Connected Creativity: Exploring Dyadic Dynamics Across Settings

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ABSTRACT

The present study investigated hybrid and in person environments and regarding creativity at the dyadic level over time. Participants met three separate times to work together on a creativity task and were assigned to either meeting face to face for the duration of the study or meeting in person for the first session and then moving to a virtual environment. A total of 42 graduate and undergraduate students from Middle Tennessee State University participated in this study. The Guilford Consequences Tasks were used to assess creativity. Measures for demographics, cognitive ability, personality, and psychoaffective variables were also collected. There were 11 dyads in the hybrid condition and 10 dyads in the in person condition. A factorial ANOVA was conducted and found no difference in creative outcomes regardless of condition but a difference in the number of scores generated depending on the session number. Overall, ideas directly related to the creativity task increased over time and ideas indirectly related to the creativity task decreased over time. These findings suggest hybrid and in person environments facilitate similar idea generation abilities.

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INTRODUCTION

The workplace is constantly changing and now more than ever organizations need to determine their creative edge while also being able to keep up with the constant changes in best practices in the workplace. There has been a recent shift in the workplace from working in-person to hybrid or remotely (Brucks & Levav, 2022). This has largely due to the impact COVID-19 had on organizations when trying to find a safe way to continue working during this crisis. An organization's success often lies in the hands of its employees and their ability to come up with original and innovative ideas to keep a company's competitive edge. Creativity is defined as the ability to come up with novel ideas to solve problems (Mumford, 2003). Many employees are often a part of a larger team and must work together to come up with these new and creative ideas and the new question these organizations are facing is if hybrid and remote teams are able to come up with just as many novel ideas as they did while they were meeting in person. This study aims to answer this question by having dyads consecutively to determine if hybrid teams are able to generate more ideas than fully remote or in-person teams.

REVIEW OF LITERATURE

What is creativity?

Creativity is a poorly defined construct due to the complexity of the construct and variety of measurement approaches (Mumford, 2003). A common trend when defining creativity is the emphasis on the ability to construct novel and new ideas (Mumford, 2003). This definition has become one of the more universal ways to define creativity and is the definition that will be used in regards to the current study. Creativity is also considered to be the ability to come up with innovative solutions to problems (Mumford et al, 2018). According to Mumford et al. (2018),

there are eight core processes needed for creative problem solving: problem definition/ problem construction, information gathering, concept selection, conceptual combination, idea generation, idea evaluation, implementation planning, and solution monitoring. While all of these processes are needed for creative problem solving, this study is focusing on idea generation which can be defined as the quantity and quality of ideas that are produced (Mumford et al, 2018).

While there are eight core processes of creativity, there are also four perspectives of creativity and the perspective being used may depend on what aspect of creativity is being study and how creativity was defined (Saide-Metwaly et al., 2017). The four perspectives (the four P's) are known as process, person, product, and press. The process perspective is related to cognitive processes of creativity; the person perspective is related to creativity at the individual level and the creative abilities of each individual; product is related to the creative outcomes; and press is related to how an individual and their environment interact to facilitate creativity defined (Saide-Metwaly et al., 2017). The person, product, and press perspectives are relevant for the current study.

The use of divergent versus convergent thinking can also impact idea generation and the production of new ideas. Divergent thinking is considered to be being able to produce multiple solutions to a problem, or "brainstorming" (Reiter-Palmon & Forthmann, 2019; Kerr & Murthy, 2004). whereas convergent thinking attempts to identify the single best solution to a problem by evaluating all of the proposed ideas and choosing the best one (Kerr & Murthy, 2004). Typically, divergent thinking often fosters creativity because originality is a key component for something to be considered creative (Runco & Acar, 2012).

There are four categories of divergent thinking: fluency, flexibility, originality, and elaboration (Paulus & Yang, 2000). Fluency is defined as the ability to produce large quantities

of ideas and flexibility can be defined as the ability to develop a large variety of different ideas (Paulus & Yang, 2000). Originality is the ability to come up with ideas that are innovative and have not been previously created and elaboration is the ability to build off of someone else's ideas (Paulus & Yang, 2000). This study will primary focus on the fluency of divergent thinking in the idea generation process.

Creativity at the individual and team level

In recent years, creativity researchers have started to expand beyond studying creativity at the individual level. Rather, these contemporary studies emphasize the role of group dynamics and the collective creative process. The use of teams in organizations has become much more prevalent throughout the years as it can impact the sharing of knowledge and development of novel ideas (Paulus & Yang, 2000). These novel ideas are associated with the ability to problem solve more effectively and many consider team brainstorming to result in more novel ideas and solutions that an individual would not have been able to come up with on their own (Baer et al., 2008). Many studies have compared the amount of ideas and the qualities of ideas during idea generating sessions between teams and individuals to determine if there is a difference in the quality and quantity of new and original ideas (Coursey et al., 2018).

Something to consider when working with teams are the initial interactions with each other and how these interactions may affect their performance on creative tasks. Using virtual and online communication has increased over the last decade and as a result there are multiple different outlets designed to be able to interact virtually (e.g., video-based text-based, audio-based). Previous research has indicated a difference in face-to-face interactions and Computer-Mediated Communication (CMC). For example, dyads who interact for the first time in face-to-face settings report more satisfaction and less conflict than when meeting using CMC, while

other studies have seen no difference in satisfaction (Spretcher, 2014). Other studies have only focused on comparing the different types of CMC and found that when using chat-based communication, interpersonal outcomes were lower than when using audio or avatar communication (Sprecher, 2014).

While group brainstorming has been shown to be effective in the production of novel ideas (Baer et al., 2008) there are some factors that can influence the productivity of idea generation at the team level. Some people have trouble with cognitive interference and being able to generate their own ideas while also listening to their teammate's ideas (Paulus & Yang, 2000) or have difficulty considering this process as a group exchange rather than an individual process (Baer et al., 2008). There are also issues with social factors. Some individuals are not comfortable sharing their ideas with the rest of their team because they are concerned about the reactions from their peers (Paulus & Yang, 2000; Baer et al., 2008). It is also not uncommon for some individuals are also more likely to take groupwork opportunities to social loaf and rely on their team members to come up with ideas because they have a lack of motivation to do so at the team level (Paulus & Yang, 2000). It is also hard to share ideas when other members of the group are talking and this can result in productivity loss (Paulus & Yang, 2000). There are some ways to limit production losses, one of them being using computer-based brainstorming (Paulus & Yang, 2000). Previous research has found that using computer mediated communication for brainstorming performs just as well or better than nominal groups (Paulus & Yang, 2000).

