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The impact of retrieval practice with factual information on the assimilation of similar novel factual information.

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Abstract

The impact of retrieval practice with factual information on the assimilation of similar novel factual information.

By Andrew T.J. Cawley-Bennett

Semantic memory refers to one's factual information about the world. Acquisition of new semantic memory is thought to build on the framework of existing semantic memory. A well-studied manipulation to promote better learning of semantic information is through an intervening test using retrieval practice, a form of elaborative encoding. Yet, what is not well-known are the implications that retrieval practice may have on the assimilation of new yet related semantic information. This study, through four experiments, examined if retrieval practice benefited the learning of trivia-style fact sentences and if retrieval practice benefited a future instance of learning additional facts stemming from the same fact category. The results from all four experiments demonstrated that retrieval practice does enhance memory for trivia-style fact sentences, more so than re-studying the material a second time, even on a final test measured one month after the intervening retrieval practice task. However, the results from Experiments 2 through 4 did not demonstrate an overall benefit to learning additional fact sentences stemming from the same fact category administered one week from the intervening retrieval practice task. Still, there were multiple significant positive correlations between new fact learning and memory performance on the retrieval practice fact learning. More specifically, this new learning effect was evident when participants were engaged with the task. Stronger retrieval practice effects demonstrated stronger new learning effects, and this retrieval practice effect was a better predictor of memory performance for new learning effects than were self-rated prior expertise levels for the fact categories used in the study. These results substantiate the idea that new related learning can be impacted by retrieval practice when encoding an original set of factual information, an implication that can have a dramatic effect in educational practices.

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Semantic memory consists of organized knowledge about facts, ideas, concepts and the rules and relations between concepts (Tulving, 1972). A number of important questions regarding semantic memory remain, including exactly how semantic knowledge is acquired (Tulving, 1972; Squire & Zola, 1998; Binder & Desai, 2011) and organized (Vinson et al., 2003; Murphy et al., 2012). Indeed, a long-standing question has been how the organization of existing semantic memory shapes the acquisition of new semantic memory (Bartlett, 1995; van Kesteren et al., 2012; 2014; Brod et al., 2016; Liu et al., 2018). The question is important because it relates to both the science of memory and educational best practices.

Newly acquired information relating to prior knowledge has been shown in some instances to be acquired and retained better than new information with no prior knowledge representation (van Kesteren et al., 2012). A study conducted by van Kesteren et al. (2014) examined if greater memory retention for learning novel educational factual information was facilitated by having prior conceptual knowledge related to the category of information being encoded. The van Kesteren et al. study (2014) recruited second-year Dutch university students as participants with one-year of college experience in either biology or one year of educational studies. The researchers then had students learn novel facts related to either biology or pedagogy and psychology. The results demonstrated that students had greater memory retention on a 24-hour subsequent final test for material relating to their self-elected university coursework versus information relating to the alternate curriculum (van Kesteren, 2014). The authors noted, however, that the results were possibly influenced by the students' motivation for learning information related to their corresponding major. For example, biology majors may have been more interested in learning more biology related material than learning pedagogy or psychology material. Thus, an open question was whether the findings could extend to experiments in which

the difference in expertise within a category of factual knowledge could be experimentally manipulated between randomly assigned groups.

A well-studied manipulation to promote better learning is elaborative encoding (Craik & Tulving, 1975), an approach to remembering that involves engaging more deeply with to-be-remembered information (Craik & Lockhart, 1972) by, for example, evaluating a word's appropriateness for a blank in a sentence. One particular elaborative encoding strategy that has been recently investigated extensively as a means of promoting enhanced learning and memory retention is the testing effect (Roediger III & Karpicke, 2006; Karpicke & Roediger III, 2007), also known as the retrieval practice effect (Pyc & Rawson, 2009). A large number of studies have observed better subsequent memory performance for a set of encoded material following an intervening test using retrieval practice as compared to simply reading the material a second time (Roediger III and Karpicke, 2006; Karpicke and Roediger III, 2006; Carpenter, 2009; Pyc & Rawson, 2009). One trend to emerge from these studies was that the benefit of retrieval practice was often observed to be greater at longer (e.g. one week) study-test intervals as compared to shorter (e.g. a few minutes) study-test intervals (Roediger III & Karpicke, 2006; McDaniel et al., 2007; Kang et al., 2007; Karpicke & Roediger III, 2007; Karpicke & Blunt, 2011; Rowland, 2014). Another trend was that using cued recall for retrieval practice tended to improve subsequent memory more than using a recognition memory format (McDaniel et al., 2007; Kang et al., 2007; Pyc & Rawson, 2009; Wissman et al., 2011; Rowland, 2014; though see Smith & Karpicke, 2014). Thus, a cued-recall retrieval practice intervention with a relatively long study-test delay could offer an experimentally tractable approach for manipulating semantic memory related to specific categories to be able to address questions about how existing semantic memory shapes the acquisition of new semantic memory. Nevertheless, most of past research

involving the retrieval practice effect has used learning word pairs or other stimulus-stimulus associations (Wheeler et al., 2003; Carpenter, 2009; Pyc & Rawson, 2009; Wing et al., 2013; Mulligan et al., 2016) and has not used factual sentences. Thus, it is unclear if trends observed for retrieval practice effects with stimulus pairs would extend to learning categorized facts.

The present study asked if elaborative encoding of categorized trivia-style factual sentences could promote future new fact learning from the same category. The overall goal across four experiments was to ask if the organization of one's semantic memory into knowledge domains with different levels of expertise would shape new semantic learning. The novelty of the present study centered on the use of retrieval practice as an intervention to boost knowledge in experimentally-assigned categories rather than rely on participants' pre-existing areas of expertise. The rationale for using retrieval practice as the intervention was that it is a well-studied depth-of-encoding manipulation that equates the number of stimulus presentations between conditions. Experiment 1 sought to identify the best retrieval practice procedure for benefitting learning of categorized facts. Experiments 2 through 4 then investigated whether deeper encoding of trivia-style fact sentences from a particular category facilitated the learning of novel fact sentences stemming from the same fact category.

General Methods

Materials and Procedures Overview

Four experiments were conducted that involved participants learning trivia-style facts presented on a computer. All procedures were approved by the Institutional Review Board at Emory University. In all four experiments, data were collected from an online participant pool (Mechanical Turk, Amazon Inc.; Bellevue, WA) in which anonymous participants were paid a small amount as compensation for their completion of the study. Participant performance

through Amazon Mechanical Turk has been shown to be as valid as performance obtained through traditional methods (Buhrmester et al., 2011; Paolacci & Chandler, 2014; Horton et al., 2010; Goodman et al., 2013) and includes a wide demographically diverse sample (Buhrmester et al., 2011), including a range of ages and educational backgrounds. The inclusion criteria required that participants reside in the United States, that their primary language was English, and that they had a Mechanical Turk approval rating of at least 99% (reflecting compliance with prior Mechanical Turk work). These online participants agreed to a waiver form in lieu of signed consent. Specifically, participants clicked on an agreement to participate button to indicate that they had read and understood the waiver form and were participating on a voluntary basis. In Experiment 3, data were also collected from Emory University undergraduate students for whom English was their primary language. These participants received course credit as compensation for their completion of the study. These participants reviewed and voluntarily signed a consent form in the presence of an experimenter prior to participating in the experiment. The fact stimuli and test procedures were similar across experiments, and thus a general description is provided below. Experiment-specific details are then noted within the relevant section for each experiment.

Stimuli

All participants learned trivia-style facts stemming from three categories: athletics, human biology, and cooking. In total, 270 factual sentences were compiled (90 facts for athletics, 90 facts for human biology, and 90 facts for cooking). For each fact sentence, a multiple-choice question was constructed by replacing one key word from the sentence with a blank and by offering five plausible answer options, only one of which was correct. Lures were used in only one question. Pilot online testing was conducted to select the 90 factual sentences in each

category from an original set of 360 facts that included 120 questions in each category (pilot n = 24; 11 and 13 participants self-identified as female and male, respectively; the number of participants identifying their age as 18-24, 25-34, 35-44, 45-54, 55-64, 65-74, and 75 + was 1, 12, 9, 1, 1, 0, 0, respectively). The final set of 90 facts for each category were chosen such that the percent correctly answered on a five-alternative multiple-choice test was similar across categories (40-50% correct). An additional 10 extremely easy questions, termed catch questions, were included in an effort to identify disengagement (e.g., random answer selection; Hauser & Schwarz, 2016; Peer, Vosgerau, & Acquisiti, 2014; Goodman, Cryder, & Cheema, 2013). Appendix A lists the 270 experimental and 10 catch questions. For some experiments, recall questions were used in which participants were asked to type the correct word to fill the blank without any possible answers provided.

Fact Testing, Demographic Questionnaire, and Instructions

All data were collected using Qualtrics software (Provo, UT), which enabled participants to complete the fact-learning study in a web browser. All participants were asked to rely only on their memory to answer all questions. Additionally, a demographic questionnaire was administered, including a question regarding if the participant's primary language was English. The demographic questionnaire also included questions in which participants were asked to rate their level of expertise for each of the fact categories on a scale from 0 to 10 (see Appendix B). The instructions informed participants that they would be learning a set of facts for eight seconds each and that later on they would be tested on their memory for these facts. Upon viewing these facts, participants were then informed that they would be re-exposed to the fact sentences again but in two different formats: either a) a fact sentence would contain a missing word or b) a fact sentence would contain a word identified in quotes. For Experiment 1a, participants during this

intervention task were asked to select the missing word in the sentence from one of five plausible options from memory or select the key word identified in quotes. For Experiments 1b through 4, participants during this intervention task were asked to type in the missing word in the sentence from memory or type in the key word identified in quotes. In all experiments, participants were informed during this intervention task that after each fact presentation they would receive feedback demonstrating the correct answer in green font. Finally, participants in Experiments 1a through 3 were instructed that they would be taking a final test in a multiple-choice format with eight seconds to select the correct answer. Participants in Experiment 4 were instructed that they would be taking a final test by typing in their answers with twelve seconds to provide their answer. Additionally, for Experiments 2 through 4, upon completion of the intervention task, participants were instructed that they were going to learn an additional set of facts for eight seconds each. Upon learning the new set of facts, they would then take a subsequent final test on these newly learned facts as well as take a final test on the original set of facts they learned initially.

Data Analysis

Memory accuracy performance was collected from participants' online surveys using MATLAB scripts (version R2019a; MathWorks; Natick, MA). Memory accuracy performance for Experiment 4 on the subsequent recall final tests were judged by human scorers so as to not penalize for typographical errors or misspellings. Inferential statistical analyses were conducted using IBM SPSS statistics version 26. For Experiments 1a and 1b, a repeated-measures ANOVA was carried out to compare the effects of participant memory performance on a subsequent final test with condition (retrieval practice, re-study) as a within-subject factor but with test delay (immediate, one-week, one-month) as a between-subject factor. Additionally, for Experiments 1a

and 1b, three one-way ANOVAs were performed at each test delay to compare memory performance on a subsequent final test with condition (baseline, retrieval practice, restudy) as a between-subject factor. In Experiments 2 through 4, a repeated measures ANOVA was also conducted comparing memory performance on a subsequent final test with condition (retrieval practice, re-study) and fact test type (repeated facts, new facts) as within-subject factors. For all experiments, the key question of interest centered on memory performance on a final test between the retrieval practice and the re-study condition in which two-tailed paired-sample t-tests were performed. Alpha was set at 0.05 throughout our analyses. Additionally, for Experiments 2 through 4, a Pearson's correlation was calculated via a simple linear regression that included as variables the mean differences between conditions (retrieval practice, re-study) for each fact test (repeated facts, new facts). Lastly, for Experiments 2 through 4, multiple linear regression was conducted to examine how participants' self-rated expertise level for the fact category used in the experimental condition and the mean differences between conditions (retrieval practice, re-study) for the repeated fact test influenced memory performance for the new fact test.

Experiment 1a

Method

Participants

One hundred twenty-seven participants were recruited using Amazon Mechanical Turk for Experiment 1a. Of those, 58 and 67 self-identified as female and male, respectively, and 2 participants self-identified as non-binary. The number of participants identifying their age as 18-24, 25-34, 35-44, 45-54, 55-64, 65-74, and 75 + was 15, 61, 34, 8, 6 ,3, 0, respectively. Participants were paid $5 for participation on the immediate test. Participants for the one-week

and one-month delay tests were paid $5 for participation in the first session, which consisted of the initial fact presentation and the intervention task, and $10 to return for the subsequent final multiple-choice test. The time period between the intervention task and final test performance was a between-participant manipulation, whereas the conditions used during the intervention period was a within-participant manipulation.

Task and procedures

The fact sentences used for each experimental condition were counterbalanced. Additionally, facts were randomly assigned to two separate lists per category, thereby making six lists in total with each list consisting of 45 fact sentences. All fact sentences were randomly displayed from their respective list during the fact presentation, the intervention task, and finally during the subsequent final test. In Experiment 1a, a recognition memory format was used both during the intervention task and on the subsequent final test using multiple-choice questions with five plausible answer options. In Experiment 1a, participants were exposed to 90 facts in total (45 facts from two fact categories). Each fact was presented on the screen for a total of eight seconds. Following, participants were re-exposed to the fact sentences (the intervention task) in two recognition memory formats: 1) fact sentences from one fact category contained one missing word (retrieval practice condition, e.g. “Another name for bowling is _____.”), and 2) fact sentences from the other fact category contained a key word identified in quotations (re-study condition, e.g. “Another name for bowling is ‘tenpins’.”). A countdown timer was displayed informing participants they had eight seconds to select the correct answer from five possible options. Feedback was then provided for two seconds displaying the correct answer in green font. The survey then proceeded to the next question. A subsequent final multiple-choice recognition memory test was administered either a couple minutes after, one-week after, or one-

month after the intervention task. Just prior to taking the subsequent final test, participants were asked to complete a demographic questionnaire. Following, the completion of the demographic questionnaire, the subsequent final test was administered in which all questions on the subsequent final test contained a missing word from the fact sentence. A countdown timer was displayed informing participants they had eight seconds to select the correct answer from five possible options. Figure 1 contains a diagram of the procedures used in Experiment 1a. Additionally, on the subsequent final test, multiple-choice questions based on a third category of facts were administered as a baseline measure to demonstrate that performance on the final test was based on learning the facts and not based on participants already possessing a great deal of prior knowledge about the fact category.

Results

Experiment 1a was conducted to validate that retrieval practice after learning trivia-style fact sentences during the recognition memory intervention task was sufficient to enhance memory performance, compared to re-study, on a subsequent multiple-choice final test. Twenty-nine participants' data were excluded from analysis for either incorrectly answering two or more catch questions or because they answered that English was not their primary language. Figure 2 shows performance for the included 98 participants on the final multiple-choice fact memory test. A 2x3 repeated-measures ANOVA was carried out to examine the effects of retrieval practice and re-study on participants' memory performance on the subsequent final test across each test delay (immediate, one-week, one-month). Condition type (retrieval practice versus re-study) was used as a within-subject factor and test delay was used as a between-subject factor. The baseline condition was not included in this initial analysis in order to compare the experimental (retrieval practice) and control (re-study) conditions. The results from the repeated

measures ANOVA demonstrated a statistically significant overall difference in memory performance on the subsequent final test between retrieval practice and re-study (effect of condition: $F(1,95) = 5.227$, $p = 0.024$, $\eta^2 = 0.052$) and that memory performance was statistically different across test delays (effect of test delay: $F(2,95) = 19.04$, $p < 0.001$, $\eta^2 = 0.286$) suggesting that overall retrieval practice was more effective at enhancing memory compared to re-study on the final tests and that memory performance decreased across each test delay. However, there was not a statistically significant condition by test delay interaction ($F(2,95) = 0.145$, $p = 0.865$, $\eta^2 = 0.003$). To understand more about the effect of each condition (baseline, retrieval practice, re-study) at each test delay, three one-way ANOVAs were carried out examining memory performance at each test delay. All three one-way ANOVAs at each test delay demonstrated statistically significant differences between condition types (baseline, retrieval practice, and re-study; immediate test delay: $F(2,84) = 92.36$, $p < 0.001$; one-week test delay: $F(2,96) = 25.78$, $p < 0.001$; one-month test delay: $F(2,105) = 18.9$, $p < 0.001$).

However, follow-up paired t-tests (specifically comparing data from the retrieval practice, and re-study conditions) failed to observe statistical significance for any of the three test delays (all p's > 0.10). Thus, although participants' performance across all delays in the retrieval practice condition was markedly better than the baseline condition, and modestly better than the re-study condition, the differences between the retrieval practice and re-study conditions for each test delay were not statistically significant.

