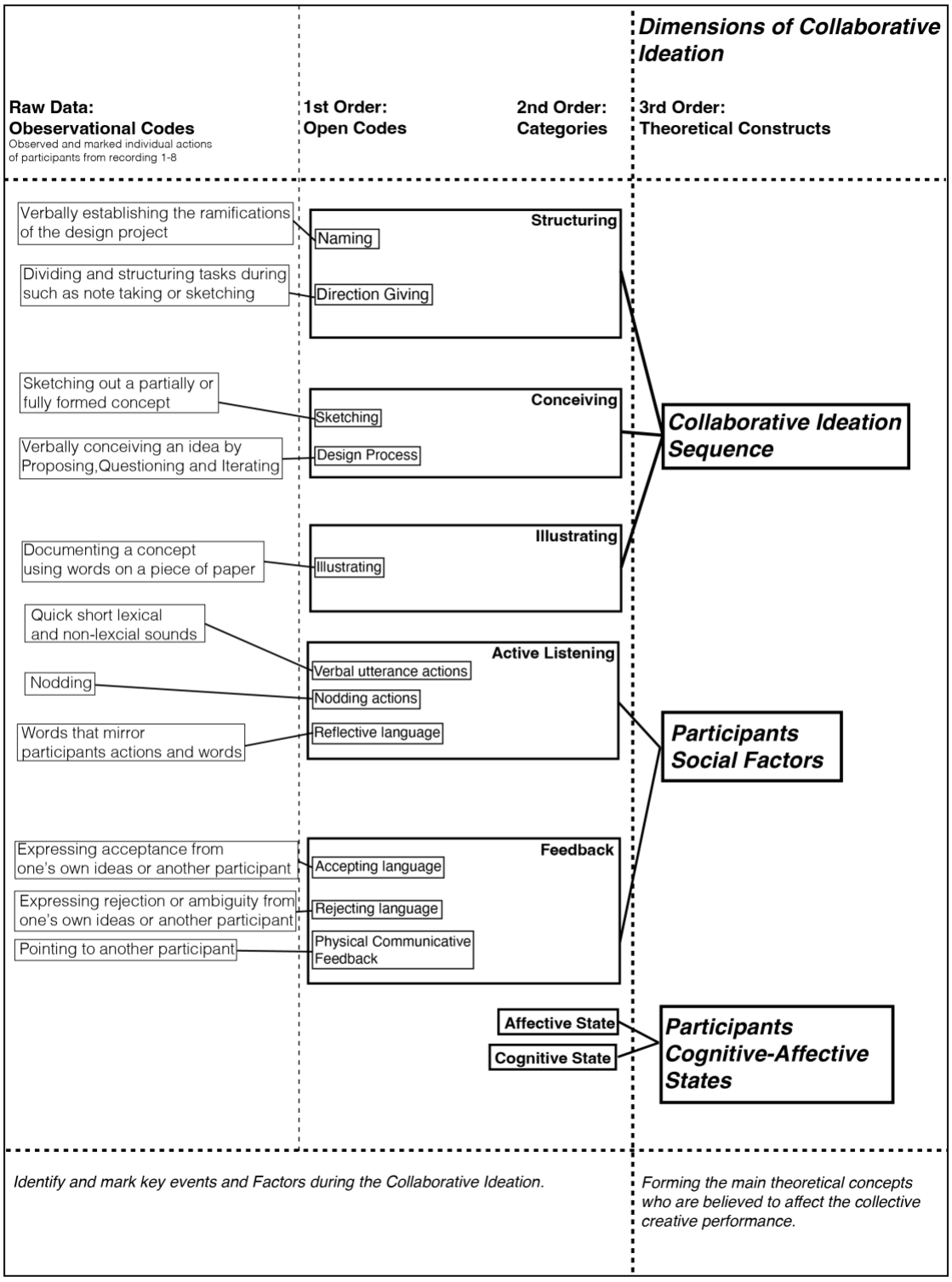

Figure 3. *Data Structure:* Based on Gioia et al. (2013) model, the data was comprehensively/systematically combined into three dimensions: Collaborative Ideation sequence, the Social Factors and the Cognitive-Affective States.

The continuous data structure of the different dimensions involved in collaborative ideation (CI) was then segmented in 30-second increments for the correlational analysis (Twining et al., 2017). For this research, a statistician conducted the statistical analysis required for this type of evaluation. To facilitate the analysis of these seemingly interrelated factors of this multifactorial phenomenon, log-transformations were applied to the CI sequence. This was necessary due to a significant number of overlaps and missing data rows within the 30-second bins of the segmented data. The log-transformations therefore eliminated cases where [XPhase]_SEC=0. The phase derived from Struct_SEC (Structuring), Con_SEC (Conceiving) and Ill_SEC (Illustrating) all respected the following log procedure for each participant and each 30-second time bin:

if Struct_SEC > 3 and (Con_SEC+Ill_SEC) < 4.5 then Phase="Structuring" for this bin,
if Con_SEC > 3 and (Struct_SEC+Ill_SEC) < 4.5 then Phase="Conceiving" for this bin,
if Ill_SEC > 3 and (Con_SEC+Ill_SEC) < 4.5 then Phase="Illustrating" for this bin,
Otherwise, this bin is not assigned any phase.

Therefore, it should be noted that the found results need to be interpreted with caution as this process eliminates variability in the data and combines multiple phases into one dominant phase.

3.2.4.2 *Data Conceptualization and Analytical Questions Formulation*

For visualization and conceptualization purposes, the data structure generated during the initial phase of data treatment was segmented into four categories based on creative performance groups (High / Low Originality and High / Low Creativity). Two different scales were used to measure two dimensions of creativity. Originality, assessed the eight teams using the Guilford 1967 scale. This scale was used to evaluate the validity and insightfulness of ideas proposed by different teams. Using the same eight teams, Creativity was then measured to determine the efficiency of the collaborative ideation (CI) development through visual or descriptive remanence, such as drawings or scripts via the TTCT scale (Torrance 1998). With this intent, a median split was performed as it proved adequate for the evaluation of uncorrelated independent variables (Huber et al., 2002). The creative scores of each team were consequently divided into two groups based on each creative performance measure, thus resulting in different teams being assigned to each of the four categories.

Utilizing the median split seen in Table 2, allowed for each described factor to be visualized in relationship to the creative performance of the teams. The median is calculated as the average of their standardized items. To be in the high group the median score for Creativity or Originality must be larger than the median. For example, to be in the High Creativity=1 the group median of creativity must be higher than the median of creativity (median across all teams).

Table 2. *Median Split to Determine Creative Groups according to their Creative Scores*

Variable	Median
creativity	-0.16803
originality	-0.02444

Note N=8 Median Split Table demonstrates the standardized median for both creative performance dimensions.

Using the segmentation described above, two visualization graphs were created as seen in Figure 4 and Figure 5. From these graphs, observations were made to establish visual trends and patterns in the data. To guide the analysis of the visualization, purple

and green translucent stripes were added to the graphs to point out areas of interest. Purple stripes indicate areas of structuring moments, while green stripes represent the illustrating phase.

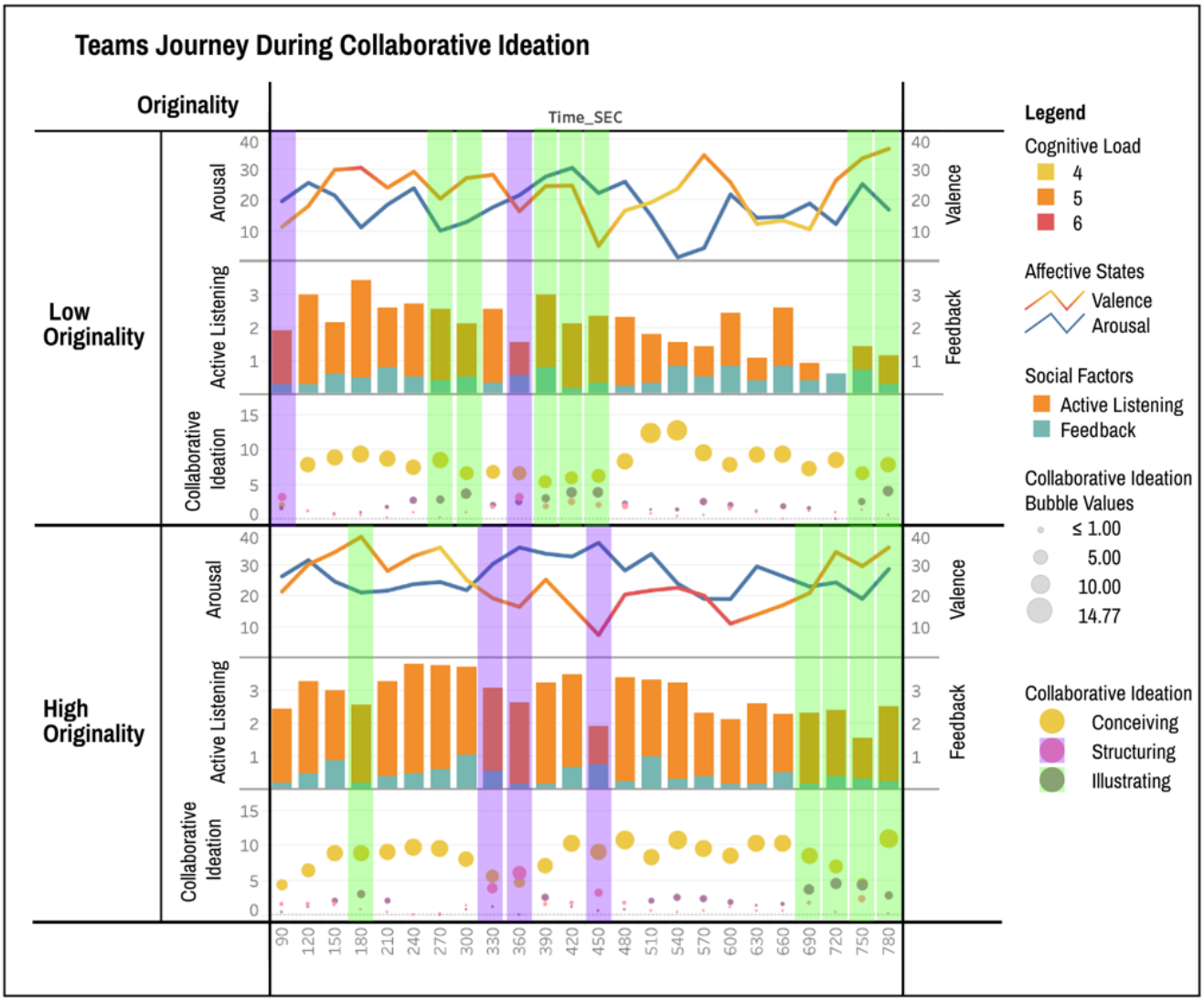

Figure 4. *Visualization of Data using the Originality Dimension of the Creative Performance divided using the median split.*

