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The Facilitating Role of Task Alternation on Group Idea Generation☆

Ut Na Sio*, Kenneth Kotovsky, Jonathan Cagan

Carnegie Mellon University, USA

During group idea generation, group members often first retrieve typical ideas from common categories. The sharing of these typical ideas is likely to lead to fixation on them preventing subsequent creative idea generation. Two experiments were conducted to examine whether a task-alternation approach can reduce such fixation and facilitate idea generation. Dyads were asked to work on idea generation tasks (Experiment 1) or category–exemplar generation tasks (Experiment 2). In both experiments, dyads had to perform the tasks in either a continuous or an alternating condition. The continuous dyads worked on one task continuously before proceeding to another. The alternating dyads switched between tasks. Both experiments found a positive role of task alternation. Moreover, the performance gap between the alternating and continuous dyads increased over time. We conclude that task alternation facilitates group idea generation, most likely via overcoming fixation.

General Audience Summary

Although it is a common belief that idea generation should be best performed in groups because overhearing others' ideas should stimulate novel ideas, studies examining group idea generation often reveal that group interaction induces fixation rather than inspiration. This paper presents two experimental studies examining whether a task-alternation approach (i.e., distributing effort across different tasks through multiple, short problem sessions interlaced with other problems being solved) can reduce fixation induced by group interaction and facilitate group idea generation. Dyads were asked to generate solutions to daily problems (Experiment 1) or to list members of categories (Experiment 2). They had to perform the tasks using a task-alternation approach or perform each problem in sequence. Both experiments demonstrated a positive impact of the task-alternation approach. Moreover, the gap in performance between the two approaches increased over time. We conclude that task alternation facilitates group idea generation, most likely via overcoming fixation.

Keywords: Group performance, Idea generation, Task alternation, Creativity, Fixation

Idea generation is the early and core phase of problem solving in many domains (Osborn, 1957). For example, industrial designers usually generate a number of possible designs and then select a few for further investigation. The quality of the initial ideas often determines the success of the final problem solution (Kornish & Ulrich, 2014). It is a common belief that idea generation is best performed in groups because overhearing others' ideas should stimulate additional ideas. However, studies examining group idea generation often reported that interacting groups performed worse than nominal groups—an

☆Author Note.

Kenneth Kotovsky and Jonathan Cagan, Department of Mechanical Engineering, Carnegie Mellon University, USA.

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* Correspondence concerning this article should be addressed to Ut Na Sio, Department of Psychology, Carnegie Mellon University, Pittsburgh, PA 15213, USA. Contact: unsio@cmu.edu.

equal number of members working individually, where ideas are summed and treated as a group output (Diehl & Stroebe, 1991; Mullen, Johnson, & Salas, 1991).

A number of factors have been suggested as hindering group idea generation. First, individuals tend to lower their performance to match the group's often lower norm (Brown & Paulus, 1996), and give less effort because of diffused responsibility (Latané, Williams, & Harkins, 1979). Individuals may also withhold ideas to avoid being judged (Camacho & Paulus, 1995). Apart from these social factors, individuals' limited cognitive capacity may prevent them from concentrating on idea generation while processing others' ideas (Nagasundaram & Dennis, 1993; Nijstad, Stroebe, & Lodewijkx, 2003). Also, in face-to-face groups, individuals may forget an idea while waiting for their turn to speak ("production blocking"; Diehl & Stroebe, 1987).

One way to minimize the impacts of some of these factors is to conduct the idea generation task electronically (i.e., individuals interact via computer). Computer-mediated communication (e.g., online discussions) can reduce evaluation apprehension by providing anonymity (Cooper, Gallupe, Pollard, & Cadsby, 1998). It also allows individuals to decide when to generate ideas and when to attend to others' contributions. This should help overcome production blocking and limitations in cognitive capacities (Dennis & Valacich, 1993). However, even in a computer-mediated setting, interacting groups still do not always outperform nominal groups (Kohn & Smith, 2011).

Idea Generation and Fixation

Somewhat surprisingly, another factor that can hinder idea generation arises from the exchange of ideas between group members. Idea generation can be viewed as a search for ideas in associative memory (Nijstad & Stroebe, 2006). Individuals tend to first retrieve ideas from typical categories because these categories are highly accessible, and these initial ideas should serve as search cues and lead to the generation of ideas from the same categories. Once individuals have exhausted all the readily retrieved ideas, they then use other search strategies such as deliberately generating a new search cue for a new category, which could produce more diverse and novel ideas (Beaty & Silvia, 2012; Gilhooly, Fioratou, Anthony, & Wynn, 2007). It has been suggested that the exchange of ideas during group interaction can inhibit rather than facilitate such a strategic shift (Kohn & Smith, 2011; Nijstad & Stroebe, 2006). During group interaction, individuals often first sample and share ideas from typical categories; overhearing ideas from these typical categories should lead to a higher activation of these categories. Because retrieval probability is related to activation values (Anderson, 1983), these typical categories are likely to be retrieved again, making it less likely for groups to generate a new search cue for a new category. One may argue that confining the search to fewer categories could potentially lead to a more comprehensive within-category search, and in turn increase the likelihood of generating novel ideas in that category (Nijstad, Stroebe, & Lodewijkx, 2002). However, this may not always be the case. When performing a within-category search, typical ideas are more likely to be retrieved first (Brown, Tumeo, Larey, & Paulus, 1998). The sharing of these typical ideas should lead to increased activation of these ideas, and the heightened activation value will then make them more likely to be retrieved again, reducing the chance of retrieving novel ideas.

