How Does Psychological Safety, Cognitive Flexibility and Perception of Meeting Effectiveness Impact Design Teams?

Shreyas Nagaraj
School of Engineering Design & Innovation,
State College, Pennsylvania, USA
Presley Dougherty
School of Engineering Design & Innovation,
State College, Pennsylvania, USA
Book Chen
School of Industrial Engineering,
State College, Pennsylvania, USA
Amal Alshammari
School of Industrial Engineering,
State College, Pennsylvania, USA

ABSTRACT

This study examines the correlation between Psychological Safety (PS) and Cognitive Flexibility (CF) in design teams and their impact on team agility during a design project. An approach was used to track PS and CF throughout the project's timeline. The results show that there is a positive correlation between early-project PS and later-project CF, emphasizing the significance of initial team comfort in shaping conversational dynamics. Teams that consistently demonstrate high CF levels are more agile in adapting to project demands. This correlation suggests that early-project PS can predict later-team agility, implying potential strategies for identifying and nurturing more agile teams from an early stage. This study contributes to understanding team dynamics in complex problem-solving environments, emphasizing the significance of fostering environments that encourage open communication to enhance team agility. These insights can be valuable for team formation and management, as they aid in the development of agile teams that can achieve effective design outcomes. Additionally, they contribute to the broader discourse on optimizing team performance and innovation in collaborative settings.

1 LINKAGE TO RELEVANT THEORY AND PRIOR LITERATURE

1.1 Literature Survey

The dynamics of team interactions within engineering design teams have gained interest among researchers.
Psychological safety is defined as a shared belief that the team is safe for interpersonal risk taking [1]. The explorations of Psychological Safety as discussed in the paper *Amy Edmondson et al. (1999)*, investigates the role of psychological safety in team learning and performance. The study involved 51 work teams in the manufacturing industry and highlights the importance of a team environment that supports interpersonal risk-taking. The findings suggest that psychological safety facilitates learning behavior, which is essential for team performance. Additionally, the paper examines the impact of team structures, such as leader support, on these outcomes [2]. *Newman et al. (2017)* offers a comprehensive review of the existing literature on psychological safety. They also gives a brief on importance of psychological safety is an important construct in understanding team dynamics and performance [3]. Organizational research has identified psychological safety as a critical factor in understanding phenomena such as voice, teamwork, team learning, and organizational learning. A growing body of conceptual and empirical work has focused on understanding the nature of psychological safety, identifying factors that contribute to it, and examining its implications for individuals, teams, and organizations [4].

Cognitive flexibility refers to the ability to quickly reconfigure our mind, as when we switch between different tasks [5]. *Dennis et.al (2010)* introduces the Cognitive Flexibility inventory a new measure designed to evaluate an individuals ability to adapt cognitively to ever changing environments. This research conducts various tests to check the CFI reliability and validity in assessing the research adaptability of individuals [6]. *Martin et al. (1995)* presents a new method for measuring cognitive flexibility and discusses the significance of adaptability in mental processes. They also presents the findings and implications of their research in psychology. The paper is crucial for comprehending the role of cognitive flexibility in human

behavior and mental health. For a more detailed understanding, please refer to the full document [7].

1.2 Literature Gap

Although the literature provides insights into individual and team dynamics, there are nuanced gaps that our research seeks to bridge:

The literature indicates a gap in understanding the interaction between cognitive flexibility (CF) and psychological safety (PS) in teams ***(RQ1)***, as well as how these dynamics evolve over time ***(RQ2)***. Although existing studies suggest a possible correlation between higher CF and PS, which predicts team agility, there is limited research on the direct relationship and its implications for team performance. Additionally, the impact of stress, such as approaching deadlines, on CF and PS and their corresponding changes have not been thoroughly investigated. This gap highlights the necessity for longitudinal studies to observe these variables over time, which can provide valuable insights for improving team effectiveness and predicting performance declines.

2 METHODS

In this section, we provide a detailed account of the methods employed in our study. We have organized this section into three key subsections: Participants, Data Collection, and Experimental Design.

2.1 Participants

Participants in our study were from diverse backgrounds which supported the scope of this study. The following demographic information was collected to provide a comprehensive overview of the study population:

1. Gender – The study involved three female participants and twelve male participants.
2. Educational background - The participants came from different educational backgrounds in mechanical engineering, engineering design and industrial engineering.

Due to the lack of background data, we have not considered it as a factor in our analysis, although the diverse backgrounds of the participants ensured the generalizability of our findings.