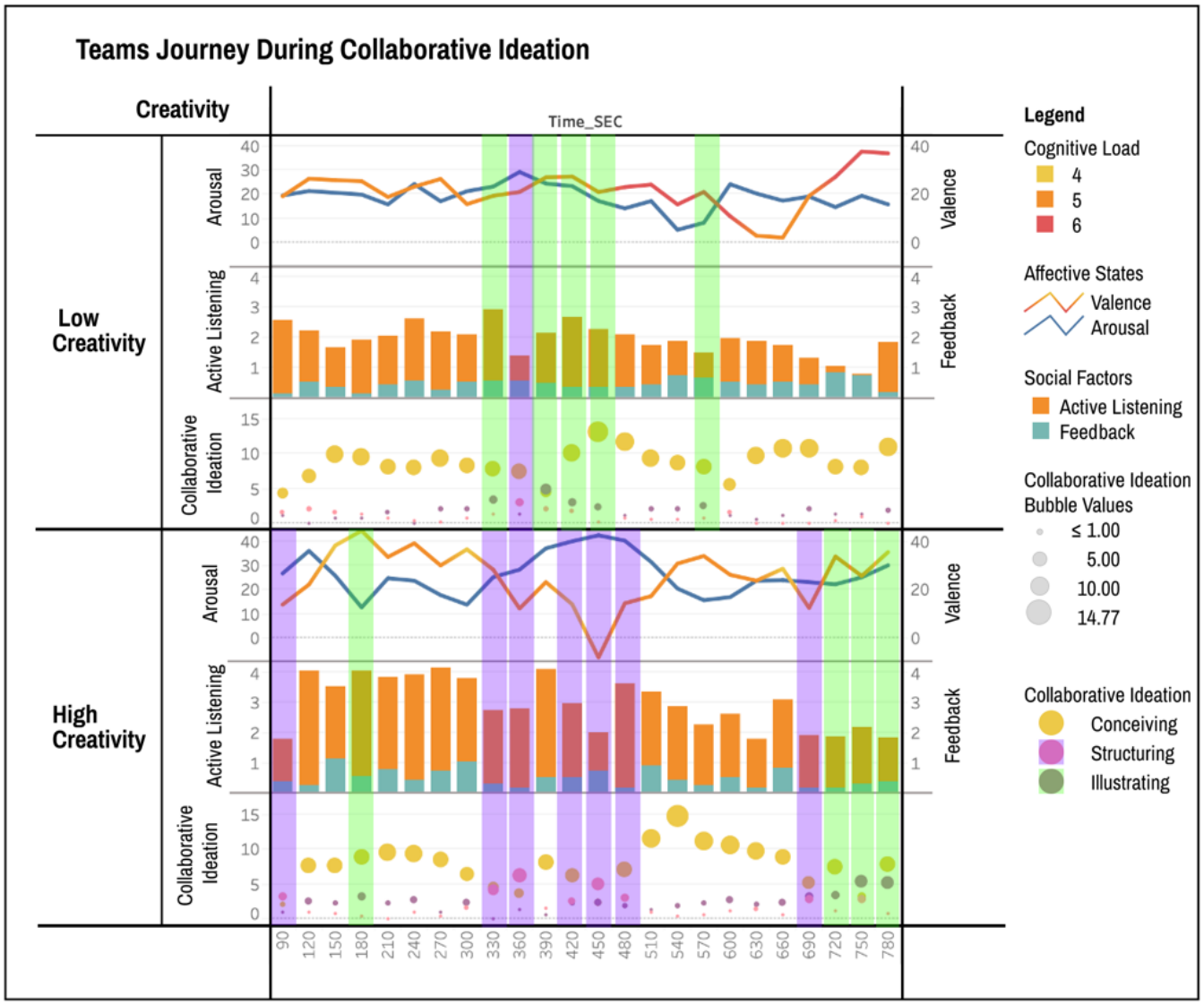

Figure 5. *Visualization of Data using the Creativity Dimension of the Creative Performance divided using the median split.*

3.2.4.2.1 **Findings from Originality and Creativity Performance Visualisation**

The overall observations above all hint at a clear impact of psychosocial patterns on the sequence and performance of CI. The collective individual experiences of participants seem to vary between the high and low categories of both originality and creativity. Valence and arousal seem to exhibit slight variations and move in parallel ways for low creativity teams. In these groups, the valence and arousal scores show minimal differentiation, with valence consistently appearing higher when there is disparity.

Conversely in the high-performing teams, valence and arousal exhibit opposite trends, with arousal levels being higher. Paired with an overall higher cognitive load, it appears that high-performing teams exhibit a greater tolerance for low valence in favour of heightened arousal during structuring moments. Therefore, valence and arousal appear to fluctuate based on participants' positions within collaborative ideation, in both levels of originality and in the high level of creativity. Social Factors also appear to be correlated to the CI process, with higher levels of active listening cues in both high originality and creativity levels, particularly during the conceiving phase. However, there appears to be only minimal variation in the levels of feedback cues across all levels of creative performance for all teams. When it comes to the CI sequence, the illustrating phase for low-performance groups seems to be more present towards the middle of the collaborative ideation (CI) sequence suggesting shorter ideation times. While not all factors appear to show significant differences in terms of quantity or time between levels of creative output, the strategic placement of these factors appears to influence performance levels of teams.

It seems that clear patterns have emerged in the structuring and illustrating moments of CI with these creative teams. The presence or not of these moments seems to be correlated with the performances of the different teams. Therefore, below these moments are investigated further.

3.2.4.2.1.a *Purple areas: Structuring moments*

The following two sections outline the discoveries concerning Originality and Creativity within the structuring moments of the collaborative ideation session. For enhanced readability, these sections in Figures 4 and 5 are accentuated in purple.

3.2.4.2.1.a.1 <u>Originality:</u>

In both levels of originality, participant's arousal levels are higher than their valence. Interestingly the gap in high-originality levels is much wider suggesting lower levels of pleasantness for the individuals in this level of originality. This lower valence could imply a (mildly) confrontational aspect of the ideation. Social Factors do not seem to correlate with the structuring moments here. Although the amount of structuring moments seems

to be similar in both high and low originality levels their placement within the ideation is different. For low-originality teams, two structuring moments happen in the first half of CI: one at the very beginning and one at the end of this first section. For high-originality groups, these moments happen in the middle of the session.

3.2.4.2.1.a.2 Creativity:

Similar to the patterns observed in the originality performances, participants' experiences (with higher levels of arousal and lower levels of valence) appear to be more conducive to a mild confrontation during these moments in both levels of creativity. Additionally, akin to the categorization in the high level of originality, the gap between arousal and valence appears to be larger than its lower-level counterpart, suggesting a higher tolerance for a lower level of pleasantness for participants during these moments. There is an apparent discrepancy in the number of structuring moments between the high and the low creativity teams. Social factors also seem to vary drastically between these two dimensions. Nevertheless, when averaged and compared, active listening cues appear to be more prevalent in high-creativity teams. Structuring moments in high creativity teams are more present and placed in the middle of the ideation and before the last illustrating phases at the end of the ideation suggesting a relationship-building between the ideas and the design brief or a situating of the conceived concepts to the larger scope of the project.

3.2.4.2.1.b *Green areas: Illustrating phase*

The following two sections outline the discoveries concerning Originality and Creativity within the structuring moments of the collaborative ideation session. For enhanced readability, these sections in Figures 4 and 5 are accentuated in green.

3.2.4.2.1.b.1 Originality:

Interestingly, the overall individual experience of participants in these moments appears more positive, with higher valence than arousal levels observed in almost every illustrating section for the high originality teams. In the low originality context, this dynamic is more complex, with a reversal occurring in 3 out of 6 instances, here arousal

levels surpass valence levels. This could suggest a level of frustration in team members and maybe lower pleasantness with the ideas being fleshed out by the team. Furthermore, feedback cues seem to be lower and active listening cues seem to be more present for the high originality teams. The illustrating time in both high and low originality seems relatively equal however the placement of the phase differs. At the low originality level, illustrating predominantly occurs in the first half and at the very end of collaborative ideation. In contrast, at the high originality level, it is primarily positioned toward the end of this progression. The first illustrating dynamic suggests three smaller conceiving phases whereas the latter suggests small and large conceiving phases. Therefore, in the high originality teams, the conceiving of creative output is longer allowing it to be better developed.

3.2.4.2.1.b.2 Creativity:

The overall individual experience of participants in the green section of high creativity CI sessions appears to fluctuate, showing a large gap between valence and arousal at the start of ideation and a smaller gap at the end, with valence consistently surpassing arousal suggesting a satisfying moment for participants in these moments. In contrast, in low creativity, this gap is minimal and constant, with valence almost always higher than arousal. Social factors appear evenly distributed across high and low creativity levels within these key sections of the CI sessions. Like in the teams arranged by high and low levels of originality, the illustrating phases seem to be equally present in both the high and low levels of creativity. However, the strategic placement of this phase also plays an integral role. In high-creativity teams, illustrating primarily takes place at the end of the CI session, while in low-creativity teams, this phase occurs in the middle. As previously seen in the originality categorization, this placement also suggests that teams with high creativity levels have a longer conceiving phase than those with low creativity levels enabling them to construct a successful creative output.

This process enabled the research team to make sense of the synthesized factors that are thought to impact the creative sequence and performance of the eight different teams. Clear social, cognitive and affective patterns have emerged from the visualization above.

The comparison of the visualized data suggests that psychosocial patterns may have an impact on the creative performance fluctuation of teams. This observational analysis goes along with the questioning found in the literature review. Therefore, confirmed by our observations our deductive analysis is divided into four general questions. Each containing the relevant analytical questions to perform the appropriate analysis. The deductive analytical sequence and questions are presented below in Table 3 and visualized through Figure 6 and 7 with Research Models A and B.

Table 3. Questions: Revised Questions Divided in Four Different Stages which will Guide the Analysis of the Observed Patterns in the Data

Q.D: What is the Impact of Collaborative Ideation Sequence and Social Factors on Participant's Cognitive and Affective States? **D-RQ1a.** How do the different dimensions of the collaborative ideation sequence influence the affective state experienced by participants during a session? **D-RQ1b.** Are there cognitive and/or affective states that are likely to yield a high creative output? **D-RQ1c.** How do the observed social factors of fellow participants involved in collaborative ideation impact a co-participant cognitive and affective state? **D-RQ1d.** How does the qualitative value of expressed feedback cues impact the cognitive and affective states of fellow co-participants?	**Q.C: What is the impact of social factors on the collaborative ideation sequence and creative performance of team?** **C-RQ3a.** How do the observed social factors of fellow participants in a collaborative ideation session impact the collaborative ideation sequence? **C-RQ3b.** Are there observed social factors that are likely to yield a high creative output?
Q.A: How does the collaborative ideation sequence impact the creative performance of teams? **A-RQ2.** Are there any dimensions of the collaborative ideation sequence that are instrumental in yielding high a creative output?	**Q.B: To what extent does the quality of feedback cues have an impact on creative performance of teams?** **B-RQ4a.** To what extent does the quality (negative/positive) of feedback in a team influence its creative output? **B-RQ4b.** To what extent does the proportionality of negative to positive feedback impact the team's creative output?