Overcoming Fixation and Task Alternation

One suggested way to resolve fixation is to set the problem aside and have a break (i.e., incubation) thus allowing the overly activated concepts to dissipate (Kohn & Smith, 2011; Sio & Ormerod, 2009; Smith, 1995). However, groups often have to solve multiple problems quickly without delay. In that context, a more efficient way to combat fixation is to prevent it from the very beginning. If group idea generation on one single topic for a considerable amount of time can lead to increased fixation, one potential way to prevent the build-up of fixation might be to break apart and distribute the group's effort across different tasks through multiple short sessions interlaced with other problems. This task-alternation approach should benefit group idea generation in at least two ways. First, the initial search for ideas usually activates typical ideas, and task alternation should mitigate against prolonged sharing of typical ideas within the group, preventing the over-activation of these ideas. Second, alternating between tasks would provide time for these highly activated ideas to decay. Together, these should make groups more likely to suppress these initial responses and explore other categories when they return to the same tasks.

Task alternation, while new in the study of group problem solving, has been studied in the context of individual problem solvers. Numerous studies have shown that alternating between different tasks leads to more robust learning in individuals than blocked schedules (Kornell & Bjork, 2008; Rohrer, Dedrick, & Burgess, 2014; Taylor & Rohrer, 2010). Recent studies have also reported a positive role of task alternation on individual problem-solving, such as idea generation tasks and semantic retrieval tasks (Lu, Akinola, & Mason, 2017; Sio, Kotovsky, & Cagan, 2017; Smith, Gerkens, & Angello, 2015). However, these studies have only examined the impact of task alternation on individual performance. Group idea generation involves the exchange of ideas at the group level as well as idea generation at the individual level; both can potentially lead to fixation (Nijstad & Stroebe, 2006). This present study examined if task alternation can also effectively combat group fixation, resulting in enhanced group idea generation performance.

Two experiments were conducted to examine the effect of task alternation on group ideation. In both experiments, dyads were asked to generate ideas on two topics in either a continuous (i.e., solve the tasks sequentially) or an alternating (i.e., alternate between the tasks) condition. In Experiment 1, idea generation tasks that required generating solutions to daily problems were presented. In Experiment 2, category-exemplar generation tasks that required generating exemplars from a specific category were presented. For both tasks, successful problem solving requires expanding the search space to reach a diverse set of ideas. If alternating between tasks reduces fixation on typical initial ideas, the alternating dyads should be able to explore a wider set of ideas

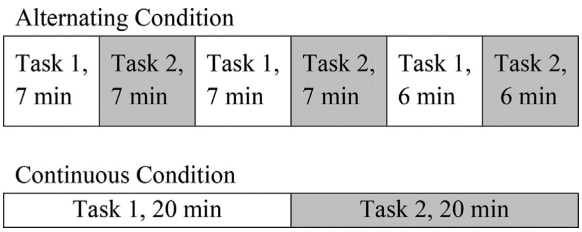


Figure 1. Sequence of the tasks in the experiment.

compared to the continuous dyads, resulting in better performance. Moreover, as fixation builds in the continuous group, the performance gap between the two dyads groups should increase over time.

Experiment 1

Experiment 1 tested whether task alternation can resolve fixation on typical initial ideas induced during group interaction and facilitate group idea generation.

Method

Participants. 78 undergraduates (48 male, 30 female, $M_{age} = 18.86$ years, $SD = 1.21$) at Carnegie Mellon University participated for course credit. Participants worked in pairs and were randomly assigned to either the continuous (20 pairs) or the alternating (19 pairs) condition. The average effect size (Cohen's *d*) of recent studies examining the effects of a task-alternation approach on individual learning and problem solving equals to .97 (Kornell & Bjork, 2008: $d = 1.02$; Lu et al., 2017: $d = .72$; Rohrer et al., 2014: $d = 1.05$; Smith et al., 2015: $d = .83$; Sio et al., 2017: $d = .61$; Taylor & Rohrer, 2010: $d = 1.20$; Rohrer & Taylor, 2007: $d = 1.34$). Having 39 dyads in total would give us a power of 80% (G*Power; Faul, Erdfelder, Lang, & Buchner, 2007) to detect an effect of task-alternation on group idea generation, if there is such an effect.

Materials. Two idea-generation tasks were used. Both tasks were about suggesting ways to enhance student life at Carnegie Mellon University. One task involved suggesting ways to increase the daily physical activity level of the Carnegie Mellon University students (the *physical activity task*). Another task was about suggesting ways to make Carnegie Mellon University campus more accessible for mobility-impaired students (the*mobility task*).

Procedure. Participants were randomly assigned to the continuous or the alternating condition. In both conditions, participants were given 20 min on each task. In the continuous condition, participants were asked to work collaboratively on one task for 20 min before proceeding to another one. In the alternating condition, the two tasks were interleaved with each other in which participants were asked to switch from one task to another every 7 min. The order of presentation of the tasks was counterbalanced. Figure 1 presents the sequence of the task presentation.

For both conditions, participants were seated at computer terminals in the same room, separated by divider walls. Participants communicated and exchanged ideas with each other by sending instant message to each other via Skype.

Participants first received instructions on the tasks as well as a modified version of Osborn's (1957) rules for idea generation: (a) criticism is ruled out, (b) freewheeling is welcomed, (c) quantity is wanted, (d) combination and improvement are sought and (e) groups are encouraged to stay focused on the task. Then, the two idea generation tasks were presented either successively for 20 min (continuous condition) or presented in an interleaved manner (alternating condition). The reasons for the communication protocol via computer were to eliminate production blocking and to track the performance of the teams over time.

Results

Coding. One researcher counted the number of ideas generated for each task and categorized them into different categories based on the similarity between them. Repeated or irrelevant ideas[1] were excluded in any analysis. Then, another researcher who had no knowledge of participants' group assignment performed the same task classifying the ideas into these categories. Inter-rater reliability as measured by Cohen's kappa was .89 for the physical activity task and .90 for the mobility task. The small number of coding differences was resolved in further discussion between the researchers. The 39 dyads generated in total 703 coded ideas that fell into the 28 categories (see Supplemental Material A) for the physical activity task and 543 coded ideas that fell into 23 categories (see Supplemental Material B) for the mobility task.