Remote work/ hybrid settings and how it impacts creativity

Recently, there has been a new focus on idea generation and creativity in virtual settings. Virtual teams are becoming much more prevalent since due to ubiquitous institutional policy changes in response to the COVID-19 pandemic. As a result, there has been an increased interest in research focusing on the ramifications of transitioning to a virtual setting on idea generation compared to an in-person setting for teams. Some research has found that using electronic outlets for divergent thinking during the idea generation process produces improved results than having groups brainstorm in face-to-face settings (Kerr & Murthy, 2004). This is due to a greater limit on the exchange of information which results in process losses when in face-to-face settings (Kerr & Murthy, 2004). Other research suggests teams that are in a virtual setting are more vulnerable to process losses and performance problems (Kirkman et al., 2004; Brucks & Levav, 2022). These process losses may be due to these teams being focused on the screen in front of them and as a result of this, their cognitive focus is limited (Brucks & Levav, 2022). There are multiple different perspectives on if in-person or remote teams demonstrate more creative behaviors but most of this conflicting research doesn't consider the possibility that using a combination of methods may be the best alternative for idea generation.

Focus of the current study

There is a current gap in research regarding how hybrid settings may impact idea generation and creative outcomes. There has been previous research conducted showing that those who interact face-to-face for the first time compared to those who interact via virtual modalities are more likely to report higher reactions towards the person they are interacting with (Spretcher, 2014). However, some of this research only used text-based virtual communication,

which has shown to be the least effective of the types of CMC (Spretcher, 2014). Some research has found that first establishing relationships with one another before moving to remote settings may allow for better idea generation (Spretcher, 2014). However, research on this is limited and there are still conflicting perspectives on whether or not meeting in person first is beneficial or has no impact. The current study aims to fill these gaps by identifying if there is a difference in idea generation when dyads first meet in person while completing brainstorming together and then moving to working remote for the remainder of the study.

METHODS

Research Questions

- Does hybrid work promote creative outcomes?
- Does meeting in person initially and then moving to remote settings result in better creative outcomes compared to fully in person?

Participants

This study was a part of a larger study that investigated an additional variables and conditions. Participants were assigned to be a part of a pair based on their availability to complete the study and were then assigned to one of three conditions for the duration of the study: completely in-person, hybrid, or completely remote. Because the remote condition was not the focus of this study, this information was not included in the analysis. This study consisted of 21 dyads of students at Middle Tennessee State University, resulting in a total of 42 students. There were 11 hybrid dyads and 10 in person dyads. Initially there were 23 dyads with 46 total participants. The data from two dyads were not able to be used due to dropping out in the middle the study resulting in missing data for the obvious and remote scores. See Table 2 for additional participant demographic information. Students were recruited via SONA and word of mouth and received course credit in exchange for participation. The student population consisted of both undergraduate and graduate psychology majors with 12 male participants and 32 female participants.

Procedure

All participants took part in three sessions and be asked to generate ideas related to a given consequences prompt and generate as many ideas as possible related to the prompt. They remained in the same dyad for each session. Those who were in the hybrid condition met in person during the first session and then moved to meeting remotely for the last two sessions. Those who were in person met in the same room for every session. Those who were in the remote condition met remotely in separate rooms for the entire duration of the study. The participants met in a classroom setting regardless of the condition they are in. For those meeting in-person, the participants were in the same room working the creativity task together. Participants who were meeting remotely for their session were each be in separate classrooms meeting via videocall through Microsoft Teams to collaborate on their creativity task. While participants were randomly assigned to a remote condition, this condition was not the focus for the current study and was not included in the analysis. In relation to the current study, the participants were asked to complete a creativity task and given a specified amount of time to come up with as many ideas as possible for each session. The creative outcomes were scored based on the number of ideas generated, the novelty of the ideas, and the number of categories generated.

A variety of administration outlets were used to collect data for this study. A Qualtrics survey was used to collect informed consent, demographics, a vocabulary IQ test, and a personality test. Paper and pencil were used to administer the Self-Assessment Manikin (SAM), the shortened version of the Positive and Negative Affect Scale (PANAS), and the creativity tasks. The SAM measures an individual's current emotional state in relation to their valence, dominance, and affect (Bradley & Lang, 1994). The PANAS measures emotional states over

time (Watson & Tellegan, 1988). The creativity tasks used were the Guilford Consequences Tasks which required participants to brainstorm ideas together based on the prompt they were given (Mind Garden). Refer to Appendix X,X, and X for a copy of the SAM, PANAS, and consequences prompts. SuperLab 6.0 was also used via computer to administer the Stroop (Stroop, 1935) and Sternberg (Sternberg, 1935) to assess cognitive ability (Cedrus Corporation). This study is a subset of a larger study and will also include an individual creativity measure during the first session for the larger study. For the first session, participants will fill out the Qualtrics survey, the SAM and PANAS and the Sternberg and Stroop before continuing on to the creativity tasks. During this session participants will complete a practice creativity task, an individual creativity task, and a creativity task that they will work together on. The session concluded with the administration of the SAM. The PANAS was only given on the first and last day of the session and the SAM was given at the start and end of every session. The second session only required participants to come in and fill out the SAM, complete their collaborative creativity task, and then take the SAM again. The third session mimicked the second session with the only differences being the PANAS was also administered at the end and participants were debriefed once the study concluded.

Measures

Extraneous Variables

Demographic information was collected regarding participant gender, sex, primary and secondary language, race and ethnicity, socio-economic status, and age via the Qualtrics self-report survey. Gender and sex were included to determine if there were any interaction effects between the dyads. Language was collected to determine if there are any communication related effects in the results. Race and ethnicity were collected to consider any social interaction effects

between dyads. Age was collected to assess if there is a cohort-based social interaction. These variables were included because previous research has shown that individual differences between teams can impact overall performance within dyads and controlling for the effects of these differences is essential to the success of this study (Coursey et al., 2019; Van Knippenberg & Schippers, 2007; Woolley et al., 2010; Nakui et al., 2011; Mumford et al., 2018).

A vocabulary IQ test, cognitive ability tests, and the International Personality Item Pool-Big Five Factor Model (IPIP-BFFM) was also collected in the self-report to assess education and the "Big Five" personality traits. Research suggest that openness and extraversion may have an impact on creative outcomes (Coursey, et al., 2018). The impact these personality traits have on creativity made these relevant variables to control for. Measures on cognitive ability and vocabulary were collected to assess if these have an impact on idea generation. Cognitive ability was measured using the Stroop and the Sternberg. The Stroop Color and Word Mismatch Test is a cognitive inhibition measure and was included in this study because cognitive inhibition has been shown to be related to creativity (Stroop, 1935; Benedek et al., 2012). Some research suggests that working memory may impact creativity and creative outcomes (Gong et al., 2023). The Sternberg Memory Task accessing the working memory of an individual and was thus included in this study (Sternberg, 1966). Previous research has indicated that cognitive ability as well as education level may have an impact on creative behaviors. (Coursey et al., 2019; Van Knippenberg & Schippers, 2007; Woolley et al., 2010; Nakui et al., 2011; Mumford et al., 2018).

The SAM and PANAS will also be given to each participant to assess their mood prior to the session to determine if there are any factors outside of the study that may have impacted their creative behaviors. The SAM is a self-assessment tool that has been found to be a useful tool to an individual's current emotional state (Bradley & Lang, 1994) whereas the PANAS measures

the emotional state of an individual for the entire week prior to taking the study (Watson & Tellegan, 1988). The SAM will be administered at the start and end of every session while the PANAS will be administered only during the beginning of the first session and end of the last session.

