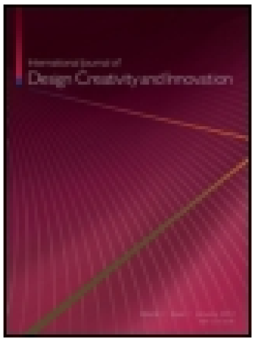

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ARTICLE

Examining the effects of mood on quality and feasibility of design outcomes

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ABSTRACT

This study examines the correlation between quality and feasibility of generated design solutions with mood and rational vs. intuitive thinking. It was hypothesized that positive moods lead to better intuitive thinking, which will result in higher design quality and feasibility. The participants, who were junior and senior level undergraduate students with a design background, were given the 32-point Brunel Mood Scale (BRUMS) before solving nine 7-min design tasks in a manner that cultivated either analytical or intuitive thinking. Cronbach's alpha was used to confirm the reliability and consistency of the self-reported mood data. Spearman's correlation was used to illustrate the mood–performance relationship, revealing that high design solution quality is significantly positively correlated with vigor and energetic mood in the Creative Intuition (CI) condition, and downhearted mood in the Problem Solving Intuition condition, while significantly negatively correlated with depression, worn-out and bad-tempered moods in the CI condition. High design solution feasibility was positively correlated with an exhausted mood in the Rational Thinking condition, and negatively correlated with composed and relaxed moods in the CI condition. These findings help further the understanding of how mood impacts design outcomes in intuitive and analytical problem solving, which may have implications design practice.

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KEYWORDS
Mood; design outcomes; intuition; design cognition

1. Introduction

Creativity is defined as the combination of usefulness and originality (Runco & Jaeger, 2012), and is an important element of success in design. A deeper understanding of creativity and its relationship to intuition and mood will better further design cognition and design science research. In the research presented here, the focus is on the *usefulness* aspect of creativity, as measured by the quality and feasibility of design outcomes produced during ideation. Instead of focusing on what impacts a particular aspect of creativity, many researchers have studied holistic creativity as it relates to problem-solving in design. Empirical studies that investigate different strategies for increasing intuitive problem-solving skills compared to more rationally and serially driven strategies are uncommon (Glöckner, 2007). Studying creativity can be challenging because of its inherent subjectivity, especially in a design context. However, uncovering the various factors that contribute to design creativity and intuitive problem-solving skills is an important endeavor for design research, practice, and education. Dane and Pratt have argued that emotion affects intuition

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processes (E. Dane & Pratt, 2007), and Epstein has argued that intuitive responses are manifested in nonconscious information processing structures (Handbook of Psychology, 2003). These connections are explored in the context of engineering design in this study.

Understanding how intuition and mood affects idea generation helps design educators and practitioners to tailor their work environments. The ability to improve one's environment, such as a classroom or office, for learning or ideation will enable maximum comprehension and retention of design content knowledge. This work explores two specific kinds of intuition – problem-solving intuition and creative intuition – and a third type of problem-solving called rational thinking, through various timed design activities to investigate the effects of incubation, distraction, and mood on design outcomes. Van Kleef et al. suggested that 'task engagement and time spent on task' affected the results in a study of mood and creativity (Van Kleef et al., 2010). Mood could also affect a designer's ability to generate ideas, create solutions, and solve problems in innovative ways. In this study, participant mood is also measured and correlated to design outcomes as an immediate influence on those outcomes.

In order to measure these different possible impact factors during idea generation, accepted metrics were implemented in this study. Design solution quality was measured using Shah's metrics (Shah et al., 2003), and feasibility was measured using an adaptation of Shah's metric by Linsey et al. (2011). These approaches have been widely used in engineering design research as a measure of design creativity (Hernandez et al., 2012; T. A. T. A. Johnson et al., 2016; J. S. Linsey et al., 2011; Moreno et al., 2014). A factor that might affect the creativity of design solutions is a designer's shifting states of emotion, mood, or sense of wellbeing. The Brunel Mood Scale (BRUMS) (Terry et al., 2003, 1999) was used to measure participants' mood while they completed the design activity. This scale has been used to measure emotional intelligence in competitive sports and academics, where results showed that beliefs of emotional intelligence are associated with different moods depending on context (A. A. Lane et al., 2009). Steps have also been taken to validate this scale for other cultures and specific contexts, such as in the work done by Hashim et al. and Lan et al. in studies on Malaysian Athletes (Hashim et al., 2010; Lan et al., 2012). However, research in the field of engineering design that addresses mood as a possible factor in design outcomes is very limited. Designer mood might help explain how design intuition affects design outcomes.

This work is motivated by a gap in engineering design research on how designer mood affects the idea generation process. Previous work in the field has shown that mood and creative thinking are closely intertwined, but very little work has explored these phenomena in a design context. In addition, intuition has been well studied with regard to creativity, but has not been investigated deeply with regard to mood. Based on previous work, mood could have a substantial impact on the early-stage design process if it affects both design intuition and design outcomes, and could have implications for the entire engineering design process. Through this investigation of different factors that might interact with design intuition, the authors aim to better understand what influences designers' ability to solve design problems and the outcomes of the design process.

This study was motivated by two specific research questions:

Research Question 1:How do intuitive and analytical task conditions impact the quality and feasibility of design solutions?

Research Question 2:What role does mood play in designer outcomes, such as quality and feasibility of design solutions?

In response to these two research questions, two formal hypotheses were formulated:

Hypothesis 1:The Problem Solving Intuition condition will yield the highest quality and feasibility scores for design solutions generated, and the Rational Thinking condition will yield lower scores than the Creative Intuition condition.

Hypothesis 2:Positive moods (such as HAPPINESS and CALMNESS) are expected to correlate with better design quality and feasibility, while negative moods (such as ANGER and FATIGUE) are expected to correlate with lower scores.

Hypothesis 1 suggests that giving a designer time to process the given tasks in a manner that is less driven by rational thinking will improve their design intuition, while incubation alone will encourage the designer to actively ruminate over the details of the given task, therefore suppressing cognitive mechanisms responsible for intuition. In an argument similar to Epstein's (Handbook of Psychology, 2003), design intuition likely requires time to manifest through nonconscious mechanisms. With no incubation, there is hypothetically no time for the nonconscious mechanism to manifest. Hypothesis 2 suggests that positive moods will have a positive impact on design quality and feasibility, since they have been shown to increase creativity (Baas, De Dreu & Nijstad, 2008). Coupled with effects from incubation, increased creativity due to a positive mood could also improve design intuition.

Creativity in design is a difficult concept to study, especially when considering mood and intuition – two concepts that are hard to capture quantitatively. However, it is important to understand what factors affect design creativity in order to empower students and practitioners to become more effective designers. In addition, intuition is also difficult to study in a design context, despite the breadth of research on the topic that has been conducted largely in the field of psychology. Through this work, factors that affect design creativity and intuition begin to reveal themselves through a novel approach. This study shows that mood interacts with design intuition and design outcomes in different ways, which contributes to the body of work on design cognition and helps fill a gap in design research on how mood and design intuition affect the early-stage design process. The following section provides a brief history of the topics explored and methods implemented in this work.

2. Background

The following section provides an overview of the range of definitions of intuition, as well as previous work on how intuition may impact the way designers practice. The two types of intuition of focus in this study are then defined and characterized: problem-solving intuition and creative intuition. The third factor in this study, mood, is described as it relates to design creativity, before moving to the study methodology.

2.1. Intuition research

Most models of cognition present two modes of thinking: a conscious and a subconscious processing system (Betsch, 2008). The first is described as deliberate, inferential, and analytical, and the second is often called the intuitive system. The intuitive system is usually described as working through automatic, speedy processes that cannot be accessed internally or verbally reasoned. However, there have been many definitions of intuition across disciplines. Dane and Pratt identified four main features of intuition across these various definitions: affective, fast, nonconscious, and holistic (E. Dane & Pratt, 2009); therefore, they formally present intuition as 'affectively charged judgments that arise through rapid, nonconscious, and holistic associations.' Dane and Pratt define the primary functions of intuition as problem-solving, moral reasoning, and creativity (E. Dane & Pratt, 2009). Sinclair similarly assigns two functions to intuition – decision-making and problem-solving – which are typically found working together (Sinclair, 2011). As designers, these are all functions that one would expect to encounter across many aspects of the design process. Glöckner criticized previous research in decision-making, and found evidence that, when compared to simplifying strategies such as heuristics, decision makers rely much more on intuition than the literature previously suggested (Glöckner, 2007). It is, therefore, beneficial to study how intuition impacts design outcomes.