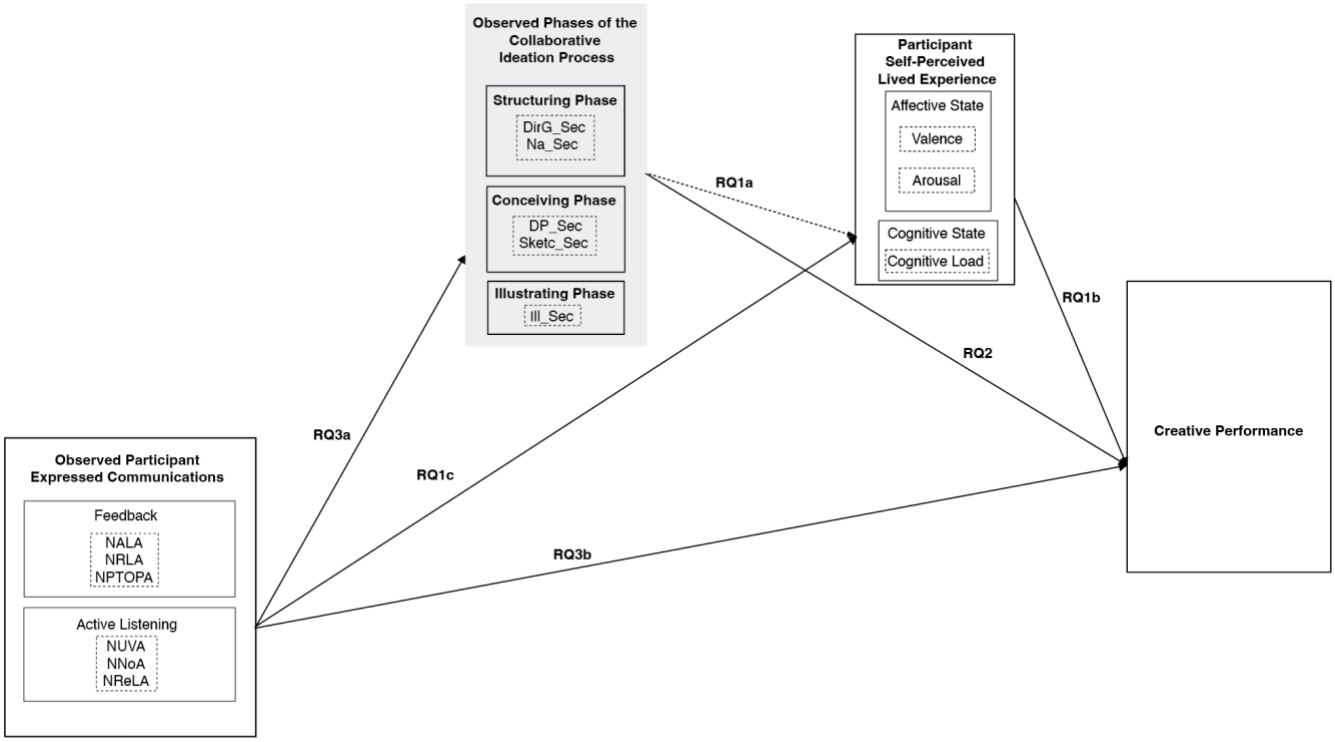

Figure 6. *Research Model A:* Visualisation of Tested Relationships Between Factors

Figure demonstrates their factors, their measures, and their relationship to one another. *Feedback: number of accepting language, number of rejecting language, number of pointing to concept. Active Listening: number of verbal utterance actions, number of nodding actions, number of reflecting language. Structuring phase: direction giving in seconds, naming in seconds. Conceiving phase: design process in seconds, sketching in seconds. Illustrating phase: illustrating in seconds. Affective States: valence, arousal. Cognitive State: cognitive load*

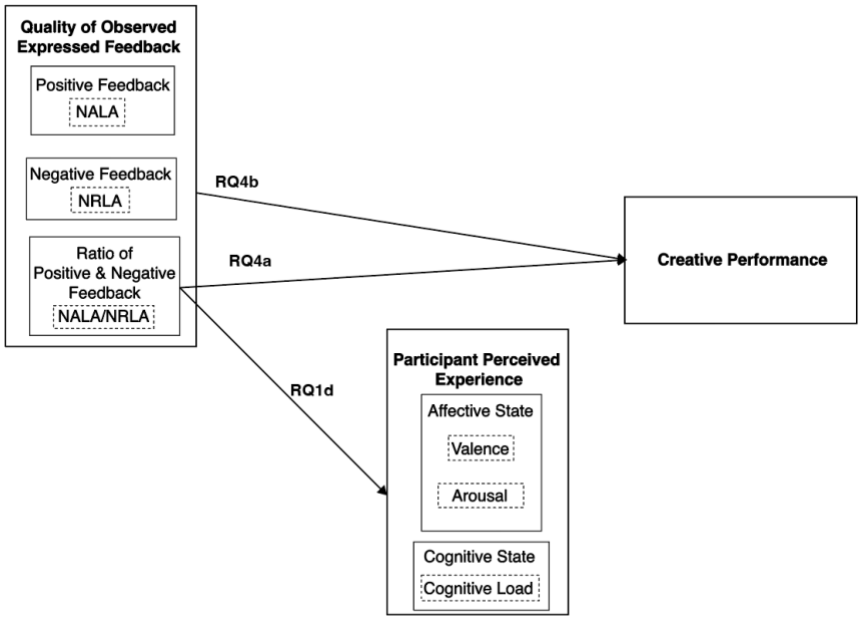

Figure 7. *Research Model B*: Visualisation of Tested Relationships Between Factors

Figure demonstrates the factors, their measures, and their relationship to one another. Feedback: number of accepting language, number of rejecting language. Affective States: valence, arousal. Cognitive State: cognitive load.

4. Results and Interpretations: The deductive analysis of Key Factors in Collaborative Ideation

This deductive analysis, guided by the established questions above, assessed the impact of visualized phenomena in the high-creative performance group and the interrelationships between key factors in collaborative ideation (CI). Consequently, comparative and regression analyses were conducted. All eight groups (N=8) were evaluated according to their creativity and originality scores as shown in Table 4 and Table 5. The groups were divided according to the median split methodology. Each group consists of four teams (n=4) and the eight factors (active listening, feedback, structuring, conceiving, illustrating, cognitive load, valence, and arousal) are compared between the high and the low group for both the originality and creativity measure of the team's performance output.

To understand if the eight psychosocial factors influenced the creative performance of a group, a comparative analysis between the two groups was performed using the *Wilcoxon Sum Rank Test*. This test was used because as seen in Table 4 and Table 5 below, the sample size of the study was small and the standard deviation for most of our recorded variables is high therefore normality of the data could not be assumed. This enabled the identification of significant differences in some of the eight factors between the high and low levels of the two creative performance measures. To investigate the questions regarding the individual experiences of participants in collaborative ideation (CI) and to identify any significant differences in their affective states and social factors during the process, three types of statistical analyses were conducted. First, *3-Way ANOVA* was used to establish relationships between factors. Then *linear regression, linear regression with random intercept* or *linear regression with random intercept model comparing least squares means* were used to establish the impact of those factors within collaborative ideation (CI).

Descriptive Statistics:

Table 4. *Originality*

Factors	Low		High	
	(n=4)		(n=4)	
	M	***SD***	***M***	***SD***
Feedback Counts	32.38	10.87	35.25	7.54
Quality of Feedback Ratio: Rejecting/Accepting Language Counts	0.61	0.24	0.73	0.42
Quality of Feedback: Accepting Language Counts	17.75	5.32	15	5.48
Quality of Feedback: Rejecting Language Counts	10.25	4.03	9.50	3.70
Active Listening Counts	138.63	38.26	212.38	56.35
Structuring Time in Seconds	62.56	18.94	125.30	30.87
Conceiving Time in Seconds	622.46	150.51	542.31	135.93
Illustrating Time in Seconds	116.20	94.28	160.86	138.72
Valence Axis magnitude of 100	21.63	2.21	25.53	12.18
Arousal Axis magnitude of 100	18.91	6.77	26.26	7.10
Cognitive Load Likert Scale 1-7	3.32	0.72	3.65	0.62

Table 5. *Creativity*

Factors	Low		High	
	(n=4)		(n=4)	
	M	***SD***	***M***	***SD***
Feedback Counts	36	8.1	31.63	10.06
Quality of Feedback Ratio: Rejecting/Accepting Language Counts	0.625	0.31	0.71	0.39
Quality of Feedback: Accepting Language Counts	16.5	5.20	16.25	6.02
Quality of Feedback: Rejecting Language Counts	9.5	4.36	10.25	3.30
Active Listening Counts	147.50	45.55	203.50	64.02
Structuring Time in Seconds	86.73	38.88	101.12	47.82
Conceiving Time in Seconds	565.45	127.91	599.32	168.19
Illustrating Time in Seconds	151.52	138.33	125.55	99.39
Valence Axis magnitude of 100	22.81	11.66	24.34	5.07
Arousal Axis magnitude of 100	18.26	5.10	26.90	7.51
Cognitive Load Likert Scale 1-7	3.04	0.28	3.93	0.62

Note n=4, Descriptive Statistics. Tables to demonstrate the Mean (M) and Standard Deviation (SD) for each measured factor during teams Collaborative Ideation.

As not all our findings reached statistical significance, we will focus solely on the significant findings of this study. This approach is appropriate for *exploratory* research, as it allows us to highlight the most meaningful and robust findings that have emerged from our analysis (Corbin & Strauss, 1990).

Demonstrated in further detail below through our developed questions, participants' social factors and their qualitative values influence the collective ideational (CI) sequence and fellow participants' cognitive-affective states which influences the creative abilities of the teams. In terms of creative output, the only significant differences between high

and low groups were observed in cognitive load and arousal states for the two tested measures of creative output (originality and creativity). Teams in the high creativity and originality groups demonstrated higher cognitive load and arousal levels compared to those in the low groups. Additionally, the amount of structuring moments in CI was found to be significantly distinct between teams with high and low creativity scores. High-creativity teams had a higher number of structuring moments. These findings suggest that coordinating the ideation of participants and their social factors fosters a conducive cognitive-affective state among co-participants for creative development and are indicative of high creative performance.

4.1 *Q.D: What is the Impact of Collaborative Ideation Sequence and Social Factors on Participant's Cognitive and Affective States?*

As seen in the literature review above and demonstrated in our data visualization, cognitive and affective states seem to influence the individual and collective creative process. Identifying how collaborative ideation and social factors affect these states can lead to the development of strategies for enhancing team creative outputs.

4.1.1 Q.D-Results

The subsequent section describes the results attained during the first analytical stage of the deductive phase of this research.

4.1.1.1 ***D-RQ1a.*** *How do the different dimensions of the collaborative ideation sequence influence the affective state experienced by participants during a session?*

As validated by the *3-Way ANOVA* statistical test in Table 6 below the different sections of the collaborative ideation (CI) sequence seem to have a significant effect on the valence of participants ($F(335)=5.11$, $p=0.0065$) and a partial effect on the arousal of participants ($F(335)=2.56$, $p=0.0785$).

Table 6. *3-Way ANOVA. Results for the effect of observed Affective States on the different dimensions of the Collaborative Ideation process.*

IV	DV	NumDF	DenDF	FValue	ProbF
Dimensions of Collaborative Ideation	**Valence**	2	335	5.11	**0.0065**
	Arousal	2	335	2.56	*0.0785*

Note N=24, p=0.05, 3-Way ANOVA Test. Table to calculate the impact of the Affective state on the different dimensions of the Collaborative Ideation sequence.

The *Linear Regression with Random Intercept Model comparing Least Squares Means for Two-tailed* statistical test in Table 7 also demonstrates the influence of the CI sequence on the affective states of participants during CI. Participant's valence is significantly higher for the illustrating phase than for the structuring moments ($T(335)=3.08$, $p=0.0066$) and significantly higher for the conceiving phase than for the structuring moments ($T(335)=3.08$, $p=0.0205$). These results suggest that participants perceive the structuring moments to be less pleasant than other phases in collaborative ideation (CI). There seems to be a partial effect for arousal between the illustrating phase and the structuring moments ($T(335)=-2.26$, $p=0.0785$). The arousal of participants seems lower for the illustrating phase than for the structuring moments. The affective states of participants did not seem to be significantly affected in any other collaborative ideation (CI) dimensions. These results seem to suggest that the structuring moments can cause participants to be more frustrated when experiencing it.

Table 7. *Linear Regression with Random Intercept Model comparing Least Squares Means for Two-tailed Test. Results for the effect of observed Affective State on the different dimensions of the Collaborative Ideation sequence.*

DV	IV	Phase	_Phase	Estimate	StdErr	DF	tValue	Probt	Adjst	Adjp
Valence										
	Dimension	Illustrating	Conceiving	6.8757	4.527	335	1.52	0.1298	Holm	0.1298
		Illustrating	**Structuring**	17.7021	5.7386	335	3.08	0.0022	Holm	**0.0066**
		Conceiving	**Structuring**	10.8264	4.1926	335	2.58	0.0102	Holm	**0.0205**
		Illustrating	Conceiving	-6.4714	4.0333	335	-1.6	0.1096	Holm	0.2191
	Dimension	*Illustrating*	*Structuring*	-11.5619	5.1067	335	-2.26	0.0242	Holm	*0.0726*
Arousal		Conceiving	Structuring	-5.0906	3.7204	335	-1.37	0.1721	Holm	0.2191

Note N=24, p=0.05, Linear Regression with Random Intercept Model comparing Least Squares Means for Two-tailed Test. Table of pairwise comparison between two dimensions to calculate the impact of the Affective State on the different dimensions of the Collaborative Ideation Sequence.