2.2 Data Collection

Data collection was conducted with meticulous attention to aligning our methods with overarching research objectives. We employed the following strategies to collect data:

The choice of data collection methods was driven by their alignment with prior literature and the need to comprehensively capture the decision-making processes under study.

The survey data focuses on cognitive diversity (CD), decision-making percentage, meeting goals, and perceived effectiveness in team meetings. This information is crucial for analyzing the impact of diverse thinking on team decisions and meeting success. The results can help understand how team dynamics affect meeting outcomes and guide improvements in team collaboration and efficiency. This data forms a crucial part of the memo, highlighting key aspects of team interaction and effectiveness.

2.3 Experimental Design

The memo presents a linear regression analysis to investigate the correlation between Psychological Safety (PS) and Cognitive Flexibility (CF), testing whether one predicts the other. The null hypothesis assumes a zero slope, indicating no correlation, while the alternative hypothesis suggests a nonzero slope. Furthermore, the Inter-class Correlation Coefficient (ICC) is used to evaluate whether PS and CF scores can be collectively represented for a team. Initially, a one-factor ANOVA is used, followed by a two-factor model if necessary. These analyses are essential for comprehending team dynamics and decision-making.

3 ANALYSIS

For the analysis of the data, various statistical methods were used to identify trends between the various data collected and develop valuable insights. Most of the data collected were dependent factors that provided qualitative data to represent the engineering design process. This data was converted to quantitative data to

allow it to be compared to the cognitive flexibility & psychological safety.

3.1 *RQ1* We hypothesized that higher psych safety will be able to predict higher cognitive flex.

Linear regression and ANOVA are conducted to explore the relationship between Psychological Safety (PS) and Cognitive Flexibility (CF). The null hypothesis assumes no relationship (slope = 0), while the alternative hypothesis suggests a significant relationship (slope ≠ 0). This analysis aims to determine if one variable can predict the other (See table 1)

Table 1: Regression and ANOVA Statistics

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.669825429
R Square	0.448666106
Adjusted R Square	0.42569386
Standard Error	0.604073908
Observations	26

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	7.126888525	7.126889	19.53079	0.000181831
Residual	24	8.757726859	0.364905		
Total	25	15.88461538			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.178208422	1.23971036	0.14375	0.886898	-2.380428008	2.736844851	-2.380428008	2.736844851
Psych Safety	1.021333631	0.231104141	4.419365	0.000182	0.544358127	1.498309135	0.544358127	1.498309135

3.2 Based on the linear regression, the coefficient of determination is low, but the results are significant at 5%

The R-squared value represents the proportion of variance in the dependent variable that can be predicted from the independent variable. The p-value associated with the F statistic is used to determine if the regression model provides a statistically significant fit compared to a model with no independent variables. In summary, these statistics aid in evaluating the predictive strength and significance of the regression model. This was vital to establish the group dynamics. There is little data in the lower CF and PS ranges, making it difficult to say if the variables will follow the same trend (Figure 2, see Appendix).

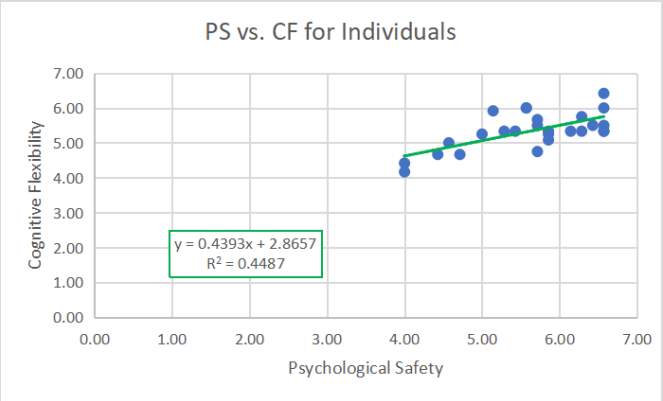


Figure 1: Graph of PS & CF

3.3 *RQ2* The team hypothesizes that there might be changes in PS or CF as the design project progresses

The study found that the team reported high satisfaction with meetings and perceived equitable contributions. Although individual data per team was limited, the Intraclass Correlation Coefficient (ICC) suggested that averaging team scores was a valid approach. A one-factor ANOVA conducted in Excel provided mean squared, degrees of freedom (df), and error for reliability calculations, with ICC values of approximately 0.5 or higher for all meetings, indicating moderate reliability. (see Figure 2).