Rational thinking has not been studied as extensively as intuition with regard to creativity, although there have been some studies comparing the two. Garfield et al. studied the creativity of undergraduate business students by comparing students with intuitive creativity techniques versus analytical techniques. The study found that intuitive creativity techniques produced more paradigm-modifying ideas than analytical creativity techniques, meaning they transformed particular elements of the problem in a novel way (Garfield et al., 2001). Analytical techniques were characterized as those following a sequence of steps, and intuitive techniques as those that require a 'leap' to arrive at solutions, as defined by Miller (Miller, 1987). Dane et al. found that the creativity in rational versus problem-solving intuition may rely on the designers typical thinking style (Erik Dane et al., 2011). The more creative concepts were produced using the method that participants self-reported as using the least in their normal processes. In design, this could have implications for how designers reach more novel and innovative solutions during the idea generation phase. This study builds upon these previous studies by exploring the comparison of analytical thinking to multiple forms of intuitive thinking, including one with an incubation period (Glöckner, 2007).

The importance of intuition in the design process has been highlighted throughout the literature. Pahl and Beitz say that intuition is critical to any systematic approach to reach a successful final product (Pahl & Beitz, 1988). Cross asserts that when designers speak of intuition, they are referring to their abductive reasoning processes within design thinking (Cross, 1999). Badke-Schaub and Eris disagree with this assessment of intuition because it assumes intuition does not include inductive or deductive properties. Additionally, they present their own definition of intuition in design as compared to intuition used in other domains (Badke-Schaub & Eris, 2014). The key difference in design intuition is that it is typically used to solve complex, ill-defined problems where the designer will likely use both the intuitive and analytical systems repeatedly over the course of the process.

The work of Badke-Schaub and others made major contributions to understanding where intuition in design is found, and to what extent. In addition to defining design intuition, Badke-Schaub and Eris conducted interviews with 15 expert designers to reflect on intuition in their design processes, and found that designers were capable of identifying instances where intuition played a crucial role in their design process (Badke-Schaub & Eris, 2014). They highlighted nine main themes of intuition in design from these interviews. For example, intuition was discussed as crucial in time-pressured situations, vulnerable to being rejected in team situations due to lack of reasoning, and subject to increasing creativity in the process. Another set of case study interviews across four design disciplines showed five main types of value judgments for decision-making: emotional, intuitive, rational, experience, and constraint-based (Vieira et al., 2010). While rational-based was the leading form of all judgments, the intuition-based priority values were consistently near 15% of all incidents across each discipline. Ling et al. concluded that intuition is mostly used in generating ideas, but also during information searching, concept selection, and presentation (Ling et al., 2014). These interviews also found that designers believe their intuition enhances their work by expanding their knowledge base, combining their interests, and making them sensitive to the details of life. Lastly, designers may elicit their intuition with actions, such as mindless browsing or relaxing. These elicitation processes could be related to creative intuition, where cognitive processes are unconsciously working in the background during this time.

Other studies have emphasized identifying where and how intuition exists in design. Ferronato et al. found intuition dispersed throughout an entire scenario-building process (Ferronato et al., 2017), and Jerrard et al. had five of six participating design firms agree that intuition played a part in new product development (Jerrard et al., 2017). Taura and Nagai show that different types of intuition can exist across the analysis and synthesis phases of a design process (Taura & Nagai, 2017). Analytical design was related to experiential intuition, but synthetic design required associative intuition, where the designer could relate multiple items together in a sensible manner. Cizgen and Uraz similarly create a framework for design intuition, showing that slower intuition is a synthesizing process, but faster types of intuition become more of a matching process. Each type is able to take advantage of the existing knowledge or create new connections (Cizgen & Uraz, 2019).

Ahmed et al. used a think-aloud process to identify when designers used intuition while developing design solutions (Ahmed et al., 2003). To extract intuitive decisions from the data, intuition was defined as when designers made decisions based on previous designs in their experiences, but could not recall exactly when or what designs they were referring to. Yang found that people who self-reported low engineering intuition ability delivered better design outcomes than those who self-reported high engineering intuition abilities, although they did not seek out where it was used during the design activity (Yang, 2005). In the present study, the authors examine the effects of intuitive vs. analytical thinking and mood on design outcomes.

2.2. Problem-solving intuition vs. creative intuition

There have been many types of intuition defined in the literature, as reviewed in the previous section. For this study, the focus is on problem-solving intuition and creative intuition. Dane and Pratt present problem-solving intuition as the most commonly recognized form of intuition. It is sometimes referred to as 'pattern-matching,' and this ability can be improved through repeated use (E. Dane & Pratt, 2009). Problem-solving intuition is known for its speed and convergent nature. Creative intuition is defined as 'linked to a creative act of synthesis in which disparate elements are fused together in novel ways' (E. Dane & Pratt, 2009). Policastro uses four sources of data to recognize the validity of creative intuition: autobiographical testimonies, historical evidence, psychometric assessment, and experimental studies (Policastro, 1995). To this extent, they confirm that creative intuition is an empirically testable process. They highlight creative intuition as phenomenological, in that it relies on the subject's experiences and establishes the preliminary scope of the creative search process. Creative intuition may have similar goals as heuristics, in that both make it possible to search for solutions by pointing toward a promising direction. However, heuristics are more explicit rules of thumb, whereas creative intuition appears as an implicit estimate of the product or goal. An extensive set of studies devoted solely to heuristics in design can be found in the work of Yilmaz, Daly, and others (Daly et al., 2012; Yilmaz & Seifert, 2011; Yilmaz et al., 2016).

Creative intuition differs from problem-solving intuition, because it is searching for novel combinations that are not initially obvious (E. Dane & Pratt, 2009). The impact of emotion or feeling has been noted to be much higher on creative intuition than on problem-solving intuition as well. Sadler-Smith and Shefy (2004) present problem-solving intuition and creative intuition as intuition-of-expertise and intuition-of-feeling, respectively. Additionally, Sadler-Smith et al. (2008) identify contexts, such as entrepreneurship, in which intuition is less aligned with expertise and more aligned with feelings and a need for creativity in order to recognize opportunities. Lastly, creative intuition requires a longer processing time to reach an intuitive judgment. This processing time may occur during a period of incubation. During incubation, there is no concentrated problem-solving, thus allowing time for misleading assumptions to dissolve, unrelated elements to emerge, and new connections to be made within the problem space. Due to the lack of strain that comes with searching for a solution, incubation may also broaden the number of associations made between elements (Claxton, 1998). Baylor identifies a critical research direction for evaluating how the incubation process impacts how one intuitively reorganizes ideas (Baylor, 1997). This is a key motivation for this paper. As designers, it would be beneficial to understand whether an incubation period could lead to better design outcomes when compared to analytical processing and intuition without incubation.

2.3. Mood and creativity

There has been a considerable amount of research done on mood and creativity. For example, Baas et al. showed that positive moods are associated with increased creativity through a synthesis of 102 references (Baas et al., 2008). In another article, Hirt et al. report on three studies that looked at mood and its effects on creativity and cognitive flexibility through a variety of tasks (Hirt et al., 2008). Ashby et al. state that 'positive affect leads to greater cognitive flexibility and facilitates creative problem solving' (Ashby et al., 1999). However, several studies have come to the opposite conclusions, and instead suggest that negative moods (particularly anger) may improve creativity more than positive moods (Akinola & Mendes, 2008; Baas et al., 2011).