One possibility for the lack of robust retrieval practice effect is that Experiment 1a used a recognition memory format for the retrieval practice intervention. Experiment 1b asked if using a cued-recall format for the intervention would lead to more robust retrieval practice effects. Experiment 1b differed from Experiment 1a only during the intervention task in which the task

changed from a recognition memory format to a cued-recall format, whereby participants were now required to type in their answer rather than selecting from multiple-choice options.

Experiment 1b

Method

Participants

Two hundred seven participants were recruited using Amazon Mechanical Turk for Experiment 1b. Of those, 97 and 109 self-identified as female and male, respectively, and 1 participant self-identified as non-binary. The number of participants identifying their age as 18-24, 25-34, 35-44, 45-54, 55-64, 65-74, and 75 + was 36, 103, 46, 14, 7, 1, 0, respectively. The inclusion criteria required that participants had not completed our survey prior. Participants were paid $5 for participation on the immediate test. Participants for the one-week and one-month delay tests were paid $5 for participation in the first session, which consisted of the initial fact presentation and the intervention task, and $10 to return for the subsequent final multiple-choice test. The time period between the intervention task and final test performance was a between-participant manipulation, whereas the conditions used during the intervention period was a within-participant manipulation.

Task and procedures

Figure 3 contains a diagram of the procedures used in Experiment 1b. The fact sentences used for each experimental condition were counterbalanced. Additionally, facts were randomly assigned to two separate lists per category, thereby making six lists in total with each list consisting of 45 facts. All fact sentences were randomly displayed from their respective list during the fact presentation, the intervention task, and finally during the subsequent final test. In Experiment 1b, participants were exposed to 90 facts in total (45 facts from two fact categories).

Each fact was presented on the screen for a total of eight seconds. Following, participants were re-exposed to the fact sentences (the intervention task) using a cued-recall format: 1) fact sentences from one fact category contained one missing word (retrieval practice condition, e.g. "Another name for bowling is _____."), and 2) fact sentences from the other fact category contained a word identified in quotations (re-study condition, e.g. "Another name for bowling is 'tenpins'."). A countdown timer was displayed informing participants they had twelve seconds to type in the correct answer. Feedback was then provided for two seconds displaying the correct answer in green font. The survey then proceeded to the next question. A subsequent final multiple-choice recognition memory test was administered either a few minutes after, one-week after, or one-month after the intervention task. Just prior to taking the subsequent final test, participants were asked to complete a demographic questionnaire. Following, the completion of the demographic questionnaire, the subsequent final test was administered in which all questions on the subsequent final test contained a missing word from the fact sentence. A countdown timer was displayed informing participants they had eight seconds to select the correct answer from five possible options. Additionally, on the subsequent final test, multiple-choice questions were administered based on a third category of facts as a baseline measure.

Results

Twenty-eight participants' data were excluded from analysis for either incorrectly answering two or more catch questions or because they answered that English was not their primary language. Figure 4 shows the results for the 179 included participants on the final multiple-choice fact memory test. A 2x3 repeated-measures ANOVA was carried out to examine the effects of retrieval practice and re-study on participants' memory performance on the subsequent final test across each test delay (immediate, one-week, one-month). Condition type

(retrieval practice versus re-study) was used as a within-subject factor and test delay was used as a between-subject factor. The baseline condition was not included in this initial analysis in order to compare the experimental (retrieval practice) and control (re-study) conditions. The results from the repeated measures ANOVA demonstrated a statistical significant overall difference in memory performance on the subsequent final test between retrieval practice and re-study (effect of condition: $F(1,175) = 28.47$, $p < 0.001$, $\eta^2 = 0.14$) and that memory performance was significantly different across test delays (effect of test delay: $F(2,175) = 34.10$, $p < 0.001$, $\eta^2 = 0.28$) suggesting that overall retrieval practice was more effective at enhancing memory compared to re-study on the final tests and that memory performance decreased across each test delay. However, there was not a statistically significant condition by test delay interaction ($F(2,175) = 0.119$, $p = 0.89$, $\eta^2 = 0.001$). To understand more about the effect of each condition (baseline, retrieval practice, re-study) at each test delay, three one-way ANOVAs were carried out examining memory performance at each test delay. All three one-way ANOVAs at each test delay demonstrated statistically significant differences between condition types (baseline, retrieval practice, and re-study; immediate test delay: $F(2,216) = 234.49$, $p < 0.001$; one-week test delay: $F(2,186) = 93.97$, $p < 0.001$; one-month test delay: $F(2,126) = 31.61$, $p < 0.001$).

A further examination using paired t-tests was conducted to examine the two key conditions in question (retrieval practice and, re-study). There was a statistically significant difference between retrieval practice and re-study at the immediate test delay ($M \pm SEM = 90.3\% \pm 1.3\%$ and $85.1\% \pm 2.0\%$, respectively; paired-samples t-test: $t(72) = 3.16$, $p = 0.002$, Cohen's $d = 0.37$), at the one-week test delay ($M \pm SEM = 78.4\% \pm 2.2\%$ and $72.3\% \pm 2.1\%$, respectively; paired-samples t-test: $t(62) = 3.46$, $p = 0.001$, Cohen's $d = 0.44$), and at the one-month test delay ($M \pm SEM = 70.3\% \pm 2.2\%$ and $63.4\% \pm 2.1\%$, respectively; paired-samples t-test: $t(42) = 2.93$,

$p = 0.005$, Cohen's $d = 0.45$). Therefore, these results suggest that retrieval practice during the cued-recall intervention task enhanced memory performance more than re-study on a subsequent multiple-choice final test at all test delays.

Summary of Experiment 1

The results from Experiment 1 indicated that retrieval practice using a cued-recall format (Exp. 1b), but not recognition memory format (Exp. 1a), significantly and robustly improved subsequent memory for categorized factual sentences. The retrieval practice effect using cued recall improved memory similarly when tested immediately, one week later, and one month later (Cohen's d values from experimental vs control condition contrasts = 0.37, 0.44, and 0.45, respectively). Thus, the results from Experiment 1 were consistent with past studies that suggested that the retrieval practice effect was more robust when using cued recall rather than recognition memory as the intervention (McDaniel et al., 2007; Kang et al., 2007; Pyc & Rawson, 2009; Wissman et al., 2011; Rowland, 2014) but were inconsistent with past studies that indicated that the retrieval practice effect tended to be greater when using longer study-test intervals (Roediger III & Karpicke, 2006; McDaniel et al., 2007; Kang et al., 2007; Karpicke & Roediger III, 2007; Karpicke & Blunt, 2011; Rowland, 2014). In any case, Experiment 1 extended the retrieval practice effect to everyday trivia-style facts and observed robust effects with cued recall at several study-test intervals. Experiment 2 sought to build on the findings from Experiment 1 to ask if a boost in category-specific knowledge via a cued-recall retrieval practice would facilitate future learning of new facts in the same category. A one-week delay between the retrieval practice session and subsequent new fact learning session was used for two reasons: 1) there was a slightly larger retrieval practice effect in Experiment 1b at the one-week versus the immediate time point, and 2) more participants returned in Experiment 1b for the final test

session for the one-week versus one-month delay (*n's* = 63 and 43, respectively). Additionally, to assess how prior expertise may facilitate the learning of fact sentences, participants in Experiment 2 were asked to rate their level of expertise for each fact category used in the experiment.

Experiment 2

Method

Participants

Fifty-four participants were recruited using Amazon Mechanical Turk for Experiment 2. Of those, 30 and 24 self-identified as female and male, respectively. The number of participants identifying their age as 18-24, 25-34, 35-44, 45-54, 55-64, 65-74, and 75 + was 8, 25, 11, 7, 3, 0, 0, respectively. The inclusion criteria required that participants had not completed our survey prior. Participants were paid $5 for participation in the first session, which consisted of the initial fact presentation and the intervention task, and $10 to return for the learning of new fact sentences and the subsequent final tests.

Task and procedures

Session 1

Figure 5 shows a schematic of the procedure for Experiment 2. The fact sentences used for each experimental condition were counterbalanced. Additionally, facts were randomly assigned to two separate lists per category, thereby making six lists in total with each list consisting of 45 facts. All fact sentences were randomly displayed from their respective list during the fact presentation, the intervention task, and finally during the subsequent final test. In session 1, participants were exposed to 90 total fact sentences (45 facts from two fact categories). Each fact was presented on the screen for a total of eight seconds. Following, participants were

then administered the intervention task using a cued-recall format: 1) fact sentences from one fact category contained one missing word (retrieval practice condition, e.g. “Another name for bowling is _____.”), and 2) fact sentences from the other fact category contained a word identified in quotations (re-study condition, e.g. “Another name for bowling is ‘tenpins’.”). A countdown timer was displayed informing participants they had twelve seconds to type in the correct answer. Feedback was then provided for two seconds displaying the correct answer in green font. The survey then proceeded to the next question.

Session 2

After a delay period of one week, participants were asked to return to study a new set of 90 fact sentences from the same fact categories used in session 1. Again, participants were exposed to each fact sentence for eight seconds. Immediately following the encoding of these new facts, participants were asked to complete a demographic questionnaire. Included in the demographic questionnaire were questions asking participants to rate their level of expertise from 1 to 10 using a Likert scale per each fact category. After completing the demographic questionnaire, a subsequent final multiple-choice recognition memory test was administered for the new facts followed by a multiple-choice recognition memory test for the repeated facts administered during session 1. All questions on the subsequent final tests contained a missing word from the fact sentence. A countdown timer was displayed informing participants they had eight seconds to select the correct answer from five possible options. Additionally, on the subsequent final test for the repeated facts, multiple-choice questions based on a third category of facts were administered as a baseline measure.

Results

Five participants' data were excluded from analysis for either incorrectly answering two or more catch questions or because they answered that English was not their primary language. Figure 6 shows the results for the 49 included participants. As expected based on results from Experiment 1, participants performed at low levels in the baseline condition in which they were tested on facts not previously presented in the experiment ($M \pm SEM$ = 39.5% ± 2.2%), indicating that the facts used in the present study were largely new to the participants. A 2x2 repeated measures ANOVA was conducted to examine memory performance between retrieval practice and re-study conditions on a subsequent final test for repeated facts versus new facts (the baseline condition was not included in this analysis). The results from the repeated measures ANOVA demonstrated a statistically significant overall memory performance difference between retrieval practice and re-study on the subsequent final tests (effect of condition: $F(1,48) = 4.196$, $p = 0.046$, $\eta^2 = 0.08$), yet participants did not perform significantly different overall on repeated versus new facts (effect of repeated vs. new facts: $F(1,48) = 4.59$, $p = 0.37$, $\eta^2 = 0.087$). Moreover, there was a statistically significant condition by fact test interaction ($F(1,48) = 6.407$, $p = 0.015$, $\eta^2 = 0.118$), suggesting that retrieval practice disproportionately benefitted the repeated facts.

Follow up paired t-tests were conducted to ask if retrieval practice significantly improved subsequent memory for the categorized repeated facts and also significantly improved same-category new fact learning. Similar to the results from Experiment 1b, participants demonstrated a statistically significant difference between retrieval practice and re-study at a one-week test delay for the repeated facts ($M \pm SEM$ = 73.6% ± 2.6% and 65.9% ± 2.7%, respectively; $t(48) = 2.87$, $p < 0.006$, Cohen's $d = 0.41$). However, there was not a statistically significant difference between retrieval practice and re-study conditions on the final test for same-category new facts

($M \pm SEM$ = 74.3% ± 2.8% and 71.7% ± 2.8%, respectively; $t(48) = 0.95$, $p = 0.35$, Cohen's d = 0.14; see Figure 6). These results indicate that cued-recall retrieval practice led to better memory for the categorized facts but that this improved memory did not reliably benefit the learning of new fact sentences stemming from the same fact category.

The overall hypothesis for Experiment 2 was that deeper encoding of categorized facts (via retrieval practice) would correspond to better learning of new facts from the same fact category. We next considered the possibility that the lack of a reliable overall benefit to learning of new facts may have been due to variability in the magnitude of the retrieval practice effect across participants. Figure 7 shows a scatterplot in which each point represented a participant's performance difference between retrieval practice and re-study conditions for categorized repeated facts (horizontal axis) and for new facts from the same category (vertical axis). The retrieval practice effect and new learning effects were strongly positively correlated ($r = 0.724$, $p < 0.001$), suggesting that deeper encoding of facts in one category did relate to improved learning of new facts from the same category.

The scatterplot in Figure 7 also suggested that participants who were randomly assigned the fact category of human biology for their experimental (retrieval practice intervention) condition tended to show small or negative experimental-control condition differences for both remembering repeated facts and learning new facts. Therefore, several additional analyses were conducted to ask if the strong correlation between the retrieval practice effect (experimental-control for repeated facts) and new learning effect (experimental-control for new facts) was attributable to poor or otherwise unusual performance on the human biology questions. First, a reexamination of the data from individual participants in the main fact conditions (Supplemental Figure 1) or baseline fact condition (Supplemental Figure 2) did not indicate that the human

biology questions were generally harder than questions from either the cooking category or athletics category. Indeed, performance on the baseline questions was similar across the fact categories (athletics facts: $M \pm SEM = 36.1\% \pm 3.0\%$; human biology facts: $M \pm SEM = 40.6\% \pm 3.6\%$; cooking facts: $M \pm SEM = 42.5\% \pm 5.1\%$), and a one-way ANOVA comparing performance across categories was not statistically significant ($F(2,46) = 0.75$, $p = 0.48$). Second, the correlation between the retrieval practice effect and the new learning effect was still positive ($r = 0.331$) even when the analysis excluded all participants for whom human biology facts served as either the experimental or control fact condition, though the limited number of remaining participants in the analysis ($n = 15$) meant that this correlation was not statistically significant ($p = 0.23$). Thus, one possibility is that human biology questions were not harder per se but may have been less compatible with deep encoding strategies-and thus less likely to show retrieval practice effects and, by this interpretation, less likely to show benefits to learning new human biology facts.

A related consideration was that variability across participants regarding pre-experimental levels of knowledge of human biology or cooking or athletics could have led to a spurious correlation between the retrieval practice effect and the new learning effect. That is, rather than a concern specific to human biology, one possibility is the lack of previous exposure to, for example, human biology may have made remembering repeated human biology facts and learning new human biology facts both more challenging for some participants. Accordingly, the correlation between the retrieval practice effect and the new learning effect (Fig. 7) was reevaluated by conducting a multiple linear regression analysis in which participant's self-rated expertise for their experimental condition fact category was included as an independent variable to be modeled simultaneously with the retrieval practice effect as the second independent

variable. The overall model was statistically significant (r = 0.761, $F(2,46) = 31.56$, $p < 0.001$), and the retrieval practice effect was still a significant predictor (ß = 0.68, $p < 0.001$) of same-category new learning even when self-rated expertise for that category (ß = 0.24, $p = 0.02$) was included in the model.

A final consideration was the possibility that a rather general third factor related to task engagement or broad experience with trivia questions may have been able to explain the relationship between the retrieval practice effect and the new learning effect. To address this possibility, performance on the baseline condition was selected as possible indicator of task engagement and/or general trivia competence, an indicator that offered the benefit of showing similar performance across the fact categories. Accordingly, an additional correlation was calculated between baseline performance and the new learning effect (see Supplemental Figure 3). The results showed almost no relationship between baseline performance and the magnitude of the new learning effect (r = -0.007, $p = 0.96$), suggesting that the benefit of retrieval practice to new fact learning was not attributable to general task engagement or trivia competence.

Summary of Experiment 2

The results of Experiment 2 indicated that deeper encoding of categorized trivia-style facts correlated strongly with new learning of facts from the same category, consistent with the original hypothesis. Despite this strong correlation, there was not a statistically significant difference in same-category new fact learning between the retrieval practice and re-study conditions. One possibility to emerge from Experiment 2 was that the human biology questions were less compatible with the type of deep encoding strategies that retrieval practice is thought to promote. If so, the inclusion of this category of questions could have attenuated the magnitude of the retrieval practice effect and in turn the magnitude of the new learning effect. Thus,

Experiment 3 sought to replicate Experiment 2 with the exception that no human biology facts were included. The omission of human biology facts meant that only two fact categories remained (cooking and athletics). Thus, no baseline condition was administered in Experiment 3, and cooking and athletics facts were counterbalanced in a random fashion to serve as the experimental (retrieval practice) and control (re-study) conditions. Another concern to emerge from Experiment 2 was related to participants' engagement with the task. Thus, Experiment 3 also sought to extend the results to data collected from participants who signed up in person to participate in the study. Accordingly, data were collected from both online participants recruited through Amazon Mechanical Turk and university students who received course credit for participation. Finally, one new question was added to the end of the survey that asked participants to rate their own engagement in the task.