Individual and dyadic idea generation ability

The Guilford Consequences tasks were administered during every session. Three prompts were administered the first day (a practice assessment, an individual assessment, and a collaborative assessment) and only one prompt was administered the second and third session (a collaborative assessment). The individual assessment collected on the first day was the focus of the larger study, but the data collected was used for this study as a potential covariate. Each prompt posed a question participant were supposed to discuss together to brainstorm the consequences if the prompt were true and were given example responses. The consequences prompts were as follows: (1) "What would be the results if people no longer needed or wanted sleep?" (2) "What would be the results if none of us needed food any more in order to live?" (3) "What would be the results if humans lost their team feeling to the extent that they all preferred to live alone?" (4) What would be the results if everyone suddenly lost the sense of balance and were unable to stay in the upright position for more than a moment?" (5) "What would be the results if all the people in the world lost the ability to reproduce?"

Each participant received two scores for each prompt: a remote score and an obvious score. The remote scores represent responses that were distantly related to the prompt and align with novelty of an idea. The obvious scores represent responses that were immediately related to the prompt and align with the fluency of an idea. There was a total of eight scores broken down

into four remote and four obvious scores for each participant. The practice Consequences trial was ungraded.

In order to grade the participant's responses on the Consequences tasks, two graduate students used the Guilford Consequences manual scoring key (Mind Garden). Intra-rater reliability was established by having each rater grade five participants individually three times across the span of one week. There was a minimum of a 24-hour gap between each scoring session. This process ensured the raters were consistent with themselves on their grading. Inter-rater was then established by randomly assigning both graders 15 participants to grade individually. The interrater reliability scores were acceptable with Intraclass Correlation Coefficients (ICC) ranging .80 and .94 across the different Consequences tasks and scores. Refer to Table 1 for additional information.

Table 1: Intraclass Correlation Coefficients (ICC) for the Consequences Tasks

Score	ICC
First task	
Obvious	.86
Remote	.91
Second task	
Obvious	.89
Remote	.94
Third task	
Obvious	.81
Remote	.79
Fourth task	
Obvious	.86
Remote	.84

RESULTS

Preliminary Analyses

Descriptive statistics were calculated for all variables relevant to the current study. There was a total of 62 participants in the larger study and a total of 44 students who participated in this study. The age range for participants ranged from 18 to 36 and the average being 21.5 years old. Table 2 portrays demographic information regarding the participant pool. The average age for the hybrid condition was 21.4 and the average age for the in person condition was 21.8.

Table 2: Participant Demographics

Demographics	In-person	Hybrid	Total
Sex			
Male	8	4	12
Female	14	18	32
Gender			
Man	8	5	13
Woman	14	16	30
Other	0	1	1
Race			
Caucasian	16	12	28
African American	1	4	5
Asian	3	0	3
Hispanic	2	3	5
Middle Eastern	0	2	2
Romani	0	0	0
Mixed	0	1	1
Language			
English	19	22	41
Non-English	2	0	2
House Income			
Below $14,999	2	3	5
Between $15,000 and $31,999	1	2	3
Between $32,000 and $69,999	7	6	13

Between $70,000 and $129,999	4	3	7
Over $130,000	5	5	10
Father Education			
No parent or guardian present	0	2	2
Did not graduate high school	1	1	2
Graduated high school	4	4	8
Received some post-high school education	4	6	10
Graduated from college	4	6	10
Received advanced degree	5	7	12
Mother Education			
Did not graduate high school	3	0	3
Graduated high school	4	6	10
Received some post-high school education	2	7	9
Graduated from college	7	4	11
Received advanced degree	6	5	11

Table 3: Descriptive Statistics for Continuous Variables

	In-person	Hybrid		
Variable	***N***		**Mean *(SD)***	**SE**
Individual obvious score (T1)	22	22	6.82(*3.72)*	0.56
Individual remote score (T1)	22	22	6.23(*3.77*)	0.57
Dyadic obvious score (T2)	22	22	5.55(*3.47*)	0.52
Dyadic obvious score (T2)	22	22	7.9(*4.16*)	0.63
Dyadic obvious score (T3)	20	22	7.63(*4.12*)	0.64
Dyadic remote score (T3)	20	22	5.07(*3.90*)	0.6
Dyadic obvious score (T4)	20	20	7.74(*4.64*)	0.73
Dyadic obvious score (T4)	20	20	4.45(*3.17)*	0.5
Vocabulary IQ	22	22	15.90*(9.48)*	1.43
Extraversion	22	22	30.80(*7.18)*	1.08
Emotional Stability	22	22	28.50*(5.71)*	0.86
Conscientiousness	22	22	34.30(*6.75)*	1.02
Agreeableness	22	22	39.40(*6.76)*	1.02
Openness to experience	22	22	36.30*(4.61)*	0.7
Stroop score	19	20	95.60(*141)*	22.5
Sternberg score	20	22	1233(*231)*	35.6
SAM(Valence)	22	22	6.68(*0.66)*	0.1

SAM(Arousal)	22	22	4.71(*1.54)*	0.23
SAM(Dominance)	22	22	7.08(*0.96)*	0.14
PANAS(Positive affect (T1))	22	22	32.30(*5.59)*	0.84
PANAS(Negative affect (T1))	22	22	21.90(*5.81)*	0.88
PANAS(Positive affect (T2))	19	20	33.0(*5.12)*	0.82
PANAS(Negative affect (T2))	19	20	20.10(*5.39)*	0.86

Primary Analyses

The repeated-measures ANOVA procedure in Jamovi was used to compare obvious and remote creativity scores with time (Time 2, Time 3, Time 4) as the within-subjects factor and dyad type (In-person, Hybrid) as the between-subjects factor. The main effect for time was significant for obvious scores, $F(2, 36)= 6.97$, $p=0.003$. The number of obvious scores increased between the first and second session and the first and third session regardless of the condition. Simple effect tests of time were conducted for each session. Obvious scores differed between time 2 and time 3, t(18)=-4.023, $p=0.002$ and time 2 and time 4 $t(18)=-2.695$, $p=0.038$ across conditions. There was no difference in obvious scores between time 3 and time 4, t(18)=0.979, $p=0.979$ across conditions. The main effect for condition was not significant when looking at obvious scores, $F(1,18)= 1.28$, $p=0.27$. There was no obvious score difference across condition. The interaction between time and condition when looking at obvious scores was not significant, $F(2,36)=1.66$, $p=0.20$. See Figure 1 and Table 4 for the obvious score ANOVA details. scores. See Table 5 for Post Hoc comparison details.