Having discovered the importance of structuring moments, it would be valuable to explore if cognitive and affective states are conducive to high creative output.

4.1.1.2 ***D-RQ1b****. Are there cognitive and/or affective states that are likely to yield a high creative output?*

As validated by the *Wilcoxon Sum Rank* statistical test seen in Table 8, when comparing the cognitive and affective states for each team using a marginally significant difference for cognitive load in high creativity ($Z(13)= -1.3068$, $p=0.0857$) and in high originality ($Z(13)= 1.5972$, $p=0.0571$) is noticed. A marginal effect can also be seen for the arousal in both high creativity ($Z(13)= -1.299$, $p=0.1$) and in high originality ($Z(23)= -1.299$, $p=0.1$). Teams with higher cognitive load and higher arousal are more likely to have higher creativity and originality scores. These results seem to suggest a higher level of activation for participants. The development of high creative output is seemingly a more arduous process which confirms our earlier proposition and aligns with Stempfle and Badke-Schaub (2002) findings. The high arousal levels coincide with what is found in the literature where activating affective states provoke a focused state in individuals

and yield higher creative performance (Baas et al., 2008; Funke et al., 2012; Knight et al., 2019). It can therefore be concluded that, whether it be at the individual level or at the team level high creativity performance requires higher levels of activations from participants.

Table 8. *Wilcoxon Sum Rank Test. Results for the effect of observed Cognitive-Affective States Variables on the creative performance.*

IV	DV	Statistic	Z	One-tail
Valence	High Creativity	14	-1.0104	0.1714
Arousal		13	-1.299	*0.1*
Cognitive Load		13	-1.3068	*0.0857*
Valence	High Originality	18	0	0.5571
Arousal		23	1.299	*0.1*
Cognitive Load		24	1.5972	*0.0571*

Note n=4, p=0.05, Wilcoxon Sum Rank Test. Table to calculate the influence of each dimension of the Cognitive-Affective States of participants within the group on the two dimensions of the creative performance (creativity and originality).

Having identified the cognitive and affective factors that emerge from the CI sequence and their contribution to team optimal creative outputs, it is now valuable to examine how co-participants influence each other. This examination will offer insights into the types of social strategies that can be employed to enhance creative performance.

4.1.1.3 ***D-RQ1c.*** *How do the observed social factors of fellow participants involved in collaborative ideation impact a co-participant's cognitive and affective states?*

From the performed *3-Way ANOVA* statistical test in Table 9, it seems that active listening of teammates has a significant effect on both the valence ($F(551)=5.06$, $p=0.0249$) and cognitive load ($F(167)=10.65$, $p=0.0013$) of their co-participants. Feedback in the other hand, does not seem to have any significant effect on the cognitive and affective states of participants during CI. Active listening of co-participant also has no significant effect on the arousal of fellow co-participants.

Table 9. *3-Way ANOVA. Results for the effect of observed Social Factors on the different dimensions of the lived experience of co-participants*.

IV	DV	NumDF	DenDF	FValue	ProbF
Feedback of co-participant		1	551	1.03	0.3109
Active listening of co-participant	Valence of co-participant	1	551	5.06	**0.0249**
Feedback of co-participant		1	551	1.87	0.1715
Active listening of co-participant	Arousal of co-participant	1	551	2.29	0.1306
Feedback of co-participant		1	167	0.12	0.7271
Active listening of co-participant	Cognitive Load of co-participant	1	167	10.65	**0.0013**

Note N=24, p=0.05, 3-Way ANOVA Test. Table to calculate the impact of the Social Factors on the different dimensions of the lived experience of co-participants.

This is further substantiated by the *Linear Regression with Random Intercept for Two-tailed* statistical test in Table 10. The active listening of teammates seems to affect the valence of their co-participants ($F(551)=2.25$, $p=0.0249$) but not their arousal—the greater the sum of active listening cues expressed by teammates the higher the valence of fellow co-participants. The active listening of co-participants seems to also significantly impact the cognitive load of co-participants ($F(167)=-3.26$, $p=0.0013$). The greater the sum of the active listening cues expressed by teammates the lower the cognitive load of co-participants. These results suggest that active listening provided by fellow teammates may create a cognitive-affective state conducive to divergent thinking in teammates. However, feedback does not have any significant effect on the cognitive-affective states of participants.

Table 10. *Linear Regression with Random Intercept for Two-tailed Test. Results for the effect of observed Social Factors on the different dimensions of the Cognitive-Affective States of co-participants.*

IV	DV	Estimate	StdErr	DF	tValue	Probt
Feedback of teammates		-1.0402	1.0256	551	-1.01	0.3109
Active listening of teammates	Valence of teammate	0.8427	0.3748	551	2.25	**0.0249**
Feedback of teammates		-1.3074	0.9549	551	-1.37	0.1715
Active listening of teammates	Arousal of teammate	0.5321	0.3514	551	1.51	0.1306
Feedback of teammates		0.03239	0.09267	167	0.35	0.7271
Active listening of teammates	Cognitive Load of teammate	-0.1054	0.03229	167	-3.26	**0.0013**

Note N=24, p=0.05, Linear Regression with Random Intercept for Two-tailed Test.
Table to calculate the influence of the Social Factors on the different dimensions of the Cognitive-Affective States of co-participants.

The study's findings regarding the effect of active listening cues on co-participants affective-cognitive states, with the lack thereof of feedback cues, offer valuable insights for further analysis. The absence of significant influence of feedback cues on co-participants cognitive and affective states underscores the necessity for additional investigation. The research team suspects that the qualitative descriptors found in the feedback cues may nullify their impact on the cognitive and affective states of co-participants. Feedback cues in the data structure had three atoms: two verbal and one physical. For the next question, the two verbal variables of Feedback were analyzed. These variables were: accepting language and rejecting language. In the last analytic segment of this analysis (RQ1d), the research team explored the impact of feedback quality on the cognitive and affective state of co-participants.

4.1.1.4 ***D-RQ1d.*** *How does the qualitative value of expressed feedback cues impact the cognitive and affective states of fellow co-participants?*

As seen when performing the *Linear Regression Test* in Table 11 below, a higher proportionality of co-participants rejecting language seems to have a significant negative impact on the overall lived arousal of fellow teammates (T (11)=-2.31, p=0.0413). On the other hand, we find a partially significant effect on two other dependent variables (perceived arousal and cognitive load). A higher proportionality of rejecting language by

teammates seems to marginally raise both perceived arousal (T (22)=1.8, p=0.0855) and cognitive load (T (22)=1.99, p=0.0589). Here participants perceived a higher arousal and cognitive load but experienced lower arousal when higher levels of negative feedback were given from colleagues. This contrasting display of affective states and the higher cognitive load could suggest frustration and disengagement from fellow participants when their colleagues share opposing views during CI. It could also suggest confusion in the participants where a teammate still feels the need to express their idea even if their collaborator have rejected their idea. Here participant is torn between feeling right about their idea (with high arousal) and experienced low arousal from the received rejection. This assumption however remains to be tested and would demand further research to be conducted. No significant effect is found for valence which suggests that valence stays stable even if a higher ratio of rejecting comments from participants is used. These results indicate that using a higher ratio of rejecting language leads to a decrease in the lived experience of fellow participants, as evidenced by higher perceived arousal, lower lived arousal, and higher perceived cognitive load. This may suggest a disengagement from fellow teammates in CI when the proportionality of rejecting language is higher.

Table 11. *Linear Regression Test. Results for effect of observed Verbal Feedback quality on the lived experience of co-participants.*

IV	DV	DF	estimate	Standard Error	t Value	Pr > |t|
Ratio: Rejecting/Accepting Language by teammates	Valence of teammate	22	-3.33067	3.86665	-0.86	0.3983
	Arousal of teammate	22	7.19575	3.99701	1.8	*0.0855*
	Arousal (EDA) teammate	11	-168.141	72.79003	-2.31	**0.0413**
	Cognitive Load teammate	22	0.57525	0.2888	1.99	*0.0589*

Note N=24, p=0.05, Linear Regression Test. Table to calculate the influence of the proportionality of rejecting to accepting language on the lived experience of co-participants within teams.

As seen above, the results of the impact of collaborative ideation (CI) sequence and social factors on participants' cognitive and affective states paint an interesting landscape of psychosocial interactions during CI and will be discussed further below.

4.1.2 Q.D-Discussion

The significant discovery of the qualitative impact of feedback cues on affective states during ideation, paired with the overall lower perceived valence for team during structuring moments represents crucial findings. The selective nature of feedback induces fluctuations in participants' cognitive-affective states and could foster the emergence of a shared mental model. An interpretation of our findings and in conjunction with existing literature, it appears that there is a preference for continuously updating the team's collective worldview and constructing a shared mental model. This practice facilitates idea development during ideation sessions and ensures high levels of creative output (Hattie & Timperley, 2007; Mory, 2004). The convergence phase where more feedback cues are present is integral to creative performance in individuals and requires a focused state akin to that of frustration (Baas et al., 2008; Funke et al., 2012; Knight et al., 2019). Here the lower valence experienced by participants in the structuring moments could suggest a collective convergence of ideas. Therefore, despite the triggered frustrative state in participants, the process of affirming goals and the merging of ideational structures serves as motivational purposes for fellow teammates (Kozlowski & Ilgen, 2006). In other words, the collaborative weaving of ideas within the larger context of problem-solving has been found to also positively impact the participants' perseverance in the CI (Kozlowski & Ilgen, 2006). However, the overall reported higher arousal and cognitive load alongside experienced lower arousal, when participants encountered higher levels of negative feedback from colleagues could also point to pernicious moments of frustration. Although frustration has often been linked to higher levels of arousal, recent studies have demonstrated that it can vary between high and low arousal (Groh et al., 2022). Paired with teammates' heightened arousal, these findings suggest that frequent use of rejecting language during CI may induce frustration, disengagement, and decreased emotional well-being among participants. This observed pattern could also signify a physiological manifestation of communication breakdowns and the collapse of a shared mental landscape conducive to idea exchange. Therefore, the dual interpretation of these findings emphasizes the importance of active listening cues.

The overall higher arousal and cognitive load in high creativity teams paired with the found impact of active listening cues on cognitive load and valence demonstrate interesting findings. By lowering the cognitive load and heightening the valence of fellow participants, active listening seems to provide an ideal physiological state for associative processes (divergent thinking) in co-participants. This finding when paired with the results of RQ3a, presented below, demonstrates the importance of active listening cues in the co-conception of an idea. It is demonstrated that active listening cues positively influence the conceiving phase. These paired results reveal that active listening cues support participants' affective states (by providing higher valence and lower cognitive load), thereby improving divergent thinking in co-participants. This phenomenon, demonstrated by longer conceiving times, and in Akbari Chermahini and Hommel (2012) research seems to suggest that active listening cues help divergent thinking essential and is for effective CI. The implicit validation of the proposed idea through active listening cues (Weger Jr et al., 2010) helps social cohesion within a team (Phutela, 2015) and forms a convenient space for associative thought processes or divergent thinking (Akbari Chermahini & Hommel, 2012; Härkki et al., 2018; Stroebe et al., 2010). As seen above and further supported below, our results demonstrate a congruent trajectory. These findings suggest that empathy through active listening could be pivotal in enhancing high creativity performance during collaborative ideation (CI) sessions. Encouraging a positive emotional state (with higher valence) through active listening cues and minimizing aversive language during the conceiving phase appears to help participants tolerate the overall higher arousal and cognitive load demanded of higher creativity teams by extending the divergent phase.

