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Group Creativity and the Time of the Day

Dermot Breslin

Sheffield University Management School

Abstract

In today's knowledge-based economies, creativity in higher education has become a central focus for policy-makers. However, developing student creativity is still a challenge for higher education institutions. This paper seeks to contribute to our understanding of the creative processes at play in educational environments by using an experimental design to explore the time-of-day effect on group creativity. Examining 36 groups of university students, Experiment 1 explored differences in creative performance between morning and afternoon, and the optimal time of day for group creative exercises. Experiment 2 comprised 18 groups, and further studied the effect of chronotype on group creativity in the morning versus the afternoon. In both experiments a significant relationship was found between the timing of the group task and creative performance, with a peak in creative fluency around midday. This research thus points to a significant time of day effect in the creative process in groups.

Key words: Group Creativity; Circadian Rhythm; Chronotype; Time of Day

Introduction

In today's knowledge-based economies, creativity in higher education has become a central focus for policy-makers (Buckingham and Jones, 2001; Gu et al., 2017; Katz-Buonincontro 2012; Wu et al. 2014). Creativity is seen to affect the behaviors of all learners, and not just those confined to the 'creative arts' (Simmons and Thompson, 2008, 604), as it is transdisciplinary in nature and applicable across a range of subjects (National Advisory Committee on Creative and Cultural Education (NACCCE), 1999). Reflecting this broad appeal, the European Parliament has identified creativity as a transversal aspect of all key competences of lifelong learning (European Parliament and the Council, 2006). However, developing student creativity is still a challenge for higher education institutions (Gu et al., 2017; Niu and Liu, 2009). Creativity has been defined in terms of the originality and value of creative outputs (Amabile, 1990), and in terms of the process of discovery and enquiry (Wyse and Ferrari, 2015). This paper seeks to contribute to our understanding of the creative processes at play in educational environments. It examines the relative improvement in creative performance (Simmons and Thompson, 2008) of groups of university students, as they engage in activities at different times of the day.

Understanding how task performance changes over the course of the day is critical in managing educational environments. Our behavioral and cognitive functions vary alongside physiological changes in body temperature and hormone production during the working day, in sync with our circadian rhythms. These rhythms differ between morning and evening types, or chronotypes. Morning types wake up early, are more active in the morning and go to bed earlier in the evening. Evening types are less active in the morning, staying awake later in the night. The distribution of morning and evening types varies with age. For instance, children tend to shift

from morning to evening types as they reach adolescence (Kim et al., 2002; Roenneberg et al., 2004). This prominence of evening types continues into young college age adults, reversing back to morning types in older generations (Adan & Alrnirall, 1990; Giampietro & Cavallera, 2007; Intons-Peterson et al., 1998; May & Hasher, 1998). Chronotype has been linked to academic performance (Preckel et al., 2013), with research showing an inverse relationship between eveningness and academic performance in university students (Besoluk et al., 2011; Onder et al., 2014; Preckel et al., 2013). This negative effect between evening types and academic performance might be due to sleep deprivation of evening types, as this group goes to bed later and so are more tired during the day (Onder et al., 2014; Preckel et al., 2013). Alternatively, the negative effect between eveningness and academic performance might be explained by a lack of synchrony, with individuals performing better in cognitive exercises when this is aligned with their optimal time of day (Preckel et al., 2013).

Research has also explored the relationship between individual chronotype and factors related to the creative process including inhibitory processes (Hasher et al., 1999), attentional control (Wieth & Zacks, 2011), and mind wandering (Carciofo et al., 2014b). These studies point to an individual's inability to ignore additional distracting information during their non-optimal time of day (May, 1999; May et al., 2005). However, such research stops short at identifying a link between chronotype, time of day and creativity. Furthermore, little research has explored the notion of 'group chronotype', or the effect of such group chronotype on group creativity and time of day. Determining a link between creativity and time of day is clearly of significant important to higher education, especially in light of policy changes noted above. Moreover, given the prevalence of groups as a vehicle for creativity in organizations, determining the

optimal time of day to carry out key activities, such as brainstorming (Osborn, 1953), is of critical importance for both education and work.

To address this gap, I carried out two experiments to determine whether there is a significant difference in group creativity between morning and afternoon. In Experiment 1, using 36 groups, each one comprising 5 university students, I sought to explore differences in group creativity between morning and afternoon, and to explore the optimal time of day for the group task. In Experiment 2, using 18 groups, each one again comprising 5 university students, I sought to replicate the findings of Experiment 1, and further study the effect of chronotype on group creativity in the morning versus the afternoon. I show that there is no significant difference in group creative performance between morning and afternoon sessions. In addition, there was no significant effect of chronotype on the creative performance of groups in these morning and afternoon sessions. In both experiments, however, a significant difference in creative fluency was seen in groups over the course of the day, with a peak in creative fluency between 11am and 2pm. This finding points to a significant time of day effect on the group creative process, and I posit that this effect is linked to diurnal variations in levels of arousal, alertness and positive affect. Performance in the group task increases rapidly in the morning towards a midday peak, falling again in the afternoon as a result of a post lunch dip.

The changing creativity of groups over the course of the working day has clear implications for work and education. Therefore, when organizations form groups for creative tasks, consideration should be given to the timing of key activities. Likewise, in an educational environment, by scheduling more creative-based subjects and pedagogical activities to the midday period,

educators might increase creative fluency within the classroom. The paper is structured as follows. First a review of literature on time of day effects and processes of socialization and cognition is given. This is followed by an outline of the methods used in the two studies. The findings of each are then presented. Finally, a discussion of the results and implications for practice is given.