Table 4: Marginal Means for Obvious Scores Based on Time and Condition

Group	Time	*M*	*SE*
In-Person	Time 2	5.98	1.18
	Time 3	9.12	1.28
	Time 4	9.07	1.46
Hybrid	Time 2	5.42	1.18

	Time 3	6.6	1.28
	Time 4	6.4	1.46

Figure 1: Average Obvious Scores for Session Number Based on Condition

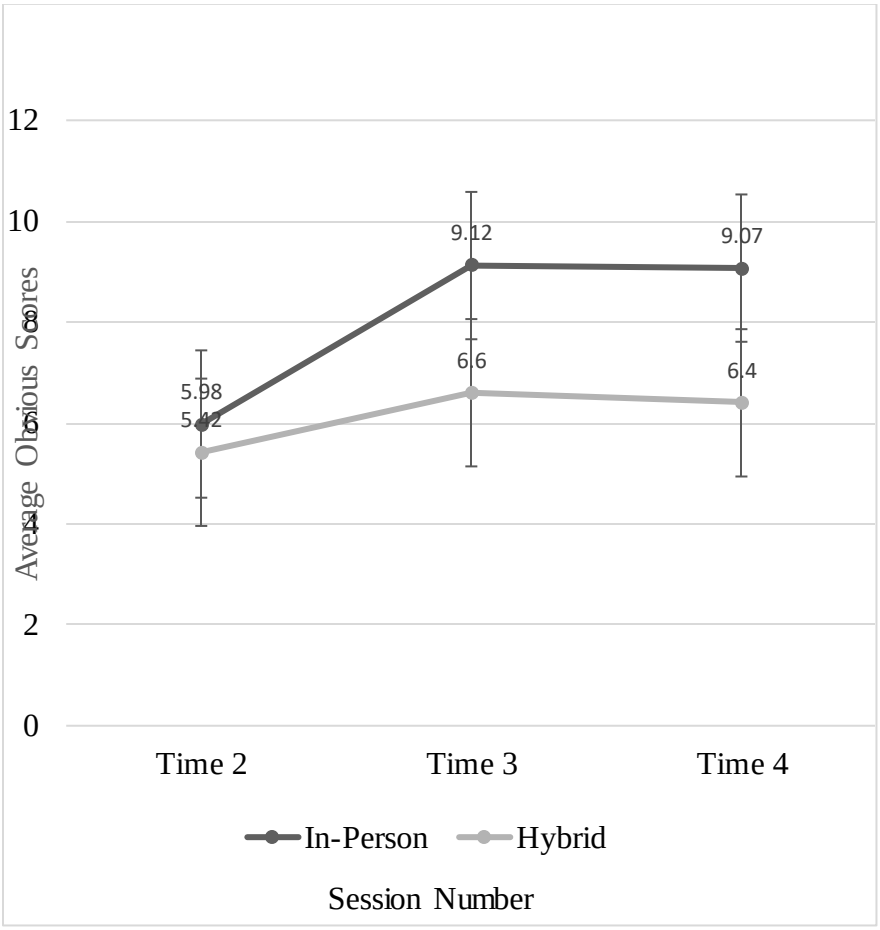

Table 5: Post Hoc Comparison Details for Obvious Scores

Comparison						
Time	Time	*Mean Difference*	*SE*	df	t	Ptukey
Time 2	Time 3	2.963	0.538	18	-4.023	0.002
	Time 4	3.488	0.756	18	-2.695	0.038
Time 3	Time 4	0.525	0.639	18	0.196	0.979

The main effect for time was significant when looking at remote scores, $F(2, 36)= 13.08$, $p< .001$. The number of remote scores decreased after every session regardless of the condition. Simple effect tests of time were conducted for each session. Remote scores differed between time 2 and time 3, $t(18)=3.128$, $p=0.015$ and time 2 and time 4 $t(18)=5.328$, $p<0.001$ across conditions. There was no difference in obvious scores between time 3 and time 4, $t(18)=0.965$, $p=0.6.8$ across conditions. See Table 7 for Post Hoc comparison details. The main effect for condition was not significant when looking at remote scores, $F(1,18)= 0.59$, $p=0.45$. There was no difference in remote scores across condition. The interaction between time and condition when looking at obvious scores was not significant, $F(2,36)=0.33$, $p=0.72$. See Figure 2 and Table 6 for the ANOVA remote results.

Table 6: Marginal Means for Remote Scores Based on Time and Condition

Group	Time	*M*	*SE*
In-Person	Time 2	8.63	1.37
	Time 3	5.8	1.28
	Time 4	4.7	1.04
Hybrid	Time 2	7.25	1.37
	Time 3	4.15	1.28
	Time 4	4.2	1.04

Figure 2: Average Remote Scores for Session Number Based on Condition

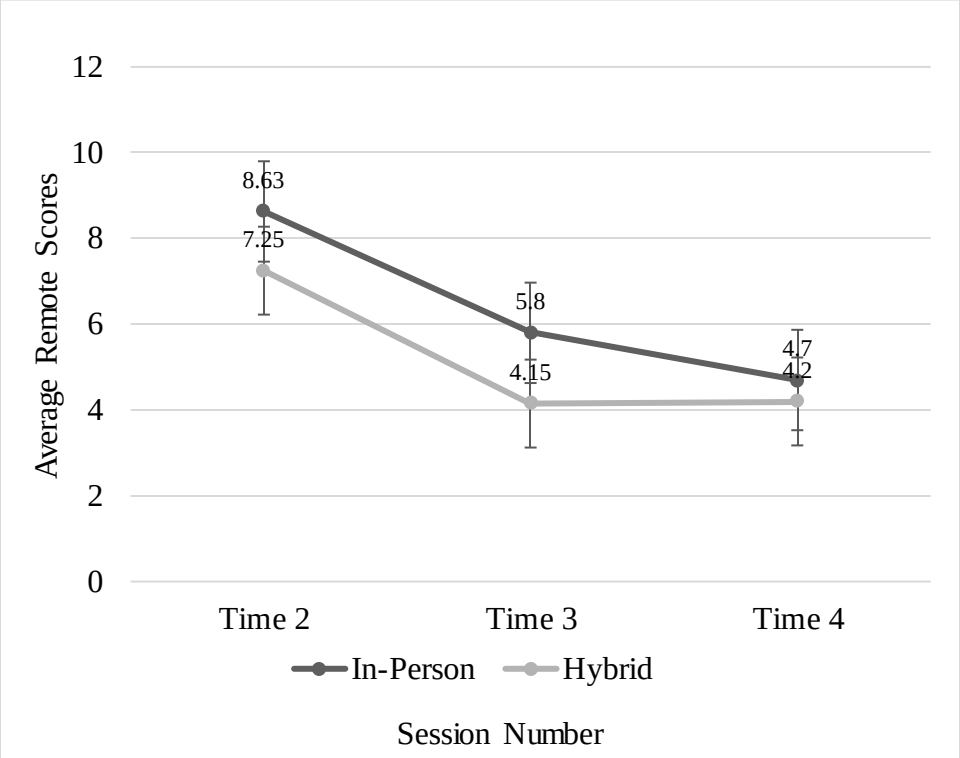

Table 7: Post Hoc Comparison Details for Remote Scores

Comparison						
Time	Time	*Mean Difference*	*SE*	df	t	Ptukey
Time 2	Time 3	2.963	0.947	18	3.128	0.015
	Time 4	3.488	0.655	18	5.328	<0.001
Time 3	Time 4	0.525	0.544	18	0.965	0.608

Assessing covariate influences.