The 20-min session for each task in the continuous condition was divided into three subsessions: ($t1$ [0:00–6:59], $t2$ [7:00–13:59], $t3$ [14:00–20:00]). The duration of each subsession in the continuous condition is equal to the amount of time participants in the alternating condition spent on the idea-generation task before each switching. To assess the impact of task alternation on group idea-generation performance, we compared the number of ideas, the number of categories of ideas, the number of new categories of ideas (in the second and the third session), and the novelty of the ideas generated in each session between the continuous and alternating dyads.

A novelty score for each idea was computed as the total number of dyads in the experiment ($N = 39$) divided by the number of those dyads who generated that specific idea. If a group listed a particular idea twice or more, it was counted only once. Past studies have used similar methods to evaluate the novelty of ideas (Shah, Smith, & Vargas-Hernandez, 2003; Smith et al., 2015).

One may argue that the ideas generated by the alternating dyads might be in lower quality (i.e., less practical) than those generated by the continuous dyads because task alternation might prevent group members from staying focused to generate useful solutions. In order to investigate whether such a trade-off existed, the quality of ideas was compared between the alternating and continuous dyads. To evaluate the quality of the ideas

[1] For the mobility task, ideas (0.5% of the data) related to other disabilities (e.g., blindness and deafness) were excluded, all in the distributed condition.

Table 1
Group Idea Generation Performance in Each Session by Task and Condition (Experiment 1)

Session	Number of categories of ideas per minute		Number of new categories of ideas per minute		Square-root transformed novelty score of ideas		Number of idea per minute		Quality of ideas	
	Continuous *M* (*SD*)	Alternating *M* (*SD*)	Continuous *M* (*SD*)	Alternating *M* (*SD*)	Continuous *M* (*SD*)	Alternating *M* (*SD*)	Continuous *M* (*SD*)	Alternating *M* (*SD*)	Continuous *M* (*SD*)	Alternating *M* (*SD*)
Physical activity task										
*t*1	.89 (.35)	1.05 (.38)	–	–	2.02 (.52)	2.22 (.63)	1.19 (.53)	1.36 (.59)	3.80 (.31)	3.80 (.44)
*t*2	.51 (.24)	.62 (.34)	.36 (.19)	.33 (.18)	2.27 (.94)	2.82 (1.13)	.67 (.35)	.86 (.36)	3.55 (.96)	3.67 (.47)
*t*3	.37 (.24)	.71 (.28)	.17 (.12)	.33 (.21)	2.15 (.84)	3.05 (.90)	.41 (.26)	.84 (.32)	3.60 (1.00)	3.70 (.60)
Overall	.60 (.22)	.79 (.25)	.27 (.14)	.34 (.11)	2.15 (.55)	2.70 (.60)	.78 (.34)	1.03 (.36)	3.65 (.59)	3.72 (.39)
Mobility task										
*t*1	.59 (.32)	.58 (.27)	–	–	2.29 (.60)	2.08 (.51)	.86 (.46)	1.03 (.51)	4.15 (.39)	4.11 (.44)
*t*2	..41 (.23)	.56 (.37)	.26 (.21)	.35 (.26)	2.36 (.92)	2.32 (.98)	.54 (.33)	.69 (.50)	4.15 (1.06)	4.16 (1.16)
*t*3	.38 (.24)	.46 (.20)	.19 (.24)	.17 (.10)	2.12 (1.14)	2.48 (.74)	.45 (.28)	.55 (.25)	3.93 (1.42)	4.43 (.50)
Overall	.46 (.20)	.54 (.24)	.23 (.17)	.26 (.15)	2.26 (.57)	2.30 (.54)	.63 (.29)	.76 (.37)	4.07 (.77)	4.15 (.64)

generated, two researchers who had no knowledge of participants' group assignment were asked to rate the quality of each idea in terms of appropriateness, realisticness, and completeness, with a rating of 0 (not at all) to 2 (highly) for each criterion. A quality score for each idea was the sum of these three scores. The quality scores from the two raters were averaged to form a quality score for that idea. The inter-rater reliability (ICC) was .75 for the physical activity task and .80 for the mobility task.

Idea-generation performance for the first session was compared and resulted in no significant difference, all $p > .18$, indicating that the alternating and continuous dyads were initially balanced in terms of idea generation performance (see Table 1 for descriptive statistics). Any subsequent significant difference between them is likely due to our experimental manipulation (alternating vs. continuous approach) that took place after the first session.

According to our fixation hypothesis that task alternation could prevent the build up of fixation on typical ideas and categories during group interaction, the alternating dyads should search more broadly, resulting in generating more ideas, more categories of ideas, and more novel ideas than did the continuous dyads. Such differences should also increase with each successive time session as fixation builds in the continuous dyads.

Statistical analyses and overall findings. In order to examine how a task-alternation approach influences group idea-generation performance, separate 2(Condition: continuous vs. alternating) × 2(Task: physical activity vs. mobility) × 3(Session: $t1$, $t2$, $t3$) ANOVAs on the number of ideas, the number of categories of ideas, and the square-root transformed[2] novelty score of ideas were conducted. For the measure on the number of new categories of ideas, non-parametric (Mann–Whitney–Wilcoxon) tests were conducted because the data exhibited heterogeneous within-group variances.

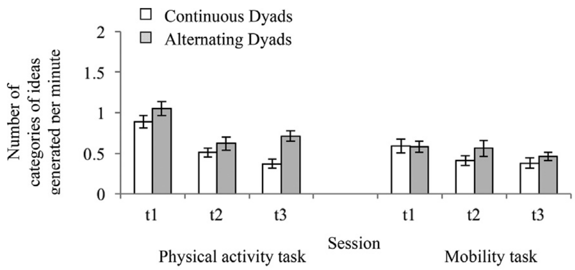
Overall, our findings support the positive role of task alternation on group idea generation. The alternating dyads generated ideas from a wider set of categories as compared to the continuous group; they were also more likely to explore new categories and produce more novel ideas, and these performance differences increased over time. However, the beneficial effect of task alternation was evident only for the physical activity task. The full ANOVA results are presented in Supplemental Material C. The non-parametric test results and ANOVA results related to the objectives of this study are discussed below.