Theoretical Background and Hypotheses Development

There is an increasing tendency to restructure work from individual to group-based activities (Nijstad & Drue, 2002), as groups are seen to outperform individuals on a number of tasks from problem solving to creativity (Levine & Moreland, 1990). Groups are also a key vehicle for the creative process, bringing together a diversity of backgrounds, knowledge, skills and abilities. It is argued that this diversity increases creativity, through the interaction of multiple perspectives and potentially constructive conflict (Paulus, 2000). Other benefits associated with creative group work include positive feelings among participants, and the development of collective knowledge and skills (Sutton & Hargadon, 1996). The creative process is facilitated amongst group members by social comparison processes, as feedback is provided on member performance (Paulus et al., 1996). With increased levels of interaction among team members, cognitive stimulation and the cross-fertilisation of ideas and perspectives is further enhanced (Nijstad & Drue, 2002). As group members share ideas, associations are stimulated in the minds of others (Paulus et al., 2000), and the more individuals are exposed to the ideas of others, then the more this process of cognitive stimulation occurs (Paulus and Yang, 2000). Ideas are also more likely to be accepted by the group (Faure, 2004), as participation in decision-making

reduces resistance to accept and implement the idea. The performance of groups in creative tasks is influenced by a number of factors related to both socialization and cognitive processes. These processes of socialization and cognition vary over the course of the day, as individual levels of energy and activity vary in synch with circadian rhythms.

In the discussion that follows, creative performance is viewed in terms of two aspects; namely fluency and quality. Whilst creative fluency refers to the number of ideas generated by the group (Paulus, 2000), quality relates to the value of each of those ideas. In this study, originality was used as a measure of quality. A group can thus be very productive in terms of the number of ideas generated, whilst at the same time producing ideas of low quality. As argued below, processes of socialization and cognition can result in opposing effects on each of these measures.

Time of Day and Socialization Processes

When considering socialization processes, previous research has found a link between variations over time and individual circadian rhythms. Morning types for instance, who have an energy peak during the working day, are seen to be more conscientious (Jackson & Gerard, 1996), reflecting a dutiful/conformist personality style (Diaz-Morales, 2007). DeYoung et al. (2007) found a negative relationship between morning types and neuroticism but positive relationships between morning types and both agreeableness and conscientiousness. Randler (2009) further links morning types and proactivity. Morning types are also seen to prefer social values (conservation, self-transcendence) over individual values (Vollmer & Randler, 2012), and tend towards cultural collectivism and with a low tolerance of ambiguity (Fabbri et al., 2007)

conforming more to social laws and norms. When one considers processes of socialization, morning types would thus seem to be key players in collective activities, working towards group goals and critical actors in team building exercises. Morning types are early risers, and so begin the working day in synch with their individual biological clocks. This alignment between individual and social rhythms, might extend to a wider alignment between individual and social behaviors and values (Vollmer & Randler, 2012) over the course of the working day. Therefore, an apparent tendency towards conformance and conscientiousness within this group may be reflective of a synchronization between individual and collective diurnal rhythms.

While morning types are associated with social traits such as conformance, conscientiousness, and agreeableness, some suggest that evening types exhibit behaviors which reflect more problems in coping with social demands than morning types (Mecacci & Rocchetti, 1998). Vollmer and Randler (2012) found that evening type adolescents had a greater preference for individual values (openness to change, self-enhancement) rather than social values. Vollmer and Randler (2012) further argue that because evening types struggle to comply with early social schedules, they often decide against pro-social behaviors of getting up early. As a result they are less likely to conform to wider social constraints. This misalignment between social and biological times can result in a 'social jetlag' (Wittmann et al., 2006, 497), which can lead to less proactivity than morning types (Randler, 2009), and even anxiety as evening types are expected to perform tasks during their non-optimal time of day (Diaz-Morales & Sanchez-Lopez, 2008). Interestingly evening types have also been associated with different cognitive styles (see below), having a higher ability to think creatively (Fabbri et al., 2007; Giampietro & Cavallera, 2007), being more intuitive and more likely to have an unconventional/dissenting personality style

(Diaz-Morales, 2007). Evening types are thus seen to be intuitive, impulsive, and creative, inclined toward cultural individualism and with high tolerance of ambiguity (Fabbri et al., 2007). While the pro-social behaviors of morning types may reflect the synchronization between their individual biological clocks and social rhythms, the more individualistic behaviors of evening types likewise reflect a mismatch between the two.

Key processes of socialization may depend on levels of motivation, energy and alertness that alter over the course of the day depending on the individual's body clock or circadian rhythm, and some studies have examined these changes. For example, Hasler et al. (2008) found that behaviors associated with positive affect (socializing, laughing, and singing) varied according to circadian rhythms. In this latter study it was seen that individuals peaked in terms of behaviors such as laughing and socialization, between 8 and 10 hours after they woke. Clearly if these peaks occur during the working day (as in the case of morning types) then such individuals may exhibit higher levels of pro-social behaviors. Evidence from Hasler et al.'s research would thus suggest that when an individual's body clock is out of synch with the timing of the task in hand, then the individual concerned may behave in a more individualistic manner. These less pro-social behaviors might negatively impact upon the group creative process in a number of ways. First, conversations within the group can become dominated by one person effectively blocking comments from other members (Nijstad et al., 2002; Rietzschel at el., 2006). Second, free riding may occur, where some individuals sit back and contribute less, or engage in social loafing as they do not feel accountable as individuals (Karau & Williams, 1993). Finally, during non-optimal times of day the individual may feel more apprehensive about negative evaluations by

others, and as a result feel inhibited to express ideas due to social anxiety (Camacho & Paulus, 1995; Rietzschel at el., 2006).