Experiment 3

Method

Participants

Sixty-two participants were recruited using Amazon Mechanical Turk for Experiment 3. Of those, 36 and 24 self-identified as female and male, respectively, and 1 participant self-identified as non-binary and 1 participant preferred not to specify. The number of participants identifying their age as 18-24, 25-34, 35-44, 45-54, 55-64, 65-74, and 75 + was 14, 28, 15, 4, 1, 0, 0, respectively. Additionally, forty-five Emory University undergraduates were also recruited for Experiment 3. Of those, 26 and 19 self-identified as female and male, respectively. The number of participants identifying their age as 18-24 was 45. The inclusion criteria required that online participants had not completed our survey prior. Online participants were paid $5 for participation in the first session, which consisted of the initial fact presentation and the

intervention task, and $10 to return for the learning of new fact sentences and the subsequent final tests. Participants from Emory University were compensated in the form of extra course credit for participation in each session.

Task and procedures

Session 1

Figure 5 contains a diagram of the procedures also used in Experiment 3. The fact sentences used for each experimental condition were counterbalanced. Additionally, facts were randomly assigned to two separate lists per category, thereby making four lists in total with each list consisting of 45 facts. All fact sentences were randomly displayed from their respective list during the fact presentation, the intervention task, and finally during the subsequent final test. In session 1, participants were exposed to 90 total fact sentences (45 facts from two fact categories). Each fact was presented on the screen for a total of eight seconds. Following, participants were then administered the intervention task using a cued-recall format: 1) fact sentences from one fact category contained one missing word (retrieval practice condition, e.g. "Another name for bowling is _____."), and 2) fact sentences from the other fact category contained a word identified in quotations (re-study condition, e.g. "Another name for bowling is 'tenpins'."). A countdown timer was displayed informing participants they had twelve seconds to type in the correct answer. Feedback was then provided for two seconds displaying the correct answer in green font. The survey then proceeded to the next question.

Session 2

After a delay period of one week, participants were asked to return to study a new set of 90 fact sentences from the same fact categories used in session 1. Again, participants were exposed to each fact sentence for eight seconds. Immediately following the encoding of the new

fact sentences, participants were asked to complete a demographic questionnaire. Included in the demographic questionnaire were questions asking participants to rate their level of expertise from 1 to 10 using a Likert scale for each fact category. After participants completed the demographic questionnaire, a subsequent final multiple-choice recognition memory test was administered for the new facts followed by a multiple-choice recognition memory test for the repeated facts administered during session 1. All questions on the subsequent final tests contained a missing word from the fact sentence. A countdown timer was displayed informing participants they had eight seconds to select the correct answer from five possible options. Lastly, this experiment posed one question at the very end of the survey inquiring about which category of facts participants were more interested in learning. Participants could select one answer from the following options: "Both", "Cooking", "Sports", or "Neither".

Results

Experiment 3 was conducted using both online survey participants and Emory University undergraduates. Five online participants' data were excluded from analysis for either incorrectly answering two or more catch questions or because they answered that English was not their primary language. Figure 8 (left panel, for individual performance data see Supplemental Figure 4) shows the results for the 57 included participants. A 2x2 repeated measures ANOVA was conducted to examine memory performance between retrieval practice and re-study conditions on a subsequent final test for repeated facts versus new facts. The results from the repeated measures ANOVA for online participants demonstrated a statistically significant overall memory performance difference between retrieval practice and re-study on the subsequent final tests (effect of condition: $F(1,56) = 9.41$, $p = 0.003$, $\eta^2 = 0.144$) and a statistically significant difference on repeated versus new facts (effect of repeated vs. new facts: $F(1,56) = 26.99$, $p <$

0.001, η^2 = 0.325). There was also a statistically significant condition by fact test interaction (F(1,56) = 22.49, p < 0.001, η^2 = 0.287), suggesting that the retrieval practice disproportionately benefitted the repeated facts.

Follow up paired t-tests were conducted to ask if retrieval practice significantly improved subsequent memory for the categorized repeated facts and also significantly improved same-category new fact learning. Similar to the results from Experiments 1b and 2, participants demonstrated a statistically significant difference between retrieval practice and re-study at a one-week test delay for the repeated facts ($M \pm SEM$ = 80.4% ±1.9% and 72.7% ± 2.2%, respectively; t(56) = 5.33, p < 0.001, Cohen's d = 0.71). However, similar to the results from Experiment 2, there was not a statistically significant difference between retrieval practice and re-study conditions on the final test for same-category new facts ($M \pm SEM$ = 83.9% ± 1.8% and 84.1% ± 1.8%, respectively; t(56) = -0.16, p = 0.88, Cohen's d = -0.02; see Figure 8).

Sixteen Emory University undergraduates' data were excluded from analysis for either incorrectly answering two or more catch questions or because they answered that English was not their primary language. Figure 8 (right panel, for individual performance data see Supplemental Figure 5) shows the results for the 29 included participants. The results from the 2x2 repeated measures ANOVA for Emory University undergraduates demonstrated a statistically significant overall memory performance difference between retrieval practice and re-study on the subsequent final tests (effect of condition: F(1,28) = 15.5, p < 0.001, η^2 = 0.356) and a statistically significant difference on repeated versus new facts, (effect of fact test: F(1,28) = 8.78, p = 0.006, η^2 = 0.239). There was also a statistically significant condition by fact test interaction (F(1,28) = 8.59, p = 0.007, η^2 = 0.235), suggesting that, again, retrieval practice disproportionately benefitted the repeated facts.

Similar to the online participants' results, follow up paired *t*-tests were conducted demonstrating a statistically significant difference between retrieval practice and re-study at a one-week test delay for the repeated facts ($M \pm SEM$ = 80.4% ± 3.2% and 70.4% ± 2.7%, respectively; $t(28) = 4.28$, $p < 0.001$, Cohen's $d = 0.79$). However, there was not a statistically significant difference between retrieval practice and re-study conditions on the final test for same-category new facts ($M \pm SEM$ = 83.6% ± 1.9% and 80.8% ± 2.2%, respectively; $t(28) = 1.69$, $p = 0.10$, Cohen's $d = 0.31$). Therefore, the combined data results from the online survey participants and Emory University undergraduates indicated that cued-recall retrieval practice led to better memory for the categorized facts but that this improved memory did not reliably benefit the learning of new fact sentences stemming from the same fact category.

Maintaining with the overall hypothesis that deeper encoding of categorized facts (via retrieval practice) corresponds to better learning of new facts from the same fact category, we continued to examine individual variability with the magnitude of the retrieval practice effect impacting the magnitude of learning new facts across participants, as was similarly carried out in Experiment 2. Figure 9 and 10 shows the corresponding scatterplots for the online group and the undergraduate group, respectively, in which each point represented a participant's performance difference between the retrieval practice and re-study conditions for categorized repeated facts (horizontal axis) and for new facts from the same category (vertical axis). The retrieval practice effect and new learning effects for the online survey group were positively correlated ($r = 0.359$, $p = 0.006$), suggesting that deeper encoding of facts in one category did relate to improved learning of new facts from the same category. The retrieval practice effect and new learning effects for the undergraduates were also correlated ($r = 0.297$), though the trend did not reach statistical significance ($p = 0.12$).

Similar to the analyses carried out in Experiment 2, the correlation between the retrieval practice effect and the new learning effect (Fig. 9 and 10) was reevaluated by conducting another correlational analysis to include only those participants who responded to being engaged in the task. That is, if participants responded to being engaged with the experimental condition fact category, then their data was included in the analysis. All other data was excluded from the following analyses. The retrieval practice effect and new learning effects for the online survey group were again positively correlated (n = 41, r = 0.399, p = 0.01), as were the results for the undergraduates (n = 21, r = 0.433, p = 0.05), furthering support that deeper encoding of facts in one category did relate to improved learning of new facts from the same category when participants were engaged in the learning task.

The correlations between the retrieval practice effect and the new learning effect were further reevaluated by conducting a multiple linear regression analysis, this time including both those participants that responded to being engaged in the task and participant's self-rated expertise for the experimental condition fact category. After including participants who responded to being engaged in the task, participant's self-rated expertise for their experimental condition fact category was included as an independent variable to be modeled simultaneously with the retrieval practice effect as the second independent variable. The overall model for the online survey group was statistically significant (r = 0.519, F(2,38) = 7.01, p = 0.003), and the retrieval practice effect was still a significant predictor (ß = 0.332, p = 0.024) of same-category new learning even when self-rated expertise for that category (ß = 0.339, p = 0.022) was included in the model. However, the overall model for the undergraduates was not statistically significant (r = 0.444, F(2,18) = 2.208, p = 0.14), even with the retrieval practice effect as a predictor approaching statistical significance (ß = 0.429, p = 0.058) for same-category new

learning and when self-rated expertise for that category (ß = 0.097, $p = 0.65$) was included in the model.

Summary of Experiment 3

In Experiment 3, the results were similar when data were collected from online participants or student participants, indicating that trends were not limited to one participant population. These results indicated that deeper encoding of categorized trivia-style facts correlated with new learning of facts from the same category, consistent with the original hypothesis and the results from Experiment 2. Despite this correlation, there was not a statistically significant difference in same-category new fact learning between the retrieval practice and re-study conditions for either the online participants or student participants. In Experiment 2, we hypothesized that the omission of human biology facts might improve the results from the paired t-test between the retrieval practice and re-study conditions for learning same-category new facts, but the results from Experiment 3 did not support this hypothesis. One major consideration for all of the results from Experiments 1 through 3 was that the final test of fact learning was always given in a multiple-choice recognition memory format for ease of scoring, even in experiments in which the retrieval practice intervention was administered in a cued-recall format. The results of Experiment 1 indicated that, as compared to a re-study control condition, cued-recall retrieval practice improved fact memory more so than recognition memory retrieval practice. Experiment 4 accordingly asked if using a cued-recall format for the final test of new and repeated fact memory might yield a reliable difference in performance for new facts learned through retrieval practice versus re-study. Thus, Experiment 4 was designed using the same procedures as in Experiments 2 and 3, with one exception. In Experiment 4, rather than

participants completing a multiple-choice final test, participants were administered a cued-recall final test.

Experiment 4

Method

Participants

Sixty-eight participants were recruited using Amazon Mechanical Turk for Experiment 4. Of those, 31 and 37 self-identified as female and male, respectively. The number of participants identifying their age as 18-24, 25-34, 35-44, 45-54, 55-64, 65-74, and 75 + was 10, 35, 13, 6, 2, 2, 0, respectively. The inclusion criteria required that participants had not completed our survey prior. Participants were paid $5 for participation in the first session, which consisted of the initial fact presentation and the intervention task, and $10 to return for the learning of new fact sentences and the subsequent final tests.

Task and procedures

Session 1

Figure 11 contains a diagram of the procedures used in Experiment 4. The fact sentences used for each experimental condition were counterbalanced. Additionally, facts were randomly assigned to two separate lists per category, thereby making four lists in total with each list consisting of 45 facts. All fact sentences were randomly displayed from their respective list during the fact presentation, the intervention task, and finally during the subsequent final test. In session 1, participants were exposed to 90 total fact sentences (45 facts from two fact categories). Each fact was presented on the screen for a total of eight seconds. Following, participants were then administered the intervention task using a cued-recall format: 1) fact sentences from one fact category contained one missing word (retrieval practice condition, e.g. “Another name for

bowling is _____."), and 2) fact sentences from the other fact category contained a word identified in quotations (re-study condition, e.g. "Another name for bowling is 'tenpins'."). A countdown timer was displayed informing participants they had twelve seconds to type in the correct answer. Feedback was then provided for two seconds displaying the correct answer in green font. The survey then proceeded to the next question.

Session 2

After a delay period of one week, participants were asked to return to study a new set of 90 fact sentences from the same fact categories used in session 1. Again, participants were exposed to each fact sentence for eight seconds. Immediately following the encoding of the new fact sentences, participants were asked to complete a demographic questionnaire. Included in the demographic questionnaire were questions asking participants to rate their level of expertise from 1 to 10 using a Likert scale for each fact category. After participants completed the demographic questionnaire, a subsequent cued-recall final test was administered for the new facts followed by a cued-recall final test for the repeated facts administered during session 1. All questions on the final cued-recall tests contained a missing word from each sentence. Similar to the intervention task, participants must once again type in the correct answer but within twenty-four seconds. A countdown timer of twelve seconds was displayed to entice participants to respond quicker. Lastly, this experiment posed one question at the very end of the survey inquiring about which category of facts participants were more interested in learning. Participants could select one answer from the following options: "Both", "Cooking", "Sports", or "Neither".

Results

Experiment 4 was conducted using only online survey participants, in part because Experiment 3 indicated that the results were very similar between undergraduates and Amazon Mechanical Turk online participants. Twenty-six online participants' data were excluded from analysis for either incorrectly answering two or more catch questions or because they answered that English was not their primary language. Figure 12 shows the results for the 42 included participants. A 2x2 repeated measures ANOVA was conducted to examine memory performance between retrieval practice and re-study conditions on a subsequent final test for repeated facts versus new facts. The results from the repeated measures ANOVA demonstrated a statistically significant overall memory performance difference between retrieval practice and re-study on the subsequent final tests (effect of condition: $F(1,41) = 7.35$, $p = 0.01$, $\eta^2 = 0.15$) and also statistically significant difference overall on repeated versus new facts (effect of repeated vs. new facts: $F(1,41) = 84.41$, $p < 0.001$, $\eta^2 = 0.67$). Additionally, there was a statistically significant condition by fact test interaction ($F(1,41) = 8.64$, $p = 0.005$, $\eta^2 = 0.17$), suggesting that retrieval practice disproportionately benefitted the repeated facts.

Follow up paired t-tests were conducted to ask if retrieval practice significantly improved subsequent memory for the categorized repeated facts and also significantly improved same-category new fact learning. Similar to the data results from Experiments 1b through 3, participants demonstrated a statistically significant difference between retrieval practice and re-study at a one-week test delay for the repeated facts ($M \pm SEM = 44.2\% \pm 2.8\%$ and $33.4\% \pm 2.7\%$, respectively; $t(41) = 3.47$, $p = 0.001$, Cohen's $d = 0.54$). However, similar to the results from Experiment 2 and 3, there was not a statistically significant difference between retrieval practice and re-study on the final test for same-category new facts ($M \pm SEM = 55.5\% \pm 3.1\%$ and $52.8\% \pm 3.1\%$, respectively; $t(41) = 0.92$, $p = 0.36$, Cohen's $d = 0.14$; see Figure 12).

Therefore, the data results further indicated that retrieval practice led to better memory for the categorized facts but that this improved memory did not reliably benefit the learning of new fact sentences stemming from the same fact category, regardless of the manner in which the final test is administered (cued-recall based or multiple-choice recognition memory based).

Similar to the analyses in Experiments 2 and 3, we further investigated the possibility that the lack of a reliable overall benefit to learning of new facts may have been due to variability in the magnitude of the retrieval practice effect across participants. Figure 13 shows a scatterplot in which each point represented a participant's performance difference between retrieval practice and re-study conditions for categorized repeated facts (horizontal axis) and for new facts from the same category (vertical axis). The retrieval practice effect and new learning effects were once again strongly positively correlated ($r = 0.55$, $p < 0.001$).

Similar to the analyses in Experiment 2 and 3, the correlation between the retrieval practice effect and the new learning effect (Fig. 13) was reevaluated by conducting another correlational analysis to include only those participants who responded to being engaged in the task. That is, if participants responded to being engaged with the experimental condition fact category, then their data was included in the analysis. All other data was excluded from the following analyses. The retrieval practice effect and new learning effects were again positively correlated ($n = 35$, $r = 0.437$, $F(1,33) = 7.777$, $p = 0.009$).

The correlations between retrieval practice effect and the new learning effect were further reevaluated by conducting a multiple linear regression analysis, this time including both those participants that responded to being engaged in the task and participant's self-rated expertise for the experimental condition fact category. After including participants who responded to being engaged in the task, participant's self-rated expertise for their experimental condition fact

category was included as an independent variable to be modeled simultaneously with the retrieval practice effect as the second independent variable. The overall model was statistically significant (r = 0.438, $F(2,32) = 3.799$, $p = 0.033$), and the retrieval practice effect was still a significant predictor (ß = 0.428, $p = 0.014$) of same-category new learning even when self-rated expertise for that category was not significant (ß = 0.035, $p = 0.83$) but included in the model.

General Discussion

Based on the results from Experiments 2 through 4, there appears to be a sizeable positive correlation between how well participants encoded the repeated facts using retrieval practice and how well participants learn new facts stemming from the same category. This idea was further supported when the correlation was reevaluated taking into consideration participants' engagement to the task. In fact, the results in Experiment 3 with university undergraduates changed from non-significance in the original correlation to statistically significant when the correlation included participants' engagement to the task. When self-rated expertise was incorporated into a multiple regression analysis, expertise for prior knowledge of the fact category was not as strong of a predictor for improved new fact memory as was participants' memory for the repeated facts. The only time that memory performance between conditions for the repeated facts was not a greater predictor than self-rated expertise levels was in Experiment 3 for the online group, though the values of both predictors were nearly identical. The multiple linear regression analysis in Experiment 3 for the undergraduate group yielded non-significant results, perhaps due to the restricted age group of the sample data. In sum, most correlational analyses demonstrated significant relationships between individual memory performance for the repeated facts and the new facts, particularly so when participants were engaged in the task,

indicating that how well individual participants' repeated facts memory was impacted their memory for same-category new facts.

