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# MEMORY AND IDEA GENERATION APPLIED TO PRODUCT REPURPOSING

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## ABSTRACT

*Many engineering problems still require novel solutions, e.g., the repurposing of retired wind-turbine blades. Increasing evidence suggests that the recall of episodic memories enhances idea generation, but its application to engineering problems has been limited. The current work investigates the effectiveness of a memory induction on generating ideas. Engineering undergraduate students in a fourth-year design course (N=38) completed a study under both of two conditions, a memory induction and a control (non-episodic-memory) induction. Participants underwent the induction before generating ideas on the Alternate Uses Task (AUT), a standard test of divergent thinking, and a wind-turbine-blade repurposing task (WRT).*

*AUT responses following the memory induction were deemed significantly more flexible (p=.045) and elaborate (p=.041) than responses following the control induction. No difference in response fluency (p=0.205) followed the two inductions, possibly due to limited time allotted for the AUT. In line with this explanation, fluency was inversely related to elaboration. In the WRT, more appropriate (p=0.009) and more feasible (p=0.015) ideas for repurposing wind-turbine blades were generated following the memory than the control induction.*

*These results suggest that strategies increasing access to episodic memory may improve generation of alternative-use ideas for both common objects and wind-turbine blades.*

Keywords: Alternate Uses Task (AUT), Wind-Turbine-Blade Repurposing, Memory, Episodic Specificity Induction.

## NOMENCLATURE

| | |
|---|---|
| Alternate Uses Task (AUT) | Creative-thinking task that asks participants to generate as many uses as possible for common objects. |
| Wind-turbine-blade Repurposing Task (WRT) | Task that asks participants to generate repurposing ideas for wind-turbine blades that are preemptively retired for safety reasons. |

## 1. INTRODUCTION

Increased urgency to address climate change has led to significant technological advances, including developments in solar, wind, and other renewable sources of power. However, end-of-life consideration of associated products have not kept pace. Specifically, wind-turbine blades are preemptively decommissioned to reduce the risk of catastrophic failure, but these blades are, as of yet, made of unrecyclable materials. While their shape is optimized for their intended function, this aerodynamic geometry limits the ways in which they can be reused (Kwon et al. 2019). Enhancing the ability of engineers and others to generate ideas to repurpose wind-turbine blades is therefore important, and a focus of this study.

### 1.1 End-of-Life of Wind-Turbine Blades

Current end-of-life solutions for wind-turbine blades can be divided into industrial-scale and occasional solutions (Beauson et al. 2016). Industrial-scale solutions include refurbishing the decommissioned blade, which is challenging for blades longer than 50m due to transport difficulties. Another possibility is incineration for energy recovery, but glass fibers in the structural composite material are not combustible (Duflou et al. 2012).

As occasional solutions, large wind-turbine-blade sections can be periodically used for architectural and related applications, with an advantage of minimal required re-processing. However, the number of possible reuses are limited by the complex geometry of the wind-turbine blade. That is, wind-turbine blades can also be used as elements in construction, but such applications are limited by the amount of re-processing required to obtain the desired geometry.

Current occasional solutions cannot keep up with the ever-increasing number of wind-turbine blades being de-commissioned. By 2024, in the US alone, approximately 32,000 wind-turbine blades will have been retired (Martin, 2020). The present work aims to improve the generation of new wind-turbine-blade-repurposing ideas.

### 1.2 Episodic Memory

Increasing evidence suggests that the ability to generate ideas (i.e., divergent thinking) relies on memories of specific episodes from the past (Roberts & Addis 2018). Known as episodic memory, this refers to the re-experiencing of past events, as opposed to semantic memory for facts (Tulving & Markowitsch 1998). For example, if you own a wristwatch, knowing *what* a wristwatch is relies on semantic memory, while reliving the *event* of obtaining that wristwatch invokes episodic memory. Recent work has demonstrated that episodic memory enables humans to mentally simulate novel experiences and ideas, in part by supporting the flexible recombination of information stored in episodic memory (Addis, 2018).

Relevant to the current work, three lines of evidence have linked episodic memory to idea generation. First, episodic memories are drawn upon when attempting to produce multiple ideas to open-ended problems, i.e., in divergent thinking (Storm et al. 2014). Second, individuals with impaired episodic-memory function perform significantly worse on divergent-thinking tasks (Duff et al., 2013). Third, cognitive-induction techniques that facilitate episodic-memory retrieval were found to enhance idea generation in divergent-thinking tasks (Madore et al. 2016).

Some theories by psychologists have focused on memory usage and their effect on idea generation (Mertens et al. 2019). One can argue that many ideas generated in divergent-thinking tasks are nothing more than recombining already-existing ideas from memory (Kirjavainen et al. 2019). Thus, accessing memory becomes critical to generating novel concepts. This, along with the above behavioral findings, suggests that inducing access to episodic memory, and increasing the specificity and detail of recall, can improve novel idea generation.