On the other hand, heightened levels of social interaction experienced during an individual's daily peak, can enhance the creative process by facilitating exchanges between individuals. In this manner, individuals build on the contributions of others leading to back-and-forth conversations (Harvey, 2013; Van Oortmerssen et al., 2015), as one idea triggers further associations in a snowballing of responses. With increased levels of interaction among team members, group members stimulate further ideas between themselves, leading to a process of cross-fertilization (Nijstad & Drue, 2002; Paulus et al., 2000). The more individuals are exposed to the ideas of others, then the more this process of cognitive stimulation occurs (Paulus and Yang, 2000). As a result, one would expect the number of ideas generated to increase, as socialization within the group intensifies during daily peaks. When studying university students, one expects to find a tendency towards evening types within the group (May et al., 1993). With expected wake up times between 7am and 9am within this group (Horne & Ostberg, 1976), and drawing on the findings of Hasler et al. (2008), one would expect groups to peak in terms of socialization behaviors between 4pm and 6pm. In other words, when studying university students one would expect that the inhibiting effects of production blocking, free riding and evaluation apprehension to be more evident in the morning than in the afternoon.

Hypothesis 1: Socialization factors result in higher levels of group creative fluency in the afternoon than the morning when studying university students.

Whilst there will be a tendency towards evening types in university students, one would still expect a range of chronotypes amongst team members. However, the greater the tendency towards evening types, the stronger the positive effect of socialization on creative fluency in afternoon sessions, as noted above.

Hypothesis 1a: The greater the tendency towards evening types within the group, then the greater the increase in creative fluency in the afternoon versus morning.

Time of day and Cognitive Processes

Whilst the effects of social processes would seem to dominate the group creative exercise, one must also consider variations in individual-level cognitive processes linked with daily rhythms. Past research on individuals has shown that circadian rhythms influence individual-level cognitive function including memory (May et al., 1993), attention (Intons-Peterson et al., 1998), and decision making (Yoon, 1997). For example morning-types, who as noted above tend to experience daily peaks during the earlier part of the day, perform better at that time than evening types, when completing cognitive activities relating to attention and memory, and vice versa (Goldstein et al., 2007). May et al. (1993) further found that younger adults performed better on memory tests when they were completed in the afternoon than in the morning. Scholars have also explored time of day effects on cognitive functions associated with the creative process. May and Hasher (1998) focused on the notion of inhibitory processes, which control the flow of information from thought and perception (e.g., Hasher et al., 1999), and thus act to suppress the processing of distracting or task unrelated information. Inhibition has a number of effects on

information processing (Hasher et al., 1999; May & Hasher, 1998), by restricting attention to only relevant, task-oriented stimuli, suppressing information that was but is no longer relevant to the task, and restraining the production of strong responses. These three inhibitory functions may be impaired at off-peak relative to peak times (May, 1999). Wieth & Zacks (2011) showed that reduced attentional control at a non-optimal time of day, can positively affect performance on insight problems. Specifically they argue that evening types perform better at insight problems in the morning, which is their non-optimal time of day (Wieth & Zacks, 2011). They therefore point to a relationship between cognitive performance and an individual's circadian arousal. Others similarly showed that individuals were less able to ignore additional distracting information during their non-optimal time of day compared to their optimal time of day (May, 1999; May et al., 2005). The link between drowsiness, daydreaming and attention-related errors has been seen in other studies. Carciofo et al. (2014a) found that evening types are more likely to experience sleep problems during the working week, resulting in increased levels of drowsiness and with this, occurrences of mind wandering during the day.

When considering the creative process in groups, a decrease in inhibitory functions, and as a result, an increase in the degree to which individuals are distracted, can be seen to also increase opportunities to make associations, and generate unique ideas. Therefore one would expect that as individuals are more easily distracted, the originality of ideas generated increases. Contrary to the effects of socialization on group creative fluency, creative quality is thus enhanced at an individual's non-optimal time of day. As noted above, evening types are in general found to be more creative (Fabbri et al., 2007; Giampietro & Cavallera, 2007). However these studies were completed during the working day, which in the case of evening types represents their non-

optimal time of day. In other words, individuals are more likely to be distracted at off-peak relative to peak times, and so opportunities for creative thought may be increased (May, 1999; May & Hasher, 1998).

Hypothesis 2: University students are less able to ignore distracting information during the morning than afternoon, and thus the originality of ideas generated would be higher at that time of day.

Again, the greater the tendency towards evening types within the group, the stronger the positive effect on creative quality in morning sessions noted above.

Hypothesis 2a: The greater the tendency towards evening types within the group, then the greater the increase in creative quality (originality) in the morning versus afternoon.

Method

Using an experimental method, this research first set out to determine whether there is a significant difference in group creativity between morning and afternoon, where creativity was measured in terms of both fluency and idea quality (originality). Second the experiments set out to determine whether any differences found, were driven by socialization or cognitive processes, as set out above. Third, in the event that differences in performance were identified, the research sought to identify the optimal time-of-day for group creativity exercises. To achieve these aims two experiments were carried out. Experiment 1 (180 participants, see Table 1) sought to explore

differences in group creativity between morning and afternoon, and to explore the optimal time of day for the group task (Hypotheses 1 and 2). Morningness-eveningness scores were not obtained from the participants in Experiment 1. Experiment 2 (90 participants, see Table 1) sought to replicate the finding of Experiment 1, and to further explore the effect of morningness-eveningness on group creativity in the morning versus the afternoon (Hypotheses 1, 1a, 2 and 2a). Morningness-eveningness questionnaires were completed by participants at the end of the experiment. Group composition was not changed based on the MEQ scores obtained. Informed consent was obtained from all participants, and institutional ethical approval given for both experiments.

Table 1 about here

Experiment 1

Participants

A total of 180 participants completed Experiment 1 as partial fulfillment of a course requirement. All the students were in their second year of a three-year undergraduate business studies degree. The majority of the participants were between the ages of 19 and 21 years old (mean 19.89; SD, 0.84), 105 were male. These 180 students were randomly divided into 36 groups of 5 students each. Each group then completed a series of creativity exercises using the Unusual Uses Task (UUT), at different times of the day. In UUTs participants are asked to generate as many unusual uses as possible for a common object within a set amount of time (Baird et al., 2012). The 36 groups were given three different objects as the basis of the UUT: a coat hanger, a blank A4

sheet of paper and a paper cup. A full breakdown of the groups, time of day and object is given in Table 2.