Number of categories of ideas per minute. In order to assess how task alternation impacted the breadth of ideas generated, a 2(Condition: continuous vs. alternating) × 2 (Task: physical activity vs. mobility) × 3(Session: $t1$, $t2$, $t3$) ANOVA on the number of categories of ideas per minute was conducted. Both the Condition effect, $F(1,37) = 4.60$, $p = .039$, $\eta^2_{\text{partial}} = .11$, 95% CI for η^2_{partial} [.003, .273], and its interaction with Task, $F(1,37) = 4.46$, $p = .042$, $\eta^2_{\text{partial}} = .11$, 95% CI for η^2_{partial} [.002, .270], were statistically significant. The interaction was due to the significantly better performance of the alternating dyads ($M = .79$, $SD = .25$) than the continuous dyads ($M = .59$, $SD = .21$) on the physical activity task, $p = .01$, $d = .87$, 95% CI for d [.19, 1.55], compared with no significant alternating versus continuous difference for the mobility task, alternating: $M = .53$, $SD = .23$, continuous: $M = .46$, $SD = .20$, $p = .27$.

The tests of within-subjects contrasts were conducted to see how the effect of task-alternation changes across sessions. There was a significant quadratic trend for the interaction between Condition, Session and Task, $F(1,37) = 4.49$, $p = .041$, $\eta^2_{\text{partial}} = .11$, 95% CI for η^2_{partial} [.002, .270]. When solving the physical activity task, there was a marginally significant quadratic trend for the effect of task-alternation over time, with the alternating versus continuous difference small during the first two sessions but becoming noticeable during the last session, Condition × Session effect: $F(1,37) = 2.74$, $p = .11$, $\eta^2_{\text{partial}} = .69$. For the mobility task, no significant difference was found, $F(1,37) = 1.78$, $p = .19$ (see Fig. 2).

In sum, there was a strong facilitating effect of task-alternation on the number of categories of ideas for the physical activity task ($d = .87$). There was a tendency that the benefit increased over time for the physical activity task; however, this temporal effect was only marginally significant, $p = .11$. It may

[2] The average novelty score was square-root transformed to diminish skew. The skewness values of the transformed data ranged from −.25 to +0.55.



	t1	t2	t3	t1	t2	t3
	M(SD)			*M(SD)*		
Continuous	.89(.35)	51(.24)	.37(.24)	.59(.32)	.41(.23)	.38(.24)
Alternating	1.05(.38)	.62(.34)	.71(.28)	.58(.27)	.56(.37)	.46(.20)
Continuous vs. Alternating	p =.18	p =.25	p <.001	p = 0.94	p =.14	p =.21

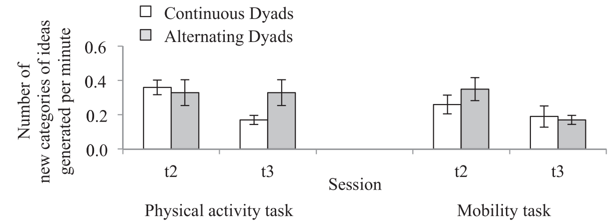
Figure 2. Number of categories of ideas generated per minute by Condition, Session, and Task. Error bars show ±1 *SE*.

be the case that the critical difference between the alternating and continuous dyads is their likelihood of expanding their search. The alternating dyads would continue to explore new categories throughout the idea-generation session while the continuous dyads would become more fixated on previously explored categories over time. Examining the number of new categories explored after the initial search may be a more sensitive measure to detect this difference.

Number of new categories of ideas per minute. Mann–Whitney–Wilcoxon tests with a Bonferroni adjustment for multiple testing (adjusted critical $p = .05/4$) were conducted to compare the number of new categories of ideas generated per minute between the alternating and continuous dyads in the second and third sessions.

When solving the physical activity task, the continuous ($M = .36$, $SD = .19$; mean rank score = 20.88) and alternating dyads ($M = .33$, $SD = .18$; mean rank score = 19.08) generated a similar number of new categories of ideas per minute during the second session, $Z = .51$, $p = .61$. During the last session, the alternating dyads continued to expand the search scope while the continuous dyads became less likely to explore new categories, resulting in a significant alternating versus continuous difference on the number of new categories of ideas generated per minute in the third session (alternating: $M = .33$, $SD = .21$, mean rank score: 25.18; continuous: $M = .17$, $SD = .12$, mean rank score: 15.08, $Z = 2.96$, $p = .003$, $d = 1.08$,[3] 95% CI for d [.39, 1.77]). This is consistent with our expectation that the alternating dyads would be more likely than the continuous dyads to expand the search, particularly in the later part of the idea generation session as fixation builds in the continuous dyads. For the mobility task, no statistically significant alternating versus continuous difference was found, all $p > .38$ (see Figure 3).