Despite this correlational support for the original hypothesis, the results from the paired t-tests in Experiments 2 through 4 did not demonstrate that retrieval practice significantly benefitted the assimilation of new facts stemming from the same fact category on an overall basis. These null results contrasted with the statistically significant differences in each experiment between the retrieval practice and re-study conditions for the repeated facts. It is unclear why the consistent correlations between retrieval practice effects and same-category new fact learning effects did not yield significant overall experimental versus control new learning differences. One possibility is that the current experiments were not well-suited to observe influences of existing semantic memory on learning new, yet, related semantic memory. Note, however, that in most of the experiments, memory performance was numerically higher for the new facts in the retrieval practice condition than in the re-study condition (results from online participants in Experiment 3 were the exception). Thus, it remains possible that small experimental versus control differences did parallel the large correlations. We next consider possible procedural revisions for future experiments to magnify any possible influence of retrieval practice on learning of new related facts.

One possible explanation for the current results is that the time delay between same-category new fact learning and the final test was too short. In the present experiments, the test of memory for new same-category facts came immediately after learning those new facts. Perhaps the new fact learning effect in the retrieval practice condition may have had a greater advantage if the final test was administered after a longer time from new fact learning. Another possible explanation for the current results is that the one-week delays in Experiment 2 through 4 were

too long to the extent that the opportunity to learn new same-category facts came too long after participants learned the original categorized facts. Wissman et al. (2011) suggested that intervention tasks using retrieval practice, did facilitate the learning of subsequent new material, regardless of the materials' interrelatedness. However, Wissman et al. (2011) demonstrated enhanced learning success from three immediate learning sessions, with session 2 and 3 conducted immediately after an intervention task, whereas the current study investigated this effect using a single intervention task and a longer learning-test delay. Perhaps a future experiment with no delay between learning original and new facts would lead to stronger experiment versus control new learning effects. Yet, an additional alternative explanation centers on understanding if the trivia-style fact sentences used in the current study were not specific enough and might benefit by narrowing the fact sentences to finer aspects within the fact category. For example, rather than learning about general sports related facts, participants would learn more specifically about baseball related facts. Perhaps if our trivia-style fact sentences were more specific within the domain of the fact category, the new fact learning effect would have benefited more. However, if humans were found to be unable to establish connections between general sports concepts and only make connections within the narrow domain of baseball, the result would seem to indict the generalizability and extensibility of semantic memory.

Despite the uncertainty regarding the interpretations of the data from new fact learning, the overall pattern of results were largely consistent with past studies. For example, the results from all the experiments determined that cued-recall retrieval practice leads to better subsequent memory for everyday trivia-style facts, regardless of the final test format. Experiment 1 demonstrated that cued-recall retrieval practice was more beneficial to memory than multiple-choice recognition memory retrieval practice. While both forms of retrieval practice used in

Experiment 1 contained one missing word from the fact sentence and required participants to probe their memory to provide the answer, multiple-choice questions provide an individual with an advantage to select the target answer from a number of lures, possibly making it easier on memory retrieval versus cued-recall questions where the target word is not provided. Thus, the difference in enhanced memory between a multiple-choice recognition memory intervention versus a cued-recall intervention for the trivia-style fact sentences is thought to result from the relative difficulty of the retrieval practice task, as described by the retrieval effort hypothesis (Pyc & Rawson, 2009). The retrieval effort hypothesis states that more difficult forms of memory retrieval demonstrate greater memory retention for the learned material better than easier forms of memory retrieval. Therefore, the results from Experiment 1b through 4 support the retrieval effort hypothesis and demonstrate that more difficult memory retrieval tasks can lead to better memory of the learned material, even weeks after administering a retrieval practice intervention task.

Another contribution of the present study was the validation of online-only data collection. Most of the data collected in the current study were also administered online. One question that remained was if there might have been unreliability in the results between participant groups, that is between online participants and university students. The results from Experiment 3 demonstrated that regardless how participant data are collected, either through enlisting participants in person or using online resources, the results were similar between the two different participant groups. These results validate the effects observed in Experiments 1, 2, and 4 demonstrating that when collecting data, performance is similar regardless how participants are able to enroll in the study (as similarly observed by Buhrmester et al., 2011; Paolacci & Chandler, 2014; Horton et al., 2010; Goodman et al., 2013). Yet, most of the

experiments were conducted using online resources for two main reasons: 1) collecting online participants' data was faster and 2) online participants encompass a broader demographic of the overall population, specifically regarding various educational backgrounds and ages. One minor discrepancy between the online group and university students was due to a contrast in ages resulting in correlational differences when incorporating prior expertise for the fact categories. This discrepancy in age, when incorporating prior expertise between participant groups, may have affected the results due to the online participants being between the ages of 18 to 74, whereas all of the university students were between the ages of 18 to 24, suggesting that university students may not have had as much prior expertise regarding cooking or athletic information as the online groups and therefore led to a non-statistically significant correlation. However, when including repeated fact memory and engagement in the task as predictors for memory on new same-category facts, but excluding prior expertise as a predictor, the results were similar between participant groups.

The current results, taken together, indicate that the depth of encoding one set of categorized facts correlates with the success of learning a second set of facts from the same category. Why these clear correlations did not translate to statistically significant overall experimental versus control differences in new fact learning is unclear. One set of possibilities considered here related to procedural limitations. The other main possibility was that learning one set of facts does not benefit learning a second set unless there are direct connections between the set of facts, connections more direct than those between, for example, facts related to baking and facts related to grilling. This possibility would imply strong constraints on semantic memory, if humans are unable to establish connections between baking and grilling, then categorized semantic memory and related ideas such as schemas (van Kesteren et al., 2012;

2014; Brod et al., 2016; Liu et al., 2018) would seem to offer limited utility to the acquisition of knowledge. Indeed, these possible constraints would limit the way in which prior knowledge facilitates the assimilation of new related information. Nevertheless, there is much evidence that humans do demonstrate deep connections between various concepts within a categorical domain (Vinson et al., 2003; Binder & Desai, 2011; Murphy et al., 2012). Therefore, perhaps building new knowledge for categorical facts is not about the relative exactness of semantic overlap but more so about participants' ability to generalize the knowledge they have already acquired. Future experiments will be required to ask if the current failures to generalize old facts to new same-category facts are inherent limitations of semantic memory of limitations impose by the current procedural details.

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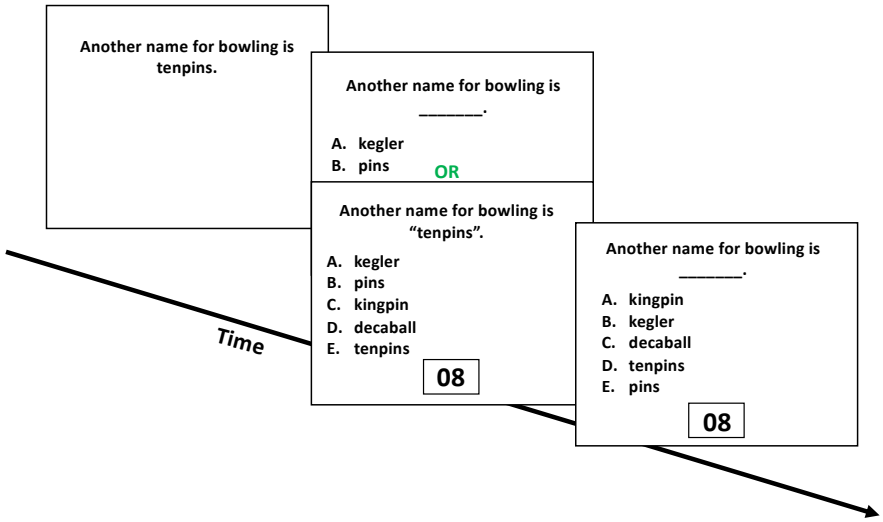
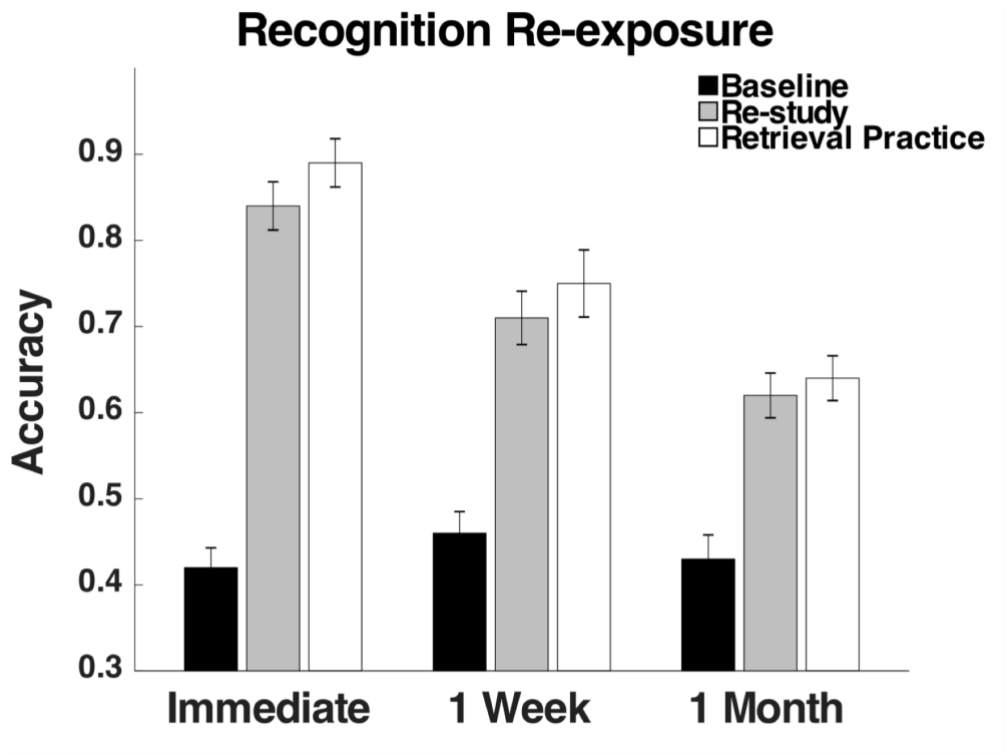
Figure 1



Note. Schematic of the memory task. In Experiment 1a, 90 facts in total were randomly displayed (45 facts from two fact categories) for eight seconds each. Following, participants were administered the intervention task in a multiple-choice recognition memory format: 1) fact sentences from one fact category contained one missing word (retrieval practice condition), and 2) fact sentences from the other fact category contained a word identified in quotations (re-study condition). Participant had eight seconds to select the correct answer from five possible options prior to the survey providing feedback for two seconds. The survey then proceeded to the next question. A subsequent multiple-choice recognition memory final test was administered either a few minutes, one-week, or one-month after the intervention task. All questions on the final test contained a missing word from each sentence, in which participants had eight seconds to select the correct answer from five possible options. Additionally, on the subsequent final test, questions based on a third category of facts were administered as a baseline measure to

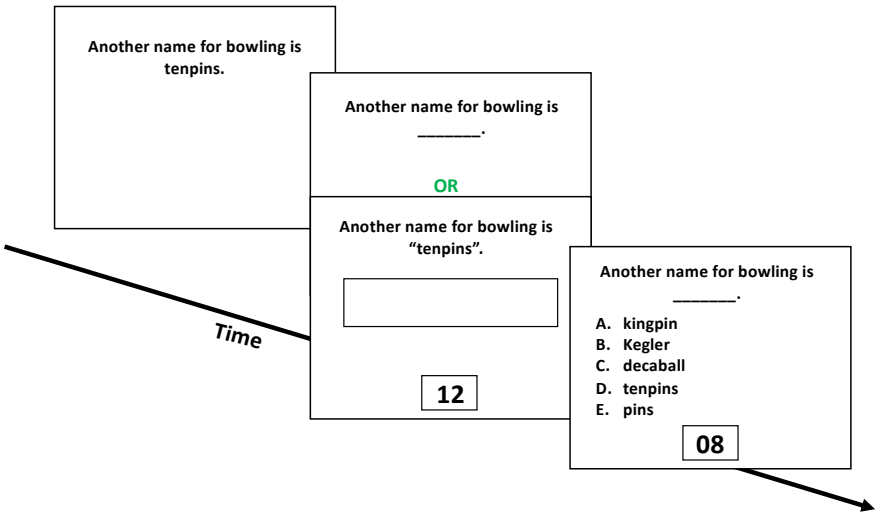
demonstrate that performance on the final test was based on learning the facts and not based on participants possessing a great deal of prior knowledge about the fact category.

Figure 2



Note. Experiment 1a, memory performance on the subsequent multiple-choice recognition memory final test administered immediately (n=29), one-week (n=33), or one-month (n=36) after the recognition memory intervention task, did not demonstrate a statistically significant difference between retrieval practice and re-study conditions. However, baseline condition performance demonstrated that participants are more accurate on a subsequent final test when they were exposed to the fact sentences.

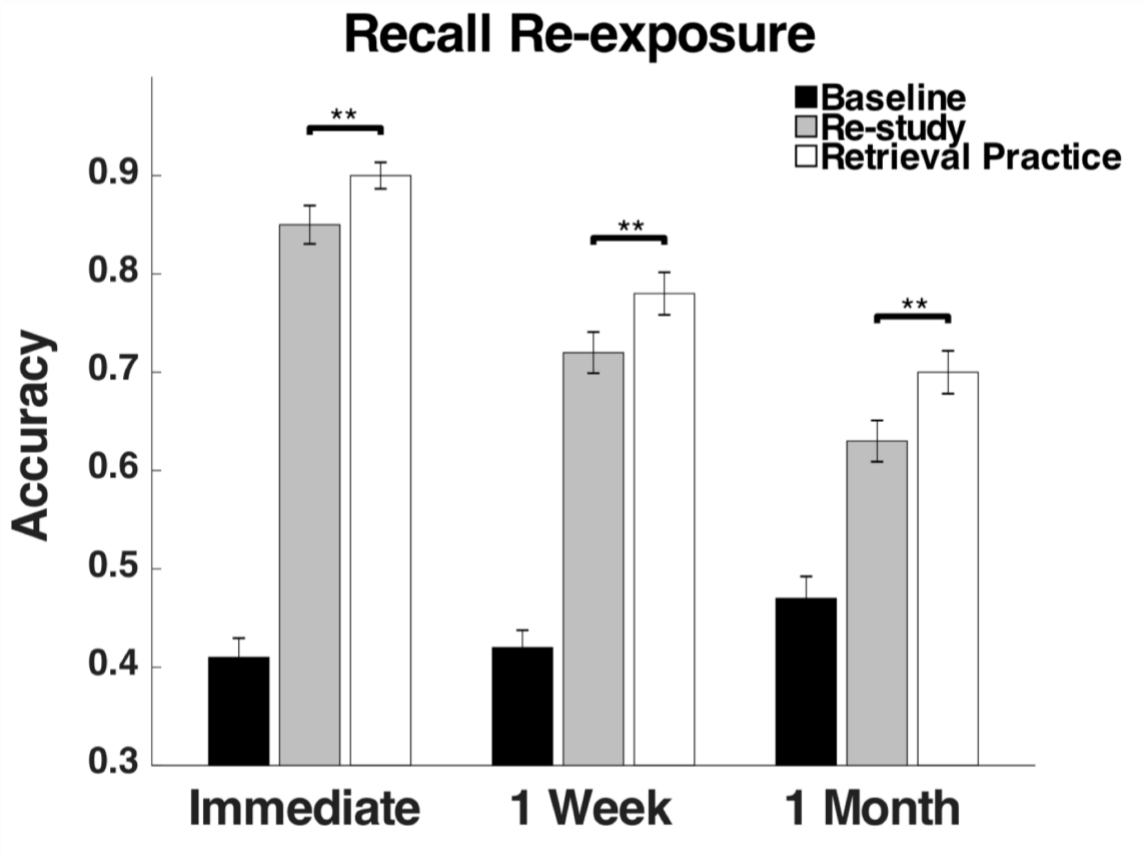
Figure 3



Note. Experiment 1, updated schematic of the memory task. During the intervention task, participants provided answers to cued-recall questions. In Experiment 1b, 90 facts in total were randomly displayed (45 facts from two fact categories) for eight seconds each. Following, participants were administered the intervention task in a cued-recall format: 1) fact sentences from one fact category contained one missing word (retrieval practice condition), 2) or fact sentences from the other fact category contained a word identified in quotations (re-study condition). Participants had twelve seconds to type in the correct answer prior to the survey providing feedback for two seconds. The survey then proceeded to the next question. A subsequent multiple-choice recognition memory final test was administered either a few minutes, one-week, or one-month after the intervention task. All questions on the subsequent final test contained a missing word from the sentence, in which participants had eight seconds to select the

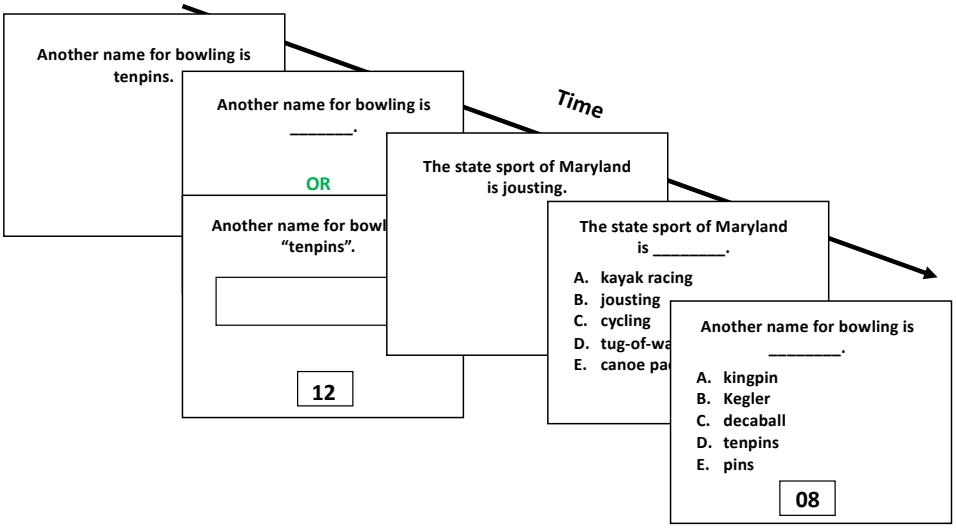
answer from five possible options. Additionally, on the subsequent final test, questions were administered based on a third category of facts as a baseline measure.