Table 2 about here

The creativity exercise was carried out as follows. At the beginning of the exercise, one individual in each group was nominated to take notes. Groups were then given 10 minutes to generate as many uses as possible for the given object, with the nominated individual writing down the ideas generated on an A4-sized sheet of paper.

Following the first creativity task, groups were given a 5-minute break, and then asked to complete the creativity task outlined above for a second time, using the same object, and asked to generate new ideas not previously written down. Repeating the exercise in this manner allowed the researcher to replicate any findings observed across tasks.

Independent Variables

Time of the Day. Groups were evenly distributed across different times of the day as shown in Table 2. These included three morning sessions (9am, 10am and 11am), and three afternoon sessions (1pm, 2pm and 3pm).

Dependent Variables

Fluency. The fluency of the group was measured by the number of ideas generated in each of the UUTs.

Idea Quality. The originality of each idea generated was based on the frequency of its occurrence in the wider pool of all ideas generated across all groups (Dennis et al., 1997). The lower the score the less frequent the idea occurred in this pool, and hence the more original. The mean originality of ideas generated in each separate creativity task was then calculated.

Results

A one-way univariate analysis (ANOVA) was used to explore the effect of time of day for each of the dependent variables.

Group Performance in the Morning Vs Afternoon

Fluency. More ideas were generated in the afternoon sessions in both Task 1 (morning mean 24.00, afternoon mean 27.94), and Task 2 (morning mean 18.72, afternoon mean 26.78). While this difference between morning and afternoon groups, and the number of ideas generated was significant in Task 2, $F(1, 34)=4.72$, $p=0.037$, no significant difference was found in Task 1, $F(1, 34)=0.80$, $p=0.377$.

Idea Quality. There was no consistent trend in terms of idea quality (originality), and morning/afternoon sessions (Task 1: morning mean 4.82, afternoon mean 5.03; Task 2: morning

mean 3.16, afternoon mean 3.13). However, this difference was not significant in either Task 1, $F(1, 34)=0.22$, $p=0.644$, or Task 2, $F(1, 34)=0.01$, $p=0.945$.

Group Performance, and the Timing of Sessions

Fluency. There was no significant relationship between the timing of the group task and the number of ideas generated in Task 1. $F(5, 30)=1.58$, $p=0.196$. There was however a significant relationship between time of day and the number of ideas generated in Task 2, $F(5, 30)=7.83$, $p<0.001$. In both tasks the number of ideas generated varied non-linearly across the day as shown in Figures 1 and 2.

Figure 1 about here

Figure 2 about here

Idea Quality. There was no significant relationship between the timing of the group task and originality of ideas in either Task 1, $F(5, 30)=0.88$, $p=0.510$, or Task 2, $F(5, 30)=1.55$, $p=0.204$.

Summary

In summary, no significant difference was found in the creative performance of the group (i.e. idea fluency, quality of idea generated) between the morning and afternoon sessions. There was however a significant relationship between the timing of tasks and idea fluency, with a peak found around midday. Therefore, in groups of university students a midday peak in creative

performance exists. In line with prior research, this experiment assumed a tendency towards evening types in the groups of undergraduates studied (Adan et al., 2012; Carciofo et al., 2014b; May et al., 1993). Experiment 2 thus set about to measure chronotype, and its effect on changing creative performance over the day.

Experiment 2

Participants

A total of 90 participants completed the experiment as partial fulfillment of a course requirement. As in Experiment 1, all the students were in their second year of a three-year undergraduate business studies degree. The majority of the participants were between the ages of 19 and 21 years old (mean 20.43; SD, 1.91), 43 were male. These 90 students were randomly divided into 18 groups of 5 students each. Each group then completed a series of creativity exercises using the Unusual Uses Task (UUT), at different times of the day. In UUTs participants are asked to generate as many unusual uses as possible for a common object within a set amount of time (Baird et al., 2012). As in Experiment 1, the 18 groups completed UUTs at different times of the day, with different objects as the basis of the UUT: a coat hanger, a blank A4 sheet of paper and a paper cup. A full breakdown of the groups, time of day and object is given in Table 3.

Table 3 about here

As with Experiment 1, the creativity exercise was carried out as follows. At the beginning of the exercise, one individual in each group was nominated to take notes. Groups were then given 10 minutes to generate as many uses as possible for the given object, with the nominated individual writing down the ideas generated on an A4-sized sheet of paper.

Following the first creativity task, groups were given a 5-minute break, and then asked to complete the creativity task outlined above for a second time, using the same object, and asked to generate new ideas not previously written down.

Independent and Dependent Variables

Morningness-Eveningness. Participants completed a morningness/eveningness questionnaire (MEQ) (Horne & Ostberg, 1976) at the end of the creativity tasks (i.e. no groups were manipulated based on the MEQ scores obtained). Of the 90 participants and using Horne and Ostberg's classification, 25 (28%) were evening types, 54 (61%) neutral, and 11 (11%) were morning types, confirming a tendency towards evening types in the cohort. The large number of intermediate types seen using this questionnaire, is in line with prior research (Adan et al., 2012). Whilst chronotype classifications have been used to categorize individuals as morning or evening types, when considering differences between individuals, it can be more useful to consider chronotype as a continuous variable (Volk et al., 2017). This is particularly the case when studying individuals within groups, where two individuals might be both categorized as morning types, yet still show peak times that are hours apart (Volk et al., 2017). To reflect this more fine-grained diversity within groups mean MEQ scores were calculated for each group (mean 48.5;

SD, 6.05). Low MEQ scores indicate a tendency towards an evening type, whereas high MEQ scores indicate morningness. The 18 groups were then evenly split into three classes each containing 6 groups; high (MEQ<44), intermediate (44<=MEQ<50) and low (50<=MEQ) eveningness. Categorizing a 'group chronotype' in this manner, can represent the tendency towards evening types within each group (Hypotheses 1a and 2a).