Madore et al. (2014) developed the episodic specificity induction, referred to more simply as "memory induction" in the current work. Derived from forensic techniques to increase recall of eyewitness detail (Fisher & Geiselman 1992), this induction increases the recall of specific and detailed episodic memories.

This memory induction is hypothesized to facilitate idea generation on a wind-turbine-blade repurposing task (WRT) compared to a control induction. Minor changes in administering this memory induction enabled its use in a group setting. In addition to completing a WRT following each induction, participants also completed the Alternate Uses Task (AUT), where they generated alternative uses for everyday objects. Memory induction was also hypothesized to improve AUT performance, as previously reported (Madore et al., 2016).

## 2. METHODS

A study was conducted to test the above hypothesis. The below sections provide details on the study participants, design, induction conditions and idea-generation tasks.

### 2.1 Participants

Participants were fourth-year engineering undergraduate students enrolled in the course "Design of Innovative Products" at the University of Toronto.

A total of 38 participants gave written informed consent for the study approved by the University of Toronto's Research Ethics Board. Four were excluded due to improper observance of study methodology (cellphone use, n=2; improper completion of intervention, n=2). One participant did not complete the wind-turbine-blade repurposing task (WRT) and was excluded from the WRT analyses.

General characteristics of participants (gender, age and discipline within engineering, i.e., mechanical, industrial, or engineering science) are shown in **Table 1**. In addition, participants were asked to rate their familiarity with key components of the experiment. With respect to wind-turbine-blade technology, almost 50% of participants indicated they were "not at all familiar", while the remaining indicated that they were either slightly or moderately familiar. Over 80% of participants stated they had never before completed an AUT.

**TABLE 1**: Characteristics of participant sample

| Characteristic | Number of Participants |
|---|---|
| Gender | Female: 21<br>Male: 17 |
| Age | 21 years old: 5<br>22 years old: 27<br>23 years old: 6 |
| Engineering Discipline | Mechanical: 15<br>Industrial: 22<br>Engineering Science: 1 |

### 2.2 Design and Procedure Overview

All participants completed the study in the same conference room. While the room had a central table, not all participants completing the study at one time could fit at the table. Thus, to provide a more uniform study condition, all participants completed the study using clipboards with study documents, seated approximately equidistantly from each other. An image of the experiment environment can be seen in **Figure 1.**

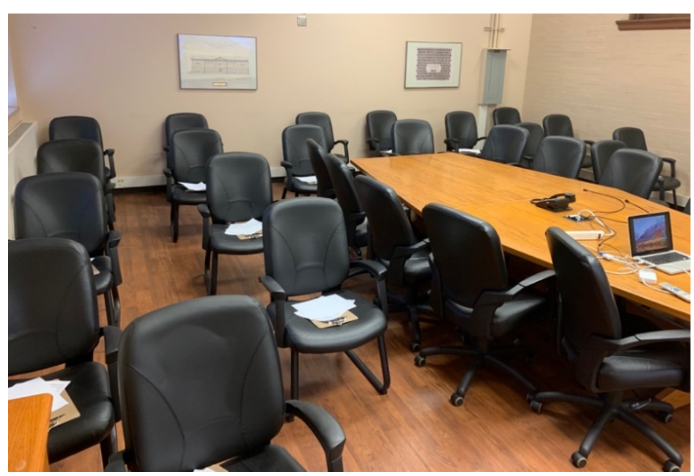

**FIGURE 1:** Study setting: View from conference-room front

In the within-subject study design shown in **Figure 2**, participants were randomly assigned to one of two groups that completed the study one after the other. The order of the induction conditions (memory, control) were counterbalanced across groups. That is, while participants in both groups underwent both conditions, Group 1 underwent the control induction before the memory induction, and Group 2 underwent the inductions in the reverse order. Groups were further randomly divided into subgroups (A, B), and the two trials of the AUT and the WRT were counterbalanced across subgroups.

At the start of the study, participants were provided booklets with all required materials and told that there would be two ~50-minute sessions. Both sessions followed the same procedure: all participants watched the same video, completed the same 3-minute filler task and then responded to questions specific to the particular induction. Sessions 1 and 2 were separated by 10 minutes, during which participants completed a filler task and took a short break. The experiment ended with a debrief of the study's objectives.

## 2.3 Induction Conditions

*2.3.1 Videos and Filler Tasks*

Each session started with a 2-minute video, shown simultaneously to all participants in the group using an LCD projection onto a screen. Video 1 showed a man and a woman performing and talking about everyday activities in a kitchen. Video 2 showed the same man and woman performing and talking about other everyday activities in the kitchen. After each video, participants completed in their booklets, a 3-minute filler task of simple arithmetic, i.e., adding single-digit integers.