$$= \frac{MS_{bet\ S} - MS_{residual}}{MS_{bet\ S} + (k-1)MS_{residual}}$$

ICC	Agreement
1.0	Perfect agreement
0.99 to 0.81	Almost perfect agreement
0.80 to 0.61	Substantial agreement
0.60 to 0.41	Moderate agreement
0.40 to 0.21	Fair agreement
0.20 to 0.01	Slight agreement
0.0 to –0.1	Poor agreement

Figure 2: Calculation process formulas for ICC

3.4 PS & CF graphs overtime

The data for the single team that provided sufficient information showed similar trends in both psychological safety (PS) and cognitive flexibility (CF), with noticeable dips occurring concurrently on the same meeting dates. Qualitatively, this team reported high levels of meeting satisfaction and felt that contributions within the team were equitable. However, both PS and CF metrics were skewed high, potentially due to social desirability bias, suggesting that team members might

have rated their experiences more positively due to apprehension about expressing their true feelings.

Figure 3: Psychological Safety trends overtime

The dataset was insufficient to analyze design teams dynamics over time, as only one team provided adequate data for a temporal graph. This limitation prevented the identification of any clear trends or changes in team behavior or effectiveness over the study period. (see Figure 3 & 4).

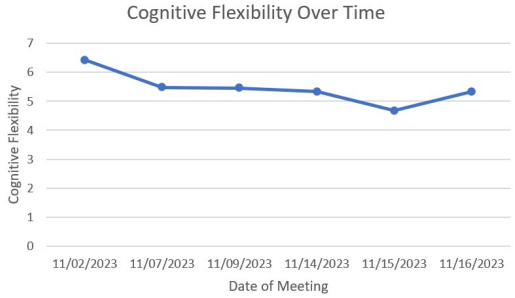


Figure 4: Cognitive Flexibility trends overtime

4 RESULTS

The regression analysis indicates a statistically significant, yet weak correlation between psychological safety (PS) and cognitive flexibility (CF) within the studied team. This is indicated by a low coefficient of determination (R^2 approximately 0.4). This suggests that while there is a relationship, it is not strong and may not hold as well for lower scores of PS and CF, possibly due to the high skew of data. The skewness observed in the data may be due to social desirability bias, where team members may have rated aspects such as PS and CF higher due to reluctance in sharing negative views. Additionally, the limited range of values resulting from the small sample size further constrains the regression analysis.

The results of the Intraclass Correlation Coefficient (ICC) indicate a reasonable level of agreement among team members regarding their PS and CF scores across multiple meetings. The data suggests that team members share a consistent perception in these areas.

Furthermore, the team expressed high satisfaction with meetings and perceived an equitable distribution of speaking time, indicating a positive collaborative environment.

REFERENCES

[1] Frazier M L, Fainshmidt S, Klinger R L, et al. Psychological safety: A meta-analytic review and extension[J]. Personnel psychology, 2017, 70(1): 113-165.

[2] Edmondson, A. C. et al. (1999). Psychological Safety and Learning Behavior in Work Teams. Administrative Science Quarterly, 44(2), 350-383.

[3] Newman, A., Donohue, R., & Eva, N. (2017). Psychological safety: A systematic review of the literature. Human Resource Management Review, 27(3).

[4] Edmondson, A. C., & Lei, Z. (2014). Psychological safety: The history, renaissance, and future of an interpersonal construct. Annu. Rev. Organ. Psychol. Organ. Behav., 1(1), 23-43.

[5] Braem, S., & Egner, T. (2018). Getting a Grip on Cognitive Flexibility. Current Directions in Psychological Science, 27(6), 470-476

[6] Dennis, J. P., & Vander Wal, J. S. (2010). The cognitive flexibility inventory: Instrument development and estimates of reliability and validity. Cognitive Therapy and Research, 34(3), 241-253.

[7] Martin, M. M., & Rubin, R. B. (1995). A New Measure of Cognitive Flexibility. Psychological Reports, 76(2), 623-626.

Appendix

Survey Questions

DDM Post-Meeting Survey

Q1 What is your team number?

- ○ Team 1
- ○ Team 2
- ○ Team 3
- ○ Team 4
- ○ Team 5

Q2 What is your name? (First and Last)

_____

JS *

Q3 When did the meeting occur (mm/dd/yyyy)?