These physiological findings seem to support the idea that the *Multiple Angles* CI sequence is more demanding due to increased merging and structuring moments (Stempfle & Badke-Schaub, 2002) and is facilitated by empathetical cues for its development. To confirm this presumption, it would be valuable to test and see if the structuring moments and/or other phases of CI contribute to high creative output. This would enable the research team to ascertain whether teams are actively involved in merging ideas and generating efficient outputs, rather than feeling frustrated and disengaged from the creative ideation process.

4.2 *Q.A: How does the collaborative ideation sequence impact the creative performance of teams?*

The high creative output of teams is influenced not only by the higher amount of time allocated to structuring actions but also by their strategic placement during CI.

4.2.1 Q A-Results.

The subsequent section describes the results attained during the second analytical stage of the deductive phase of this research.

4.2.1.1 ***A-RQ2.*** *Are there any dimensions of the collaborative ideation sequence that are instrumental in yielding high a creative output?*

From the *Wilcoxon Sum Rank* statistical test for each team seen in Table 12, when comparing the time spent in the different phases of CI, we only notice a significant difference for the structuring moments for groups with high creativity ($Z(10)= -2.1651$ $p=0.0143$). All the other results suggest that the different phases of CI do not impact teams creative output.

Table 12. *Wilcoxon Sum Rank Test. Results for the effect of observed Collaborative Ideation dimensions on the creative performance.*

IV	DV	Statistic	Z	One-tail
Structuring	High Creativity	10	-2.1651	**0.0143**
Conceiving		19	0.1443	0.4429
Illustrating		15	-0.7217	0.2429
Structuring	High Originality	20	0.433	0.3429
Conceiving		19	0.1443	0.4429
Illustrating		18	0	0.5571

Note n=4, p=0.05, Wilcoxon Sum Rank Test. Table to calculate the influence of each dimension of the collaborative ideation sequence on the two dimensions of the creative performance (creativity and originality).

Teams with longer total structuring time are more likely to have a higher creativity score. This finding presented in Table 12 aligns with what is found in the literature. The actions of structuring the collaborative ideation of a team need to be present and well-established to ensure the quality of the teams' creative outputs (Convertino et al., 2008; Stempfle & Badke-Schaub, 2002).

4.2.2 Q.A-Discussion

From the results from section 8.1, it seems that teams in high creativity groups are indeed involved in longer processes of ideation structuring and merging. This process of analyzing, merging, and integrating multiple ideas to collectively build a shared understanding and generate collaborative creative output seems to require more effort from all the participants involved (Akbari Chermahini & Hommel, 2012) and is demonstrated here by a higher level of structuring moments.

Upon closer investigation, the visualized results provide additional support to the existing literature's assertion that the act of structuring should be positioned in opposition to the proposition of an idea (Hennessey & Amabile, 2010; Keum & See, 2017; Osborn, 1953). As shown in Figure 8, the strategic placement of structuring moments within CI is essential for fostering high creative output. It seems that having interchangeable moments between structuring and proposing is more impactful than the individual who structures. This contrasts with Convertino et al. (2008) finding where the structuring phase should occur at the beginning of CI sessions for high-creativity teams. In our study, high-creativity teams allowed members to first generate ideas and then structure them in relation to the design brief by naming and clarifying their goals, while low-creativity teams constantly generated and punctually structured ideas (see Figure 8). Aligning with Keum & See (2017) finding, it seems that the temporary hierarchical authority granted to a participant to situate the teammate's ideational input during the structuring moments hinders the potential growth and expansion of the discussed idea. It is apparent in Figure 8 that teams who separated their conceiving phase from their structuring moments appeared to have higher creativity. Therefore, it can be assumed that teams who allow for a time and a place for generating ideas without the imposed judgement of the structuring moments have greater chances to achieve higher creative performance.

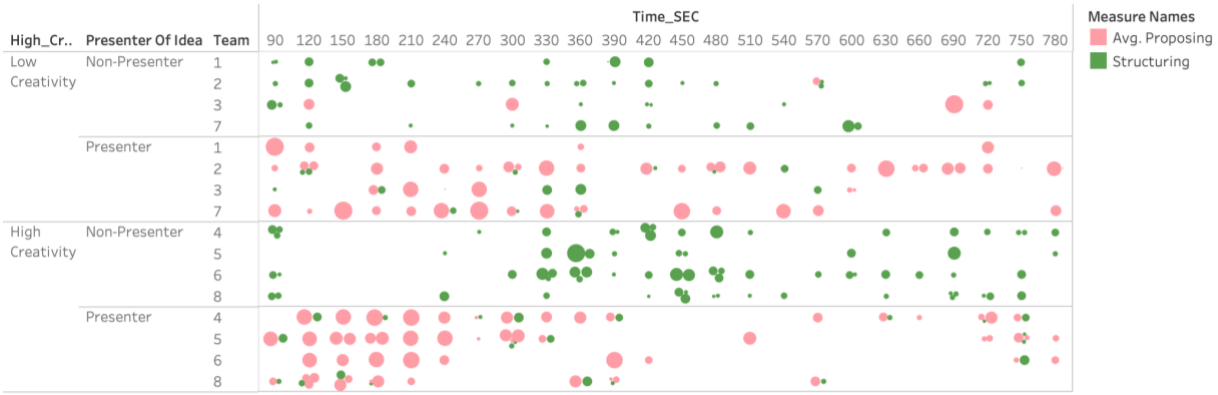

Figure 8. *Visualization of Structuring and Proposing within the Creativity dimension divided using the median split.*

This finding further substantiates the key differences between *Energetic Brainstorm* characterized by concurrent rapid idea generation and structured punctual evaluation and the *Multiple Angles* approach, involving iterative and longer qualitative idea assessment leading to higher creative performance. Figure 8 demonstrates that the *Multiple Angles* method leads to higher creative performance, as participants allocate time and space for their co-participants to develop ideas, followed by an iterative evaluation process guided by the design brief through longer dedicated structuring moments.

Naming the goals of the project and giving directions to teammates in terms of the collective objectives are all part of the structuring moments (Dorta et al., 2011a; Stempfle & Badke-Schaub, 2002). These verbal actions, as explained in Figure 8 and supported by the collective physiological state (lower valence) experienced by teams during structuring moments (see Table 7), indicate that they play a pivotal role in weaving ideational input together (convergent thinking). They facilitate the iterative decision-making process during CI. Our results, validate that the presence of the structuring moments or processed-based interactions seems to play an indispensable role in idea generativity in a collaborative context. Therefore, investigating whether social factors influence this ideation-building process and other elements of CI as well as the trio's outputs is a worthwhile avenue for further exploration.

4.3 *Q.C: What is the impact of social factors on the collaborative ideation sequence and creative performance of team?*

Intriguingly, social factors influenced the conceiving phase and the creative output of high-creativity teams. To comprehensively investigate this impact, we delve into the study of social factors and aim to determine their precise influence on the collaborative ideation sequence and creative output.

4.3.1 Q.C-Results

The subsequent section describes the results attained during the third analytical stage of the deductive phase of this research.

4.3.1.1 ***C-RQ3a.*** *How do the observed social factors of fellow participants in a collaborative ideation session impact the collaborative ideation sequence?*

From the performed *3-Way ANOVA* statistical test in Table 13, both feedback ($F(377)= 12.5$, $p=0.0005$) and active listening ($F(377)= 7.55$, $p=0.0063$) from teammates have a significant effect on the conceiving time of fellow teammate. All other results seem to suggest that feedback and active listening of teammates do not affect the two other dimensions (structuring and illustrating).

Table 13. *3-Way ANOVA. Results for the effect of observed Social Factors on the different dimensions of the Collaborative Ideation sequence.*

IV	DV	NumDF	DenDF	FValue	ProbF
Feedback of teammates		1	130	0.19	0.6614
Active listening of teammates	Structuring time of teammate	1	130	0.2	0.6552
Feedback of teammates		1	377	12.5	**0.0005**
Active listening of teammates	Conceiving time of teammate	1	377	7.55	**0.0063**
Feedback of teammates		1	83	0.06	0.8146
Active listening of teammates	Illustrating time of teammate	1	83	2.55	0.1138

Note N=24, p=0.05, 3-Way ANOVA Test. Table to calculate the impact of the Social Factors on the different of The Collaborative Ideation sequence.

As substantiated by *Linear Regression with Random Intercept for Two-tailed* statistical test in Table 14, feedback and active listening of teammates seem to not have a significant effect on both the structuring moments and illustrating phase of CI. The

conceiving phase, however, seems to be significantly positively impacted by active listening ($T(377)=2.75$, $p=0.0063$). The more active listening cues are expressed by co-participants the longer the conceiving phase seems to be for fellow participants. Interestingly enough, however, feedback significantly impacts the conceiving phase in the opposite direction ($T(377)=-3.54$, $p=0.0005$). The more feedback cues are expressed by the co-participants the shorter the conceiving phase seems to be for the third participant.

Table 14. *Linear Regression with Random Intercept for Two-tailed Test. Results for the effect of observed Social Factors on the different dimensions of the Collaborative Ideation sequence.*

IV	DV	Estimate	StdErr	DF	tValue	Probt
Feedback of teammates		-0.03045	0.06937	130	-0.44	0.6614
Active listening of teammates	Structuring time of teammate	0.008819	0.01971	130	0.45	0.6552
Feedback of teammates		-0.1574	0.04453	377	-3.54	**0.0005**
Active listening of teammates	Conceiving time of teammate	0.04481	0.01631	377	2.75	**0.0063**
Feedback of teammates		-0.01953	0.08304	83	-0.24	0.8146
Active listening of teammates	Illustrating time of teammate	-0.05394	0.03374	83	-1.6	0.1138

Note N=24, p=0.05, Linear Regression with Random Intercept For two-tailed Test.
Table to calculate the influence of the social factors on the different dimensions of The Collaborative Ideation process.

The validation of the proposed idea through active listening cues seems impact the longevity of the conceiving time and further substantiates the discussion of section 8.1 and 8.2. The negative impact of feedback cues on the conceiving phase aligns with the existing literature, which suggests that providing immediate feedback, whether positive or negative after the conception of an idea can be perceived as a judgment (Keum & See, 2017; Osborn, 1953). Having identified the effect or the lack thereof of social factors on the CI sequence it would be valuable to see if they affect the team's creative performance.

4.3.1.2 ***C-RQ3b****. Are there observed social factors that are likely to yield a high creative output?*

Using the *Wilcoxon Sum Rank* statistical test seen in Table 15 to compare the sum of active listening and feedback for each team, we only notice a partially significant

difference for active listening in creativity (Z(12)=-1.5877, p=0.0571). Hence, teams with a higher total of active listening cues are more likely to have a high creativity score.

Table 15. *Wilcoxon Sum Rank Test. Results for the effect of observed Expressed Communications on the creative performance.*

IV	DV	Statistic	Z	One-tail
Active Listening	High Creativity	12	-1.5877	*0.0571*
Feedback		18.5	0	0.4714
Active Listening	High Originality	21	0.7217	0.2429
Feedback		15.5	-0.5808	0.2714

Note n=4, p=0.05, Wilcoxon Sum Rank Test. Table to calculate the influence of each dimension of the social factors within the group on the two dimensions of the creative performance (creativity and originality).