Novelty of ideas. A 2(Condition: continuous vs. alternating) × 2(Task: physical activity vs. mobility) × 3(Session: $t1$, $t2$, $t3$) ANOVAs on the square-root transformed novelty score of ideas was conducted. The Condition effect was marginally significant, $F(1,37) = 3.90$, $p = .056$, $\eta^2_{\text{partial}} = .95$. There was



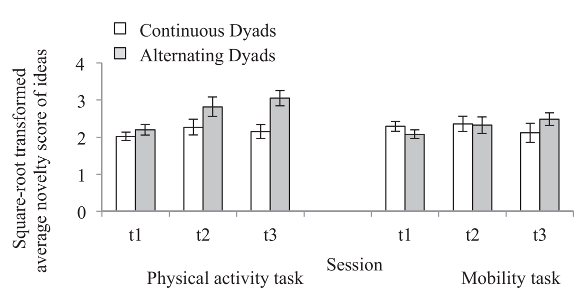
	t2	t3	t2	t3
	M(SD); Mean Rank Score		*M(SD);* Mean Rank Score	
Continuous	.36 (.19);20.88	.17(.12);15.08	.26(.21);18.48	.19(.24);18.95
Alternating	.33(.18);19.08	.33(.21);25.18	.35(.26);21.61	.17(.10);21.11
Continuous vs. Alternating	Z = .51 p = .61	Z = 2.96 p = .003	Z = .87, p = .38	Z =.66, p = .51

Figure 3. Number of new categories of ideas generated per minute by Condition, Session, and Task. Error bars show ±1 *SE*.

a significant Condition × Task effect, $F(1,37) = 6.16$, $p = .018$, $\eta^2_{\text{partial}} = .14$, 95% CI for η^2_{partial} [.014, .309]. For the physical activity task, the alternating dyads produced more novel ideas than did the continuous dyads, alternating: $M = 2.70$, $SD = .60$, continuous: $M = 2.15$, $SD = .84$, $p = .005$, $d = .73$, 95% CI for d [.06, 1.40]. No significant alternating versus continuous difference was found for the mobility task, $p = .83$.

There was a significant linear trend such that the alternating versus continuous difference increased with each successive session, Condition × Session effect: $F(1,37) = 9.83$, $p = .003$, $\eta^2_{\text{partial}} = .21$, 95% CI for η^2_{partial} [.046, .378]. This temporal trend was significant for the physical activity task, $F(1,37) = 5.56$, $p = .024$, $\eta^2_{\text{partial}} = .13$, 95% CI for η^2_{partial} [.010, .296], and marginally significant for the mobility task, $F(1,37) = 2.84$, $p = .10$, $\eta^2_{\text{partial}} = .07$ (see Figure 4).

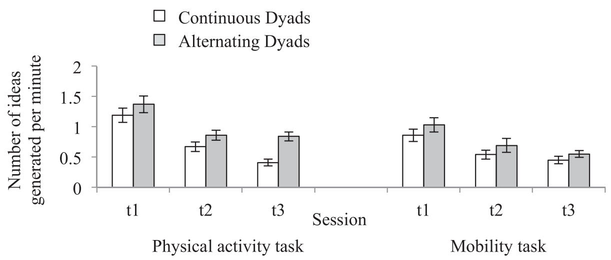
Number of ideas generated per minute. A 2(Condition: continuous vs. alternating) × 2(Task: physical activity vs. mobility) × 3(Session: $t1$, $t2$, $t3$) ANOVA on the number of ideas generated per minute was conducted to examine if task alternation could also increase the idea-generation rate. The direction of the effect of task alternation on the quantity of the ideas was the same for those on the variety and the novelty of the ideas, with the alternating dyads outperforming the continuous dyads when solving the physical activity task, particularly in the later part of the task session (see Figure 5). However, the effect on the quantity of the ideas was just marginally significant, Condition: $p = .052$, Condition × Task: $p = .073$, and



	t1	t2	t3	t1	t2	t3
	M(SD)			*M(SD)*		
Continuous	2.02(.52)	2.27(.94)	2.15(.84)	2.29(.60)	2.36(.92)	2.12(1.14)
Alternating	2.22(.63)	2.82(1.13)	3.05(.90)	2.08(.51)	2.32(.98)	2.48(1.06)
Continuous vs. Alternating	p =.28	p =.11	p =.003	p =.24	p =.90	p =.24

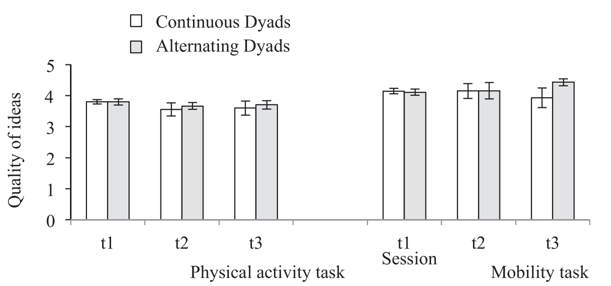
Figure 4. Square-root transformed average novelty score of ideas generated by Condition, Session, and Task. Error bars show ±1 *SE*.

[3] The effect size r was computed as the square root of $Z/\sqrt{N}$. It was then converted to d using the formula $d = 2r/\sqrt{1 - r^2}$ (Friedman, 1968).



	Physical activity task t1	t2	t3	Mobility task t1	t2	t3
	M(SD)			*M(SD)*		
Continuous	1.19(.53)	.67(.35)	.41(.26)	.86(.46)	.54(.33)	.45(.28)
Alternating	1.36(.59)	.86(.36)	.84(.32)	1.03(.51)	.69(.50)	.55(.25)
Continuous vs. Alternating	p =.34	p =.10	p <.001	p =.30	p =.30	p =.21

Figure 5. Number of ideas generated per minute by Condition, Session, and Task. Error bars show ±1 *SE*.



	Physical activity task t1	t2	t3	Mobility task t1	t2	t3
	M(SD)			*M(SD)*		
Continuous	3.80(.31)	3.55(.96)	3.60(1.00)	4.15(.39)	4.15(1.06)	3.92(1.42)
Alternating	3.80(.44)	3.67(.47)	3.70(.60)	4.11(.44)	4.16(1.16)	4.43(.50)
Continuous vs. Alternating	p =.34	p =.10	p <.001	p =.30	p =.30	p =.21

Figure 6. Quality of ideas by Condition, Session, and Task. Error bars show ±1 *SE*.

Condition × Task × Session: $p = .069$ (see Supplemental Material C for ANOVA results).