Despite the numerous articles associated with mood and creativity, there are relatively few that explicitly address design ability. However, empathy and creativity are addressed quite often in the field of design. In one example, student creativity was assessed after briefing participants on the difficulties suffered by those with visual impairments (Raviselvam et al., 2016). Genco et al. found that participants exposed to an Empathic Experience Design (EED) method showed improved design originality (Genco et al., 2011), while Johnson et al. further showed that this empathic method improves design originality without decreasing design feasibility (D. G. D. G. Johnson et al., 2014). In these examples, increases in designer creativity are correlated with increased customer empathy, but empathy is not exactly an emotional response, in and of itself; rather, it is the capacity to respond to someone else's emotional state. In contrast, this study focuses on an individual's own longer-term emotional state (or mood) as it relates to design.

Because this is a study of the impact of mood, it is important to note some distinctions between mood and emotion, which are often used interchangeably. Emotions are intense, short-term feelings. They typically develop quickly from a single cause (Desmet et al., 2016). Moods are less intense, longer-term feelings that can last days and influence all of one's responses during that time. They gradually arise over several events, rather than one specific cause. Desmet developed a popular tool, PrEmo, that measures the emotions of participants who have just interacted with a product. PrEmo is a set of 14 emotional responses in picture form, where participants rate whether the product made them feel the emotion shown in the image (Desmet, 2003). Some studies use emotion-inducing methods, instead of measuring a current emotional state. For example, Akinola manipulated emotional responses by assigning participants to social acceptance, rejection, or nonsocial environments (Akinola & Mendes, 2008). Participants gave a speech, either to an empty room or to a panel that accepted or rejected their performance. Hirt played videos meant to induce happy, sad, or neutral feelings, then asked participants to rate themselves on a Likert scale for various affect adjectives (Hirt et al., 2008). This type of induction process is not necessary for this study, as the authors are not targeting one specific mood to be manipulated.

There are many mood measurement tools that could have been chosen for this study. For example, PANAS-X uses a survey of 60 mood descriptors to measure 11 mood types, categorized as positive or negative affect (Watson & Clark, 1999). Desmet has produced the Pick-a-Mood method, which presents eight moods categorized into four mood states: calm-pleasant, energized-pleasant, calm-unpleasant, energized-unpleasant (Desmet et al., 2016, 2012). This is a more recent creation that has not been used as extensively in design as the PrEmo method.

As previously mentioned, the Brunel Mood Scale (BRUMS) was used to measure participant mood during this study (Terry et al., 2003, 1999). The Brunel Mood Scale (BRUMS) is a self-reported assessment, derived from Profile of Mood States (POMS) assessment. It is used to measure eight mood states of a person within the past week, up to the day it is completed. Many studies have validated the effectiveness of this instrument for assessing mood (Brandt et al., 2016, 2010). The scale has been used in a wide variety of contexts: Malaysian Athletes (Hashim et al., 2010; Lan et al., 2012), water-skiing competitions (Fazackerley et al., 2003), Chinese adolescents (Zhang et al., 2014), and pregnant women (Keen et al., 2017). In this study, BRUMS is implemented to investigate whether or not mood affects design outcomes in any or all of the three experimental conditions. This approach is novel in engineering design research, and could offer unique insights into design outcomes that contribute to a larger body of research on design outcomes and empathic design.

3. Methods

This section describes the experimental method, summarized in Figure 1, employed to conduct this study of the effect of mood, intuition, and rational ability on design quality and feasibility. This procedure is explained further in the subsections that follow.

3.1. Participants

Data was collected with 26 participants at Georgia Institute of Technology in Atlanta, GA, USA. These participants comprised junior and senior-level undergraduate students with a background in either industrial or mechanical engineering design, or both. Participants included 16 men and 10 women. The average amount of design experience among the participants was 2.37 years, with a standard deviation of 1.24 years. Additional demographic data describing the participant pool can be found below in Figure 2, 3, and 4.

3.2. Study design

The study duration was 75 min. First, participants were asked to complete a demographic survey and a BRUMS mood assessment. Then, they completed nine 7-min design tasks across three experimental conditions, with three tasks per condition. Nine tasks were used in order to reduce problem-specific effects on experimental outcomes that can occur when only one design problem is used, or when design problems are coupled with conditions. Participants were given 7 min per design task to induce intuitive thinking, as it is defined to occur under shorter time scales (E. Dane

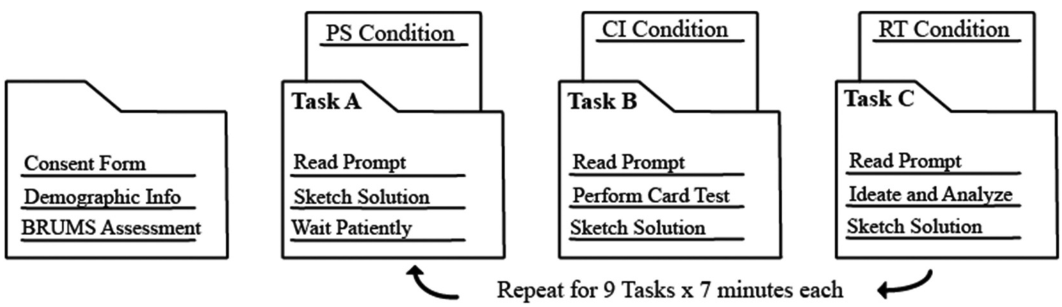

Figure 1. Overview of the Experiment Process.

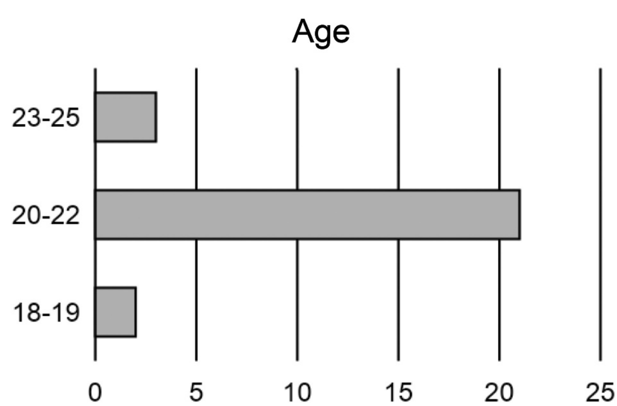

Figure 2. Age Distribution of Participants.

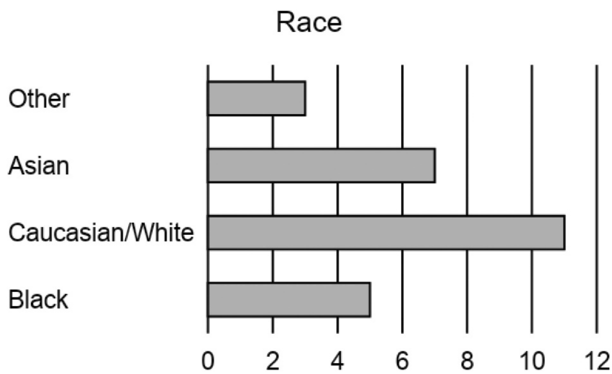

Figure 3. Race Distribution of Participants.

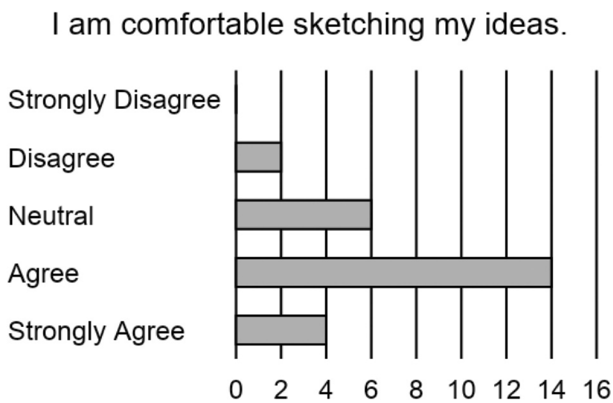

Figure 4. Level of Comfort with Sketching of Participants.