All other independent (time of day) and dependent (idea fluency, quality of idea generated) variables were defined as noted above in Experiment 1.

Results

A two-way univariate analysis (ANOVA) was used to explore the effect of time of day, and tendency towards evening types within the group, for each of the dependent variables.

Group Performance in the Morning Vs Afternoon

Fluency. As in Experiment 1, more ideas were generated in the afternoon sessions in both Task 1 (morning mean 26.78, afternoon mean 33.44), and Task 2 (morning mean 25.22, afternoon mean 29.44). The main effect of morning and afternoon sessions on the number of ideas generated (Hypothesis 1) was not significant in either Task 1, $F(1, 12)=1.35$, $p=0.27$, or Task 2, $F(1, 12)=0.37$, $p=0.556$. There was no significant interaction between the factor of tendency towards evening types and the factor of morning-afternoon session in either Task 1, $F(2, 12)=0.02$, $p=0.98$, or Task 2, $F(2, 12)=0.83$, $p=0.46$. Therefore, Hypothesis 1a is also not supported.

Idea Quality. There was no consistent trend in terms of idea quality, and morning/afternoon sessions (Task 1: morning mean 4.67, afternoon mean 4.44; Task 2: morning mean 2.67, afternoon mean 2.89). The main effect of morning and afternoon sessions on the quality of ideas generated (Hypothesis 2) was not significant in either Task 1, $F(1, 12)=.01$, $p=0.93$, or Task 2, $F(1, 12)=0.43$, $p=0.526$. There was no significant interaction between the factor of tendency towards evening types and the factor of morning-afternoon session in either Task 1, $F(2, 12)=0.84$, $p=0.46$, or Task 2, $F(2, 12)=1.08$, $p=0.37$. Therefore, Hypothesis 2a is also not supported.

Group Performance and the Timing of Sessions

Fluency. As in Experiment 1, there was a significant relationship found between the specific timing of the group task and the number of ideas generated in Task 1, $F(5, 12)=8.23$, $p=0.001$. There was also a significant relationship between the timing of the group task and the number of ideas generated in Task 2, $F(5, 12)=4.87$, $p=0.012$. In both tasks the number of ideas generated varied non-linearly across the day as shown in Figures 3 and 4.

When considering the additional effect of group chronotype, the main effect of the session timing on the number of ideas generated in Task 1 was significant, $F(5, 6)=9.57$, $p=0.008$. There was no significant interaction between the factor of tendency towards evening types and the factor of session timing in Task 1, $F(4, 6)=1.70$, $p=0.27$. For Task 2, the main effect of the session timing on the number of ideas generated was not significant, $F(5, 6)=3.34$, $p=0.09$. There

was also no significant interaction between the factor of tendency towards evening types and the factor of session timing, $F(4, 6)=0.45$, $p=0.77$.

Figure 3 about here

Figure 4 about here

Idea Quality. There was no significant different in the timing of the group task and originality of ideas in either Task 1, $F(5, 12)=0.57$, $p=0.72$, or Task 2, $F(5, 12)=0.45$, $p=0.808$. Again, when considering the additional effect of group chronotype, the main effect of the session timing on the originality of ideas generated in Task 1 was not significant, $F(5, 6)=1.98$, $p=0.214$. There was however a significant interaction between the factor of tendency towards evening types and the factor of session timing in Task 1, $F(4, 6)=5.18$, $p=0.04$. For Task 2, the main effect of the session timing on the originality of ideas generated was not significant, $F(5, 6)=0.94$, $p=0.52$. There was also no significant interaction between the factor of tendency towards evening types and the factor of session timing, $F(4, 6)=2.30$, $p=0.17$.

Summary

In summary, no significant difference was found in the creative performance of the group (i.e. idea fluency, quality of idea generated) between the morning and afternoon sessions. In addition, the group chronotype had no further influence on group performances at different times of the

day. There was however a significant relationship between the timing of tasks and idea fluency, with a peak found around midday. The findings from Experiment 2 would suggest that in groups, the distribution of evening/morning/neutral types has little impact on the creative fluency of the wider group. The collective endeavor would seem to dampen individual differences, with a midday peak in creative performance emerging.

As in Experiment 1, no significant difference was found in the creative performance of the group (i.e. idea fluency and quality of idea generated) between the morning and afternoon. However, as with Experiment 1 a significant relationship was found in the timing of tasks and idea fluency, with a peak found around midday.

Discussion

In both experiments carried out, no significant difference was found between morning and afternoon sessions, when examining the creative process in groups. In addition, there was no significant effect of the mean morningness-eveningness of the participants within the group, or group chronotype, and performance in the creative tasks at different times of the day. However significant relationships were found in both experiments between creative fluency and the specific timing of group tasks. It is seen above that the fluency of ideas generated in these experiments varied over the course of the day, rising from a low point at the beginning of the day (9-11am) to a peak around midday (11am-2pm), then falling again in the late afternoon (2-4pm). Given the demographic mix of the participants (i.e. university students), and in agreement with previous research Carciofo et al., 2014b; May et al., 1993), it was seen that there was a tendency

towards evening types. With expected wake up times between 7am and 9am within this group (Horne & Ostberg, 1976), and drawing on the findings of Hasler et al. (2008), one would expect such groups to peak in terms of socialization behaviors between 4pm and 6pm. As argued above, this peak could lower the inhibiting effects of production blocking, free riding and evaluation apprehension, increasing creative fluency. However, the peak in fluency seen in these studies occurred several hours earlier around midday.