Quality of ideas. A 2(Condition: continuous vs. alternating) × 2(Task: physical activity vs. mobility) × 3(Session: *t*1, *t*2, *t*3) ANOVA on the quality of ideas was conducted to examine if the ideas generated by the alternating dyads were as good as those of the continuous dyads. Both the Condition and Condition × Task effects were not significant, $p > .40$, implying that the continuous and alternating dyads did not differ in terms of the quality of ideas generated (see Figure 6). Thus the increased variety and novelty in the alternating dyads was not obtained by sacrificing quality.

Discussion

A facilitating effect of task alternation was observed for the physical activity task but not the mobility task. When solving the physical activity task, the alternating dyads generated more diverse ideas than did the continuous dyads. The alternating dyads also explored more new categories and produced more novel ideas. These effects were all statistically significant, large, and of similar magnitude (number of categories: $d = .87$, number of new categories: $d = 1.08$, novelty of ideas: $d = .73$). Furthermore, these alternating versus continuous differences all increased as the experiment proceeded, particularly for the number of new categories of ideas and the novelty of ideas generated. These support our prediction that the benefit of task alternation should increase over time as fixation builds in the continuous dyads. Also noteworthy, the ideas generated by the alternating dyads were as useful as those of the continuous dyads, suggesting that task alternation can increase the variety and novelty of ideas without any trade-off on the quality of ideas.

No significant effect of task alternation was found for the mobility task. The lack of effect may be due to the lower familiarity of the participants with this topic. Indeed, participants, even those who were in the continuous dyads receiving no experimental manipulation, generated fewer ideas and categories of ideas on the mobility task than on the physical activity task, number of ideas per minute: $M = .78$, $SD = .34$ (physical activity), $M = .63$, $SD = .29$ (mobility), $p < .001$; number of categories of ideas per minute: $M = .60$, $SD = .22$ (physical activity), $M = .46$, $SD = .20$ (mobility), $p < .001$. The key difficulty of the mobility task possibly resides in a lack of knowledge instead of fixation induced by domain knowledge, a situation that may have limited the impact of our manipulation. To further examine this issue, Experiment 2 was conducted in which dyads were asked to generate ideas on two familiar topics. We examined if a similar effect of task alternation would be observed for both tasks.

Another objective of Experiment 2 was to specify the mechanism underlying the effect of task alternation. One may argue that in addition to idea retrieval, other cognitive processes (e.g., idea modification and recombination) are also involved in the solving of an idea generation task (Ward, Patterson, & Sifonis, 2004), and that task alternation might facilitate these cognitive processes rather than idea retrieval. To examine more directly the effect of task alternation on the memory search process, in Experiment 2 we presented participants with tasks that rely more heavily on the memory retrieval process—category–exemplar generation tasks. Category–exemplar generation tasks require individuals to generate exemplars from a specific category (e.g., list members of category "bird"). Memory retrieval has been suggested to be the key process underlying exemplar generation (Barsalou, 1982; Rosen & Engle, 1997). Replicating the facilitating effect of task alternation on category–exemplar generation tasks would provide strong evidence supporting our prediction that alternating between tasks can facilitate group ideation.

Experiment 2

Experiment 2 was conducted to replicate the findings of Experiment 1 with category–exemplar generation tasks. Dyads were presented with two category names and were asked to produce exemplars of each category with or without task-alternation. The categories presented were those that participants should be familiar with. We examined whether task alternation can reduce fixation and lead to better performance, and if a similar effect of task alternation would be observed across the two tasks.

Method

Participants. 80 undergraduates (45 male, 35 female, $M_{age} = 20.78$ years, $SD = 2.62$) at Carnegie Mellon University participated for course credit or payment. Participants worked in pairs and were randomly assigned to either the continuous (20 pairs) or the alternating (20 pairs) condition.

Materials. Two category–exemplar generation tasks were used. One task involved listing members of the category “cold things,” and the other was about listing members of the category “heavy things.” Both “cold things” and “heavy things” were flexible categories in that they could be defined in multiple ways (Smith et al., 2015). If task alternation, as predicted, helps reduce repeated retrieval of members and expands the search space to include a diverse set of members, then the alternating dyads should be more fluent in generating members of the presented category and the members retrieved should be more novel, as compared to those of the continuous dyads.

Procedure. Participants were asked to work in pairs to solve the category–exemplar generation tasks. They were given 3 min on each task and were randomly assigned to the continuous or alternating condition. In the continuous condition, participants were asked to work collaboratively on one task for 3 min before proceeding to the other one. In the alternating condition, the two tasks were interleaved with each other and participants were asked to switch from one task to the other after every 1 min. The order of presentation of the tasks was counterbalanced.

Prior to the experiment, participants first received instructions on the tasks and completed a practice trial, in which they were given 2 min to work together to generate members of the category “clothing”. Then, the two category–exemplar generation tasks were presented for 3 min either continuously (continuous condition) or in an interleaved manner (alternating condition).

Similar to Experiment 1, participants were seated at computer terminals in the same room, separated by divider walls. Participants communicated and exchanged ideas with each other by sending instant messages to each other via Skype. They were reminded to pay attention to each other’s ideas and avoid generating the same ideas.

Results

In order to examine the effect of task alternation on group performance on this category–exemplar generation task, the number and the novelty of ideas generated between the continuous and alternating dyads were compared. Repeated ideas were excluded from any analysis. Similar to Experiment 1, a novelty score for each idea was computed as the total number of dyads in the experiment ($N = 40$) divided by the number of those dyads who generated that specific idea. These two measures have been used to good effect in evaluating category–exemplar generation task performance at the individual level (Smith et al., 2015).

For analysis, the problem-solving session for each task in the continuous condition was divided into three subsessions ($t1$ [0:00–:59], $t2$ [1:00–1:59], $t3$ [2:00–2:59]). The duration of each subsession in the continuous condition is equal to the amount of time participants in the alternating condition spent on the task before each switching. The quantity and the novelty of ideas generated in each session between the continuous and alternating dyads were compared in order to assess the impact of task alternation on group performance over time.