& Pratt, 2009). Pilot studies were conducted to confirm the appropriateness of this time scale for design task completion. Further information about the timing of the experimental design for each condition is described in Section 3.3 and Figure 5. Compensation was provided to participants in the amount of 25 USD after completion of the study.

The BRUMS mood assessment includes 32 mood adjectives, which are self-reported using a 5-point Likert scale from 0 to 4 (0 = Not at all, 1 = A Little, 2 = Moderately, 3 = Quite a Bit, 4 = Extremely). These 32 adjectives are divided into eight categories. Each participant's category

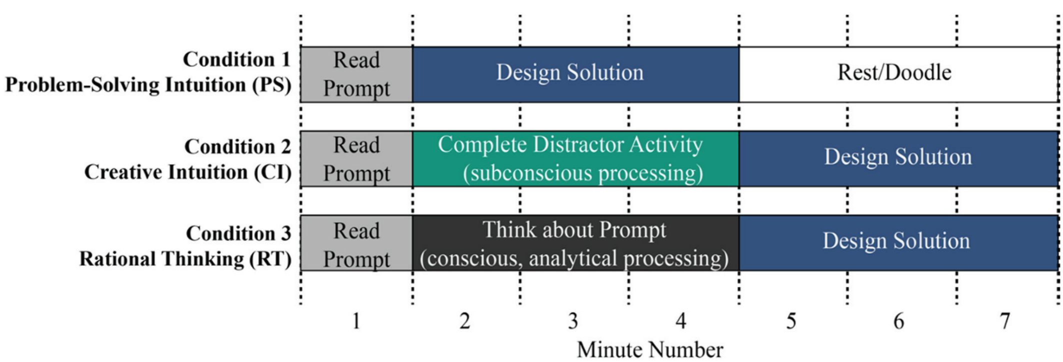

Figure 5. An overview of all three conditions, highlighting variations in experience after exposure to the design tasks.

scores are the sum of the adjectives associated with that category. The BRUMS-32 mood adjectives and mood categories are highlighted in Tables 1 and 2, separated by negative and positive affects. The BRUMS-32 assessment was employed, rather than the BRUMS-24, because it includes a more even balance of positive and negative moods. BRUMS-32 includes all moods from the BRUMS-24 assessment, plus 8 additional adjectives for calmness and vigor. Note that mood categories are differentiated from mood adjectives in this paper by using all capital letters to describe categories.

Cronbach's Alpha was used to measure scale reliability, or how closely related a set of items are as a group, for BRUMS. The reliability coefficient of $\alpha \geq 0.7$ has been considered acceptable in most social science research (Tavakol & Dennick, 2011). Cronbach's alpha was computed as the following for each mood category: ANGER ($\alpha = 0.836$), TENSION ($\alpha = 0.832$), DEPRESSION ($\alpha = 0.775$), CONFUSION ($\alpha = 0.648$), FATIGUE ($\alpha = 0.797$), HAPPINESS ($\alpha = 0.856$), CALMNESS ($\alpha = 0.756$), and VIGOR ($\alpha = 0.814$). CONFUSION is omitted for data analysis as its internal consistency is considered questionable ($a < 0.7$). CONFUSION has been excluded in other studies as well, due to questionable internal consistency using Cronbach's alpha (A. M. A. M. Lane et al., 2007), and also due to the fact that it is not necessarily a mood but a state-of-being.

After completing the BRUMS assessment, participants completed nine design tasks, with three tasks in each condition. Each task (labeled A – I) included a design prompt that asked the participants to design a product with particular functions specified. Each task packet included the prompt, timing information, condition-specific instructions, and room on the page for the participants to sketch their solution. These design tasks are specified below in Table 3.

3.3. Experimental conditions

The design tasks were structured to follow three types of thinking conditions: Problem Solving Intuition (PS), Creative Intuition (CI), and Rational Thinking (RT). The comparative timing of the design task activities across the three conditions is shown below in Figure 5.

3.3.1. Condition 1: problem-solving intuition condition (PS condition)

The PS condition was structured using the direct intrusion method (E. Dane & Pratt, 2009). This method requires immediate decision-making without a chance to think at length about a topic. The

Table 1. An overview of all negative mood adjectives that participants scored 1–4 and the corresponding negative mood categories (shown in all caps).

	Negative Affect				
	Negative Moods				
Mood Categories	ANGER	TENSION	DEPRESSION	CONFUSION	FATIGUE
Negative Mood Adjectives	Angry Annoyed Bad-Tempered Bitter	Anxious Nervous Panicky Worried	Depressed Downhearted Miserable Unhappy	Confused Uncertain Mixed-Up Muddled	Exhausted Sleepy Tired Worn-Out

Table 2. An overview of all positive mood adjectives that participants scored 1–4 and the corresponding positive mood categories (shown in all caps).

	Positive Affect		
	Positive Moods		
Mood Categories	HAPPINESS	CALMNESS	VIGOR
Positive Mood Adjectives	Cheerful Contented Happy Satisfied	Calm Composed Relaxed Restful	Active Alert Energetic Lively

Table 3. Design Tasks A-I.

Design Tasks
A Design a device to safely store people's' wallets and phones and protect them from theft on the beach. The device should: ● Make it more difficult for a thief to gain access to someone's wallet or phone that was left on the beach. ● Allow the owners to get back their things whenever they want. ● Be compatible with the beach and should perform in sand.
B Design a suitcase that has a mechanism by which it can weigh itself for the purpose of assisting people in packing for flights. ● The suitcase should display its total weight, including the weight of the suitcase itself and its contents. ● The suitcase itself should not exceed 50 lbs, the average accepted weight for checked bags with no additional charge. ● The suitcase should provide as much room as a standard suitcase and should be as easily used as one.
C Design a portable device for backpackers to sit on while camping so they do not have to sit on the ground. ● The device should weigh less than 5 pounds. ● The device should be compact and fit inside a backpack or attach to the outside. ● The device should support a person weighing up to 200 pounds.
D Design a new way to amplify sound for use in roadside emergencies to alert other drivers of your position and need for assistance. ● The new method should be portable. ● The new method should not require any electrical energy.
E Design a water carrying mechanism for hikers that: ● Allows them to carry at least 2 liters of water. ● Is not carried by hand.
F Design a method for clearing snow from a pathway that: ● Requires minimal/no exertion. ● Works on different terrains like concrete or grass.
G Design a way for at least four people to listen to the same music together: ● Without playing the music aloud. ● Without needing to sit incredibly close together.
H Design a device to capture trash, recyclables and compost that: ● Separates the three types of refuse from each other. ● Facilitates materials getting to their designated section.
I Design a mechanism to distribute free wifi throughout Midtown Atlanta for tourists traveling without cellphone network. ● The mechanism should blend into the neighborhood's design. ● It should not require a password to use the wifi. ● It should be translatable to multiple neighborhoods.

structure of the PS condition included 1 min to read the design prompt, 3 min to sketch a solution, and 3 min to doodle or rest silently.

3.3.2. Condition 2: creative intuition condition (CI condition)

The CI condition was structured using Dijeksterhuis et al.'s incubation method (Dijksterhuis et al., 2006), in which a distractor task is incorporated after the problem is presented to cultivate the subconscious thought that is considered to be a part of intuition (E. Dane & Pratt, 2009). After the distractor task, the participant is asked to develop the solution. The structure of the CI condition included 1 min to read the design prompt, 3 min to do a Card Rotation Test, and 3 min to sketch a solution. The Card Rotation Test (Ekstrom et al., 1976) is a two part 3 min timed test that measures 2-D spatial orientation. Each part consists of 10 items. The test assesses the participant's cognitive spatial ability, which can be seen as a distractor task due to solution formulation being the main focus for the design tasks. One part of the test was a suitable candidate for a distractor task because it is the same length as the needed distractor task time. It is used so that the participant will focus on their spatial knowledge while subconsciously thinking about the design solution.