Further substantiated by the results above, active listening cues thus facilitate the development of high creativity output. Active listening seems to augment the ideational input of fellow participants during CI, by providing support and expansion. As evidenced by the CI study conducted by Badke-Schaub and Stempfle (2003). Participants in their study rarely engaged in self-reflection for expansion regarding their ideational propositions, and such reflection was only prompted by fellow participants. Therefore, active listening cues serve as a base to create a shared understanding which is essential for CI.

4.3.2 Q.C-Discussion

As seen previously, active listening cues serve as vectors of social cohesion that aid teams in creating highly creative performances. The above results are a great example of this. Active listening which demonstrates empathetic social cues (Weger Jr et al., 2014) seems to play a positive role in the conceiving phase. Active listening cues, by fostering encouragement and prolonging the conceiving phase, can enhance team performance and better the collective creative sequence. Here, the provided implicit approval of active listening cues facilitates uninterrupted idea formulation with visual and auditory support allowing for a shared understanding to be built (Davitz & Davitz, 1961; Wagner et al., 2005).

The qualitative nullifying attributes of the feedback cues appear to be the reason for the lack of significant results. As demonstrated by the literature they either hurt social cohesion and cause individuals to withdraw from group participation in favour of an introspective state (Dow et al., 2011; Kozlowski & Ilgen, 2006) or the challenging aspect of this cue can allow for a more thorough idea development (Badke-Schaub & Stempfle, 2003). This opposing finding and the lack of significant impact on the other factors of the CI sequence and performance raises important questions which will be analyzed further in this article. Therefore, in this last analytic segment (RQ4a-RQ4b), the research team explored the impact of feedback quality on the creative performance of the team.

4.4 *Q.B: To what extent does the quality of feedback cues have an impact on creative performance of teams?*

Here the absence of significant findings on feedback cues has brought this research team back to the literature to uncover new dynamics that could be at the heart of this assessment. In this context, we present the results of our investigation and introduce our new assumptions.

4.4.1 Q.B-Results

The subsequent section describes the results attained during the fourth and final analytical stage of the deductive phase of this research.

4.4.1.1 ***B-RQ4a.*** *To what extent does the quality (negative/positive) of feedback in a team influence its creative output?*

Using the Wilcoxon Sum Rank Test seen in Table 16 below, the quality of feedback does not seem to significantly impact the two dimensions of creative performance.

Table 16. *Wilcoxon Sum Rank Test. Results for effect of observed Verbal Feedback quality on the creative performance.*

IV	DV	Statistic	Z	One-tail
Accepting Language	High Creativity	18	0	0.4429
Rejecting Language		15	-0.7442	0.8
Accepting Language	High Originality	16	-0.4437	0.6571
Rejecting Language		16.5	-0.2977	0.3857

Note n=4, p=0.05, Wilcoxon Sum Rank Test. Table to calculate the influence of each verbal quality of feedback within the group on the two dimensions of the creative

performance (creativity and originality).

The lack of significant results at the performance level is similar to what has been found in the literature. Leshed et al. (2007) propose that this could be because these effects can only be seen in a longitudinal setting when teams work together over long periods. Another possible avenue for the absence of significance in this context may be due to the interdependencies of these two variables (accepting & rejecting language). Therefore, it is worth testing whether the balance of negative to positive feedback impacts team performance.

4.4.1.2 ***B-RQ4b.*** *To what extent does the proportionality of negative to positive feedback impact the team's creative output?*

Using the Wilcoxon Sum Rank Test seen seen in Table 17 below, the proportionality of negative to positive feedback does not seem to significantly impact the two dimensions of creative performance.

Table 17. *Wilcoxon Sum Rank Test. Results of effect for observed Proportionality of Rejecting to Accepting Feedback on the creative performance.*

IV	DV	Statistic	Z	One-tail
Ratio: Rejecting/Accepting Language	High Creativity	16	-0.4356	0.6286
Ratio: Rejecting/Accepting Language	High Originality	19.5	0.2904	0.7429

Note n=4, p=0.05, Wilcoxon Sum Rank Test. Table to calculate the influence of the proportionality of rejecting to accepting language in the group on the two dimensions of the creative performance (creativity and originality).

The non-significative results in Tables 16 and 17 and the earlier positive impact of team management through structuring moments on creativity seem to point to other variables which was not considered in this research such as the management style of the teams or constraints/direct differential incentives. Competitive rewards and management styles are seen as important factors in collaboration. However, in this study, all participants were treated equally and told to develop as many ideas as they saw fit. This could potentially explain the lack of significance found, as such factors have been demonstrated to enhance motivation, thereby mediating the relationship between feedback levels and performance (Barr & Conlon, 1994).

The participatory perspective in this research gives an adequate perspective of how structuring moments impact CI performance but the lack of evidence seen in Table 16 and 17 raises interesting questions about team management during this process.

4.4.2 Q.B-Discussion

Three different kinds of team management styles are thought of as impacting the iterative decision-making process in CI: *dominating*, *consensus* and *rotating* (Davis & Eisenhardt, 2011). Here it is uncovered that using *rotating* leadership by enabling team participants to align with their expertise, is a management style that appears to be optimal for fostering effective collaboration. The discovery of this concept post-experiment helps explain the lack of significance for the quality of feedback cues on creative performance. Consequently, it appears that the quality of feedback does not have a direct impact on performance and key factors such as managerial process remains to be tested.

The evaluation of CI group dynamics through feedback can be pushed further. For individuals to integrate feedback cues from fellow participants effectively the cue must align with both the collective and the participants' pre-existing structural mental model (Hattie & Timperley, 2007). If this cue fails to align with the established collective creative landscape, participants will simply reject or ignore the feedback (Hattie & Timperley, 2007). Establishing shared knowledge related to the collective problem-solving at hand facilitates the formation of collective assumptions and enables the team to concentrate on creating ideas (Bierhals et al., 2007). Hence, the individual informational structures have to be merged to avoid misunderstandings or premature rejections of ideas (Bierhals et al., 2007). Empirical evidence in the literature supports that a shared team cognitive structure facilitates dynamic idea exchange during CI, fostering creative performance (Dong, 2005). Bierhals et al. (2007), suggests that recognizing knowledge gaps enables teams to develop a "meta-cognition model", aiding in the formation of a shared mental model and enhancing creative output. Thus, as earlier suggested, to create higher creative output, teams have to construct a shared landscape by giving feedback cues and asking questions on inputs from fellow participants (Badke-

Schaub & Stempfle, 2003; Bierhals et al., 2007). This concept seems to point to a new variable such as “concept understanding” that was not considered in this study.

The feedback negative tone during this process, as demonstrated by the physiological findings in this research and the literature, may result in adverse effects on social cohesion and mutual understanding, potentially leading individuals to disengage from group participation and adopt an introspective state (Dow et al., 2011; Kozlowski & Ilgen, 2006). The above aforementioned studies paired with our findings bring an interesting understanding of group dynamics in CI. Perhaps demonstrating empathy and showing interest in each other’s point of view are more crucial acts than the qualitative evaluation of ideas during team idea development. This comprehensive understanding of feedback functionality offers a better idea as to why no significant impact was shown. It seems that to have efficient collaborative creative output a team needs to have a common mental model from which collective ideational input can emerge however the process of the merging of experiential knowledge need to be managed collaboratively with tact and empathy. This reasoning will be dissected and discussed in further detail below.

5. Discussion The Significance of Empathy during Collaborative Ideation (CI)

Our findings indicate that generating original/creative ideas collaboratively demands a substantial cognitive load from participants. Hence, punctually diminishing this load and increasing the valence in fellow participants through active listening cues may not only enhance participatory motivation but also establish an optimal space for divergent thinking (Akbari Chermahini & Hommel, 2012). Here, the implicit validation of the proposed idea through active listening cues (Weger Jr et al., 2010) helps social cohesion within a team (Phutela, 2015) and forms a convenient space for associative thought process or divergent thinking (Akbari Chermahini & Hommel, 2012; Härkki et al., 2018; Stroebe et al., 2010). Hence by creating more successful communication between participants (Härkki et al., 2018; Kohpeima Jahromi et al., 2016; Stroebe et al., 2010) and a better generation of creative outputs, active listening cues are integral to high creative performance.

Although no significant impact was found at the performance level of teams the impact of feedback cues on participants' cognitive and affective states points to interesting implications for supplementary research on this section of CI. A more nuanced comprehension of the analytical process of CI is needed to guide further research. For example, the context within the group during CI is important (Clark et al., 1983). A team composed of different experts or individuals with different individual goals for the project at hand can affect contextual perceptions. Divergent interpretations of words among group members can lead to dissociation and subsequently result in lower creative performance (Clark et al., 1983). Hence, opposing individual goals and perceptions of the problem can negatively affect the process of collaboration through the lack of common communication cues. Creating a common understanding or communication grounding in teams is therefore essential for CI. Consistent with this proposition Köppen and Meinel (2014) define empathy in the context of design thinking as a facilitator for knowledge construction. To avoid confusion with the team, the articulated creative input has to be well understood by all the parties involved (Clark & Brennan, 1991). A common understanding is in constant evolution in CI and requires constant monitoring and adaptability from participants involved in the collective development of the creative output to ensure that all in the team are on the same page so to speak (Convertino et al., 2008; Köppen & Meinel, 2014). For example, "internal empathy" involves techniques of fostering ideational integration and community building within teams. The beneficial properties of using internal empathy strategically during CI with cognitive actions such as "building on the ideas of others" and "deferring judgment" are demonstrated in this study and by Köppen and Meinel (2014).

It is essential for participants to understand the impact of their feedback cues on the team's physiological state during CI for optimal performance. The physiological findings in this study seem to be catalysts for expressed social dynamics such as feedback cues and cohesion among the groups. This exteriorizing process creates a space for shared understanding to be found and it seems that feedback cues are related to the structuring moments of collective ideation and help teams manage their *content* sharing. These cues have to be properly distributed to avoid the lack of common ground or trigger "Functional Fixedness" within a group if members of the team spend a prolonged time merging their

worldviews into an excessively comprehensive mental model (Abraham & Windmann, 2007). Therefore, as the results suggest the need to be well structured for the team to focus their energy into a comprehensive collaborative structure is essential for both motivation and creativity in the team.

In light of these findings, it becomes evident that empathy through team management and active listening cues plays a pivotal role in fostering both high creative performance and the progression of the CI sequence. The heightened emotional state and the creation of a shared understanding facilitated by empathetic cues ultimately amplifies content generation and creativity. The *Multiple Angles* method, supported by our aforementioned findings, represents a first step toward optimizing empathy within the realm CI and fostering a deeper understanding of its effective practice. The collective production of optimal creative outputs is not about emotional equality but about fostering curiosity, support, and openness to differing opinions (Köppen & Meinel, 2014) and understanding each other's cognitive-affective experiences.

5.1 *Analytic Limitations*

This study acknowledges and emphasizes the importance of contextualizing the reported marginally significant results in its analysis. Field Pritschet et al. (2016) noted that marginal-effect reports should be interpreted with caution and the nature of these effects should be clearly defined. As seen in the validated theoretical frameworks *in appendix B & C* the incomplete validation of cause and effect between certain variables or partial mediation should also be acknowledged and contextualized. These unvalidated results could be because of the observatory nature of this study where saturation has been reached (Corbin & Strauss, 1990) as opposed to effective sample size calculation. Additionally, variables unbeknown to the research teams could also be involved in the complex phenomenon of CI (Frazier et al., 2004).

Although insightful, these initial findings in this research would therefore need more rigorous testing. To ensure comprehensive evaluation, it is important to independently test the factors in psychosocial patterns that are believed to influence the *content*, *process*, and performance of CI. This would allow the identification of any potential factors that may

have been overlooked by this research team or eliminated in the data segmenting process. Further investigation is therefore required to examine and test our noteworthy initial deductions of the impact of participants' psychosocial patterns on this complex structure.