Because of our small sample size, a series of independent samples t-tests were conducted to determine if there are any mean differences in the hybrid and in person conditions across all variables. Table 8 highlights the means, standard deviations, t-value, p-value, and effect size for both conditions. Each dyad received an average score and a delta score for every assessed variable. The delta score represents the difference in scores between the individual's scores in

the dyad. There was a significant difference between the hybrid and in person groups for the Conscientiousness delta and the SAM affect delta. Participants in the hybrid condition reported higher levels of conscientiousness (*M*=11.27, *SD*=3.82) than participants in the in-person condition (*M*=5.20, *SD*=4.02), *t*(19)= -3.547, *p*= 0.002. Participants in the hybrid condition also reported slightly higher affect scores on the SAM (*M*=2.03, *SD*=1.25) than participants in the in-person condition *M*=1.05, *SD*=0.66), *t*(19)= -2.07, *p*= 0.052. However, these variables were not correlated with obvious or remote scores at any time point and were not further analyzed.

Table 8: Independent Samples T-Test and Descriptive Statistics

	Hybrid	**In-Person**			
Variable	**Mean(*SD*)**	**Mean(*SD*)**	**t-value**	***p*-value**	***d*-value**
Individual obvious score (T1) High	7.70(*3.40)*	9.70(*4.92)*	1.1935	0.247	0.5215
Individual obvious score (T1) Low	4.85(*2.38)*	5.55*(2.73)*	0.7111	0.486	0.3107
Individual obvious score (T1) Delta	2.85(*3.18)*	4.15*(2.89)*	1.0642	0.301	0.465
Individual obvious score (T1) Avg	6.28(*2.47)*	7.63(*3.71)*	1.0902	0.289	0.4763
Individual remote score (T1) High	6.95(*2.75)*	7.50*(4.19)*	-0.2034	0.841	-0.0889
Individual remote score (T1) Low	4.70(*1.49)*	4.15*(3.74)*	-0.868	0.396	-0.3793
Individual remote score (T1) Delta	2.25(*2.28)*	3.35*(2.81)*	0.7599	0.457	0.332
Individual remote score (T1) Avg	5.83(*1.90)*	5.83*(3.72)*	-0.5243	0.606	-0.2291
Avg Age	21.55(*3.19)*	21.8(*2.29)*	0.3645	0.72	0.1593
Sex Match	0.40(*0.52*)	0.40*(0.52)*	0.1631	0.872	0.0713
Gender Match	0.50(*0.5*3)	0.40*(0.52)*	-0.2403	0.813	-0.105
Race Match	0.80(*0.42)*	0.50(*0.53)*	-1.5607	0.135	-0.6819
Language Match	0(0)	0.20(*0.42)*	1.5774	0.131	0.6892
SESFin Match	0.80(*0.42*)	0.80(*0.42*)	-0.1008	0.921	-0.0441
SESFather Match	0.90(*0.32)*	1*(0)*	0.9512	0.353	0.4156
SESMother Match	0.80(0.42)	0.80(*0.42*)	-0.1008	0.921	-0.0441
VocabScore Avg	17.85(*6.30)*	14.05(*6.82)*	-1.0469	0.308	-0.4574
VocabScore Delta	11.10(*7.69)*	10.90(9.95)	-0.2049	0.84	-0.0895

Extraversion Avg	29.70(*3.12)*	32.05(*4.42*)	0.8809	0.389	0.3849
Extraversion Delta	9.20(*8.13)*	8.30(*7.09)*	-0.4078	0.688	-0.1782
EmotStab Avg	29.95(*4.99)*	27.10(*2.63)*	-1.7341	0.099	-0.7577
EmotStab Delta	7.70(*6.65)*	4.60(*2.95)*	-1.3424	0.195	-0.5865
Conscient Avg	35.05(*4.44)*	33.6(*4.23)*	-1.0464	0.309	-0.4572
Conscient Delta	11.50(*3.95)*	5.20(*4.02)*	-3.5466	0.002	-1.5496
Agreeableness Avg	41.25(*4.21)*	39.55(*4.11)*	-0.2517	0.804	-0.11
Agreeableness Delta	6.90(*5.86)*	6.30(*6.11)*	-0.0244	0.981	-0.0107
Openness Avg	36.75(*4.14)*	35.65*(3.01)*	-0.7855	0.442	-0.3432
Openness Delta	4.70(*2.91)*	6.30(*3.50*)	1.0789	0.294	0.4714
Stroop Avg	71.88(*109.55)*	131.94(*90.20*)	1.4068	0.176	0.6147
Stroop Delta	176.87(*141.04)*	149.76(*116.42)*	-0.2296	0.821	-0.1003
Sternberg Avg	1298.43(130.36)	1249.04(*220.16)*	-0.0862	0.932	-0.0377
Sternberg Delta	315.39(*409.83)*	386.69(*529.41)*	0.2642	0.794	0.1154
SAM(Valence) Avg	6.69(*0.38)*	6.61(*0.63)*	-0.521	0.608	-0.2276
SAM(Valence) Delta	0.75(*0.47)*	0.62(*0.41)*	-1.0437	0.31	-0.456
SAM(Arousal) Avg	4.63(*1.14)*	4.63(*1.42)*	-0.2429	0.811	-0.1061
SAM(Arousal) Delta	2.03(*1.25)*	1.05(*0.66)*	-2.0712	0.052	-0.905
SAM(Dominance) Avg	7.23(*0.38)*	6.89(*0.56)*	-1.9488	0.066	-0.8515
SAM(Dominance) Delta	0.87(*0.88)*	0.88(*0.87)*	0.043	0.966	0.0188
PANAS(Positive affect (T1)) Avg	32.20(*3.64)*	32.55(*3.88)*	-0.1554	0.878	-0.0679
PANAS(Positive affect (T1)) Delta	5.40(*3.50)*	6.90(*5.38)*	0.5461	0.591	0.2386
PANAS(Negative affect (T1)) Avg	21.35(*4.42)*	22.05(*4.17)*	0.425	0.676	0.1857
PANAS(Negative affect (T1)) Delta	8.10(*4.72)*	6.30(*3.13)*	-0.754	0.46	-0.3294
PANAS(Positive affect (T2)) Avg	33.80(*3.79)*	31.45(*4.99)*	-1.186	0.251	-0.5304
PANAS(Positivee affect (T2)) Delta	5.40(*2.72)*	7.70(*5.58)*	1.1722	0.256	0.5242
PANAS(Negative affect (T2)) Avg	19.25(*3.63)*	20.70(*2.95)*	0.9808	0.34	0.4386
PANAS(Negative affect (T2)) Delta	5.90(*2.68)*	9.90(*5.70)*	2.0061	0.06	0.8972

Note. $H_a\ \mu_0 \neq \mu_2$

[a] Levene's test is significant ($p < .05$), suggesting a violation of the assumption of equal variances

Pearson correlations were conducted to determine whether there were significant correlations among creativity and demographic, cognitive, psychoaffective, and personality variables. For remote scores, the PANAS positive affect delta for time one and the vocabulary score Delta were identified as significant potential covariates. The PANAS positive affect time one delta was significant for the last session (T4), $t(18)= 2.525$, $p=0.021$. the vocabulary score delta was also significant for the last session(T4), $t(19)= 2.590$, $p=0.018$. For obvious scores, the PANAS negative affect Delta for time two was identified as a significant potential covariate. The PANAS negative affect time two delta was significant for the second session (T3), $t(18)=2.140$, $p=0.046$. Follow-up analyses were conducted using an ANCOVA to determine if these had an impact on the results of the study.