3.3.3. Condition 3: rational thinking condition (RT condition)

The RT condition was structured to cultivate reasoning with rational thinking by allowing the participant time to think about the design without drafting the solution immediately. The structure of the RT condition included 1 min to read the design prompt, 3 min to think about the design, and 3 min to sketch a solution.

Table 4. Design Tasks Randomized Packet Example (PS, CI, and RT correspond to experimental condition; Letters A-I correspond to design task).

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9
Participant 1	PS-E	PS-H	CI-F	PS-C	CI-D	RT-G	RT-A	CI-B	RT-I
Participant 2	RT-F	CI-E	CI-G	CI-B	PS-C	RT-H	RT-D	PS-A	PS-I

Each participant received an envelope with three PS condition design tasks, three CI condition design tasks, and three RT condition design tasks. These tasks were randomly presented to the participant by the order and condition of the task (i.e., one participant might receive condition PS – design task A, and another might receive condition PS – design task B). The two-fold randomization was done to eliminate the possibility that the quality and feasibility of a design solution was caused by the task-condition pair or the particular design task order. Table 4 shows an example of two participant packets.

4. Design outcome metrics

Each of the nine design prompts asked participants to generate an idea to solve a given design problem, and listed the problem's corresponding functional requirements. Each design task was different and chosen to be unique compared to the others. Each design task product of each of the 26 participants was scored by a graduate-level engineering design researcher, based on design quality and feasibility. An inter-rater agreement process was conducted by a second graduate-level engineering design researcher, to assure that homogeneity existed in the scores and the metrics were robust.

4.1. Quality

Quality is often evaluated in design research using a rubric developed based upon the requirements of the given design prompt (Chan et al., 2011; Fu et al., 2013). This method was employed here, with a unique quality rubric developed for each design task. Quality was scored based on whether the design solution fully or partially incorporated the given functional requirements. The design solutions were scored using a 3-point scale for each attribute in the rubric. Each attribute received a −1, 0, or 1, where 1 means that the design incorporated that requirement, and −1 means that the design did not meet that requirement at all. An example quality rubric is shown below in Table 5, used for evaluating design solutions to Design Task F.

Table 5. Example Quality Metric Scoring Scale for Task F.

DESIGN TASK F: Design a method for clearing snow from a pathway that requires minimal/no exertion and works on different terrains like concrete or grass.			
Attribute/ Rating	−1	0	1
Exertion required	A large amount of exertion from the user is required to use this design, or it is not possible to perform task	Some exertion from the user is required to use design	Minimal to no exertion is required to use design
Terrain performance	Does not work on concrete or grass	Performs well on concrete or grass, but not both	Works on both concrete and grass

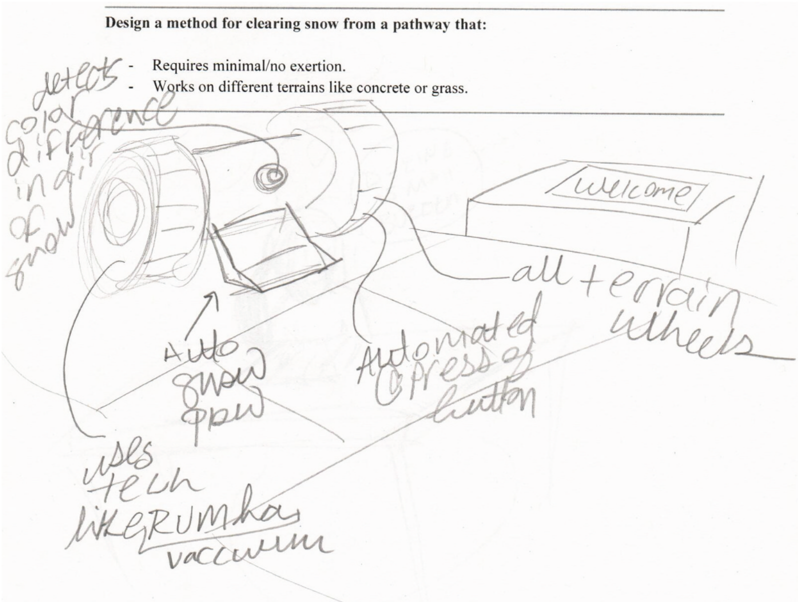

Figure 6. Problem Solving Condition design solution for Task F.

The process of scoring the quality of a design solution for Design Task F was to check the attribute against the solution, give the necessary ratings for both attributes, and sum the ratings of both attributes. For Task F, a participant's solution is shown in Figure 6.

The solution the participants developed was an automated snowplow with all-terrain wheels and vacuum-like properties. This solution does not require exertion from a user due to its automated trigger; therefore, the quality was rated 1 for this attribute. The solution has all-terrain wheels, which means the system should work on concrete and grass; therefore, the quality was rated 1 for this attribute. The sum of the two categories was 2, and this sum was used for statistical analysis.

4.2. Feasibility

Feasibility was scored based on whether the design was feasible for the specific function outlined in the design prompt. This was assessed using a 4-point scale, created by Linsey (2007), depicted in Figure 7. This method of measurement allows the scorer to judge whether the design is complicated due to the given context or due to its technical feasibility.

Referencing the example design solution shown Figure 6, the design is feasible as an automated snowplow with minimal exertion; however, since there is no existing idea similar to the design, the feasibility score given, based on the metric in Figure 7, was 7.

5. Results

The data in this study covered a breadth of personal characteristics and performance metrics. As previously noted, each participant completed the Brunel Mood Scale. Individual scores were calculated for each assessment. Each of the 26 participants produced nine design solution sketches, resulting in a total of 234 solution sketches. The solutions were grouped by design task (A – I) and received individual scores for quality and feasibility. Scores for design tasks within the same condition were averaged to calculate the participants' average quality and feasibility scores by condition.

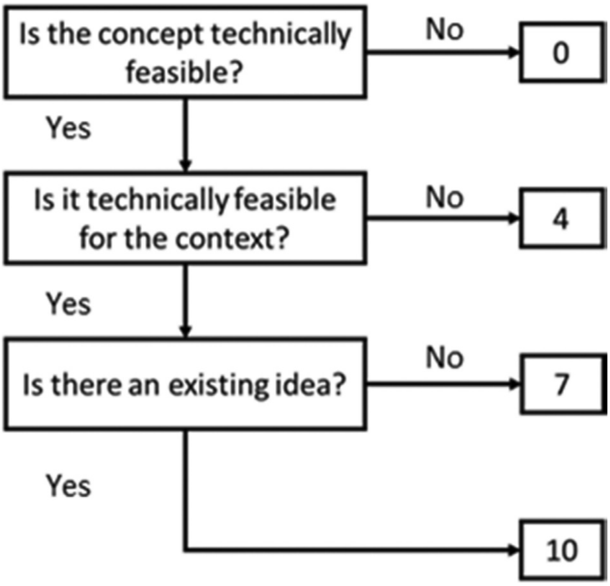

Figure 7. Feasibility Metric.

5.1. Inter-rater agreement

Two individual coders, graduate-level engineering design researchers, scored quality and feasibility in order to measure inter-rater agreement using Cohen's Kappa. A good rating of agreement was achieved for all Design Tasks, as shown in Table 6. For quality, the average was κ = 0.726 for all nine design tasks. For feasibility, the overall agreement was κ = 0.613. Because the design space was small, inter-rater agreement was perfect for Task G. All disagreements between the two coders were resolved through discussion, and the results were used for analysis.

5.2. Rational vs. intuitive thinking and design outcomes

As discussed earlier, the study included three conditions to investigate the relationship between rational versus intuitive thinking and design outcomes. Participants relied on problem-solving intuition, creative intuition, and rational thinking in their respective experimental conditions. Each participant completed all nine design tasks with three design tasks per condition, allowing for a within-subjects quantitative analysis of performance. The average quality of design solutions by condition is shown in Figure 8, and the average feasibility of design solutions by condition is shown

Table 6. Inter-rater Agreement (Cohen's Kappa) by Design Task.