*2.3.2 Induction*

Two induction conditions corresponded to two different sets of questions, read aloud by the experimenter, which referenced the video viewed before the filler math task. The experimenter used generic verbal prompts, e.g., "Please move on to Question 3 now." Participants worked silently, writing responses next to the corresponding question number in their booklets, and were told that responses in point form were acceptable.

**Episodic Specificity (Memory) Induction** For the memory induction, participants were instructed to put themselves in the mindset of an audio-description writer for the visually impaired. Three memory-recall sections of the induction focused on the video's 1) surroundings, 2) people and 3) actions. For each of the three sections, participants were instructed to first close their eyes for 30s, as eye closure has been shown to help memory recall by reducing cognitive load and enhancing visualization (Vredeveldt et al. 2011). Participants were then instructed to silently recall as many details as possible about the surroundings, people and actions shown in the video. For example, regarding the surroundings, participants were asked to picture the types of things in the environment shown on the video, how they were arranged and what they looked like. Once instructed to open their eyes, participants were given 2 minutes to write down everything they could remember, being as specific and detailed as possible. During those 2 minutes, participants completed a series of probing questions printed in their booklets, e.g., "describe more about how the kitchen was arranged" or "describe more about what was in the kitchen". Similar probes were used regarding the people and actions shown in the video. The experimenter script for the memory induction is provided in **Appendix A**.

**Control Induction** To provide a comparable control condition, the control induction also involved participants recalling aspects of the video in response to a set of questions in their booklets. Critically, in contrast to the memory induction, the control induction does not induce recollection of past experiences and thus does not increase access to episodic memory (Madore et al. 2014). Participants were told that they had 30 to 60s to answer each question. The first control-induction question asked participants about their general impressions of the video. They were told not to give a summary or any details, but to describe just their thoughts and opinions. Subsequent questions further probed their general impressions of the surroundings, people and actions in the video, e.g., "Can you guess the people's occupation based on the video?" and "When do you think the video was made?" The experimenter script for the control-induction condition is provided in **Appendix B**.

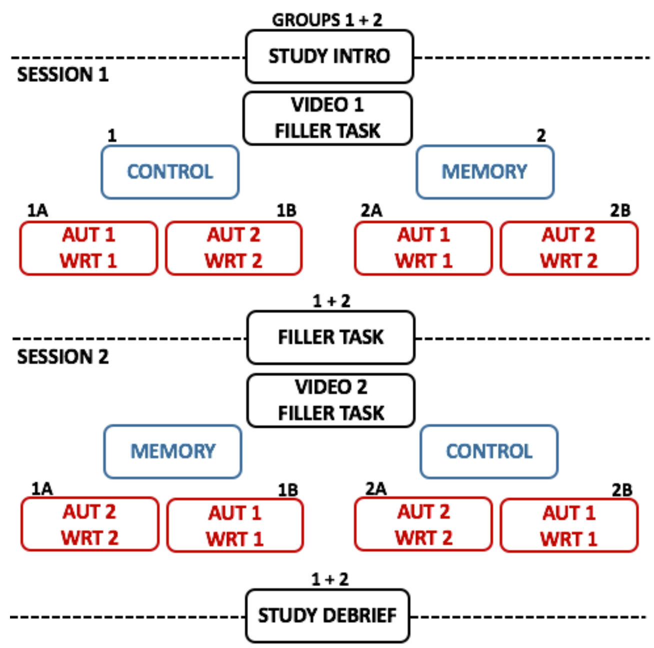


**FIGURE 2:** Study design: Both sessions comprised a video and filler task, followed by induction (shown in blue, counterbalanced across groups 1 and 2) and idea generation tasks, Alternate Uses Task (AUT) and Wind-turbine-blade Repurposing Task (WRT) (shown in red, trials counterbalanced across subgroups A and B).

### 2.4 Idea-Generation Tasks

*2.4.1 Alternate Uses Task (AUT)*

Past research has shown that warm-up activities help reduce inhibition during concept generation (Hu et al. 2015). Therefore, following the video-based induction, participants completed a 1-minute trial of the Alternate Uses Task (AUT). This divergent-thinking task was intended to prime participants into producing many ideas for the more challenging, wind-turbine-blade repurposing task described below. Participants were instructed to list as many uses as possible for the single item printed at the top of the page in their booklet. "Pencil" and "paperclip" were chosen as the two AUT items, as these objects are relatively similar in size, structure, and commonness. To increase proper AUT completion, example alternative uses for another item (i.e., book) were given verbally (i.e., "Alternative uses for a book could include a door stop, a weight or a bug-whacker"). As participants in the same room received different AUT objects (based on their subgroup), they were asked to complete the task silently, and not read aloud the object printed in their booklet.