This finding highlights two effects. First the gradual increase in creative fluency following 9am is indicative of a time-of-day effect seen in other studies of diurnal variations. As noted above, Hasler et al. (2008) found significant sinusoidal variations in measures of positive affect, such as socializing and laughing, over the course of the day. Across these variables, they found significant fits with a cosinor model, centered on participants' mean waketimes (Hasler et al., 2008), with peaks in socializing and laughing variables were found between 8 and 10 hours after mean waketimes. Others studies highlight early morning increases in measures of mood (Owens et al., 2000), with better mood being attained about 4 hours after waking, before falling over the day (Monk et al., 1985). In addition to mood and positive affect, past studies have also identified variations in levels of arousal (Colquhoun, 1971) and alertness (Monk et al., 1983, 1985; Owens et al., 2000). Alertness is thus seen to increase rapidly between 8 and 10am, reach a midday peak and then fall again towards the end of the working day (Monk et al., 1983, 1985; Owens et al., 2000). Whilst some point to links in performances with sinusoidal variations in core body temperature over the course of the day (Colquhoun, 1971; Rajaratnam & Arendt, 2001; Tankova et al., 1994), others refute this parallelism (Monk et al., 1983, 1985; Owens et al., 2000). When considering the creative process in groups, increasing levels of arousal and mood are likely to

have a positive impact on social interaction. As social exchanges are facilitated, individuals build on the contributions of others leading to back-and-forth conversations (Harvey, 2013; Van Oortmerssen et al., 2015), increasing the fluency of the group creative process. In addition, increases in alertness can be seen to have a positive effect on reactions of individuals to responses of others, again resulting in an increase in creative exchanges and fluency.

Second, whilst past research has seen increases in alertness and mood in the early morning, they also highlight subsequent falls towards the end of the working day (Monk et al., 1983, 1985; Owens et al., 2000). Scholars point to a 'sleep inertia' or 'wake up' effect following lunch (Owens et al., 2000, 53). This rise and fall over the course of the day, is also seen in this study when examining group creative fluency. The drop after 2pm highlights a significant post-lunch effect. The effects of this post-lunch dip have also been shown in sleep-related research, with incidents of car accidents increasing in the mid-afternoon (Horne & Reyner, 1999). The post-lunch effect has also been seen in lab-based work (Blake, 1967) and in the field (Monk & Folkard, 1985), highlighting a dip in performance in attention tasks (Hughes & Folkard, 1976). Whilst increasing levels of alertness and cheerfulness in the early morning can lead to greater creative fluency as tasks are scheduled nearer midday, likewise a drop in both after lunch would similarly be linked to a fall in creative performance. In summary, the findings of this study point to a significant time of day effect on the group creative process, linked to diurnal variations in levels of arousal, alertness and positive affect.

Future research

Future research might build on the findings of this study in a number of ways. First, while this result highlights a time-of-day effect in group creative fluency, it is unclear what factors are driving this change. As noted above, past research points to similar diurnal variations in alertness, arousal and positive affect. However, these variables were not included in this study. Future research should therefore seek to capture such performance and mood measures, and establish a relationship with group performance.

Second, this study did not find a significant effect of chronotype on changing group creative performance. However, this may be due to small samples sizes seen in both experiments. Future research might expand on this work to include larger samples of groups, and in addition to explore multi-level relationships between individual chronotype and group-level creative performance. In addition, an alternative approach might be taken in the research design, to create homogeneous groups composed of similar chronotypes. Participants would thus complete MEQ questionnaires in advance, then be allocated into groups of similar types. Time of day peaks in the creative process could then be investigated for different morning and evening groups.

Third, future research might explore the notion of group chronotype diversity, which Volk et al. (2017, 684) defined as the 'extent to which team members differ in their biological predispositions towards the optimal timing of daily periods of activity and rest'. They posit that such group chronotype diversity can either enhance or constrain team processes and outcomes, depending on whether group members are aware of this diversity (Volk et al., 2017). When teams understand chronotype diversity, they can enhance performance by altering the timing and pacing of their work to match the different energy peaks of group members. Equally team

performance can be impaired if chronotype differences among members are not recognized and understood within the group (Volk et al., 2017). As noted above, future research might be designed to create and investigate groups with different levels of chronotype diversity.

Fourth, the group task used in this study was a simple UUT. Future studies might explore group performance in more complex creative tasks, and indeed broader group tasks involving social interaction. The proposed relationship between changing mood and levels of alertness on fluency, might similarly impact on group performance in others tasks involving high levels of social interaction. Fifth, this study did not gather data on individual wake-up times, core temperatures, hormone levels etc. Given the relevance of these variables to circadian rhythms, future research might explore more complex interrelationships. Finally, the findings of this study highlight a group-level effect. Future research might explore individual-level variations in creative performance. Such variations might be linked to diurnal changes in cognitive and social factors as noted earlier in the paper.

Implications for Practice

The changing creativity of groups over the course of the working day has clear implications for work, education and research methods. Given the wide change in creative outputs seen in the findings above, it is clear that the time of day has a significant impact on experimental results (May et al., 1993, May, 1999). Research exploring the creative process should therefore carefully control for the time of day effect, as they analyze difference in performances across groups. Groups have a significant role to play in the creative process in organizations (Faure, 2004) through activities such as brainstorming (Osborn, 1953). The findings of this research would thus

suggest that these activities would be more productive if they are scheduled around the lunch period. While this study focused on adults with a similar age, the chronotype of group participants might also influence the creative process at different times of the day. Therefore, when organizations form groups for creative tasks, consideration should be given to the mix of circadian rhythms, in addition to the mix of knowledge and experience. When one considers the education sector, the scheduling of different classroom activities would clearly be influenced by early morning and post-lunch dips. This time-of-day effect cuts across a wide range of disciplines and subjects, and reflects the relative nature of improved creative performance (Simmons and Thompson, 2008). By scheduling more creative-based subjects and pedagogical activities to the midday period, educators might increase fluency within the classroom. In summary, the midday period represents a unique opportunity for group creativity within the working day.