Design Task	K	Strength
A	0.649	Excellent
B	0.600	Good
C	0.593	Fair
D	0.754	Excellent
E	0.666	Good
F	0.833	Excellent
G	1.000	Excellent
H	0.671	Good
I	0.761	Excellent

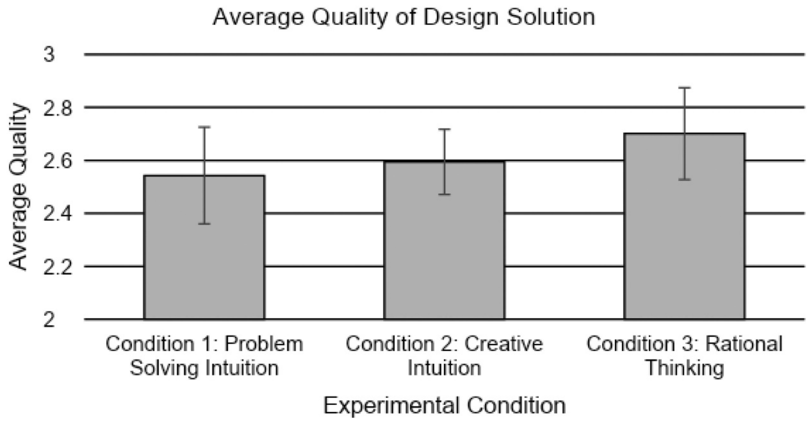

Figure 8. Average Quality of Design Solution by Condition, Error Bars Show ± One Standard Error, n = 26.

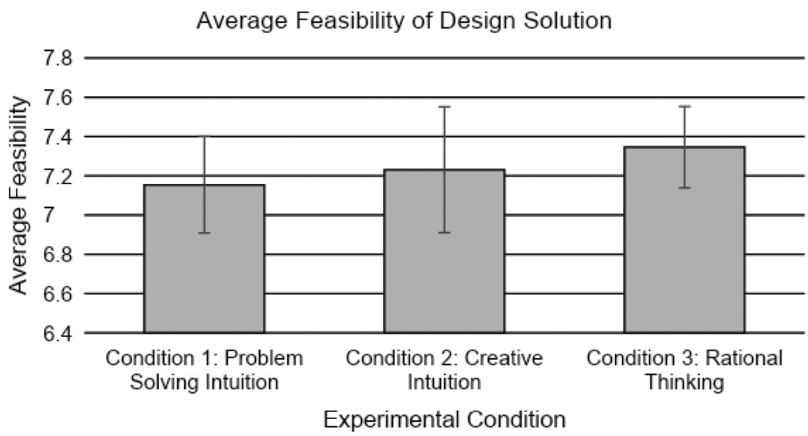

Figure 9. Average Feasibility of Design Solution by Condition, Error Bars Show ± One Standard Error, n = 2.

in Figure 9. No significant differences were found between the three conditions for the quality or feasibility of the design solutions.

5.3. Mood and design outcomes

Spearman's rank correlation is used to illustrate the mood-design outcome relationship (strength and direction), done at the mood category and individual mood adjective level, conducted using SPSS v24. Spearman's correlation was used to test how one ranked (mood) and one measurement variable is associated while taking into account non-normality. To implement this analysis, each of the measured variables was converted into ranks, from 1 for the highest measured variable to 26 for the lowest measured variable, and Spearman's rank correlation was applied to the two sets of ranked variables. This enabled the analysis of correlations of participants' moods (seven mood categories and 28 mood adjectives) with quality and feasibility scores of design outcomes in the three conditions (Problem Solving, Creative Intuition, and Rational Thinking). The correlation results are shown in Table 7. Correlations between mood categories were also determined, as shown in Table 8. The significant correlations from the individual mood category and adjective analysis are shown in Figures 10 and 11 for quality and feasibility, respectively.

Table 7. Correlations between Mood Category (all caps) and Adjectives Scores and Design Outcomes.

	Quality			Feasibility		
Moods	Condition 1 Problem Solving Intuition	Condition 2 Creative Intuition	Condition 3 Rational Thinking	Condition 1 Problem Solving Intuition	Condition 2 Creative Intuition	Condition 3 Rational Thinking
ANGER	0.068	−0.237	−0.266	−0.095	0.163	0.075
Angry	−0.020	−0.23	−0.166	−0.047	0.039	−0.102
Annoyed	−0.041	−0.134	−0.149	−0.257	0.314	0.246
Bad-tempered	0.361	−0.393*	−0.372	0.153	−0.071	0.072
Bitter	0.101	−0.072	−0.341	−0.057	0.026	−0.224
TENSION	−0.003	−0.223	−0.086	−0.018	−0.034	−0.245
Anxious	−0.015	0.019	−0.147	0.076	0.145	−0.117
Nervous	0.093	−0.197	0.091	−0.121	−0.096	−0.109
Panicky	−0.161	−0.323	0.150	0.057	−0.16	−0.014
Worried	0.035	−0.362	−0.204	0.005	0.029	−0.267
DEPRESSION	0.025	−0.483*	−0.235	0.082	−0.100	−0.004
Depressed	−0.049	−0.329	−0.396*	0.047	0.032	0.075
Downhearted	0.436*	−0.345	−0.118	0.357	0.040	−0.017
Miserable	0.006	−0.368	0.032	−0.108	−0.291	0.023
Unhappy	−0.220	−0.376	−0.045	−0.042	−0.123	−0.141
FATIGUE	−0.109	−0.231	−0.114	−0.193	0.069	0.172
Exhausted	−0.029	−0.035	0.137	−0.017	0.248	0.391*
Sleepy	−0.386	0.004	−0.044	−0.264	−0.066	0.111
Tired	−0.043	−0.274	−0.092	−0.082	0.061	0.281
Worn-out	−0.112	−0.509*	−0.204	−0.201	−0.026	0.035
HAPPINESS	0.213	0.011	0.204	−0.001	−0.164	−0.004
Cheerful	0.044	−0.026	0.383	−0.106	−0.165	−0.018
Contented	0.135	−0.114	0.163	0.038	−0.178	−0.008
Happy	0.291	0.159	0.099	0.043	−0.132	−0.274
Satisfied	0.227	0.158	0.173	−0.056	−0.141	0.108
CALMNESS	0.305	0.008	0.023	−0.044	−0.344	0.090
Calm	0.094	0.010	0.047	−0.210	−0.295	−0.073
Composed	0.155	−0.191	0.131	−0.155	−0.391*	0.208
Relaxed	0.300	−0.027	−0.132	−0.092	−0.443*	−0.105
Restful	0.289	0.113	0.055	0.073	−0.108	0.084
VIGOR	0.056	0.460*	0.102	−0.201	−0.344	0.090
Active	−0.045	0.361	−0.090	−0.041	0.088	0.034
Alert	0.147	0.116	−0.179	0.008	−0.076	0.007
Energetic	−0.081	0.531*	0.100	−0.245	0.097	−0.058
Lively	0.205	0.300	0.179	−0.275	−0.156	0.027

*$p < 0.05$

Table 8. Correlations among Mood Category Scores.

	ANGER	TENSION	DEPRESSION	FATIGUE	HAPPINESS	CALMNESS	VIGOR
ANGER							
TENSION	0.491*						
DEPRESSION	0.676**	0.516**					
FATIGUE	0.449*	0.556	0.574**				
HAPPINESS	−0.111	−0.157	−0.182	−0.417			
CALMNESS	−0.048	−0.285	−0.174	−0.414*	0.469*		
VIGOR	−0.029	−0.185	−0.403*	−0.545	0.556**	0.393	

*$p < 0.05$
*$p < 0.01$

High design solution quality was found to be significantly positively correlated with VIGOR and energetic mood in the Creative Intuition condition, and with downhearted mood in the Problem Solving Intuition condition. High design solution quality was significantly negatively correlated with DEPRESSION and worn-out and bad-tempered moods in the Creative Intuition condition. In addition, high design solution quality was significantly positively correlated with downhearted

Figure 10. Significant Correlations between Mood Categories (all caps) and Adjectives and Quality of Design Solutions by Condition.