*2.4.2 Wind-Turbine-Blade Repurposing Task (WRT)*

Participants were given 15 minutes to read the background, instructions page and complete the Wind-turbine-blade Repurposing Task (WRT) in their booklets (see **Appendix C** for instructions). Two different sections cut from a single wind-turbine blade were chosen as the task objects. Participants received background on the challenges of wind-turbine-blade reuse, and were asked to find creative uses for a section of a retired wind-turbine blade. They were shown multiple views of one section of a single wind-turbine blade with a stick-figure scale to convey the part's size, i.e., as shown in **Figure 3**.

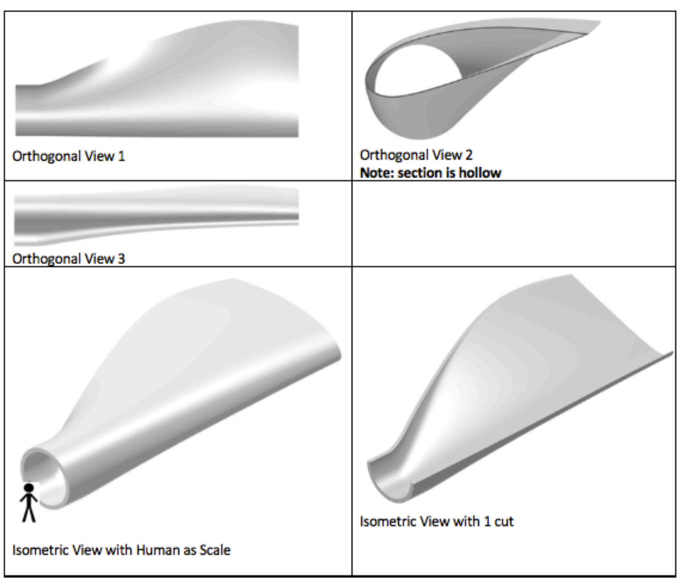


**FIGURE 3:** Wind-turbine-blade section shown for 1 of the Wind-turbine-blade Repurposing Task (WRT).

To reduce the number of concepts that participants repeat from their first WRT, they were strictly instructed not to flip through their study booklet unless told to do so. In addition, a 10-minute filler task was introduced between the two sessions to reduce the effect of consecutive test conditions. In all, fewer than 10% of ideas were repeated from previous conditions. Moreover, the experimental design counterbalanced item order across subgroups to control for the effect of repetition on the results.

## 3. EVALUATION CRITERIA

### 3.1 Alternate Uses Task (AUT) Scoring

Responses on the AUT were scored using three measures (Guilford, 1967). **Fluency**, the total number of uses generated for the target item, and was calculated by attributing one point to each distinct use and summing these points. **Flexibility**, the total number of categories of a participant's uses, was calculated by attributing one point to each category, and summing these points. **Elaboration** is the average degree of supplementary detail across all uses generated by a participant. The degree of elaboration for each use was scored on a 3-point scale (0-2) and then averaged for objects/participants. For example, "to break" is scored 0 points on elaboration; "to break to test strength" is scored 1 point, and "to break to test strength of user", 2 points. Scoring was performed by two raters, with a high degree of reliability between the two raters, i.e., average intra-class correlation (ICC) > 0.9 in all cases.

### 3.2 Wind-turbine-blade Repurposing Task Scoring

Concept ideas generated for the WRT were first scored on *raw* fluency and flexibility. Unlike the AUT, elaboration was not scored, as all WRT ideas involved either a detailed explanation, a sketch or both. Scoring followed the protocol used in previous work by Kwon et al. (2019). First, the following reuse ideas were not counted due to safety concerns: Wind-turbine/mill part/blade; rotor blade; airfoil (unless specified for wind-tunnel studies); airplane part/whole; propeller. Remaining concepts were then assessed with respect to scale, feasibility and appropriateness (combined scale and feasibility).

*3.2.1 Scale Scoring*

Wind-turbine-blade reuse concepts were categorized as either shrunk, to-scale, or enlarged. Shrunk corresponds to a part being infeasibly reduced in scale to satisfy the identified reuse, e.g., a ski. To-scale corresponds to using the wind-turbine blade in the correct scale, including by cutting it, e.g., into tiles. Enlarged corresponds to stated reuses larger than the wind-turbine blade section without any reference to combining multiple wind-turbine-blade parts, e.g., a building. Examples of differently scaled concepts are shown in **Appendix D**. Ideas that were categorized as either shrunk or enlarged were excluded from "scaled" and "appropriate" results, as described below.

*3.2.2 Feasibility Scoring*

Feasibility accounts for the technical viability and amount of modification required for participants' reuses. While concepts that require many cuts or combinations may be "to-scale," they may not be technically viable. Concepts were classified as unfeasible, or of low, medium or high feasibility in comparison with existing or expert-proposed solutions, e.g., tables, playgrounds, construction material, etc. (Beauson et al., 2016).