ANCOVA

A factorial ANCOVA was conducted to establish if the potential covariates had an impact on time or condition. When looking at obvious scores, the ANCOVA indicated there was no difference in obvious scores regardless of the session when controlling for PANAS2-Delta scores, $F(2,34)= 1.84$, $p=0.175$. This indicates that when controlling for negative mood states, the time effect was no longer present. When looking at remote scores, the potential covariates (the PANAS positive affect Delta for time one and the Vocabulary score Delta) did not impact the significance time main effect $F(2, 36)= 13.08$, $p< .001$, meaning that when controlling for these covariates the results were significant and these covariates did not impact the study.

DISSCUSION

This study aimed to determine if there are differences in creative outcomes and idea generation abilities when in a partially virtual environment (hybrid) or an in-person environment over time. Team brainstorming has become increasingly popular within organizations for topics that require a high frequency of creativity (such as problem solving) because teams tend to promote creative synergies and produce ideas they would not have come up with on their own (Baer et al., 2008). There has been previous research looking at the differences in completely virtual compared to completely in person environments but the focus on hybrid work has only recently begun to be explored due its increase since COVID-19. While many researchers have agreed on a universal definition of creativity being the generation of ideas that are both novel and useful in order to solve complex problems (Mumford, 2003), the construct is still lacking in research and continues to be a focus for review.

Participants were randomly assigned to one of three conditions (in-person, hybrid, remote) and paired with another participant for the duration of the study. These dyads met on three separate occasions to work together to brainstorm on a creativity task. While data for the remote condition was collected, this data was not the focus of this study and was not included in the analysis. The Consequences tasks were used as the creativity task and participants were told to come up with as many ideas as possible together in relation to the prompt they were given. Participant ideas were graded on if the ideas were directly related to the prompt (obvious scores) or indirectly related to the prompt (remote scores).

An ANOVA was conducted for both the obvious scores and the remote scores in relation to time and condition. For the obvious scores, time was significant and the participants generated more obvious scores at the beginning of the study compared to the second session and the third

session regardless of condition. There was no difference in obvious scores between the hybrid and in person conditions. For the remote scores, time was also significant and participants generated more obvious ideas during the first session when compared to the second and third session regardless of condition. There was no difference in scores when comparing conditions. These results indicate that there is no difference in performance on creativity tasks when participants are working in person and then moving to a virtual environment compared to when they are consistently working in person.

Independent samples *t*-tests and Pearson's correlations were conducted as follow up analyses to determine if there are any covariates may impact the results of this study. The additional analyses revealed that negative affect scores impact the relationship between obvious scores and time. When controlling for negative affect scores, there was no difference in obvious scores regardless of the session. This indicates that an individual's mood state may impact their creative ability and idea generation process. These findings are consistent with previous research that found negative moods had a negative effect on ideation fluency (Vosburg, 1998). This is an under researched area and the results of this analysis should be investigated further.

Overall the results suggest that there is a difference in the amount of ideas that are generated over time. However, there is also a difference in the type of ideas generated. Ideas that are directly related to the construct tend to increase over time while ideas that are indirectly related to the construct tend to decrease over time. This may be due to study fatigue and finding it more difficult to continue to come up with more novel ideas the longer the study went on as well. While the consequences tasks are valid and considered to be of the same difficulty level, some prompts may have been considered easier to answer due to participant's previous exposures compared to other prompts. A larger sample size would help combat this issue.

Additionally, the majority of the measured covariates did not portray meaningful relationships with creative outcomes. This goes against previous research that suggests that personality, cognitive ability, and intelligence have an effect on creativity (Coursey, et al., 2018; Benedek et al., 2012; Van Knippenberg & Schippers, 2007; Woolley et al., 2010; Nakui et al., 2011; Mumford et al., 2018; Gong et al., 2023). This may be due to individuals not feeling comfortable sharing their ideas with people they are unfamiliar with due to the fear of being negatively perceived regardless of their personality, intelligence, or cognitive ability and thus not having the ability to experience creative synergy (Baer et al., 2008). More research on these areas and how they interact with the creative outcomes is suggested.

The results of this study have assisted in the understanding of creativity at the dyadic level and idea generation ability within teams over time in different modalities. Creativity at the dyadic level is lacking in current research due to the difficulty developing research studies with adequate data collecting methods compatible with these forms of research. This study introduces a method that can allow for further replication and research in order to understand idea generation and divergent thinking at the dyadic level. Additionally, research on hybrid settings and their relationship with creativity is also an under researched area. This is likely because hybrid environments have only recently gained popularity due to the COVID-19 Pandemic. Previous research has compared in person environments to virtual environments, but they have not focused on environments that begin in person and then move to virtual outlets for communication. The current study opens a segway into this underrepresented area so that future research can begin to understand if there are differences in idea generation and the entire creative process depending on if a variety of communication outlets are being used and compared to one source of communication.

Limitations

There were several limitations to this study. The first limitation was that the study did not reach the desired sample size which could have impacted the significance of the results. Additionally, the dropout rate for participation in the study was higher than anticipated. Many students began the study and did not finish all three sessions. While their data was able to be used for the larger study, the participants data who did not complete all three sessions was not able to be used for this study which could have also impacted the results. Related to this, many participants had to reschedule their sessions due to forgetting to show up or personal conflicts. This resulted in many dyads straying away from the intended session scheduling. The sessions were set to be conducted on a Monday-Wednesday-Friday schedule or a Tuesday-Thursday-Monday schedule. Some dyads had to do their sessions sooner than scheduled or later than intended which could have had an impact on the results of this study as there was no way to control for time between each session.

This study was conducted in a controlled environment using college age students which may limit the generalizability of the findings. The materials used for brainstorming may not be applicable to real world settings and brainstorming within an organization. There are also several other factors that may affect how ideas are generated within an organization such as the amount of people present within a brainstorming session and the need for tangible ideas in order for them to be approved and implemented within an organization. The consequences tasks are valid and reliable methods for gaining insights regarding a dyadic brainstorming ability but not be an accurate representation of the brainstorming sessions used in organizations.

Future Directions

Many studies compare the differences between in person and virtual teams, however some fail to take into consideration that virtuality is more multidimensional than originally thought and there are different levels to the degree a team works virtually amongst each other (Kirkman et al., 2004). Some teams are highly virtual and rarely, if ever, interact in person while others may interact frequently in person with each other and use a hybrid setting. Taking into consideration if teams interact at all in person or are strictly virtual may have an impact on creative outcomes and should be further investigated. Additionally, the type of virtual environment that is being used may not be generalizable to other virtual settings such as virtual reality or augmented reality settings. Simulated environments are becoming increasingly popular but studies have not considered how the methods for creating a virtual environment may impact idea generation and creative outcomes.