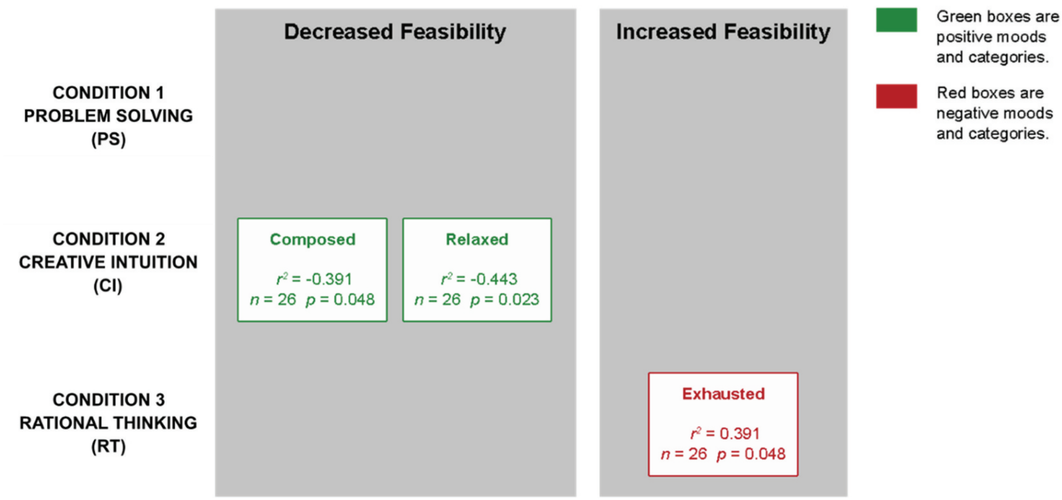

Figure 11. Significant Correlations between Mood Adjectives and Feasibility of Design Solutions by Condition.

mood in the Problem Solving Intuition condition, and significantly negatively correlated with depressed mood in the Rational Thinking condition. High design solution feasibility was positively correlated with exhausted mood in the Rational Thinking condition, and significantly negatively correlated with composed and relaxed moods in the Creative Intuition condition. Correlations between mood categories show that those who experienced negative emotions did not experience many positive moods over the time frame that was considered in the BRUMS assessment. DEPRESSION is positively correlated with ANGER, TENSION, and FATIGUE. The negative moods of DEPRESSION and FATIGUE were inversely correlated with the positive moods of CALMNESS and VIGOR. Participants that experienced CALMNESS and VIGOR also experienced HAPPINESS.

6. Discussion

In this study, the aim was to explore the relationships between self-reported mood and intuition with the quality and feasibility of design solutions. Two hypotheses were tested that explored design outcomes, mood, and intuition. The results reveal these three factors are linked, and the exploration of mood and design may introduce considerations for design education and practice.

6.1. Intuition and design outcomes

To examine the relationship between intuition and design outcomes, the following research question and hypothesis were posed:

> **Research Question 1**:How do intuitive and analytical task conditions impact the quality and feasibility of design solutions?

Hypothesis 1:The Problem Solving Intuition condition will yield the highest quality and feasibility scores for design solutions generated, while the Rational Thinking condition will yield lower scores than the Creative Intuition condition.

The differences between the three conditions were not statistically significant; thus, hypothesis 1 was not supported. However, time to process has been shown to impact quality and feasibility for a variety of reasons. In the previous work with mechanical engineering students, Tseng et al. (2008) found that open goals in problem-solving led to better recognition and bias toward identifying relevant information (p. 215). An open goal in problem-solving can be defined as 'a goal which has been set but one for which the associated tasks have not been completed' (Moss et al., 2007b, p. 1817). In addition, they found that the timing of available information directly impacted the novelty of design solutions (p. 212). Although participants did not receive additional information in the present study, processing time after exposure to the design task could create space for participants to draw from personal experiences and prior knowledge (actively or passively).

The two intuition conditions were not statistically different in quality and feasibility. The conditions were designed to induce creative intuition and problem-solving intuition. Prior studies show that goals activate relevant memories and 'open goals persist as sources of activation, even when people move on to other tasks' (Moss et al., 2007a, p. 888). The Card Rotation Test was intended to induce incubation and open goals in this way. Alternatively, incubation time can provide space for 'erroneous [solutions] to die out and leave the[m] free to take a fresh look at the problem' (Smith & Blankenship, 1991, p. 63; Woodworth & Schlosberg, 1954, p. 841). While these conditions did not produce statistically significant results, the data did indicate that they were modulated by mood in a significant way, discussed next.

6.2. Mood and design outcomes

To examine the relationship between mood and design outcomes, the following research question and hypothesis were posed:

> **Research Question 2**:What role does mood play in designer outcomes, such as quality and feasibility of design solutions?

Hypothesis 2:Positive moods (such as HAPPINESS and CALMNESS) were expected to correlate with better design quality and feasibility, while negative moods (such as ANGER and FATIGUE) were expected to correlate with lower scores.

Two specific mood categories correlated significantly with the quality of design solutions: VIGOR and DEPRESSION. VIGOR is positively correlated with design quality in the Creative Intuition condition. DEPRESSION is negatively correlated with design quality in the Creative Intuition condition. In addition, in the Creative Intuition condition, energetic moods positively correlated with higher quality design outcomes, while worn-out and bad-tempered moods negatively correlated with higher quality design outcomes. This condition relied on a distractor task to induce incubation, and these results suggest that subconscious intuition is more beneficial to shorter-term design outcomes when one is feeling more positive emotions. This could be due to fixation on negative emotions causing negative rumination during incubation, leading to the lower quality performance when compared to positive moods. There is an opportunity to follow up on this work with neuroscientific studies of mood, intuition and outcomes of design problem-solving to gain a better picture of the brain activation patterns of individual designers over the course of problem-solving.

Depressed moods are negatively correlated with high-quality design outcomes in the Rational Thinking condition. Downhearted moods are positively correlated with high-quality design outcomes in the Problem Solving Intuition condition. These findings are supported by a study by Vosburg (1998), in which it was shown that 'task performance under satisficing requirements was facilitated by positive mood and inhibited by negative mood' after a mood assessment and completion of divergent thinking tasks.

There were no significant correlations between mood categories and design solution feasibility, but individual moods did show statistically significant correlations. High feasibility is negatively correlated with composed and relaxed moods in the Creative Intuition condition. This suggests that intuitive thinking while calm and collected may hinder the tendency to consider feasibility in design. Exhaustion, a negative mood, is positively correlated with higher feasibility design solutions in the Rational Thinking condition. This suggests that when one is exhausted and has time to think about a design, one is likely to develop a solution that already exists (a 10 on the feasibility metric) and make modifications to the existing design. The feasibility metric used in this work is biased against novel solutions, and toward more incremental advancement in design, although this matches the assessment that if a design has been created previously, it will be more feasible to create again.

6.3. Implications for design

This study shows no statistically significant difference in design quality and feasibility with respect to the intuitive conditions that were manipulated. The results imply that, just as there is no one best method to perform ideation, there is also no one best way to incorporate one's intuition into the design process. Instead, the designer should tailor the use of intuition to their own personal traits. In this case, mood is the state designers can use to determine the use of one form of intuition over another. For simplification, the moods can be viewed through the categorization performed by Desmet et al. (2012), where mood is considered a combination of two axes: an energized-calm axis and a pleasant-unpleasant axis. This gives four different quadrants of mood states: energized-pleasant, energized-unpleasant, calm-pleasant, and calm-unpleasant. It is worthwhile to consider the creative intuition condition as moods move across the four quadrants. Results shown in Figure 10–11 indicate that design quality benefits from energetic-pleasant mood categories (Vigor) and suffers from calm-unpleasant mood categories (Depression). While calm-unpleasant moods perform poorly in creative intuition, they may have some advantages in problem-solving intuition and rational analysis. Two descriptors of fatigue (worn-out and exhausted) result in increased quality and increased feasibility, respectively. This fatigue likely led participants to use solutions they were aware of that addressed similar design problems, which meant they had a feasible idea that already met some of the design requirements. This data suggests that a designer may benefit from processing information through incubation if they find themselves in more energetic-pleasant mood states, but may want to try a different approach when they are in an unpleasant mood state.