Unfeasible concepts often exceeded the wind-turbine-blade's technical capabilities, e.g., use to build a bio-gas chamber. Low and medium feasibility were assigned to a range of concepts that, while technically possible, would require an increasing amount of modification. For example, low feasibility would be assigned to a paddle or domestic fencing while a garage wall or roofing material would be rated medium feasibility. Finally, concepts were categorized as highly feasible if they were technically simple to implement with few or no modifications, e.g., playground/skate-park structure, shelters. **Appendix D** shows examples of concepts with different levels of feasibility.

### 3.3 Statistical Analysis

The software, IBM SPSS Statistics 26.0 was used to perform statistical analyses. All variables were checked for outliers based on visual inspection of a boxplot. Data located more than 1.5 box-lengths from the edge of the plot were considered outliers, whose treatment is described below in the results section. Samples were also checked for normality using the Shapiro-Wilk's test. As AUT data were normally distributed, they were compared across induction conditions using paired-samples t-tests. Normally distributed WRT data were also evaluated using paired t-tests, while non-normally distributed data were analyzed using Wilcoxon signed-rank test (the non-parametric equivalent of the paired t-test). For all analyses, statistical significance was established at a nominal alpha value of 0.05.

## 4. RESULTS

### 4.1 Alternate Uses Task (AUT) Results

Complete datasets from 34 participants were analyzed using paired-samples *t*-tests to determine whether statistically significant differences existed between the memory and control inductions on fluency, flexibility and elaboration. A summary of AUT results is shown in **Figure 4**.

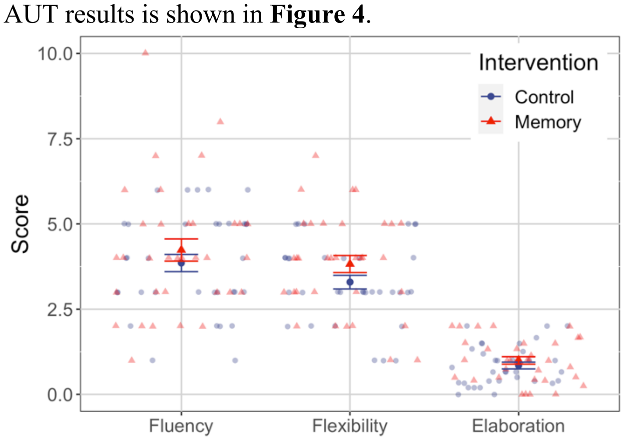


**FIGURE 4:** AUT fluency, flexibility and elaboration following memory and control inductions. For a given intervention, opaque (dark) points represent mean results of all participants while translucent (light) points indicate participants' individual results.

#### *4.1.1 Fluency*

Fluency scores for the AUT had no outliers and the assumption of normality was not violated ($p$ =.122). Participants generated more alternative uses following the memory induction ($M$=4.24, $SD$=1.892) than the control induction ($M$=3.85, $SD$=1.480), but this increase was not statistically significant, $t(33)$=1.294, $p$=0.205.

#### *4.1.2 Flexibility*

There were no outliers in the AUT flexibility data, which were normally distributed ($p$=0.060). After the memory induction, participants generated more flexible uses ($M$=3.82, $SD$=1.466) than after the control induction ($M$=3.29, $SD$=1.169). This mean increase of 0.529 was statistically significant, 95% CI [0.012, 1.046], $t(33)$=2.083, $p$=0.045, $d$=0.36.

#### *4.1.3 Elaboration*

One outlier was detected in the AUT elaboration scores. Since exclusion of this outlying value did not have a significant effect on the results, it was retained in the analysis. The assumption of normality was not violated ($p$ = 0.178). In the memory-induction condition, participants generated more elaborate uses ($M$=1.00, $SD$=0.638) than in the control-induction condition ($M$=0.85, $SD$=0.581), with a statistically significant mean increase of 0.150, 95% CI [0.006, 0.294], $t(33)$=2.126, $p$=0.041, $d$=0.36.

### 4.2 Wind-Turbine-Blade Repurposing Task (WRT) Fluency Assessments

Data from the 33 participants who completed the WRT were analyzed. Fluency assessments were separated into four categories: 1) correctly scaled, 2) feasible, 3) appropriate (feasible + scaled), and 4) raw. **Figure 5** summarizes WRT fluency results.

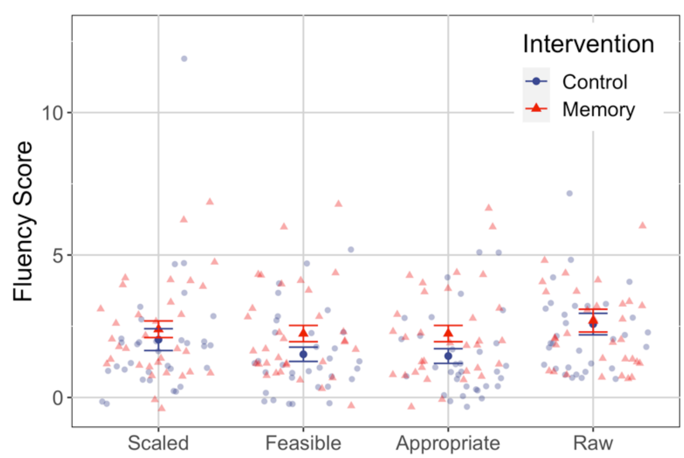


**FIGURE 5:** Wind-turbine-blade Repurposing Task (WRT) fluency results. For a given intervention, opaque (darker) points represent mean results of all participants while translucent (lighter) points indicate participants' individual results.