Table 2
Group Category–Exemplar Generation Performance in Each Session by Task and Condition (Experiment 2)

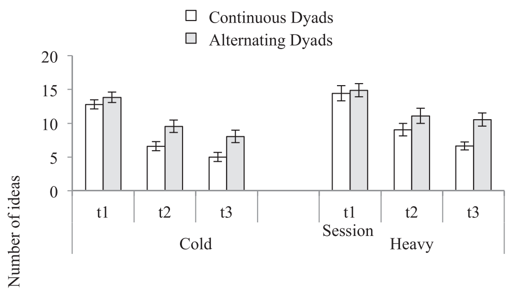
Session	Number of ideas		Novelty score of ideas	
	Continuous *M* (*SD*)	Alternating *M* (*SD*)	Continuous *M* (*SD*)	Alternating *M* (*SD*)
Cold things				
$t1$	12.75 (3.04)	13.85 (3.51)	18.70 (4.00)	20.22 (3.72)
$t2$	6.60 (3.00)	9.55 (4.08)	26.19 (5.00)	25.90 (4.29)
$t3$	5.00 (2.97)	8.05 (4.07)	27.28 (6.64)	27.28 (5.48)
Overall	8.12 (2.70)	10.42 (3.28)	24.05 (3.55)	24.47 (3.90)
Heavy things				
$t1$	14.45 (5.07)	14.90 (4.35)	21.56 (3.54)	22.68 (2.99)
$t2$	9.05 (4.19)	11.10 (5.00)	25.84 (5.29)	28.03 (5.03)
$t3$	6.65 (2.68)	10.55 (4.39)	29.85 (3.66)	28.94 (3.92)
Overall	10.05 (2.93)	12.18 (3.86)	25.75 (2.25)	26.55 (2.68)

The alternating and continuous dyads were initially balanced in terms of task performance as there was no significant performance difference for the first session between the alternating and continuous dyads, all $p > .20$ (see Table 2 for descriptive statistics). Hence, any significant between-groups difference is likely due to different problem-solving conditions (alternating vs. continuous) that took place after the first session.

Number of ideas generated. A 2(Condition: continuous vs. alternating) × 2(Task: cold vs. heavy) × 3(Session: $t1$, $t2$, $t3$) ANOVA on the number of ideas generated was conducted to examine if the alternating dyads were more fluent in generating ideas than the continuous dyads. A significant Condition effect was revealed, $F(1,38) = 5.50$, $p = .03$, $\eta^2_{\text{partial}} = .13$, 95% CI for η^2_{partial} [.009, .289]. As predicted, the alternating dyads generated more ideas than did the continuous dyads, total number of ideas per task: $M = 33.90$, $SD = 10.08$ (alternating), $M = 27.25$, $SD = 7.72$ (continuous), $d = .74$, 95% CI for d [.08, 1.40]. Also, this alternating versus continuous difference increased with each successive session, as indicated by the significant linear trend for the interaction of Condition and Session, $F(1,38) = 8.80$, $p = .005$, $\eta^2_{\text{partial}} = .19$, 95% CI for η^2_{partial} [.035, .354] (see Figure 6). This is consistent with the findings of Experiment 1 showing an increasing benefit of task alternation on task performance over time. A similar pattern of results was observed for both tasks, as neither the interaction effect of Task and Condition nor their interaction with other factors were significant, all $p > .58$ (see Figure 7).

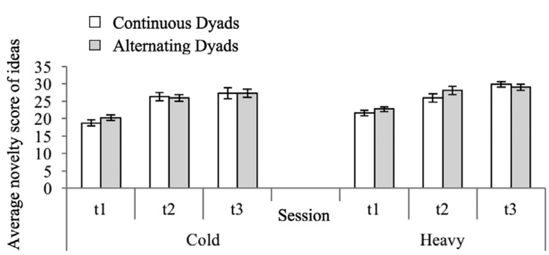
Novelty of ideas. A 2(Condition: continuous vs. alternating) × 2(Task: cold vs. heavy) × 3(Session: $t1$, $t2$, $t3$) ANOVA on the novelty score of ideas was conducted. The main effect of Session was significant, $F(2,76) = 79.14$, $p < .001$, $\eta^2_{\text{partial}} = .68$, 95% CI for η^2_{partial} [.514, .758], showing that ideas generated at the later time points were more novel than those generated at the early time points. Neither the main effect of Condition nor its interaction with other factors was significant, all $p > .33$, suggesting a similar increasing trend for both the alternating and continuous dyads (see Figure 8).

The analysis of the novelty of ideas revealed that later ideas were more novel than early ones and the analysis of the quantity



	t1	t2	t3	t1	t2	t3
	M(SD)			*M(SD)*		
Continuous	12.75 (3.04)	6.60(3.00)	5.00(2.97)	14.45(5.07)	9.05(4.19)	6.65(2.68)
Alternating	13.85 (3.51)	9.55(4.08)	8.05(4.07)	14.90(4.35)	11.10(5.00)	10.55(4.39)
Continuous vs. Alternating	*p* =.30	*p* =.02	*p* =.01	*p* = .77	*p* =.17	*p* =.002

Figure 7. The number of ideas generated by Condition, Session, and Task. Error bars show ±1 *SE*.



	t1	t2	t3	t1	t2	t3
	M(SD)			*M(SD)*		
Continuous	18.70(4.00)	26.19(5.00)	27.28(6.64)	21.56(3.54)	25.84(5.29)	29.85(3.66)
Alternating	20.22(3.72)	25.90(4.29)	27.28(5.48)	22.68(2.99)	28.03(5.03)	28.94(3.92)
Continuous vs. Alternating	*p* =.22	*p* =.85	*p* =1.00	*p* = .29	*p* =.19	*p* =.45

Figure 8. Average novelty score of ideas generated by Condition, Session, and Task. Error bars show ±1 *SE*.

of ideas revealed that the alternating dyads generated more ideas than did the continuous dyads, particularly at the later stage of problem-solving. Together, this implies that the alternating dyads generated a large number of novel ideas as compared to the continuous dyads. This again supports the positive effect of task alternating on group idea generation.