Pleasant moods have mixed results with creative intuition. While the energetic-pleasant moods were associated with increased quality, calm-pleasant mood adjectives were found to decrease feasibility. As previously mentioned, the feasibility metric tends to bias against more novel designs due to the lack of prior technical implementation. This means that while the calm-pleasant moods decreased feasibility, they may also increase novelty. The calm-pleasant moods and their impact on novelty could be explored in future studies. If this relationship is true, then the designer may choose to activate creative intuition for all pleasant moods, depending on the goal they have in mind. The goal of a high quality, feasible idea would be best achieved when experiencing energetic-pleasant moods, while the goal of a more novel approach to the solution would be best achieved when in calm-pleasant moods.

As this study was performed with novice designers (i.e., design students), any potential implications for design practice are limited in scope or generalizability for this population. The findings presented in Section 5.2 imply that novice designers may cultivate better design outcomes by manipulating their mood state, along with the way they process information. To generate rational thinking environments, novice designers could be encouraged to sit and think instead of rushing to develop a design solution for problems that may be given. As higher feasibility was found for exhausted moods in the Rational Thinking condition, novice designers could consider focusing on generating feasible design solutions toward the end of their day or working session, at which time they may feel more tired and be more likely to produce feasible solutions. To generate creative intuition environments, they can be encouraged to engage in tasks unrelated to the design problem while incubation on the design task occurs. This 'distraction' does not have to be a test such as the Card Rotation Test, but rather any age-appropriate, low-cognitive load task that allows the subconscious intuition to evolve and suggest creative solutions. Given that more energetic-pleasant moods with incubation led to statistically significantly higher quality design solutions, a distractor task to consider could be one that invigorates the novice designer, such as a brisk walk, as a way to create this mood state if it is not already present. This idea is in line with previous work linking physical activity to increased creativity. More specifically, activities such as arm movement and walking have been shown to increase creativity and not analytical thought (Kuo & Yeh, 2016; Oppezzo & Schwartz, 2014; Slepian & Ambady, 2012).

Considering mood in the classroom or during design activities may be useful for educators when selecting activity types, methods, or other curricular materials. Novice designers could be encouraged to use mood to their advantage when selecting a mode of cognitive processing. In this study, unpleasant moods, such as fatigue and depression, were primary factors affecting design outcomes in a negative way. It would be advantageous to adjust to a more positive mood, since positive moods were shown to increase design quality in this study. Overall, these findings show the importance of considering mood during engineering design because it can affect the quality of design outcomes as related to intuitive problem-solving strategies.

7. Limitations

This study focuses on design quality and feasibility, and how they relate to intuitive vs. rational thinking and mood. Methods were employed to capture two of the many types of intuition: problem-solving and creative intuition. As with any laboratory study of design, short-term design problem-solving may not directly mimic real-world design practices. Nonetheless, the study of design in laboratory settings is a valuable format to advance the knowledge and understanding of design cognition.

The problem-solving method is tested through direct intrusion, but Dane and Pratt (2009) suggest that it is difficult to assess whether intuition is being employed or not; it is assumed. This assumption comes from the definition of the direct intrusion method, in which the participant is given a design problem and must immediately offer a solution, although, in intuition research, researchers typically assume intuition is employed when asked for an immediate request for an answer. Dane et al. (2012) used the method of immediacy in their study by allowing the participants with a shortened period of time (5 seconds) to think about a problem intuitively compared to a longer period (30 seconds) to think analytically (or rationally). The study showed that there are two distinct modes of thinking associated with time. In this study, immediacy is reflected through timing, and intuition occurs immediately with no planning (Baylor, 1997), but there is a possibility that the participant is using their analytical skills in the short time allotted to come up with the solution, rather than their intuition. The assumption that intuitive thinking was induced is common in studies of intuition.

The incubation method is used for creative intuition. One could challenge the contribution of intuition, rather than analysis of the situation, while the distractor task is being completed by the participant to cultivate the subconscious thought (E. Dane & Pratt, 2009). This method assumes that intuition is primarily used to develop the solution after the distractor task. Although uncertainties exist regarding the intended effects of the interventions, the study results are consistent with others' findings regarding intuition and creativity in multiple fields (Dorfman et al., 1996; Wallas, 1926). Again, the assumption that these conditions produced this effect is common in studies of intuition.

There is a distinct difference in the granularity of the analysis of the research questions set forth in the paper. The difference in granularity is due to the methods by which the variables of the experiment had to be obtained. For Research Question 1, the intuitive/analytical thinking conditions are being examined, and there is no direct way to assess whether a person employed the particular thinking method, other than following the protocols set forth by vetted prior research. The research question was analyzed to a level that only included the quantitative correlation of the design metrics to one type of variable – the task conditions. This produced one level of analysis, compared to the in-depth analysis of Research Question 2. For Research Question 2, the level of granularity reached for the mood analysis is different because of the initial method of information about mood obtained through the BRUMS survey, and comparing the results to the task conditions and design methods. The analysis of the results relating to Research Question 2 included the correlation of three factors: mood, task conditions, and design metrics.

BRUMS is used to understand short-term moods, rather than long-term moods. This study captures a short-term mood sequence (over the span of 2 weeks) that is self-reported by the user. Self-assessment metrics have been deemed appropriate for analysis, but come with their own set of limitations due to reliance on the perception and self-awareness of the respondent. Future work could examine the impact of long-term moods of participants on design outcomes.

The design tasks vary in scope; therefore, they may not be a true representation of things one would create in an in situ design environment. Some tasks, such as Task I, had very broad requirements, potentially leading to different interpretations by participants. In addition, the design tasks may not have been in an area that students were familiar with, so their solutions may have lacked quality or feasibility due to their unfamiliarity with a situation or problem.

Participants could have recognized the patterns in the way the packets gave directions, so they could have started to think about the problem before they were expected to do so. There are only two pages of the Card Rotation Test that could be given to the students and three tasks within the corresponding condition. If they were given the same test twice, the participant may have been able to complete the test faster than 3 min, allowing them to consciously think about the design problem for a longer period time. This has the potential to affect the ability of the incubation intervention to induce subconscious processing.

Finally, participants have had design experience and rigorous design coursework in engineering and/or industrial design. However, as the participant pool is comprised of students, the findings cannot be generalized to those with no design experience at all, nor to those with many years of design experience.

8. Conclusion

The study presents new findings on the impact of mood and intuitive vs. rational thinking on design outcomes. The three experimental conditions manipulated the type of thinking employed during problem-solving, including problem-solving intuition, creative intuition, and rational thinking. The Brunel Mood Scale gathered self-reported mood data from participants. Intuition and mood were then correlated with quality and feasibility of design outcomes. Energetic-pleasant moods promoted higher quality design solutions during intuitive thinking, and unpleasant moods hindered design quality during intuitive thinking. Exhausted moods led to more feasible designs during rational thinking, while composed and relaxed moods led to less feasible designs during creative intuition thinking. The contribution of this study is its unique perspective on intuition and mood in design. Many prior studies have contributed to understanding when and how intuition is used in the design process. This study sought to shed light on which type(s) of thinking, if any, use intuition most effectively. Additionally, prior studies have focused more on how a design manipulates the emotions of the end-user, whereas this study sought to understand how the designer's own mood may influence design outcomes. While there was no significant correlation between the types of thinking for using intuition and design outcomes, there was a difference in results when considering the mood of the designer. By considering mood states and intuition-based thinking types during design, design outcomes may be improved for novice designers. Future work includes exploring the impact of long-term moods on design outcomes, and examining the impact of intuition and mood in expert design outcomes. This work explores two important factors that impact quality and feasibility design outcomes, and may inspire new approaches to cultivating more successful design outcomes in the classroom or workplace.

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