*4.2.1 Correctly Scaled Fluency*

Exclusion of two outliers in the correctly scaled fluency data did not significantly affect the results, so the values were retained in the analysis. The assumption of normality was not violated ($p$=0.086). Participants generated more correctly scaled reuses of wind-turbine blades following the memory induction ($M$=2.394, $SD$ = 1.676) than the control induction ($M$=2.030, $SD$=2.201), but the difference was not statistically significant, $t(32)$= 1.071, $p$=0.292.

*4.2.2 Feasible Fluency*

For the number of feasible wind-turbine blade reuses, one outlier was detected; its exclusion did not have a significant effect on the results and was therefore retained in the analysis. The assumption of normality was not violated ($p$=0.058). Participants generated more feasible reuses following the memory induction ($M$=2.242, $SD$=1.640) than the control induction ($M$=1.515, $SD$=1.439), a significant mean increase of 0.727, 95% CI [0.151, 1.304], $t(33)$=2.570, $p$=0.015, $d$=0.45.

*4.2.3 Appropriate Fluency*

A Wilcoxon signed-rank test was conducted to determine the effect of the memory versus control inductions on appropriate-idea generation. The difference in scores between the two inductions were approximately symmetrically distributed, as assessed by a histogram with a superimposed normal curve. The memory induction elicited more appropriate wind-turbine-blade reuse ideas in 20 of 33 participants compared to the control induction. However, 7 participants showed no difference, and 6 participants generated fewer appropriate ideas in the memory-induction condition. There was a statistically significant increase in appropriate ideas generated after the memory induction (Mdn=2.00) compared to the control induction (Mdn=1.00), $z$=2.603, $p$=.009, $r$=0.45.

*4.2.4 Raw Fluency*

One outlier was detected, exclusion of which did not significantly affect the results, so it was retained in the analysis. The assumption of normality was not violated ($p$=0.215). There was no statistically significant difference between the number of wind-turbine-blade reuses generated following the memory induction ($M$=2.697, $SD$=2.298) and the control induction ($M$=2.576, $SD$=2.165), $t(32)$=0.399, $p$=0.693.

### 4.3 Wind-Turbine-Blade Repurposing Task (WRT) Flexibility Results

Data from 33 participants who completed the WRT were analyzed. Similar to fluency, flexibility results were also separated into four categories: 1) correctly scaled 2) feasible, 3) appropriate (feasible + correctly scaled) and 4) raw responses. Wilcoxon signed-rank tests were conducted to determine the effect of the memory induction on these flexibility measures. **Figure 6** summarizes the results for WRT flexibility.

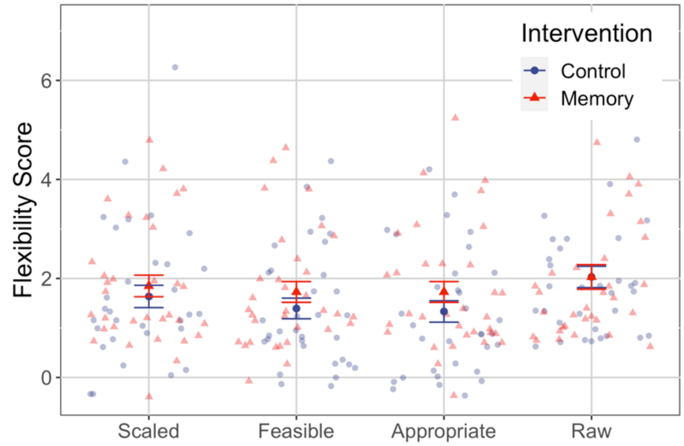


***FIGURE 6:*** *Wind-turbine-blade Repurposing Task (WRT) flexibility results. For a given intervention, opaque (dark) points represent mean results of all participants while translucent (lighter) points indicate participants' individual results.*

*4.3.1 Correctly Scaled Flexibility*

Compared to the control condition, the memory-induction condition elicited higher correctly scaled flexibility in 12 participants, no change in 13, and lower correctly scaled flexibility in 8. As such, there was no statistically significant increase in correctly scaled flexibility following the memory induction (Mdn=1.00) compared to the control induction (Mdn=1.00), $z$=0.716, $p$=0.474.