Figure 4



Note. Experiment 1b, memory performance on the subsequent multiple-choice final test administered immediately (n=73), one-week (n=63), or one-month (n=43) after the cued-recall intervention task, demonstrating a statistically significant difference between retrieval practice and re-study conditions (** indicate $p < 0.01$). Again, baseline condition performance demonstrated that participants are more accurate on a subsequent final test when they were exposed to the fact sentences.

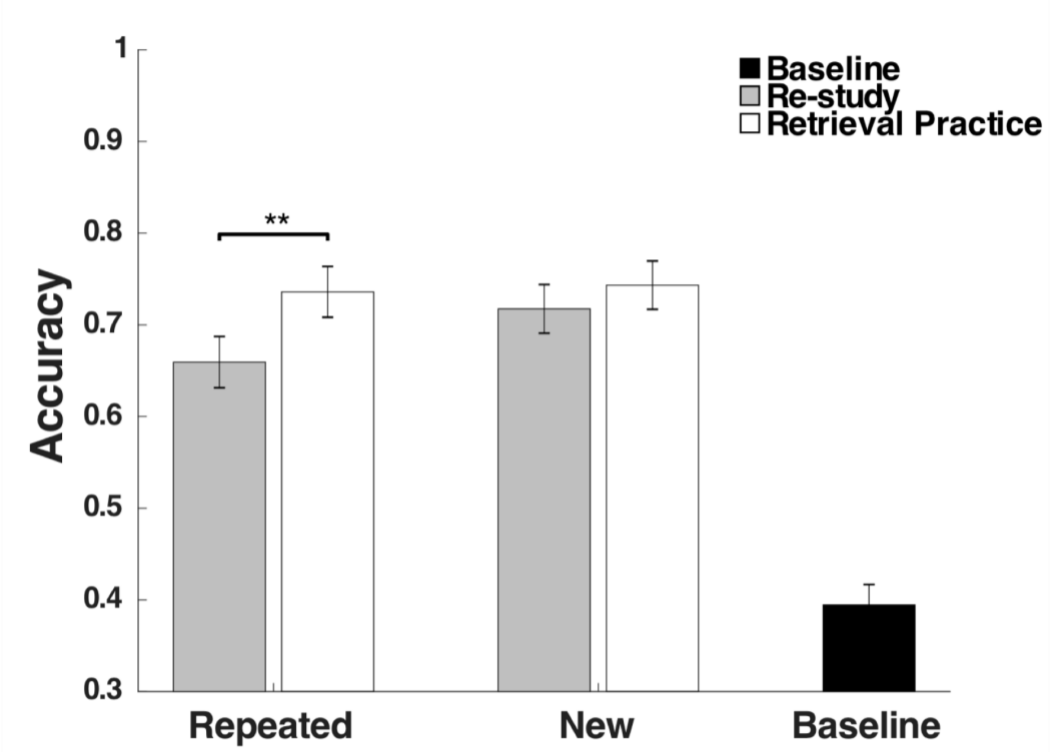
Figure 5



Note. Schematic of the memory task in Experiment 2. In Experiment 2, 90 facts in total were randomly displayed (45 facts from two fact categories) for eight seconds each. Following, participants were administered the intervention task in a cued-recall format: 1) fact sentences from one fact category contained one missing word (retrieval practice condition), and 2) fact sentences from the other fact category contained the word identified in quotations (re-study condition). Participants had twelve seconds to type in the correct answer prior to the survey providing feedback for two seconds. The survey then proceeded to the next question. One-week after the intervention task, participants were administered an additional 90 facts from the same two fact categories used one week before (45 facts from two fact categories) displayed at random for eight seconds each. Then, participants filled out a demographic questionnaire followed by a subsequent multiple-choice recognition memory final test for the new facts. All questions on the final test contained a missing word from each sentence, in which participants had eight seconds to select the correct answer from five possible options. Participants then took a similar

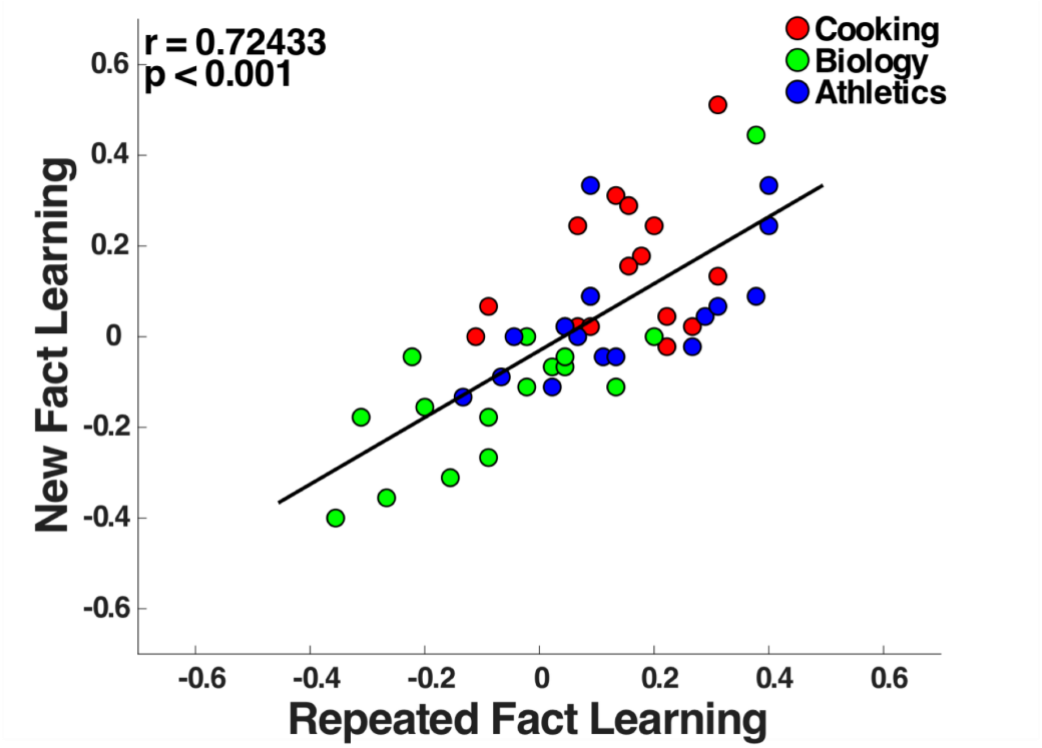
subsequent multiple-choice recognition memory final test on the facts they learned initially. Additionally, questions based on a third category of facts were administered as a baseline measure.

Figure 6



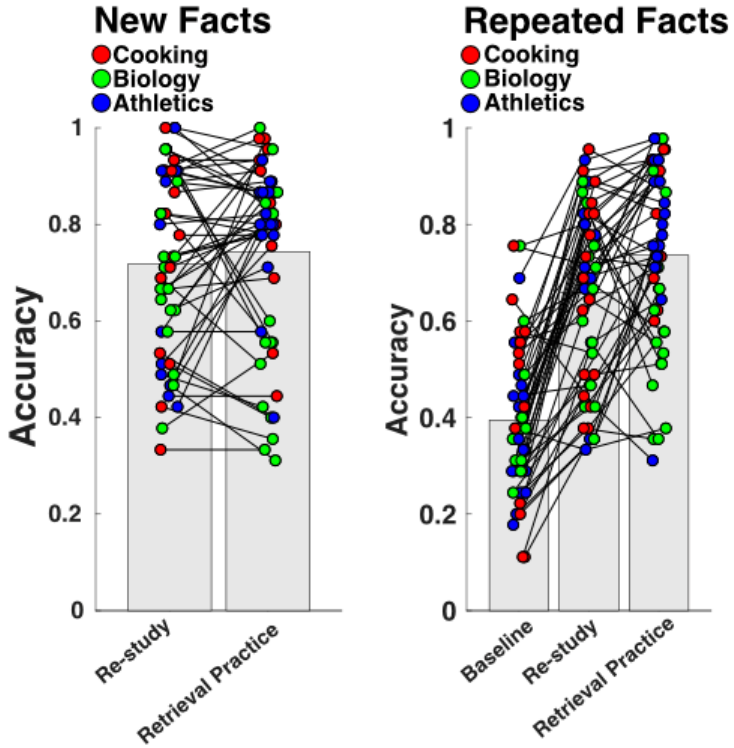
Note. Experiment 2 memory performance on the subsequent multiple-choice recognition memory final test administered one-week after the cued-recall intervention task (n=49), demonstrating a statistically significant difference between retrieval practice and re-study for the repeated facts (** indicate $p < 0.01$). However, memory performance for learning the new facts was not statistically significant between conditions. Baseline condition performance demonstrated that participants are more accurate on a subsequent final test when they were exposed to the fact sentences.

Figure 7



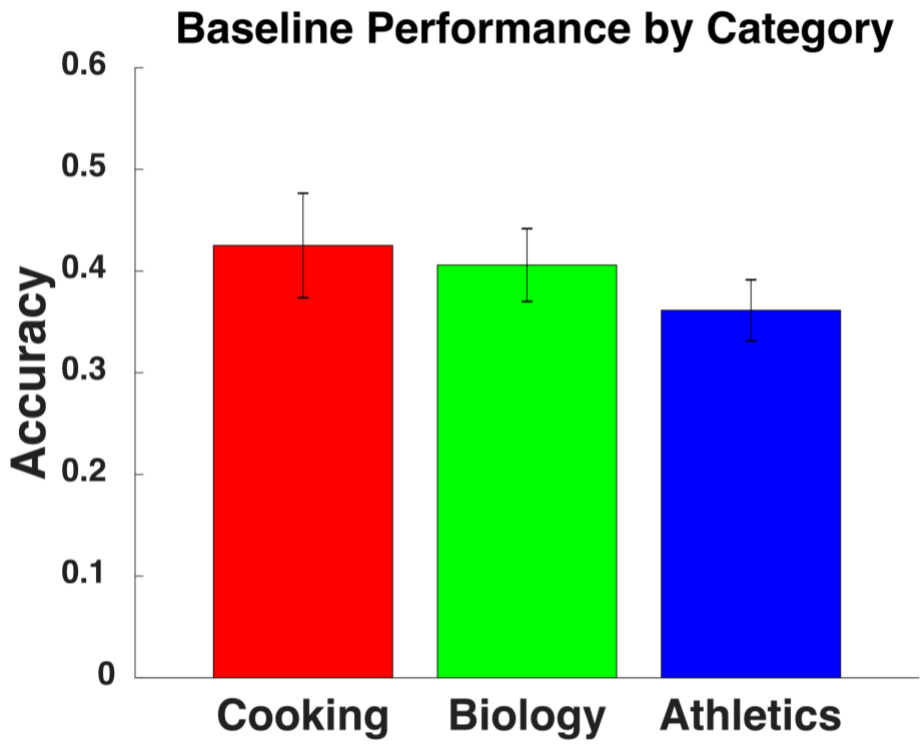
Note. A correlation scatterplot for Experiment 2 indicating a strong positive correlation. Each point represents a participant's performance difference between retrieval practice and re-study for categorized repeated facts and for new facts from the same fact category. The color of each point represents the fact category participants were exposed to in the retrieval practice condition (experimental condition). Participants exposed to the human biology fact category for the experimental condition appeared to demonstrate impaired memory performance on the subsequent final test compared to participants who learned facts from one of the other two fact categories during the experimental condition.

Supplemental Figure 1



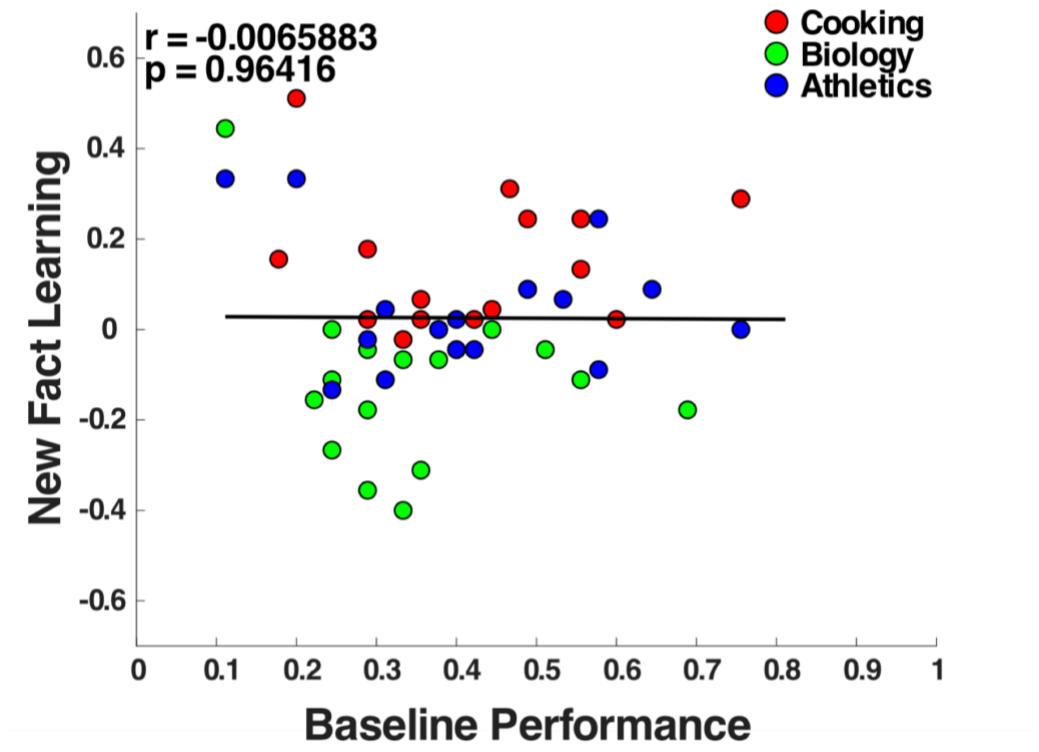
Note. Experiment 2 individual performance with online participants (n=49) for new and repeated facts.