Given the exploratory nature and limited sample size of this study, it was deemed appropriate to report on the social, affective, and cognitive effects within the psychosocial patterns that influence the creative sequence and performance. The claims made in this study, hope to serve as a foundation for future testable research on CI.

5.2 *Limitations and Future Research*

A few limitations are present in this research because of the observatory nature of this experimental process. The complex process of CI and the continuous collection of observational data has proven challenging in some aspects of the analysis. First, as seen previously the analytical construction of the different CI phases could affect the variability of the data. Second, the mitigating factors caused by this construction did not allow for an analysis of the cognitive load on an individual level during the three different dimensions of CI. Therefore, a clear separation of the phases in later research is recommended even if it reduces the ecological validity of the results.

This experiment was conducted during the pandemic, consequently, the faces of the participants were obstructed by masks which impeded the view of the researchers on the facial expressions of the participants. The participants had no prior working experience with their teammates. They also were provided a short collaborative ideation time. Therefore, to generalize our findings this experiment should be repeated longitudinally with design experts in a working environment, as organizational and work dynamics are also important factors in the collaborative ideation (Dow et al., 2011; Hennessey & Amabile, 2010).

In addition, the managerial effect on creative performance, the silence between teammates and a deeper understanding of mimicry in active listening seem to be promising impacting factors. These variables were not or partially empirically considered in this experiment and seem to intuitively affect the creative sequence and performance

of collaborative ideation (CI). As seen in Hans and Hans (2015) non-verbal communications are thought to be great vectors of content communication: “7% of the messages are sent through words with the remaining 93% sent through non-verbal expressions” p.50 and would be a great avenue of scientific exploration. Mimicry is also found to increase “prosocial behaviours”, heighten participation and create “dependent cognitive processing styles” (Van Baaren et al., 2004). This insight in the context of CI could be beneficial to the development of better CI sequences for effective collective creative output. Furthermore, the subsequent specific actions of participants after receiving feedback were not investigated and can refine our understanding and shed light on the purpose of feedback cues in CI (Barr & Conlon, 1994). This study has opened the door to expanding the understanding of the complex social factors that are found in collaborative ideation (CI). These valuable insights for practitioners and researchers alike pave the way for future advancements in the field.

6. Conclusion

Collaborative ideation (CI) is the interplay between “individual and collective ideation” (Dorta et al., 2011b) and has become instrumental in diverse sectors for complex service and product development (Davis & Eisenhardt, 2011; Dorst, 2015). As demonstrated above, understanding this process aids organizations in implementing resources that enhance creative development, ultimately resulting in superior designs. To establish a healthy innovative practice, organizations must have the appropriate infrastructures in place to prevent fluctuation in their creative results.

The initial results of this study revealed intriguing findings regarding the interrelated influence of various factors present in the collective creative development of the observed teams. Social factors and the emotional flux of participants appear to explain the discrepancies in creative performance and the different CI sequences. The lower creativity teams seem to fail to activate the appropriate cognitive and affective states in fellow participants for the corresponding ideation dimension. Additionally, they appear to exhibit less structured ideation sequences. Support from fellow participants through active listening and a constructive understanding of the problem through structuring moments are primordial for effective CI. As demonstrated above if properly coordinated these

factors are optimal for creative performance. Therefore, to collectively explore the diverse aspects of ideational input from fellow teammates and generate high-quality collaborative creative output, teams must empathetically structure idea conception and adeptly handle collaborative ideation through ideal social factors.

The study of psychosocial patterns in Collaborative Ideation (CI) is a significant first step in understanding the occurrence of creative output fluctuation. It also shifts the common understanding that the later presented concrete implementations can only be achieved through intuitive familiarity with the CI process (Stempfle & Badke-Schaub, 2002) to concrete teachable units. Therefore, given the continuous expansion of the creative innovation field into multiple working sectors, it is imperative for managers to fully understand how to effectively implement collaborative ideation (CI). The psychosocial patterns expressed and experienced by participants have to be considered to effectively support this dynamic process in CI.

Here are the concrete/practical implementations:

- Structuring through keeping track of the progression of the team by making sure that the problem-solving ideational landscape and the concept framing are understood by everyone on the team.
- Bringing awareness to team leads that the social fabric of teams impacts the creative sequence which in turn impacts the creative performance of teams.

  Meaning:

    - Active listening cues seem to aid teammates in their ideational expansion (divergent thinking process) and feedback cues seem to aid teammates in merging and focusing their ideas (convergent thinking process). This finding is a further step into one of designing golden rules to never judge during ideation established by Osborn (1953) in Applied Imagination.

    - Being supportive when a teammate first proposes an idea through active listening cues and then offering feedback later when this idea is fully presented seems optimal for creative performance.

- Empathetic understanding of an ideation proposal from a co-ideator appears to offer a distinct advantage in generating high creative outputs.

Comprehending and adjusting to the collaborative ideation sequence seems to lead to a new adaptive strategy *micro-fluctuating* coordination style. These practical applications further demonstrate the need to examine how different team coordination affects the different selective iterative loops and visualize their optimal placement for teams in collaborative ideation (CI). As seen earlier, decision-making in the context of CI is not a yes/no binary process. Instead, it is an iterative process and requires all parties involved to foster mutual understanding and openness to the contributions of others. Teams who interchange decisional power between teammates lead to higher innovation. This would be valuable to research in a collaborative ideation context. Knowledge workers need to assess and understand the impact of their expressed communications on the cognitive-affective states of their teammates and their creative development to adjust their participation for optimal creative performance.

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Chapter 4: Conclusion

The practice of design has evolved and infiltrated multiple fields. Its methods are now used for strategic planning, systematic integration or as communication tools for collaborative ideation (CI) (Buchanan, 1992). In the industry, designers and knowledge workers alike are increasingly tackling "wicked problems". Using design-born techniques this workforce is resolving issues and generating disruptive solutions for better communal futures. Design thinking, has therefore evolved to serve as the blueprint for these innovative thinkers, guiding them in strategic planning, meaningful product creation and experience optimization (Buchanan, 1992). Pluralistic teams, characterized by diverse expertise and working methodologies, have become the norm in innovation circles, where their sole common ground is curiosity and openness to problem-solving (Amabile, 1983; Buchanan, 1992). This triggers multiple uses of different methodologies. This research is the first step in understanding these intuitive thinking methods behind collaborative ideation (CI). Two collective ideational methods were identified and observed. The autonomously determined *Multiple Angles* method, demonstrated by high-performance teams, appears to be the most effective. This study identifies psychosocial patterns in collaborative ideation, contributing to the understanding of effective design thinking methods and in doing so provides a detailed blueprint for this process.

The sentiment of openness and curiosity within an innovative team, discussed earlier, along with our results, directs our attention to the concept of empathy as a catalyst for effective CI. Köppen and Meinel (2014) emphasis on "internal empathy" and their call for improved instructions for effective Collaborative Ideation (CI) underscores the importance of the findings presented in this memoir. Our subsequent discoveries align with this observation, offering specific action points for innovation teams to implement.

1. Concluding Ripples: Nurturing Fluid and Open Exchanges in Collaborative Ideation

The validity of collaborative ideation as an instrument to develop sound and effective ideas for organizations is still a point of contention in the scientific community. To address

this scientific divide, this study aimed to demonstrate the significance and impact of psychosocial patterns on collective creative output. As a result, ecologically valid insights for professionals were provided. This section highlights the key findings of this research according to their respective areas of contribution.

1.1 *Methodological Contributions: Understanding How to Observe and Collect Important Factors in Collaborative Ideation*

The multi-factorial analysis of collaborative ideation (CI) proved challenging. This study heavily relied on continuous and qualitative observations, thus, employing the deductive-exploratory method to analyze CI proved effective. This approach provided a rigorous framework, allowing for the sound analysis of the data to understand this complex phenomenon.

Gathering the physiological information of multiple participants during CI can prove to be a challenge. Most physiological measuring tools for collecting participatory data typically require the subject to stay relatively immobile. However, designers during CI tend to gesture, write, draw etc… These tools can also be both expensive and generate intricate records for analysis. To address this, our research team successfully utilized and developed cost-effective, accessible methods that synchronously collected subjects' arousal and cognitive load during CI. These tools not only offer flexibility of movement but are also efficient. The joint utilization of the Cobalt Bluebox (Courtemanche et al., 2022) to record participants' electrodermal activity for measuring arousal, along with mini keyboards to capture cognitive load at specific intervals, provided robust data on affective and cognitive states throughout the collaborative ideation (CI) sequence.

The combination of qualitative observations and continuous physiological/self-observational data collected during CI contributed immensely to the methodological aspect of studying creativity in a collaborative context. Inherent to the creative experience, it afforded the research team experiential confirmation of observed patterns during CI. For example, structuring moments, during CI, have a complex role. They are understood as areas during CI when the team organizes and relates their collective ideational input to the design brief to form a creative output. Our results demonstrated that participants

perceive these moments as significantly less pleasurable (lower overall valence). This assessment paired with our other finding that structuring moments positively impact the creative output of the group could seem at first glance perplexing. Nevertheless, paired with the literature on individual creative development, we find that to converge ideas individuals need to have a focused state (Baas et al., 2008; Funke et al., 2012; Knight et al., 2019) which presents itself with lower valence in participants (Bradley & Lang, 1994). This multi-factorial understanding demonstrates that while participants perceive these moments as less pleasurable, and seemingly counterproductive to collaborative ideation (CI), they are, in fact, beneficial for the convergent development of the creative team. The mix of qualitative and quantitative observations, therefore, allows for discoveries to be made and seemingly contradicting findings both in the literature and in our study to be explained.

1.2 Theoretical Contributions: The Impact of Social Factors on Collaborative Ideation and its Contributors

The holistic view of this study and its multi-factorial analysis allowed for multiple theoretical contributions. Below the results of this research are summarized, divided and categorized according to the four areas of significance provided in the earlier empirical article.

1.2.1 Exploring the Impact of Collaborative Ideation Sequence and Social Factors on Participant's Cognitive and Affective States

Uncovered by this research cognitive and affective states of participants are inherent to both individual and collective creative development (Baas et al., 2008; Funke et al., 2012; Knight et al., 2019). It seems that the use of active listening cues seems to trigger higher emotional states and lower cognitive load in co-participants conducive to aiding the divergent thinking process. This cognitive phenomenon is exemplified by longer conceiving phases. The elevated arousal and cognitive load associated with high creative performance teams indicate an overall focused state in the participants of those teams (Akbari Chermahini & Hommel, 2012). As discussed previously, this showcases an increased combination of ideas and perceived higher cognitive work for these teams. These results, therefore, suggest the avoidance of cognitive failures such as "Path-Of-

Least Resistance" in creative development by allowing the strategic placement of empathetic cues during the conceiving phase and effectively converging ideational input from co-participants with structuring moments.

1.2.2 Evaluating the Impact of Collaborative Ideation Sequence on High Creative Output

The structuring moments during CI are important to achieve higher levels of creative performance. These results when visualized echo the literature. Teams with high levels of creativity autonomously place these moments in opposition to the ideational development of others. In other words, teammates need to listen to the proposed ideas without judgement before evaluating them (Hennessey & Amabile, 2010; Keum & See, 2017; Osborn, 1953). Our results demonstrate the importance of these moments for the iterative decision-making process in collaborative ideation (CI) and showcase its a pivotal role in achieving effective creative output.

1.2.3 Social Factors in Collaborative Ideation: Determining Their Impact on Sequence and Creative Output

Active listening cues had a positive impact on both the conceiving phase and the creative output of a team. The implicit approval of co-proposed concepts facilitated by these empathetic cues enabled participants in teams to delve deeper into their proposed ideas, resulting in extended conceiving phases and enhanced creative outputs. This allowed for a shared understanding to be built (Davitz & Davitz, 1961; Wagner et al., 2005) which seems key to the development of communal high creativity outputs.