General Discussion

Two experiments were conducted to examine the effect of task alternation on group ideation. Dyads were asked to solve idea-generation tasks (Experiment 1) or category–exemplar generation tasks (Experiment 2). In both experiments, dyads had to perform the tasks with or without alternation between the presented tasks. The results of Experiments 1 and 2 were consistent with each other, showing a positive role of task alternation on group performance.

During idea generation, individuals tend to first retrieve typical ideas. The exchange of these ideas is likely to make group members fixate on these typical initial responses, and continued group interaction may lead to increased fixation because these recently retrieved easily activated ideas are likely to be retrieved and shared repeatedly. Breaking down the idea-generation session into multiple, short sessions interlaced with other tasks should help prevent the build up of such fixation and facilitate the retrieval of novel ideas, and such beneficial effects should become more visible over time as fixation builds in the continuous dyads. In line with this proposal, a positive role of task alternation was found. In Experiment 1, when solving the physical activity task, the alternating dyads generated more diverse and novel ideas as compared to the continuous dyads. These alternating versus continuous differences also increased over time. Similarly, in Experiment 2, the alternating dyads generated a larger number of novel ideas than did the continuous dyads, and the effect of task alternation increased over time for both tasks.

In Experiment 1, the benefit of task alternation was found for the physical activity task but not for the mobility task. The lack of effect for the mobility task may be related to the lower familiarity of the participants with this topic. In Experiment 2, participants were asked to generate responses on two familiar domains (i.e., cold and heavy things), and a facilitating effect of task alternation was found for both tasks.

One may argue that the effects of task alternation may be due to other factors, rather than the overcoming of fixation. For example, in the alternating condition, the tasks were presented repeatedly interleaved with others. The alternating dyads might assimilate the ideas generated for one task into the other task; their performance might thus be due to cross-task priming. However, only 7 out of 703 ideas for the physical activity task (alternating: 3 ideas; continuous: 4 ideas) were mobility related[4]; only 11 of the 538 ideas for the mobility task were physical-activity related[5] (alternating: 6 ideas; continuous: 5 ideas). Similarly, only 38 out of 2444 ideas were listed as both cold and heavy things (alternating: 16 ideas, continuous: 22 ideas). These ideas were also equally frequent for alternating and continuous conditions. Thus, cross-task priming is unlikely to be the mechanism underlying the effect of task alternation.

Another alternative account is that the increased performance of the alternating dyads might be due to the reduction in the feeling of failure. Throughout the idea generation session, it should become more difficult to generate new ideas after participants have exhausted easily accessible ideas, leading to the impression that not many ideas are still possible. This may be a motive for individuals to end their efforts at the task (Nijstad & Stroebe, 2006). Alternating between tasks might weaken this negative feeling by preventing further fruitless attempts and by providing time for such feeling to decay. The alternating dyads should therefore be more persistent than the continuous dyads in idea generation. According to this motivational perspective, a larger effect of task alternation should be found for tasks that individuals have difficulty generating ideas for and thus find frustrating, as in the mobility task in Experiment 1, opposite to the effect found in Experiment 1. The idea that alternating between tasks reduces fixation appears to be a better candidate to account for the present findings.

[4] Ideas containing the words "mobility impaired," "mobility impairment," or "handicapped."

[5] Ideas containing the words "sport," "exercise," "gym," "physical activity," "work out," or "fitness."

To consider whether the interaction effects could be underpowered given our relatively small sample size (39 dyads in Experiment 1 and 40 dyads in Experiment 2), we have computed the statistical power of our ANOVA results using PANGEA (Westfall, 2015), a software that can estimate power for general ANOVA designs. According to this analysis, Experiment 1 had enough power (80%) to detect the main effect of Condition and the 2-way interaction between Condition and Task, but not the 2-way interaction between Condition and Session or the 3-way interaction between Condition, Task and Session (power = 63%). As a result, the magnitude of these interaction effects could be exaggerated (Button et al., 2013); however, we have replicated very similar interaction effects in Experiment 2. Also, the effects in both experiments were close in magnitude. Thus, it is very unlikely that the initial effect size observed in Experiment 1 was overestimated.

Both experiment 1 and 2 focused on dyadic interaction. This raises a follow-up question of whether task alternation would be equally helpful for large groups. When group size increases, individuals are more likely to be exposed to a diverse set of ideas, increasing the likelihood that the idea pool will include cues that help individuals switch to a new category (Larson, 2009). In that case, idea sharing may induce inspiration rather than fixation, and the benefit of task alternation may become less noticeable. Future research exploring how the impact of task alternation changes as group size increases is needed in order to make use of this task-alternation technique effectively to enhance group performance.

To conclude, idea generation is an initial and critical step in problem- solving, and the sharing of ideas during idea generation, while commonly thought to be beneficial, can induce fixation. On the basis of the findings of this study, we suggest that simply breaking the idea-generation session into multiple, short, sessions interlaced with other idea-generation tasks can enable groups to search more broadly and generate more novel ideas, most likely via overcoming the fixation.

Conflict of Interest Statement

The authors declare no conflict of interest.

Author Contributions

All authors contributed to the development of the study concept and the study design. Testing and data collection were performed by U. N. Sio. U. N. Sio performed the data analysis and interpretation under the supervision of K. Kotovsky and J. Cagan. U. N. Sio drafted the manuscript, and K. Kotovsky and J. Cagan provided critical revisions. All authors approved the final version of the manuscript for submission.

Appendix A. Supplementary Data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jarmac.2017.08.005.

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