Conclusion

In our working and educational environments the group is a key vehicle for the creative process, and understanding how this process changes over the course of the working day is of significant importance. Research has shown how socialization and cognitive processes can be influenced by the time of day. This paper points to an enhancing effect around the middle of the working day. As the group enters this optimal time period, increased alertness, arousal and positive affect, result in a more fluent social interaction, and with this higher creative fluency. The scheduling of creative work and educational activities should thus target this window of creativity.

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Table 1. Profile of Participants for Experiments 1 and 2

Experiment	Number of Participants	Female	Male	Age	
				Mean	Standard Deviation
Experiment 1	180	75	105	19.89	0.84
Experiment 2	90	47	43	20.43	1.91

Table 2. Experiment 1 Breakdown of Number of Groups at each time of the day and UUT Object

Time of Day	UUT Object		
	Coathanger	Paper Cup	A4 Blank sheet
9am	2 groups	2 groups	2 groups
10am	2 groups	2 groups	2 groups
11am	2 groups	2 groups	2 groups
1pm	2 groups	2 groups	2 groups
2pm	2 groups	2 groups	2 groups
3pm	2 groups	2 groups	2 groups

Table 3. Experiment 2 Breakdown of Number of Groups at each time of the day and UUT Object

Time of Day	UUT Object		
	Coathanger	Paper Cup	A4 Blank sheet
9am	1 group	1 group	1 group
10am	1 group	1 group	1 group
11am	1 group	1 group	1 group
1pm	1 group	1 group	1 group
2pm	1 group	1 group	1 group
3pm	1 group	1 group	1 group

Figure 1: Experiment 1 Distribution of Number of Ideas Generated per Group in Task 1 and Time of day. Error bars indicate standard errors of the mean.

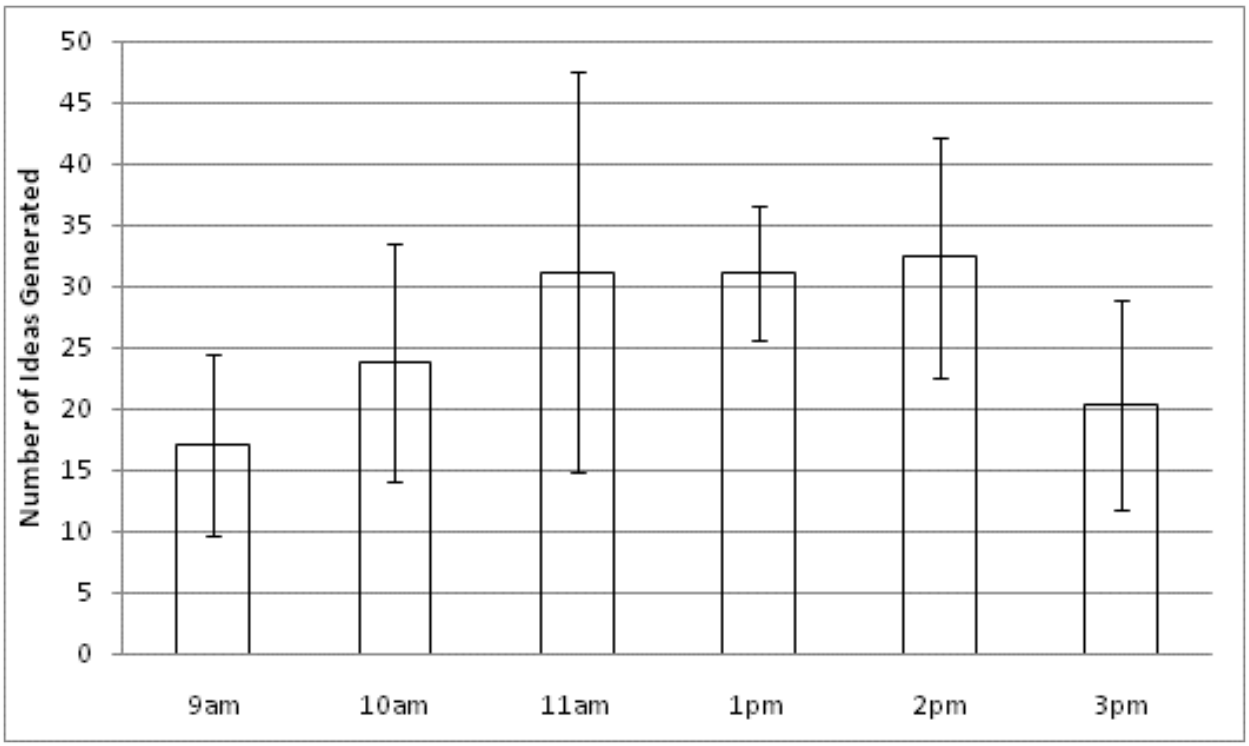

Figure 2: Experiment 1 Distribution of Number of Ideas Generated per Group in Task 2 and Time of day. Error bars indicate standard errors of the mean.