As aforementioned, negative affect states may have an impact on idea generation abilities based on the findings of this study. Based on the findings of this study, negative affect states may impact idea generation and affect the amount of ideas that are generated. Future research is suggested to further investigate this notion as well as how other factors may affect creative outcomes.

There were limited relationships between creative outcomes and the measured covariates. Previous research has suggested personality traits such as extraversion and openness have an influence on creative behaviors which goes against the findings of this study (Coursey, et al., 2018; Baer, et al., 2008). Additional research should be conducted on how specific personality

traits interact with each other during the idea generation process and how personality traits may impact the collective idea generation process (Baer et al., 2008).

CONCLUSION

The results of this study suggest that there is no difference in idea generation regardless of the environment (in-person vs. partially in-person and then partially virtual) over time. Additional research is suggested to further investigate these findings as this is an under-researched areas. Virtual environments are increasing in popularity within the workplace and should continue to be researched in order to understand the impact these environments can have on productivity and creativity. The results also suggest that when brainstorming ideas directly related to the construct, idea generation gets better over time and when brainstorming ideas indirectly related to the construct, idea generation gets worse over time. The practical implications of these results suggest that it is more difficult to continue to generate novel ideas over time and research should continue to work to understand how this can impact the workplace. The goal of any organization is to increase the bottom line and maximize profit and productivity and organization should investigate how idea generation fatigue may impact performance and productivity and how novel ideas can be increased within the workplace.

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APPENDECIES

Appendix A

IRB Approval Form

Date: 7-14-2024

IRB #: IRB-FY2024-55
Title: Creativity in pairs: Investigating individual and interactive factors underlying dyadic creativity
Creation Date: 9-20-2023
End Date:
Status: Approved
Principal Investigator: James Houston
Review Board: MTSU Institutional Review Board
Sponsor:

Study History

Submission Type	Review Type	Decision
Initial	Exempt	Exempt

Key Study Contacts

Member James Houston	Role Principal Investigator	Contact james.houston@mtsu.edu
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Member Hannah Rogers	Role Co-Principal Investigator	Contact hgr2u@mtmail.mtsu.edu

Appendix B

PANAS

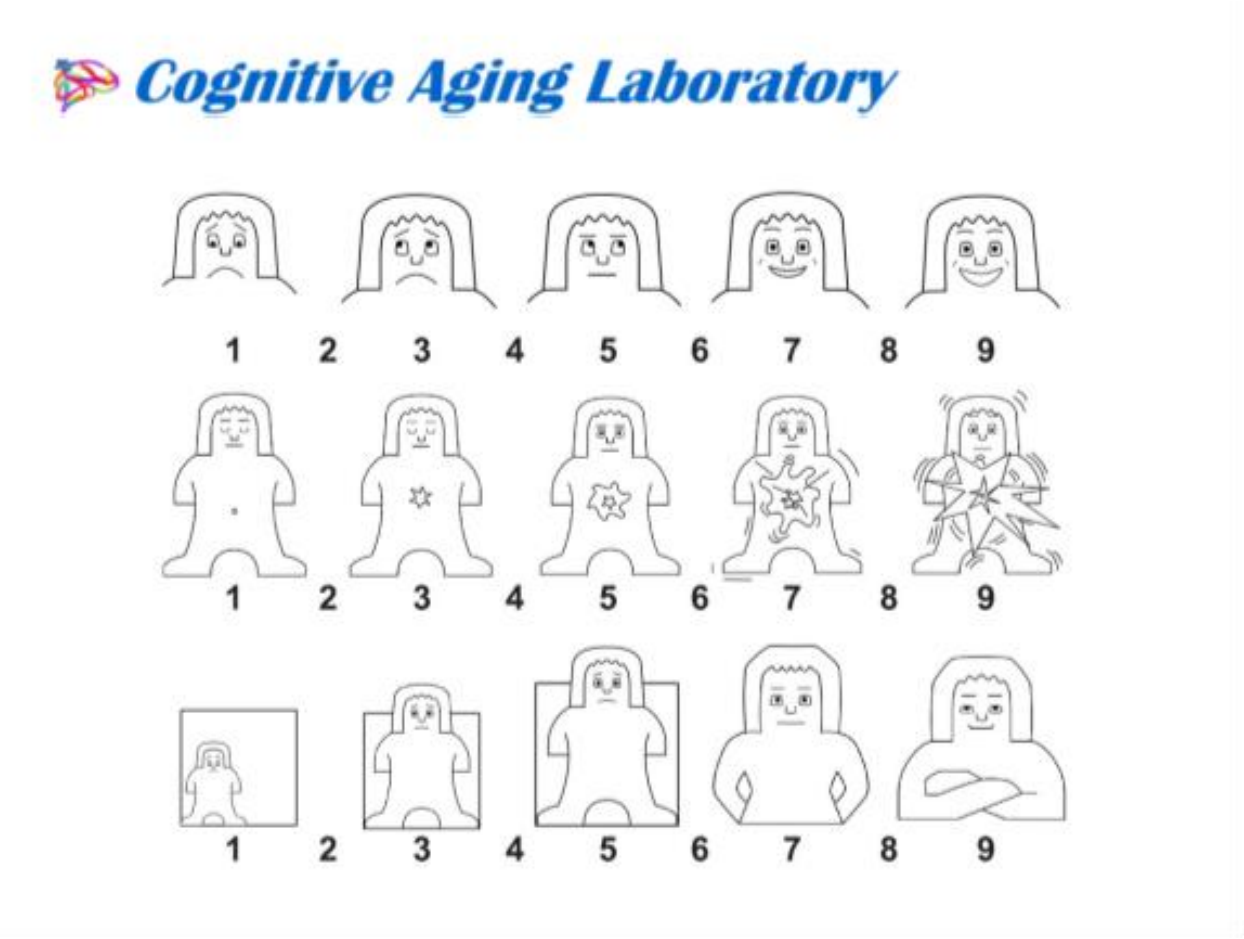
Cognitive Aging Laboratory

Positive and Negative Affect Schedule (PANAS-SF)

Indicate the extent you have felt this way over the past week.		Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
PANAS 1	Interested	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 2	Distressed	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 3	Excited	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 4	Upset	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 5	Strong	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 6	Guilty	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 7	Scared	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 8	Hostile	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 9	Enthusiastic	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 10	Proud	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 11	Irritable	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 12	Alert	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 13	Ashamed	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 14	Inspired	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 15	Nervous	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 16	Determined	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 17	Attentive	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 18	Jittery	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 19	Active	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 20	Afraid	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Appendix C

SAM



Appendix D

Qualtrics Informed Consent and Demographics Questionnaire

Study Title: Creativity in pairs: Investigating individual and interactive factors underlying dyadic creativity
Protocol Number: IRB-FY2024-55
Approval Date: November 13, 2023
Principal Investigator: James R. Houston Ph.D.
Institution: Middle Tennessee State University

You are being asked to participate in a research project. The following information is provided to inform you about the research project and your participation in it.