Supplemental Figure 2



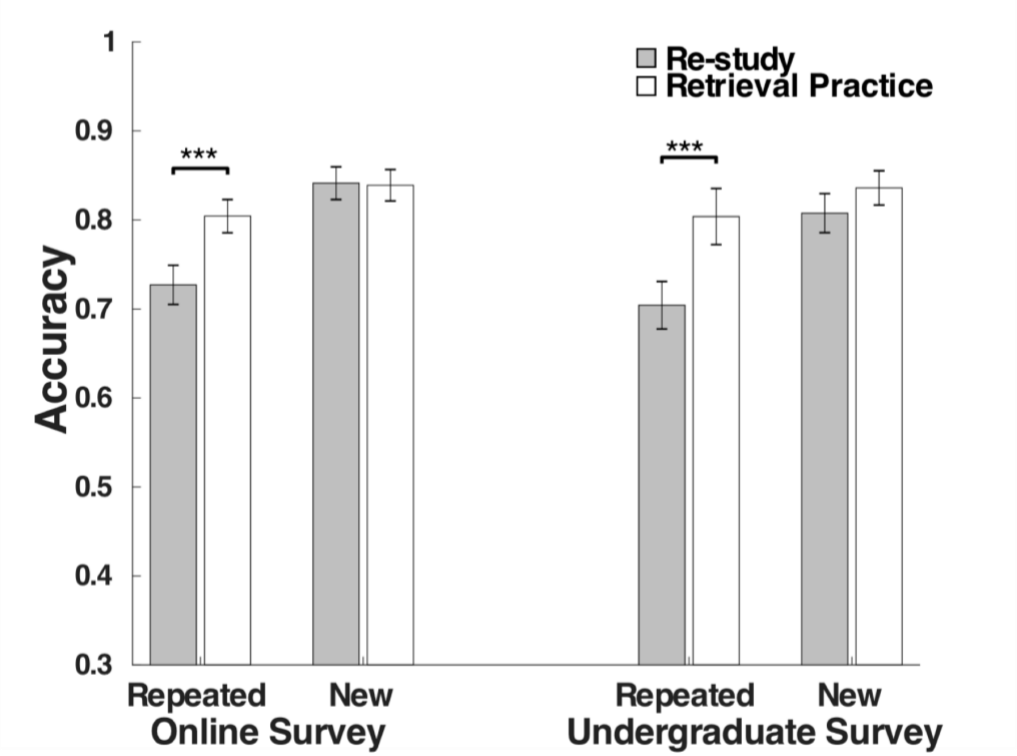
Note. Participant results from Experiment 2 for performance on the baseline condition, separated by individual fact category. A one-way ANOVA indicated that human biology questions were not significantly harder than questions from the other two fact categories.

Supplemental Figure 3



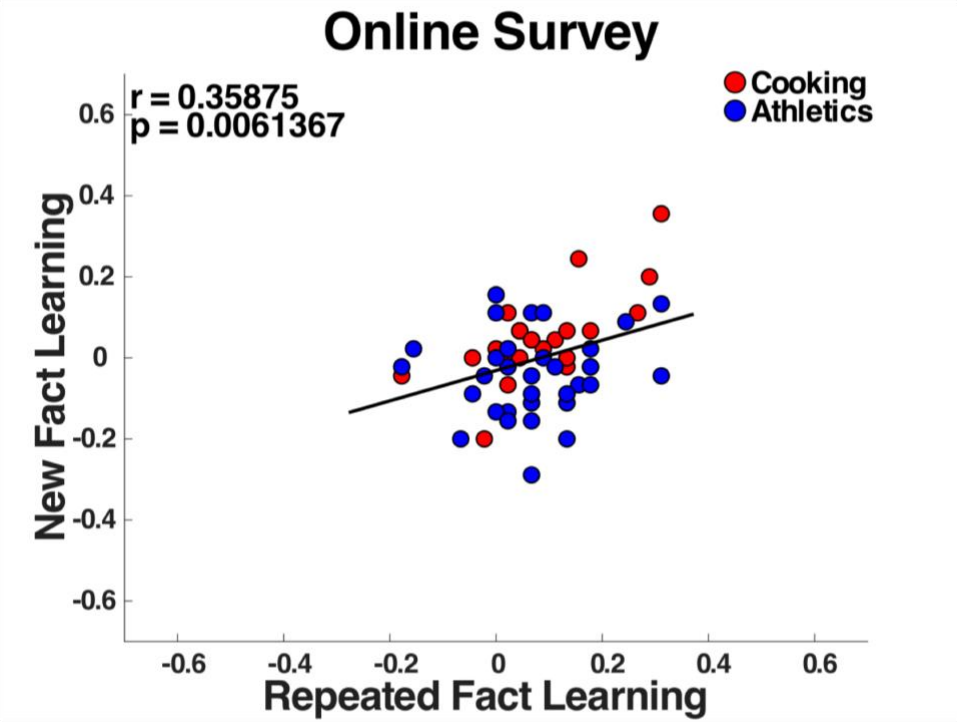
Note. Another correlation scatterplot from Experiment 2 comparing individual participant's performance in the baseline condition to their mean difference between retrieval practice and re-study conditions for new fact learning was not significant. The results indicate that the benefit of retrieval practice to new fact learning was not attributable to general task engagement or trivia competence.

Figure 8



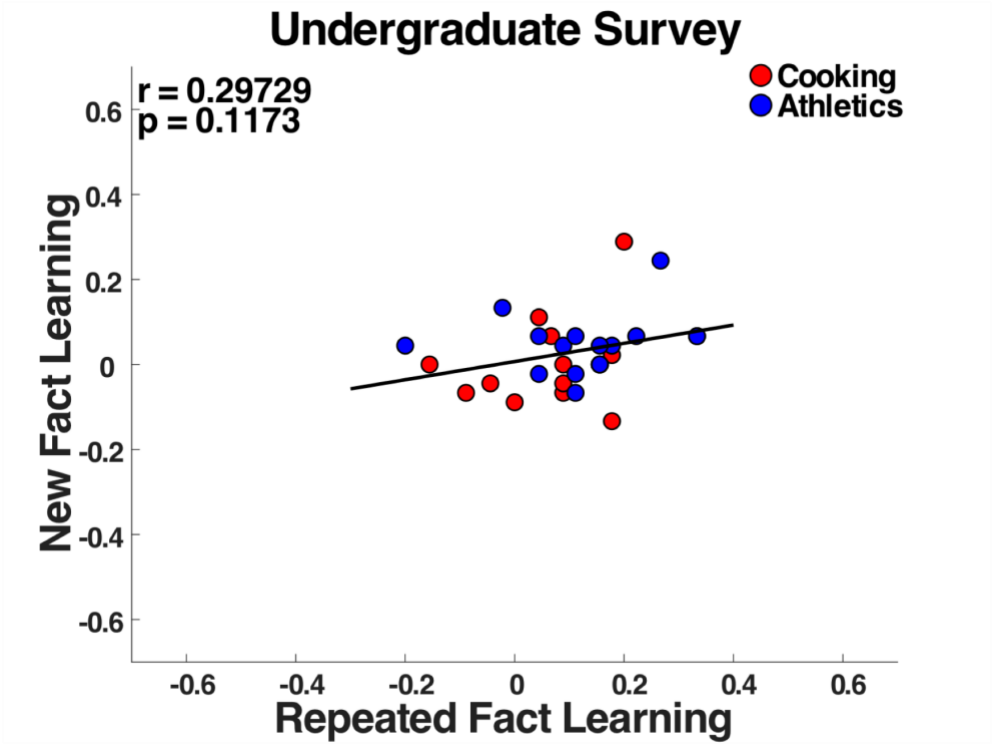
Note. Experiment 3 memory performance with online participants (n=57) and Emory undergraduates (n=29) on the subsequent multiple-choice recognition memory final test administered one-week after the cued-recall intervention task, demonstrating a statistically significant difference between retrieval practice and re-study for the repeated facts in both participant groups. However, memory performance for learning the new facts was not statistically significant between conditions for both participant groups (*** indicate $p < 0.001$).

Figure 9



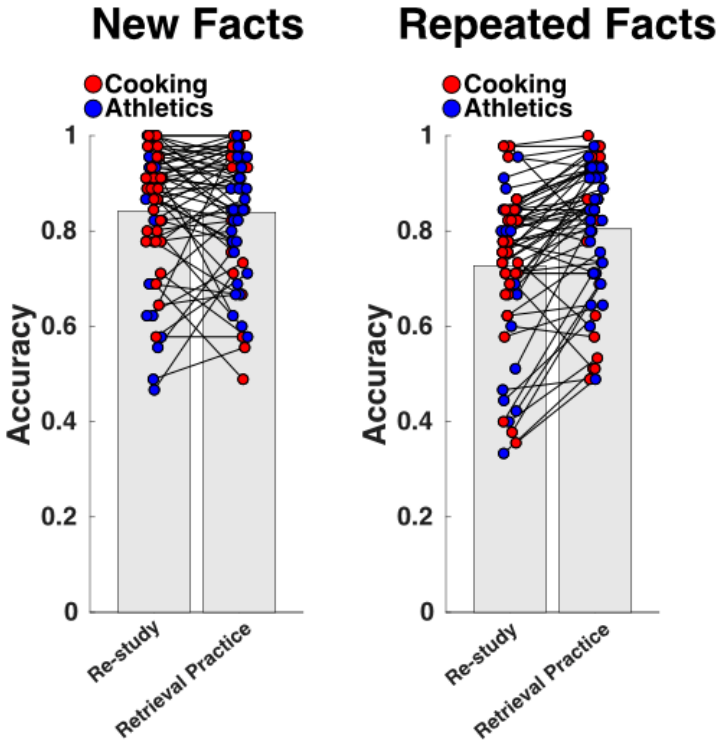
Note. A correlation scatterplot for online participants in Experiment 3 indicating a significant positive correlation. Each point represents an online participant's performance difference between retrieval practice and re-study for categorized repeated facts and new facts from the same fact category. The color of each point represents the fact category participants were exposed to in the retrieval practice condition (experimental condition).

Figure 10



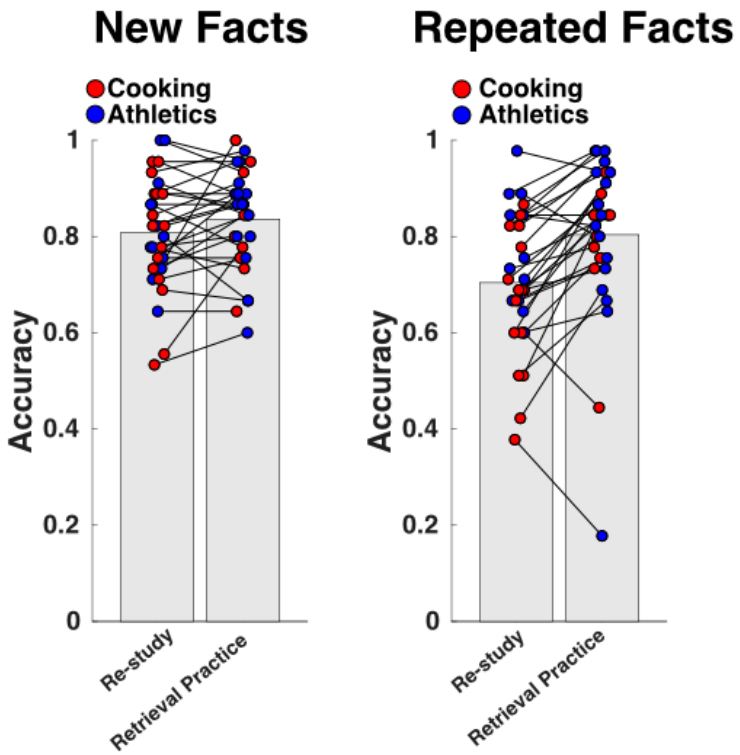
Note. A correlation scatterplot for undergraduate participants in Experiment 3 was not significant. Each point represents a student's performance difference between retrieval practice and re-study for categorized repeated facts and for new facts from the same fact category. The color of each point represents the fact category participants were exposed to in the retrieval practice condition (experimental condition).

Supplemental Figure 4



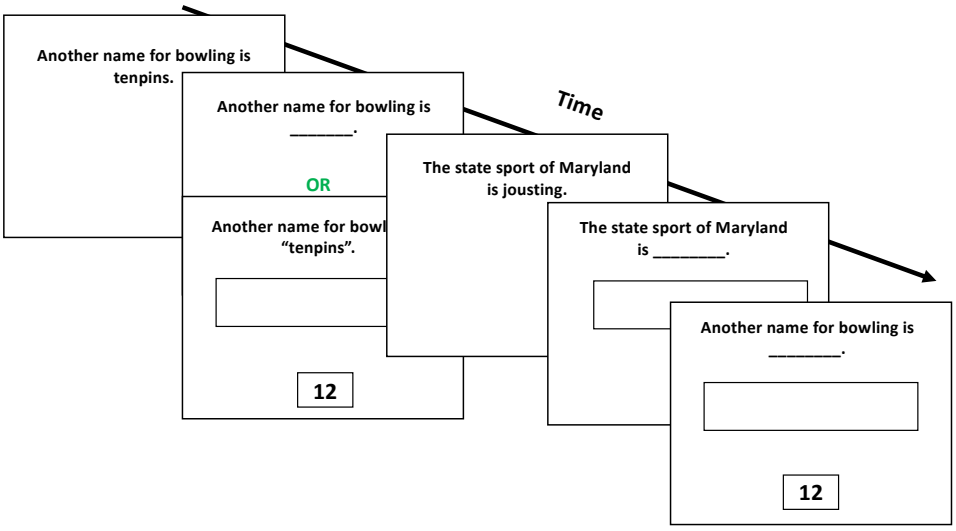
Note. Experiment 3 individual performance with online participants (n=57) for new and repeated facts.

Supplemental Figure 5



Note. Experiment 3 individual performance with Emory University undergraduates (n=29) for new and repeated facts.

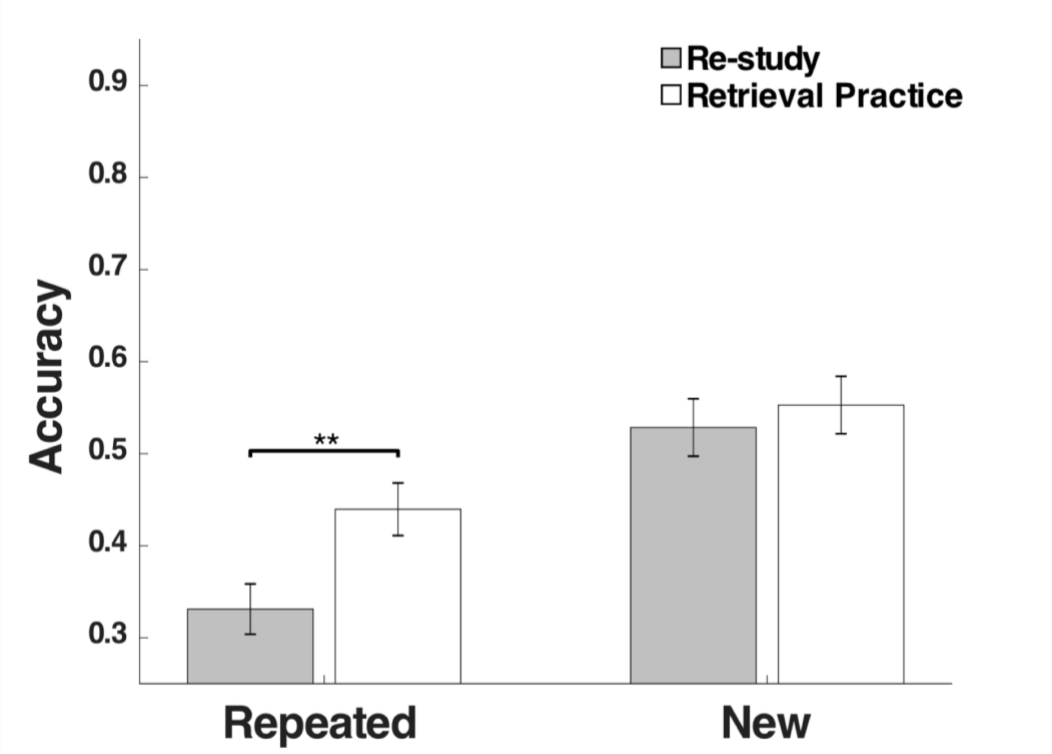
Figure 11



Note. Schematic of the memory task in Experiment 4. In Experiment 4, 90 facts in total were randomly displayed (45 facts from two fact categories) for eight seconds each. Following, participants were administered the intervention task using a cued-recall format: 1) fact sentences from one fact category contained one missing word (retrieval practice condition), and 2) fact sentences from the other fact category contained the word identified in quotations (re-study condition). Participants had twelve seconds to type in the correct answer prior to the survey providing feedback for two seconds. The survey then proceeded to the next question. One-week after the intervention task, participants were administered an additional 90 facts from the same two fact categories used one week before (45 facts from two fact categories) displayed at random for eight seconds each. Then, participants were asked to fill out a demographic questionnaire followed by a subsequent cued-recall final test for the new facts. All questions on the final cued-

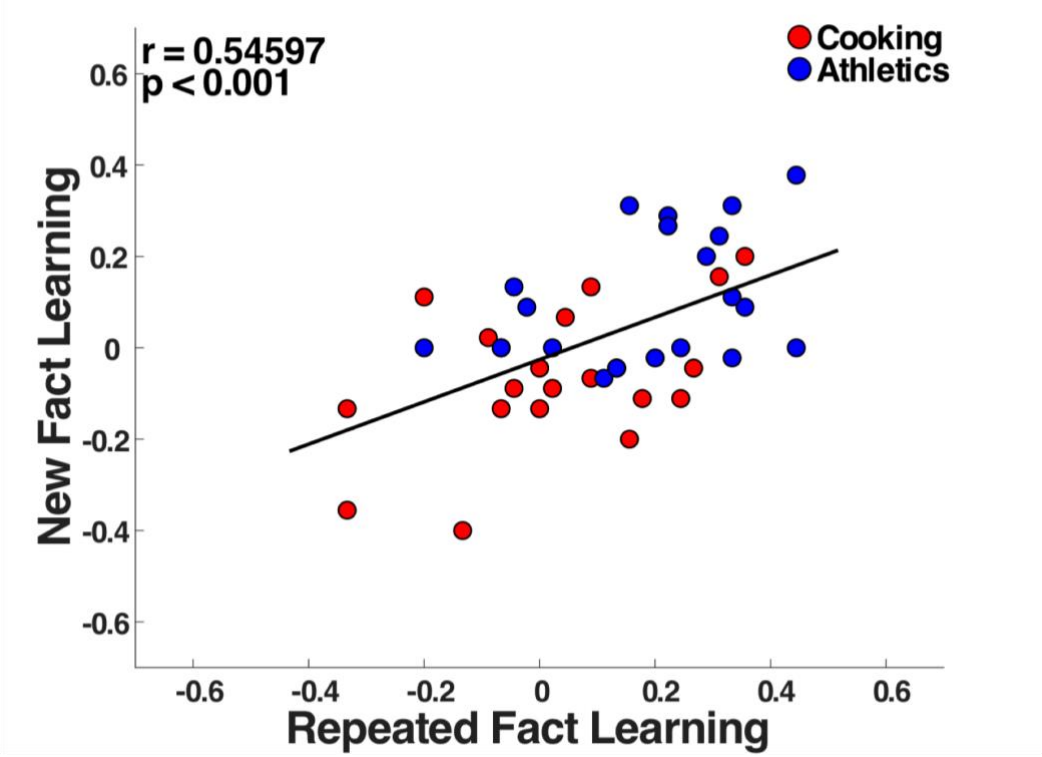
recall test contained a missing word from each sentence in which participants had twenty-four seconds to type in the correct answer. A countdown timer of twelve seconds was displayed to entice participants to respond quicker. Participants then took a similar subsequent cued-recall final test on the facts they learned initially.