The observed negative impact of feedback cues on the conceiving phase, coupled with their limited influence on the collective creative output, prompted a re-evaluation by our research team. In light of our findings and the diverse perspectives in the literature, we analyzed the quality of feedback cues to deepen our understanding of collaborative ideation (CI), laying the foundation for the subsequent analysis.

1.2.3.1 Qualitative Assessment of Feedback Cues on Creative Output

The quality of feedback provided no clear impact on the creative output of teams in this study. Nevertheless, the discernible impact on the cognitive-affective states of participants when the ratios of negative feedback are higher might obscure a long-term effect or an unknown variable such as "team management styles" (Davis & Eisenhardt, 2011) unbeknownst to this research team at the time of the experiment. The absence of conclusive findings serves as a reminder that the research presented in this memoir is an initial step toward understanding how psychosocial patterns influence the collaborative ideation sequence and its output.

1.2.4 Practical Implications: What does this mean for Innovation and the People Involved in It?

Our results confirm that the autonomously generated Multiple Angles method is the most effective option for teams in creating impactful outputs collectively. This perspective on collaborative ideation (CI) is critical for understanding its dynamics. Therefore, to optimize creative performance, organizations should prioritize awareness of the impact of psychosocial patterns on co-participants cognitive-affective states. Social cues seem to impact the CI sequence in different ways. Active listening cues serve as support for ideational expansion while structuring moments and feedback cues serve as focusing vectors to help merge multiple ideas. These results highlight their roles in divergent and convergent thinking processes, respectively. Similar to the literature, the separating process of proposal and structure is identified in this research as advantageous for generating high creative outputs. Thus, the ability of a team to coordinate and strategically adapt to the context of the ideation sequence and co-participant's ideation process seems to be optimal for creating collective high performance. This micro-fluctuating coordination style seems to be optimal in the context of an iterative decision-making process.

2. Discussion: Exploring the Critical Role of Team Management in Fostering Creativity

The rigorous mixed-method process of demystifying Collaborative Ideation (CI) unveiled its intricate nature, both in terms of interactions within it and the multi-field

individuals who contribute to its process. This research is a first step in understanding the impact of psychosocial patterns on the creative process of individuals while in a team setting. Our findings, combined with our post-experimental insights, highlight multiple avenues for continued investigation. The observed positive impact of active listening and the "increased prosocial orientation" associated with mimicry (Van Baaren et al., 2004) suggests a potential exploration of mimicry for a deeper understanding of empathetical cues within the context of CI. This investigation could prove to be a promising direction for a better grasp of effective CI. Furthermore, the diverse statistical results regarding the influence on team creative performance, coupled with the proven positive impact of diverse participatory attitudes in CI for optimal creative output (van Oorschot et al., 2022) reveal promising avenues for future research. Establishing a common goal and linking it to the broader design brief through feedback serves as crucial factors of ideational development. Subsequent investigations could yield valuable insights by conducting a more in-depth exploration of these moments within the collaborative ideation (CI) process. These moments, where collective understanding and adaptation to the CI sequence emphasize the necessity of exploring the impact of different team coordination styles on the CI process and its optimal sequence for efficient creative output.

While there is still ongoing debate within the scientific community regarding the value of empathy due to its potential for individual biases (Heylighen & Dong, 2019), in the context of collaborative ideation (CI), it appears to be a crucial contributing factor. This research through the analysis of individual cognitive and affective data during CI has provided both an empirical validation of scientific assumptions and a valuable framework for further exploration on this subject. Examining the impact of "emotional and cognitive empathy" on CI performance will offer valuable insights for organizations seeking effective processes for creative output (Gasparini, 2015). A genuine curiosity about the perspective of others and rotating decisional power as a management style in CI seems to be beneficial for the internal processing and development of knowledge as well as the generativity of creative outputs (Davis & Eisenhardt, 2011; Surma-Aho & Hölttä-Otto, 2022). This research cautiously proposes that this curiosity mindset and empathetic knowledge-sharing could provide new insights into effective ways to achieve high creative performance. In this context micro-fluctuating coordination style through an

acknowledgment of the perspectives and processes of others during CI could be beneficial for team performance. The key here is to understand/adapt and not assume the approach of others. Therefore, the leadership style within this sequence, though not tested in this study, holds significant potential and should be a subject of future investigations.

3. Closing Statement

The ever-evolving knowledge sector requires futuristic projections to ascertain its constant reinvention. The management of human potential during this growth must be effective to develop and foresee the best possible future for an organization. Bringing awareness to the psychosocial patterns in CI that help achieve effective creative output is not only good for the knowledge sector but also across industries in the early stages of innovation. This study aims to raise awareness about the impact of these patterns, enabling the utilization of these subtle processes. This, in turn, can assist researchers and educators in providing a more comprehensive understanding and effective instruction to a broader audience on how to manage psychosocial patterns during CI. The research is a first step in understanding the crucial role of social factors on CI and is one step closer to fully demystifying collaborative ideation. It creates an understanding which explains the scientific divide about the effectiveness of CI for optimal creative output. This area of study contributes not only to innovation in collaborative contexts but also to understanding how humans collaborate to find strategic solutions for complex problems.

4. References

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Appendices

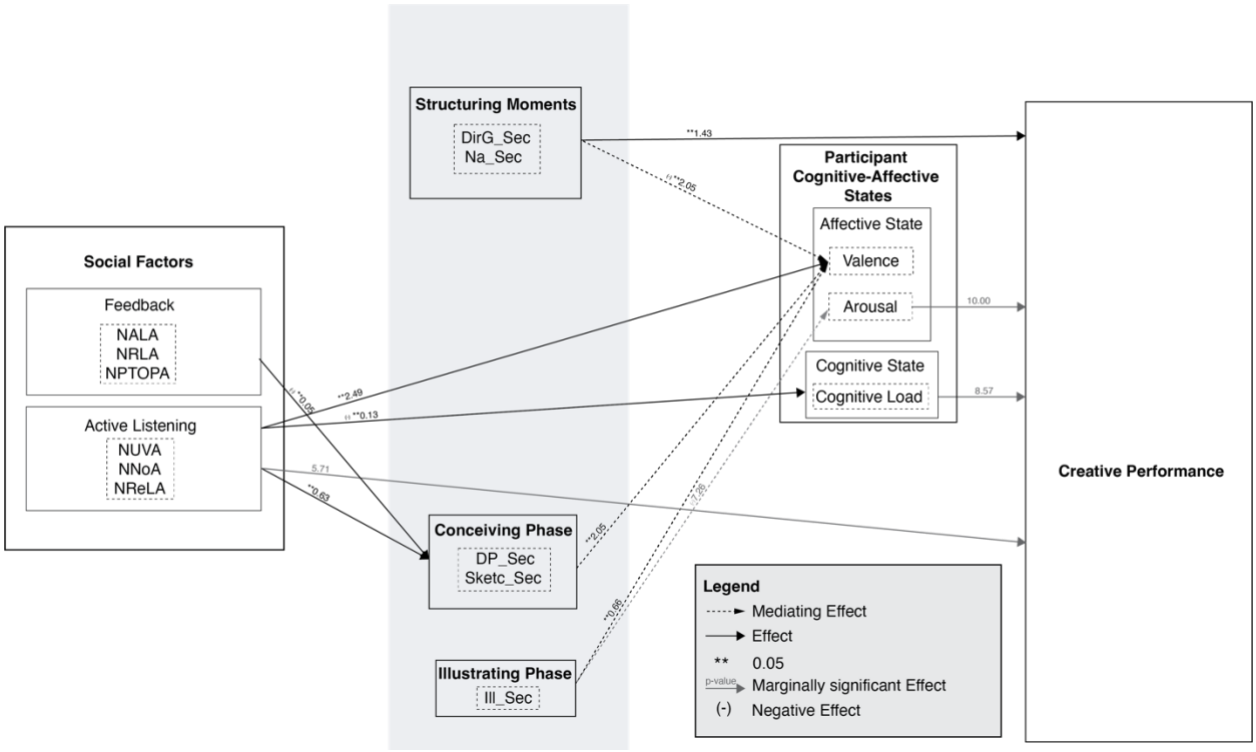
2. Appendix A: Ideational Prompt for Collaborative Ideation

You have been **Teleported to 2032** in a positive future and here are the factors to consider for the exercise:

1. What does Audio-visual content look like?
2. What do social networks and the people you follow look like?
3. Are there economic factors involved in your consumption of audio-visual media (eg. Do you pay for your content?)
4. How is information shared (who shares what and on what type of platform?)

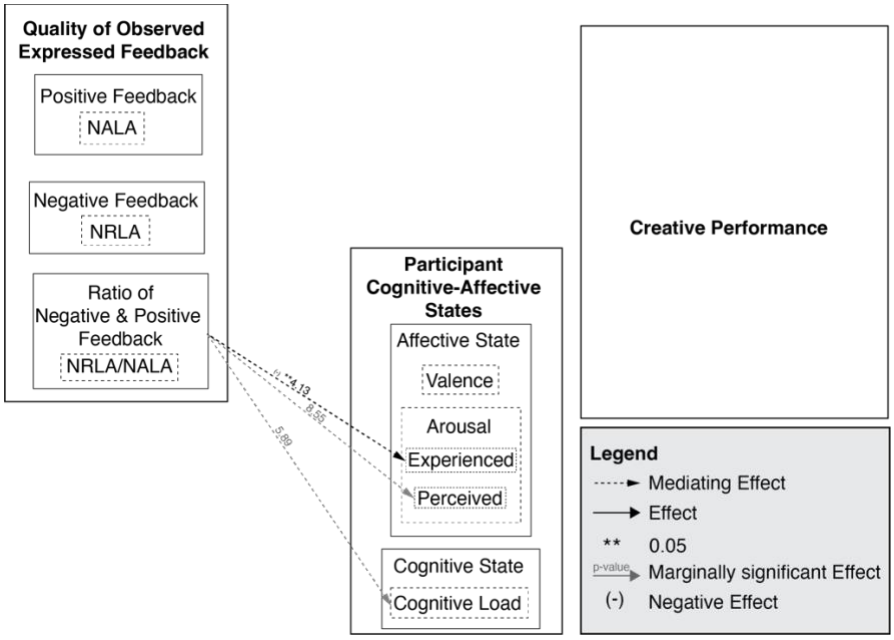
Appendix B: Research Model A

Validated Research Model for RQ1a.-RQ1b.-RQ1c.-RQ2.-RQ3a.- RQ3b.:



Appendix C: Research Model B

Validated Research Model for RQ1d-RQ4a-RQ4b.:



Appendix D: Ethics Approval

HEC MONTRÉAL

Comité d'éthique de la recherche

ATTESTATION D'APPROBATION ÉTHIQUE COMPLÉTÉE

La présente atteste que le projet de recherche décrit ci-dessous a fait l'objet des approbations en matière d'éthique de la recherche avec des êtres humains nécessaires selon les exigences de HEC Montréal.

La période de validité du certificat d'approbation éthique émis pour ce projet est maintenant terminée. Si vous devez reprendre contact avec les participants ou reprendre une collecte de données pour ce projet, la certification éthique doit être réactivée préalablement. Vous devez alors prendre contact avec le secrétariat du CER de HEC Montréal.

Projet # : 2022-4887 **-** 302 - Walter Talk

Titre du projet de recherche : Demystifying Collaborative Ideation

Chercheur principal : Annemarie Lesage

Cochercheurs : Barbara Scheed; Constantinos K. Coursaris; David Brieugne

Date d'approbation initiale du projet : February 25, 2022

Date de fermeture de l'approbation éthique : January 17, 2024

Maurice Lemelin
Président
CER de HEC Montréal

Signé le 2024-01-17 à 16:31