*4.3.2 Feasible Flexibility*

The memory-induction condition elicited increased feasible flexibility in 14 participants, no change in 14, and reduced feasible flexibility in 5. Thus, overall there was no statistically significant increase in feasible flexibility following the memory induction (Mdn=1.00) compared to the control induction (Mdn=1.00), $z$=1.627, $p$=0.104.

*4.3.3 Appropriate Flexibility (Feasible + Scaled)*

Compared to the control induction, the memory induction elicited increased appropriate flexibility in 15 participants, no change in 13 and decreased appropriate flexibility in 5. There was no statistically significant difference in appropriate flexibility following the memory induction (Mdn=1.00) versus the control induction (Mdn=1.00), $z$=1.769, $p$=0.077.

*4.3.4 Raw Flexibility*

The memory induction elicited increased flexibility in 9 participants compared to the control, no difference in 14, and decreased flexibility in 10. Thus, the memory induction did not significantly increase flexible idea generation (Mdn=2.00) compared to the control condition (Mdn=2.00), $z$=-0.150, $p$=0.881.

## DISCUSSION

### 5.1 Alternate Uses Task (AUT)

Completing the AUT following the memory induction resulted in significantly increased scores for flexibility and elaboration, but not fluency, compared to the control induction. These results are broadly consistent with our hypothesis and with prior findings that this memory induction improves AUT measures, particularly flexibility (Madore et al., 2015, 2016). The results also support that the induction is successful when used simultaneously on a group. However, the memory induction did not increase fluency, contradicting the results of Madore et al. (2016). One explanation based on the demonstrated effects of this induction on episodic memory follows. Greater recall of more specific and detailed memories during the AUT may facilitate a greater range of concept types, while not affecting overall rate of idea generation. Due to time constraints, the AUT trial duration was 1 minute, not the typical 2 minutes. This shorter AUT trial duration may have inadvertently capped fluency (the number of uses participants can express) more so than flexibility (the number of categories of uses), particularly as flexibility is by definition no larger in value than fluency. Thus, the effects of the memory induction on fluency but not flexibility may have been concealed by the reduced time limit.

Following the memory induction, AUT elaboration was also significantly increased compared to the control induction. This result is consistent with the induction increasing access to more detail in episodic memory, leading to more detailed responses. Increased elaboration could have also contributed to the lack of significant increase in fluency, further supporting the idea that the AUT time limit concealed effects on fluency. That is, spending more time describing one alternative use (i.e., being more elaborate) would leave less time to list other uses (i.e., being more fluent) in the limited trial duration. This inverse relationship between fluency and elaboration is consistent with Dippo et al. (2015)'s findings that in time-limited situations, elaboration on a drawing negatively affects fluency.

### 5.2 Wind-turbine-blade Repurposing Task (WRT)

Results for the wind-turbine-blade repurposing task only partially supported our hypotheses. Neither raw fluency nor any category of flexibility were increased significantly by the memory induction. These results could be attributed to previously identified challenges associated with the WRT, e.g., difficulty reasoning with the very large wind-turbine-blade size compared with objects in the AUT.

In addition, almost half of the participants were industrial-engineering students, who reported less confidence in their knowledge of the wind-turbine-blade's described material than mechanical-engineering students.

Importantly, following the memory induction, appropriate fluency (i.e., the number of WRT concepts that were both feasible and correctly scaled) did increase significantly, as did concept feasibility, compared to the control induction. These findings support our hypothesis and extend findings of the beneficial effect of the memory induction on appropriate (i.e., feasible) alternative uses (Madore et al., 2015, 2016).

Together, these results suggest that increasing episodic memory recall may boost an individual's ability to generate more feasible concepts in real-world engineering problems. Such increased recall promotes cross-referencing with what the individual knows through their own personal experience.

## 5. CONCLUSION

If innovation truly involves the recombination of existing ideas, then using induction that promotes greater access to specific and detailed memories could have wide implications on current design methodologies. Further research is required to confirm whether this memory induction can increase the number of concepts generated as well as the degree to which the concepts are feasible. Many studies have shown relationships between engineering-education level, years of experience and willingness to take risks on creative ideas during the early stages of the design process (Zheng et al. 2017). It may thus be worthwhile to examine the effects of the memory induction in non-engineering-student study participants, particularly experts with more relevant episodic memories from which to draw.

While the current research focused on wind-turbine-blade reuse, this or other memory inductions may also be applied to generate creative solutions to other environmental challenges.

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## APPENDIX A: Memory Induction – Experimenter Script

Introduction: Please flip your booklet to the page which should be titled “Video Activity 1//2”. You will be answering a few questions about the video watched. When answering the questions put yourself in the mindset of an audio description writer for the visually impaired.

*Mental Imagery About the Surroundings*

- Close your eyes and get a picture in your head about the surrounding environment of the video you watched.
- Think about what types of things were in the environment, how they were arranged and what they looked like. (30 sec)
- Open your eyes. You have 2 minutes to write down everything you remember about the surroundings under #1 - be as specific and detailed as you can. Point form is acceptable. (2 min)

  **Ask the following probes periodically during the 2 min**
  - Describe more about how the kitchen was arranged.
  - Describe more about what was in the kitchen.
  - Describe write down if there were any other rooms?