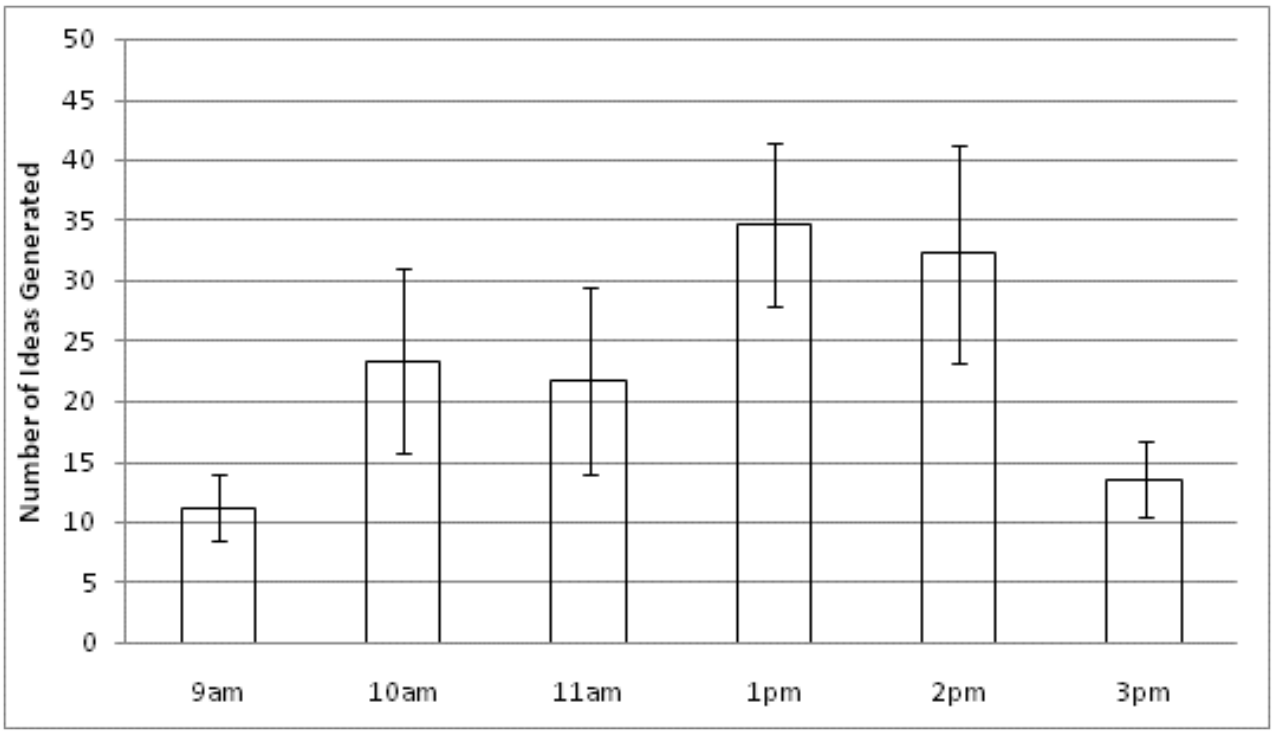

Figure 3: Experiment 2 Distribution of Number of Ideas Generated per Group in Task 1 and Time of day. Error bars indicate standard errors of the mean.

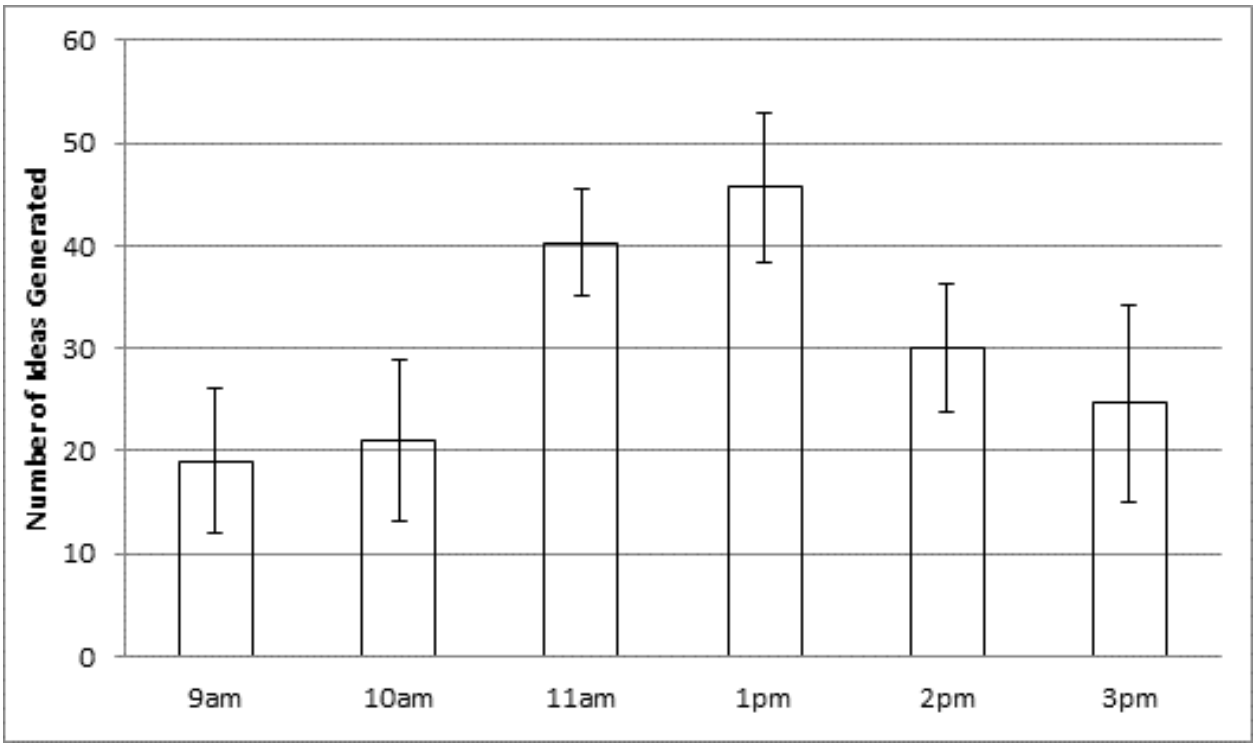

Figure 4: Experiment 2 Distribution of Number of Ideas Generated per Group in Task 2 and Time of day. Error bars indicate standard errors of the mean.