_____

Q4 In your own words, please describe the goals of your meeting today:

_____

_____

_____

_____

_____

Q5 Given the goals you outlined above, do you feel the meeting was a success? Please explain your response:

_____

_____

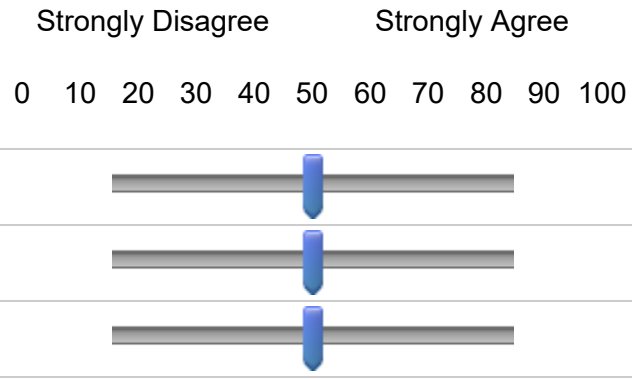
_____

_____

_____

Page Break

Q6 Please rate your level with each of the items below:



Page Break

Psych Safety Please rate your agreement with the statements below in regards to your team during the meeting.

	1 (Very Inaccurate)	2	3	4	5	6	7 (Very Accurate)
If you make a mistake on this team, it is often held against you	○	○	○	○	○	○	○
Members on this team are able to bring up problems and tough issues	○	○	○	○	○	○	○
People on this team sometimes reject others for being different	○	○	○	○	○	○	○
It is safe to take a risk on this team	○	○	○	○	○	○	○
It is difficult to ask other members of this team for help	○	○	○	○	○	○	○
No one on this team would deliberately act in a way that undermines my efforts	○	○	○	○	○	○	○
Working with this team my unique skills and talents are valued and utilized	○	○	○	○	○	○	○

Cognitive Flex Scale The following statements deal with your beliefs and feelings about your own behavior. Please select your level of agreement with each statement.		Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree

I can communicate an idea in many different ways	○	○	○	○	○	○	○
I avoid new and unusual sitations	○	○	○	○	○	○	○
I feel like I never get to make decisions	○	○	○	○	○	○	○
I can find workable solutions to seemingly unsolvable problems	○	○	○	○	○	○	○
I seldom have choices when deciding how to behave	○	○	○	○	○	○	○
I am willing to work at creative solutions to problems	○	○	○	○	○	○	○
In any given situation, I am able to act appropriately	○	○	○	○	○	○	○
My behavior is a result of conscious decisions that I make	○	○	○	○	○	○	○
I have many possible ways of behaving in any given situation	○	○	○	○	○	○	○

I have difficulty using my knowledge on a given topic in real life situations	○	○	○	○	○	○	○
I am willing to listen and consider alternatives for handling a problem	○	○	○	○	○	○	○
I have the self-confidence necessary to try different ways of behaving	○	○	○	○	○	○	○

Page Break

Q7 Was the meeting in-person, hybrid (some team members online and some in-person), or virtual (all team members online)?

- ○ In-person
- ○ Hybrid
- ○ Virtual

Q8 How did you participate in this meeting?

- ○ In-person
- ○ Virtual

Q9 In comparison to the your team members, how much or how little do you feel you spoke during the meeting today?

Note, move the slider to 100 would indicate that you spoke the entirety of the time and your team members remained silent.

0 10 20 30 40 50 60 70 80 90 100

Percent Speaking Time	

Q10 In comparison to the your team members, how many or how few decisions were you directly responsible for at the meeting? Please move the slider to indicate the percentage of decisions you were directly responsible for.

Note, move the slider to 100 would indicate that you made all the decisions that occurred during the meeting and your team members made no decisions.

0 10 20 30 40 50 60 70 80 90 100

Percent Decisions Made	

Q11 With which gender do you identify?

- ○ Man
- ○ Woman
- ○ Non-binary
- ○ Another gender
- ○ Prefer not to answer

Q12 With which racial/ethnic groups do you identify? (Select all that apply).

- ☐ Hispanic or Latinx
- ☐ African-American or Black
- ☐ Asian
- ☐ Native Hawaiian or other Pacific Islander
- ☐ Native American or Alaskan Native
- ☐ Caucasian or White
- ☐ Another _____
- ☐ Prefer not to answer

Q13 How old are you?

- ○ Under 18
- ○ 18-24 years old
- ○ 25-34 years old
- ○ 35-44 years old
- ○ 45-54 years old
- ○ 55-64 years old
- ○ 65+ years old