*Mental Imagery About the People*

- Once again, close your eyes and get another picture in your head - this time about the people in the video you watched.
- Think about what the people looked like and what they were wearing. (30s)
- Open your eyes. You have 2 minutes to write down everything you remember about the people under #2 - be as specific and detailed as you can. Once again, point form is acceptable. (2 min)

  **Ask the following probes periodically during the 2 min**
  - Write down more about the man/woman’s outfit.
  - Write down more about the man/woman’s face.
  - Write down what color hair did the man/woman have.

*Mental Imagery About the Actions*

- For the last time, close your eyes and get a picture in your head about the actions in the video you watched.
- Think about what the people were actually doing in the video and how they did these things. (30 sec)
- Open your eyes. You have 2 minutes to write down everything you remember about the actions under #3 starting with the first one and ending with the last one - be as specific and detailed as you can. (2 min)

## APPENDIX B: Control Induction - Experimenter Script

Introduction: Please flip your booklet to the page titled “Video Activity 1/2”. You will be answering a few questions about the video watched. You will have approximately 30 to 60 seconds to answer each question. Point form is acceptable.

Under #1 I want you to write down what you thought about the video. I don’t want you to give me a summary of it and I don’t want you to write about its details. Just write down what your thoughts and opinions of it were. What were your general impressions of it? (60s)

2. What adjectives would you use to describe the setting of the video? The people? The actions? (60s)
3. Can you describe the whole video in one or two words? What one or two words would you use? (30s)
4. Did you like the video? Why or why not? (30s)
5. When do you think the video was made? (30s)

Please flip over to the next page.

6. How do you think it was made? (what equipment do you think they used?) (30s)
7. Did the video remind you of anything? (from your own life) (60s)
8. Can you guess how big the place was based on the video? (60s)
9. Can you guess the people’s occupations based on the video? (60s)
10. Were there any other thoughts or opinions you had about the video? Is there anything else you wanted to write about it? (30s)

## APPENDIX C: Wind Turbine Blade Concept Generation Activity Instructions

***Background***

According to the Global Wind Energy Council, there were 341,320 wind turbines deployed globally at the end of 2016. As wind turbines age and retire, their disposal must be considered. Wind turbine blades are made of materials such as glass-fiber reinforced polyester to increase lightweightness, stability, and corrosion-resistance.

Such composites are often challenging to recycle; therefore, we must find alternatives to disposal. However, this is also an opportunity to repurpose the used wind-turbine blades for other creative uses.

In this activity you will be given isometric drawings of 1 section of a single wind-turbine blade. It is now up to you to find creative uses for this blade.

***Instructions***

Develop concepts to reuse the part shown that would for example, allow people to build towards a sustainable future, protect people from the impact of climate change, etc.

Please do NOT reuse such parts in wind-turbine, airplane or similar applications that risk safety.

You should maximize the amount of material reused for each part, which is made of fiber-reinforced composites and not meltable (high strength/strong, high stiffness/brittle, low density/light).

You may further cut the parts but must minimize the amount of cutting needed. If you do cut the parts, mark where these cuts are on the views.

The same part is shown in 3 different orthogonal (top, front, side) and at least 1 isometric view. In addition, if the part is hollow, an isometric view of the part cut in half is shown.

A human scale, shown below, is used to convey the size of the part on the isometric views.

## APPENDIX D: Scale & Feasibility Concept Examples

**TABLE 2:** Examples of Concepts Categorized for Scale

| Category | Examples | | |
|---|---|---|---|
| Shrunk | BLADES to cut off/collect agriculture products | PARACHUTE | Can be used as BOAT |
| To-scale | Can be cut in several units to be used in LAWN MACHINES to cut grass at bigger scale | The blade could also be cut in half and used as a FLOOD BARRIER | Make it into a WATER SLIDE |
| Enlarged | To build a BUILDING | | |

**TABLE 3:** Examples of Concepts Categorized for Feasibility

| Category | Examples | | |
|---|---|---|---|
| Not feasible | WATER FILTER PIPE | JARS to hold certain chemical because material is corrosion resistant | AXE |
| Low Feasibility | PADDLE BOARD | DOOR | EAVES TROUGH |
| Medium Feasibility | Use as a ROOF for commercial building by cutting it in half like the isometric view | Use as SIDING for houses /buildings by slicing so that its rectangular | BATHTUB/ POOLS (multiple cuts) |
| High Feasibility | WATER SLIDE | Can be used as ROOFS FOR BUS/TRAIN SHELTERS | Could be cut in half vertically and used to PREVENT RAIN from entering residential areas in developing countries /during flooding |

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