Figure 12



Note. Experiment 4 memory performance on the subsequent cued-recall final test administered one-week after the cued-recall intervention task (n=42), demonstrating a statistically significant difference between retrieval practice and re-study for the repeated facts (as similarly observed in Experiments 1b through 3). However, memory performance for learning the new facts was not statistically significant between conditions. (** indicate $p < 0.01$).

Figure 13



Note. A correlation scatterplot for Experiment 4 indicating a strong positive correlation. Each point represents a participant's performance difference between retrieval practice and re-study for categorized repeated facts and for new facts from the same fact category. The color of each point represents the fact category participants were exposed to in the retrieval practice condition (experimental condition).

Appendix A

Fact question list

101. _____ onions before chopping them reduces the reaction to tearing up.
A) Heating
B) Freezing
C) Cooking
D) Salting
E) Chilling

102. _____ is an open-face sandwich served usually on rye bread and covered with a fat-like substance, meat, and fresh produce.
A) Torta
B) Bauru
C) French dip
D) Smorrebrod
E) Muffuletta

103. To prevent an avocado slice from browning, one can cover it with _____ and store it in a tight container.
A) lemon juice
B) olive oil
C) uncooked rice
D) dry coffee beans
E) garlic salt

104. _____ is the milk left over from making butter.
A) Evaporated milk
B) Whole milk
C) Buttermilk
D) Skim milk
E) Whey

105. _____ is the red food-coloring used in candies, e.g. skittles, and is made from a type of beetle.
A) Amaranth
B) Carmine
C) Red no. 40
D) Allura red
E) Indiogotine

106. Adding salt to juicy vegetables in a salad will bring out excess water and make them _____.
A) soft
B) crunchy
C) tart
D) brittle
E) smaller

107. _____ are sponge or butter cake cookies in the shape of a shell.
A) Madeleines
B) Biscottis
C) Shortbread cookies
D) Whoopie pies
E) Snowball cookies

108. A _____ knife has one or more curved blades and a handle on each end and is used by rocking back and forth to mince food.
A) boning
B) paring
C) cleaver
D) mezzaluna
E) santoku

109. _____ are actually considered legumes, not nuts.
A) Hazelnuts
B) Walnuts
C) Pecans
D) Cashews
E) Peanuts

110. _____ food means to coat food with a dry ingredient such as flour prior to cooking.
A) Dredging
B) Drizzling
C) Flaking
D) Patting
E) Dusting

111. Bromelain is an enzyme found in _____ that helps fight pain and inflammation.
A) grapefruit
B) pineapple
C) bananas

D) mangos
E) pomegranates

112. _____ is a chemical found in peppers that gives its 'flavor of hotness'.
A) Capsaicin
B) Piperine
C) Allyl isothiocyanate
D) Propyl gallate
E) Astaxanthin

113. _____ wax is used to provide a gloss on certain candy, and it is also used on cars.
A) Carnauba
B) Turtle
C) Shellac
D) Resin
E) Hard

114. _____ sauce is an Italian sauce that includes lots of onions and is often made with meat.
A) Amatriciana
B) Genovese
C) Aglio e olio
D) Bolognese
E) Carbonara

115. The first _____ were originally purple or white.
A) soy beans
B) carrots
C) broccoli
D) sweet potatoes
E) oranges

116. _____ is a chemical injected into farm raised salmon to mimic the natural pink hue of wild salmon.
A) Citric acid
B) Ammonia
C) Carnitine
D) Erythrosine
E) Carotenoid

117. _____ is when one allows dough to rise after it has been shaped and before it is baked.
A) Starling
B) Tempering
C) Proofing
D) Fermentation
E) Cooling

118. _____ is an outer covering such as from a husk or pod.
A) Ear
B) Leaf
C) Pedicel
D) Valve
E) Shuck

119. The ability to spread dough without tearing is known as the _____, which ensures the gluten is well-developed.
A) spreading method
B) gluten thickness test
C) splay method
D) window pane test
E) finger stick technique

120. One main difference between white sugar and brown sugar is that brown sugar contains _____.
A) ascorbic acid
B) food dye
C) maple syrup
D) molasses
E) vanilla extract

121. When added to egg whites, _____ will boost air bubbles and slow down the tendency to deflate.
A) milk
B) butter
C) cardamom powder
D) ghee
E) cream of tartar

122. _____ is a fillet of brined salmon and is often served on a bagel.
A) Roulade
B) Lox

C) Sautoir
D) Allemande
E) Consomme

123. _____ is a Middle Eastern dish composed of eggplant mixed with olive oil, tahini, and various seasonings.
A) Ful Medames
B) Hummus
C) Baba Ganoush
D) Turkish Cacik
E) Labneh

124. _____ is the main ingredient found in thousand island dressing.
A) Mustard
B) Ketchup
C) Mayonnaise
D) White Vinegar
E) Relish

125. Chemical additives that contain sorbate, e.g. potassium sorbate, are used as food _____.
A) coloring
B) preservatives
C) leavening agents
D) sweeteners
E) dehydrators

126. Sauerkraut is made from finely cut _____ that has been lacto-fermented.
A) cucumbers
B) onions
C) peppers
D) cabbage
E) radishes

127. _____ is made of silicone so it is nonstick, heatproof and grease-resistant.
A) Vapor paper
B) Parafilm
C) Cling film
D) Parchment paper
E) Kraft paper

128. _____ are delicate airy meringue-like cookies with a crunchy exterior and weightless interior.
A) Almond biscuits
B) Gingerbread blondies
C) Pizzelle
D) Molasses cookies
E) Macarons

129. _____ is the white part of the inside of an egg, otherwise known as egg whites.
A) Yolk
B) Air Cell
C) Albumen
D) Chalazae
E) Lecithin

130. A _____ is a cooking utensil used for slicing and cutting food into thin strips.
A) colander
B) zester
C) remoska
D) mandoline
E) horno

131. A _____ is Nestles brand name for their style of chocolate chips.
A) chocolate morsel
B) chocolate kiss
C) chocolate wafer
D) chocolate baking chip
E) chocolate teardrop

132. A _____ is a small breadcrumbed fried food roll with various ingredients, such as a crab cake.
A) awameh
B) tulumba
C) bannock
D) croquette
E) beignet

133. The _____ references the threshold of an oil at which it can heat up without smoking or burning.
A) carcinogenic point

B) draft point
C) heat standard
D) smoke point
E) burnt constant

134. _____ when cooking in a pan can lead to more steam than direct heat and should be avoided.
A) Basting
B) Coring
C) Croquetting
D) Overcrowding
E) Broiling

135. _____ is an antioxidant compound found in garlic and is beneficial to the body.
A) Lutein
B) Lycopene
C) Allicin
D) Selenium
E) Manganese

136. Using a(n) _____ spatula helps smooth the top of cake batter in a pan and helps it bake evenly.
A) rubber
B) metal
C) offset
D) scraper
E) leveling

137. The process of cooking food in oil or fat at low temperatures for long periods of time is known as _____.
A) deep frying
B) dehydration
C) froiling
D) confit
E) parfrying

138. Of most game animals, the _____ contains the highest amount of protein with the least amount of fat per gram.
A) alligator
B) wild pheasent
C) snow goose

D) jack rabbit
E) squirrel

139. _____ is a softening agent used for baking some breads and is made from poultry feathers or hog hair.
A) Fumaric Acid
B) Sodium Bisulfite
C) L-Cysteine
D) Alginate
E) Sulfur dioxide

140. The _____ is the scale used to measure the spicy heat of peppers.
A) BTU scale
B) Scoville scale
C) degrees calor
D) Kelvin scale
E) degrees brix

141. _____ is a traditional dried corn dough used to make tortillas, tamales and other mexican dishes.
A) Masa Harina
B) Cornmeal
C) Polenta
D) Pod Corn
E) Zein

142. _____ is the process where uncooked food, usually a vegetable, is scalded in boiling water and then plunged into ice water.
A) Parboiling
B) Blanching
C) Braising
D) Pascalization
E) Coddling

143. Challah is Jewish bread where the bread is _____.
A) unleavened
B) gluten-free
C) slightly undercooked
D) boiled before baking
E) braided

144. Cake flour can be quickly made by combining flour and _____ in a one to one ratio.
A) baking powder
B) sugar
C) leavening dust
D) cornstarch
E) egg starch

145. _____ is a high-concentration solution of salt in water, and can be used to keep meat moist prior to grilling or cooking.
A) Hydrochloride
B) Sodium chloride
C) Halite
D) Seltzer
E) Brine

146. Spreading a coat of egg wash on pastries or bread prior to baking them gives it _____.
A) a shiny golden color
B) a pale eggy color
C) a harder outer layer
D) a fluffier coating
E) a dry texture

147. To _____ is to cut off the outer skin of something, like an apple.
A) allumette
B) dice
C) bisque
D) effiler
E) pare

148. _____ is found in ranch dressing, sunscreen and white paint to give it a whiter look.
A) Titanium Dioxide
B) Tricaclcium phosphate
C) Canthaxanthin
D) Propylene glycol alginate
E) Tin(IV) Oxide

149. _____, when cooking, involves submerging food in a liquid at a relatively low cooking temperature between 140-180 F.
A) Poaching
B) Simmering

C) Reducing
D) Smothering
E) Tandooring

150. Pressure cookers use steam to build up pressure inside a sealed pot to help _____.
A) make food more flavorful
B) help bread rise prior to baking
C) cook food faster
D) dehydrrate meats faster
E) ferment vegetables faster

151. Baking at _____ can cause cakes and pastries to rise higher and dry out due to liquids evaporating faster.
A) lower altitudes
B) lower humidities
C) higher altitudes
D) higher pressures
E) colder oven temperatures

152. Using a _____ oven will cook food faster than using a conventional oven.
A) gas
B) conduction
C) convection
D) roaster
E) wood burning

153. _____ is a preserving chemical used to cure meats like ham and bacon from botulism-causing bacteria.
A) Sodium Benzoate
B) L-Absorbic Acid
C) Phenylalanine
D) Saccharin
E) Sodium Nitrite

154. Roquefort is a French _____ made from the milk of sheep.
A) cream cheese
B) ice cream
C) yogurt
D) blue cheese
E) cottage cheese

155. _____ means to fry in a pan using a small amount of fat.
A) Stirfry
B) Glazing
C) Deglaze
D) Panfry
E) Fricassee

156. _____ is used as a food thickener, such as in twinkies, and is also used in cosmetics and medications.
A) Polysorbate 60
B) Potassium sorbate
C) Methylparaben
D) Erythorbic acid
E) DL-Alanine

157. Ripe cranberries will _____.
A) stick to walls when thrown
B) turn into a blue shade
C) bounce like rubber balls
D) glow under a blacklight
E) sink when placed in water

158. To _____ is to place small pieces of ingredients, such as butter, over or within food as to enhance added flavor evenly.
A) dot
B) fleck
C) spot
D) dripple
E) tad

159. The process of pressing a decorative pattern on the edge of a pie crust before baking is referred to as a _____.
A) steeping
B) fluted edge
C) velveting
D) garnishing
E) spotting

160. The best way to use a kitchen _____ is to place the index finger and thumb where the handle meets the metal and wrap the remaining fingers around the handle.

A) skimmer
B) knife
C) whisk
D) citrus zester
E) spatula

161. A _____ is a dessert layered with fruit, sponge cake, and custard and can be topped with whipped cream.
A) trifle
B) devil's food cake
C) doberge cake
D) bread pudding
E) cobbler

162. Cremem De Cassis is blackcurrant _____ added to berry and chocolate desserts.
A) frosting
B) chocolate sauce
C) liquer
D) dip
E) fondant

163. A _____is a type of cylindrical clay or metal oven, originally used in India.
A) belan
B) patli
C) tawa
D) kadai
E) tandoor

164. _____ is the process of adding frosting from a bag for decorating.
A) Silhouetting
B) Shaping
C) Piping
D) Coursing
E) Quatrefoiling

165. Genoise, an Italian _____, uses air to suspend the batter to provide volume rather than a chemical leavening agent.
A) brownie
B) sponge cake
C) doughnut
D) custard

E) biscuit

166. La bete noire, otherwise known as the black beast, is a chocolate _____ cake.
A) molten
B) mint
C) gateau
D) praline
E) flourless

167. A _____ is a type of multilayered cake.
A) chiffon
B) bundt
C) torte
D) baumkuchen
E) dundee

168. _____ is a whipped filling of chocolate and cream, only, and used in desserts.
A) Chocolate A La Taza
B) Chocolate Vermicelli
C) Ganache
D) Chocolate Couverture
E) Mousse

169. _____ is a thin layered dough used in a variety of Greek sweet pastries and savory dishes.
A) Rizogalo
B) Phyllo, or Filo
C) Kourabiethes
D) Revani
E) Melomakarona

170. A _____ is a wooden round tool made to wrap dough around the wooden form to make a deep shell.
A) ladle
B) turner
C) pestle
D) pie dolly
E) rolling pin

171. _____ method is the process of baking a pie crust or other pastry without the filling.