Purpose: This research project is designed for two reasons: (1) differences between individual member and team creativity within dyads, and (2) differences between team creativity performance in-person and remotely.

Description: This study is longitudinal and involves three sessions of brief creativity assessment. Demographics, vocabulary, personality, cognitive ability, and mood will be measured. Individuals will complete a creativity task and then complete another creativity task in assigned dyadic (group) conditions. There will be in-person and remote dyad groups. Groups will complete two other creativity tasks on two following days. You will NOT be audio recorded or videotaped in this study. The first participant session will last approximately one hour. The second and third participant sessions will last approximately 20 minutes.

Benefits/Compensation: You will receive course credit in return for your participation in the study. No direct monetary compensation will be provided.

Here are your rights as a participant:

- Your participation in this research is voluntary.
- You may skip any item that you don't want to answer, and you may stop the research at any time. Note that if you leave an item blank, you will be warned that you missed one, just in case it was an accident. You can still click that you don't want to answer. Some items may be required in order to accurately present the study.
- There are no risks associated with your participation besides possible discomfort with some of the questions.
- There are no real benefits to you from participating besides possibly learning something about the research.
- You will NOT be asked to provide any identifiable personal information.
- All efforts, within reason, will be made to keep the personal information in your research record private, but total privacy cannot be promised. Your information may be shared with people at MTSU (such as the MTSU Institutional Review Board) or other agencies (such as the Federal Government Office for Human Research Protection) if you or someone else is in danger or if we are required to do so by law.

Contact Information. If you should have any questions about this research study or possibly injury, please feel free to contact the student co-investigators or the faculty principal investigator:

Co-Investigators
Andrea Chalut (ac2de@mtmail.mtsu.edu)
Hannah Rogers (hgr2u@mtmail.mtsu.edu)
Raif Al Mezraani (rra2y@mtmail.mtsu.edu)

Faculty Principal Investigator
James R. Houston, Ph.D. (james.houston@mtsu.edu)

For additional information about giving consent or your rights as a participant in this study, please contact the Middle Tennessee State University (MTSU) Office of Compliance at 615-494-8918 or via email at irb_information@mtsu.edu. (http://www.mtsu.edu/irb)

If you're ready to get started, please make your choice below before clicking the arrow button.

Thanks again for volunteering your time to this project!

I have read the information above. I am at least 18 years old. I believe I understand the purpose, risks, and benefits of the research, and I know what I will be expected to do as a study participant.

I have read the information above. I am at least 18 years old. I believe I understand the purpose, risks, and benefits of the research, and I know what I will be expected to do as a study participant.

- I consent to participate (1)
- I decline to participate (2)

I understand that I can freely withdraw from this study without facing any consequences.

- Yes, I understand (1)
- No, I do not understand (2)

Type your age in whole years. (e.g: 18) _____

What sex were you assigned at birth, as indicated on your birth certificate?

- Male (1)
- Female (2)
- Non-binary (3)
- Other (Please describe) (4)
- Prefer not to say (5)

What best describes your gender? (select all that apply)

- Man (1)

- Woman (2)
- Non-binary (3)
- Transgender (6)
- Other (Please describe) (4)
- Prefer not to say (5)

Select your race.

- Caucasian (1)
- African American (2)
- Asian (3)
- Hispanic (4)
- Middle Eastern or North African (5)
- Native American (6)
- Pacific Islander or Native Hawaiian (7)
- Other (Please specify). (9)
- Prefer not to say (10)

Is English your primary language?

- Yes (1)
- No (please indicate primary language) (2)

Please choose the answer that indicates your entire household income before taxes.

- Below $14,999 (1)
- Between $15,000-$31,999 (2)
- Between $32,000-$69,999 (3)
- Between $70,000-$129,999 (4)
- Over $130,000 (5)
- Don't know (6)

What is your father's (or 1st parental guardian's) educational attainment?

- I did not have this parent or guardian present when I was growing up (1)
- Did not graduate from high school (2)
- Graduated from high school (3)
- Received some post-high school education/training (4)
- Graduated from college or received their bachelor's degree (5)
- Received advanced training beyond a bachelor's degree (6)
- Don't know (7)

What is your mother's (or 2nd parental guardian's) educational attainment?

- I did not have this parent or guardian present when I was growing up (1)
- Did not graduate from high school (2)
- Graduated from high school (3)
- Received some post-high school education/training (4)
- Graduated from college or received their bachelor's degree (5)
- Received advanced training beyond a bachelor's degree (6)
- Don't know (7)

Appendix E

Consequences Tasks

Consequences Trial 1

This is a test of your ability to think of a large number of ideas in connection with a new and unusual situation.

Look at a sample item.

Sample item:

What would be the results if people no longer needed or wanted sleep?

Sample results:

1. Get more work done
2. Alarm clocks not necessary
3. No need for lullaby song books
4. Sleeping pills no longer used

Of course, there are many more possible results that could have been written.

Four common examples will be included for each item. You will be given five minutes to write down other possible results of the situation in the space below. Your answers need not be complete sentences. Your score will be the total number of different consequences that you write in the time given.

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Consequences Trial 2

This is a test of your ability to think of a large number of ideas in connection with a new and unusual situation.

Look at the item.

Item:

What would be the results if none of us needed food any more in order to live?

1. No need for farmers
2. No plates, knives, and forks
3. No grocers
4. Save time

Of course, there are many more possible results that could have been written.

You have five minutes to write down other possible results of the situation in the space below. Your answers need not be complete sentences. Your score will be the total number of different consequences that you write in the time given.

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Consequences Trial 3

This is a test of your ability to think of a large number of ideas in connection with a new and unusual situation.

Look at the item.

Item:

What would be the results if humans lost their group feeling to the extent that they all preferred to live alone?
1. No more marriages
2. Population decline
3. More hermits
4. No more cities

Of course, there are many more possible results that could have been written.

You have five minutes to write down other possible results of the situation in the space below. Your answers need not be complete sentences. Your score will be the total number of different consequences that you write in the time given.

This is a test of your ability to think of a large number of ideas in connection with a new and unusual situation.

Look at the item.

Item:

What would be the results if everyone suddenly lost the sense of balance and were unable to stay in the upright position for more than a moment?
1. People would fall down
2. Could not walk
3. Many accidents
4. Confusion

Of course, there are many more possible results that could have been written.

You have five minutes to write down other possible results of the situation in the space below. Your answers need not be complete sentences. Your score will be the total number of different consequences that you write in the time given.

This is a test of your ability to think of a large number of ideas in connection with a new and unusual situation.

Look at the item.

Item:

What would be the results if all the people in the world lost the ability to reproduce offspring?
1. Race would die out
2. No more babies
3. No more baby doctors
4. No more diapers or toys

Of course, there are many more possible results that could have been written.

You have five minutes to write down other possible results of the situation in the space below. Your answers need not be complete sentences. Your score will be the total number of different consequences that you write in the time given.