A) Rub In
B) Hot Milk
C) Baking Blind
D) Creaming
E) Folding

172. _____ are weights used to make pie crust to retain its shape while baking.
A) Kettlebell Wafers
B) Aluminum Wafers
C) Baking Beans
D) Iron Cubes
E) Baking Egglettes

173. _____ yogurt is made by straining out extra whey in regular yogurt, making it thicker with less sugar and more protein.
A) French
B) Low-fat
C) Non-fat
D) Australian
E) Greek

174. _____ is different than caramel because it's made by adding butter and heated to a higher 300 F.
A) Peanut Brittle
B) Dulce De Leche
C) Fudge
D) Toffee
E) Chocolate

175. Macaroons are _____ flavored cookies, whereas a macaron is a small sandwich cookie.
A) berried
B) coconut
C) date
D) fig
E) lemon

176. _____ is grilling, braising, or roasting at high temperatures until a browned crust forms on the surface of the food.
A) Scalding
B) Staling

C) Searing
D) Emulsion
E) Jacquarding

177. _____ is the branch of cooking devoted to cured meat products, primarily from pork.
A) Gaucho
B) Charcuterie
C) Al Forno
D) En Papillote
E) Cocido

178. _____ in butter acts as a preservative allowing butter to last three to four months longer.
A) Vegetable oil
B) Emulsifier
C) Acetic acid
D) Tartric acid
E) Salt

179. _____ is milk with fat content between 36 - 40%, while whole milk has fat content of less than 3.5%.
A) Heavy cream
B) Condensed milk
C) Ropy milk
D) Half and half
E) Medium cream

180. _____ and pancakes are made from the same ingredient, except pancakes contain baking powder as a rising agent.
A) Waffles
B) Injera
C) Crepes
D) Aebleskiver
E) Dosa

181. _____ sauce, a popular French cuisine sauce, is a combination of egg yolk, butter and lemon juice.
A) Demi-glace
B) Hollandaise
C) Bechamel
D) Coulis

E) Veloute

182. _____ is a vegetable with stalks commonly used with sugar in sweet desserts and leaves that are poisonous if consumed.
A) Watercress
B) Cardoon
C) Kohlrabi
D) Rhubarb
E) Red chard

183. A(n) _____ is a French pastry also known as an elephant ear and comes in a butterfly shape.
A) eclair
B) canele
C) palmier
D) religieuse
E) chouquette

184. A _____ is a type of hors d'oeuvre consisting of a small bread or pastry with a savory topping.
A) brochette
B) canape
C) concasse
D) emince
E) gazpacho

185. A _____ is a grated fried potato pancake.
A) gratin
B) savoury pattie
C) lefse
D) chapalele
E) latke

186. A _____ is a French cuisine made from choux pastry mixed with cheese.
A) cassoulet
B) poulet basquaise
C) charente mouclade
D) carbonnade flamande
E) gougere

187. Adding _____ to tomato sauce will neutralize the acidity in the sauce.
A) sorbic acid
B) parmesan cheese
C) citrus juice
D) baking soda
E) red wine

188. _____ is the culinary term for slightly undercooked pasta and is often the desired way of cooking pasta.
A) Au gratin
B) Molto al dente
C) Au sec
D) A la grecque
E) Molto au poivre

189. Foie gras is a French delicacy made from the liver of _____.
A) cow
B) goat
C) duck or goose
D) pheasant
E) pig

190. The _____ occurs when amino acids react with sugar as a result of the application of heat, giving browned foods their flavor.
A) curdling process
B) maillard reaction
C) infusion process
D) yeast process
E) clumping reaction

201. _____ are a class of steroids that have 21 carbons and are precursors to glucocorticoids.
A) Secosteroids
B) Dihydrotestosterones
C) Dianabols
D) Progestins
E) Oxandrolones

202. _____ look like branches of a tree and are found on neurons made and also receive signals from other neurons.
A) Lenticels

B) Bronchioles
C) Dendrites
D) Mitochondrion
E) Capillaries

203. _____ is the pigment found in your skin and hair that gives it that color.
A) Chlorophyll
B) Carotenoid
C) Urochrome
D) Melanin
E) Myoglobin

204. The _____ is the name of the upper arm bone found in humans.
A) ulna
B) radius
C) phalanges
D) metacarpals
E) humerus

205. Gregor _____ is considered the father of modern genetics.
A) Maehle
B) MacGregor
C) Mendel
D) Clegane
E) Edmunds

206. _____ positive blood type is considered the most common blood type in humans.
A) O
B) A
C) B
D) AB
E) OB

207. The thyroid is a gland in the human body that regulates _____.
A) sex drive
B) adrenaline
C) glucose
D) bile
E) metabolism

208. The central nervous system is developed from _____ cells, first serving as progenitor cells generating new neurons and glia.
A) osteoblast
B) epithelial
C) mononuclear
D) radial glia
E) neutrophils

209. In humans, the _____ is the only internal organ capable of regenerating lost tissue.
A) liver
B) stomach
C) gallbladder
D) colon
E) small intestine

210. _____ are proteins that act as a biological catalyst converting substrates into different molecules.
A) Enzymes
B) Messengers
C) Microtubules
D) Receptors
E) Substrates

211. The largest organ of the human body is/are _____.
A) intestines
B) heart
C) skin
D) lungs
E) brain

212. Unconjugated steroids easily move through cell walls because they are _____.
A) liquids
B) made of a single amino acid
C) lipophilic
D) micromolecules
E) hydrophilic

213. _____ is a steroid required in both males and females to make gametes (sperm or ovum).
A) Estradiol
B) Aldosterone

C) Serotonin
D) Progesterone
E) Testosterone

214. Macrophages are _____ of the immune system that surround and contain foreign cells to prevent the spread of disease.
A) plasmids
B) microbes
C) white blood cells
D) eukaryotic cells
E) prokaryotic cells

215. _____ can damage blood vessels.
A) Working out
B) The ketogenic diet
C) Sunburns
D) Bathing in hot water
E) Stretchng

216. In the adult human body, a quarter of our bones are found in our _____ .
A) wrist
B) feet
C) ribs
D) skull
E) hands

217. _____ signaling is a form of cell-to-cell communication that acts directly on neighboring cells.
A) Paracrine
B) Autocrine
C) Proxocrine
D) Vicinocrine
E) Neuroendocrine

218. The _____ is an endocrine gland that produces all classes of steroids.
A) parathyroid
B) thymus
C) gastrin gland
D) adrenal gland
E) pineal gland

219. The _____, or jaw muscle, is the strongest muscle in the human body in terms of exerting the highest amount of force on an object.
A) quadricep
B) abdomen
C) tricep
D) trapezius
E) masseter

220. The brain floats in _____ fluid, protecting it from harm and providing nutrients to cells of the brain.
A) synovial
B) pericardial
C) cerebrospinal
D) peritoneal
E) aqueous

221. The _____ helps us keep balance and coordinate body movements.
A) occipital lobe
B) thalamus
C) cerebellum
D) hippocampus
E) superior colliculus

222. Babies are born with more _____ than adults.
A) bones
B) DNA
C) hair cells
D) organs
E) white matter in the brain

223. Three _____ linked to one glycerol molecule results in the composition of a triacylglycerol.
A) hydrocarbons
B) galactoses
C) maltoses
D) fatty acids
E) phosphates

224. Synaptic signaling is the process of cell to cell communication via chemical signals known as _____ .

A) interneurons
B) neuroglia
C) neurombloids
D) neurotransmitters
E) neurexins

225. _____ is the energy source for neurons, formed from glucose, and provides energy for various functions.
A) ATP
B) Lactase
C) Elastin
D) Coronin
E) Beta sheet

226. _____ binding occurs when a signal molecule binds to a receptor and causes the receptor to change shape.
A) Vesicle
B) Ion
C) Ligand
D) Mutation
E) Viral

227. _____ is the process by which a nucleotide sequence is copied from DNA to RNA.
A) Replication
B) Splicing
C) Transduction
D) Transcription
E) Proliferation

228. A(n) _____ is a celled organism with a nucleus surrounded by a membrane and its DNA is bounded into chromosomes.
A) phage
B) eukaryote
C) cristae
D) prokaryote
E) bacilli

229. In a cell, the synthesis of mRNA into a specific protein occurs within _____ .
A) golgi body
B) mitochondria
C) vacuoles

D) ribosomes
E) nucleus

230. A _____ consists of three nucleotides in a genetic code that corresponds to a single amino acid.
A) muton
B) codon
C) primer
D) capsid
E) trinomer

231. When one or more bases are added to a DNA sequence it is known as _____.
A) glycosylation
B) dimerization
C) insertion
D) permutation
E) synthesization

232. Polypeptides are just chains of amino acids and are alos sometimes referred to as _____.
A) purines
B) peroxygenase
C) phosphors
D) proteins
E) polysome

233. _____ is part of the process of making proteins whereby mRNA is converted into amino acids.
A) Hematopoiesis
B) Transfixation
C) Sublimation
D) Transformation
E) Translation

234. _____ are supporting cells essential for the structural integrity of the nervous system and normal functioning of neurons.
A) Monocytes
B) Glia
C) Platelets
D) Chromatids
E) Polysaccharides

235. _____ is a process of cell division, that is when one cell divides to become two identical daughter cells.
A) Metaphase 2
B) Interphase
C) Meiosis
D) Mitosis
E) Telophase

236. _____ are the long extensions found on neurons that transmit signals to other neurons.
A) Axons
B) White adipose tissue
C) Ganglion tendons
D) Motor tracks
E) Myelin

237. _____ are reproductive cells that transmit genes from one generation to the next.
A) Progenitor cells
B) Gametes
C) Pleocytes
D) Gonidia
E) Osteocytes

238. In polygenic _____ , a single phenotypic character is affected by two or more genes.
A) imprinting
B) incontinence
C) inheritance
D) induction
E) inundation

239. _____ are a superfamily of motor proteins best known for their role in muscle contraction and other motility processes.
A) Ferritin
B) Myosins
C) Ferritins
D) Isosolins
E) Preatchins

240. The _____ nervous system is made up of the brain and spinal cord.
A) sensory

B) main
C) primary
D) central
E) essential

241. If a chromosome has an extra copy, it is said to be _____ .
A) tetrasomic
B) monosomic
C) trisomic
D) diplosomic
E) deviated

242. Both sexes produce and secrete _____ promoted by FSH and LH which are made in the anterior pituitary.
A) electrolytes
B) digestive enzymes
C) dopamine
D) steroid sex hormones
E) oxytocin

243. In nucleotide _____ repair, enzymes cut out and replace damaged stretches of DNA.
A) excision
B) incision
C) mechanistic
D) deletion
E) allogenic

244. _____ is a region at the end of DNA chromosome that prevents deterioration or fusion with other chromosomes.
A) Short arm
B) Telomere
C) Centromere
D) Centrosome
E) Long Arm

245. Allopatric _____ occurs when two populations of one species are geographically separated and evolve differently.
A) speciation
B) division
C) separation
D) segregation

E) divergence

246. A _____ describes a cell as containing a pair of chromosomes that are homologous to each other.
A) tetraploid
B) polyploid
C) diploid
D) paleopolyploid
E) allopolyploid

247. Homo neanderthalensis coexisted with the species Homo _____ until about 30,000 years ago.
A) heidelbergensis
B) antecessor
C) erectus
D) habilis
E) sapiens

248. The _____ cycle refers to one complete sequence of pumping and filling blood.
A) cardiac
B) contraction
C) assimilation
D) circadian
E) dispersion

249. Cardiac _____ depends on two factors: heart rate and stroke volume in each contraction.
A) pressure
B) output
C) ventilation
D) input
E) diffusion

250. Oxygen rich blood first flows into the _____ of the heart.
A) pulmonary artery
B) left ventricle
C) superior vena cava
D) right ventricle
E) inferior vena cava

251. Blood leaving the heart exits through the _____ , which conveys blood to arteries throughout the body.
A) veins
B) alveolar duct
C) septum
D) aorta
E) right atrium

252. _____ are important for transporting oxygen to cells.
A) Lymph nodes
B) Plasma cells
C) Myocardiocytes
D) Hemoglobin
E) Perixosomes

253. The thalamus directs _____ from the body to the appropriate place in the cerebral cortex for processing.
A) blood
B) oxygen
C) sensory information
D) aerobic respiration
E) glycolysis

254. _____ is another name for a red blood cell.
A) Erythrocytes
B) Thrombocytes
C) Agranulocytes
D) Leukocytes
E) Granulocytes

255. _____ lipoproteins are "bad" cholesterol in the inner walls of arteries.
A) Thick-Density
B) High-Density
C) Intermediate Density
D) Very Low-Density
E) Low-Density

256. After air passes through the upper respiratory tract, or the larynx, It then passes into the _____ , or windpipe.
A) oral cavity
B) vestibule

C) trachea
D) pharynx
E) epiglottis

257. Carbon dioxide and oxygen are exchanged within thin epithelia of the lung's millions of air sacs, known as _____.
A) vestibuli
B) lung cysts
C) alveoli
D) mucous glands
E) interstitial space

258. Blood pressure is the _____ pressure that blood exerts against the wall of a vessel.
A) back
B) differential
C) over
D) absolute
E) hydrostatic

259. Cells made from B lymphocytes secrete defensive proteins called _____ that bind and mark microbes for elimination.
A) lipoproteins
B) chylomicrons
C) lysosome
D) cerumines
E) antibodies

260. _____ is the ingestion of invading microorganisms by certain types of white blood cells.
A) Exocytosis
B) Autolysis
C) Endopiptosis
D) Phagocytosis
E) Exploytosis

261. _____ is a form of programmed cell death.
A) Apoptosis
B) Necrosis
C) Endocytosis
D) Atrophy
E) Lysis

262. _____ are proteins that aide in recruiting lymphocytes and other cells of the immune system.
A) Kinases
B) Sarcomeres
C) Oxyphils
D) Myeloidism
E) Cytokines

263. _____ are substances that stimulate production of or are recognized by antibodies in the immune system.
A) Antigens
B) Papillae
C) Autophagies
D) Antioxidants
E) Anticoagulants

264. _____ immunity is the short-term immunity that results from the introduction of antibodies from another person.
A) Indirect
B) Passive
C) Independent
D) Active
E) Secondary

265. The nervous system conveys high-speed electrical signals via specialized cells called _____ .
A) neurons
B) conductors
C) transmitters
D) circuits
E) organelles

266. By releasing hormones, the _____ system plays a role in growth, metabolism, and sexual development.
A) lymphatic
B) endocrine
C) renal
D) sympathetic
E) exocrine

267. The _____ is a part of the brain that maintains homeostasis and controls the endocrine system.
A) temporal lobe
B) frontal lobe
C) hypothalamus
D) parietal lobe
E) fornix

268. _____ molecules are molecules that can increase or decrease enzyme activity, gene expression, or cell signaling.
A) Neurotensin
B) Chelation
C) Modulated
D) Effector
E) Dysplasia

269. _____ cells are nerve cells that release hormones into the blood via extracellular fluid.
A) Cytotoxin
B) Neurosecretory
C) Neurula
D) Neuro-release
E) Megakaryocytes

270. The _____ is the space between neurons allowing neurotransmitters to bind or float around.
A) junction space
B) neuro field
C) synaptic cleft
D) neurotransmitter field
E) synapse zone

271. The axon _____ is the last site where membrane potentials are propagated from the summation of synaptic inputs.
A) hillock
B) ganglion
C) node of ranvier
D) terminal
E) hub

272. _____ is a hormone important for its role in fight-or-flight response and is otherwise known as adrenaline.
A) Epinephrine
B) Glycerol
C) Glucogen
D) Brain-derived neurotrophic factor (BDNF)
E) GABA

273. _____ is a steroid hormone released in response to stress and low blood-glucose concentration.
A) Cytosol
B) Cortisol
C) Estrogen
D) Glutamine
E) N-methyl-D-aspartate

274. _____ is a peptide hormone produced in the pancreas and is the main anabolic hormone regulating glucose in blood.
A) Thymosin
B) Noradrenaline
C) Insulin
D) Histamine
E) Thyroxine

275. A _____ occurs from fertilization between two gametes, leading to the development of a newborn human.
A) zephyr
B) leukocyte
C) zygote
D) replisome
E) haploid

276. Gamete fusion of a sperm and egg depolarizes the egg cell membrane and initiates a fast block of _____.
A) meispores
B) parthenogenesis
C) polyspermy
D) hormone release
E) merkel cells

277. The neural _____ is the beginning process of embryonic development that forms the basis for the nervous system.
A) sporangium
B) coelom
C) pleura
D) plate
E) somite

278. _____ are a type of cell produced by mitotic cell division of the zygote that lasts for about a week.
A) Catomeres
B) Blastomeres
C) Rumatoids
D) Mitocyte
E) Blastoise

279. The membrane potential of an inactive neuron is called the _____ potential.
A) action
B) waiting
C) resting
D) low-level
E) zero

280. The _____ is a hollow sphere or layer of blastomeres that form a blastoderm leading to gastrulation.
A) blastospore
B) blastula
C) blastocill
D) blastocymes
E) blastullium

281. A(n) _____ occurs when the membrane potential of a neuron depolarizes, or activates, the neuron to fire.
A) action potential
B) ligand-binding
C) excitatory release
D) dielectric potential
E) threshold potential

282. _____ are glia in the brain that form myelin sheaths around the axons of vertebrate neurons.

A) Astrocytes
B) Ependymal Cells
C) Microglia
D) Oligodendrocytes
E) Satelitte Cells

283. _____ is a structural protein used for connective tissue.
A) Tubulin
B) Collagen
C) Fibroin
D) Casein
E) Kinesin

284. _____ are alkaline proteins that act as spools around which DNA binds and play a role in gene regulation.
A) Immunoglobulins
B) Karyotypes
C) Histones
D) Angstroms
E) Prolamin

285. The _____ nervous system is made up of nerves that branch off of the spinal cord and extend throughout the body.
A) peripheral
B) kinetic
C) tertiary
D) numismatic
E) motor

286. Many endocrine pathways contain a _____ feedback mechanism to prevent wild fluctuations in regulation.
A) negative
B) phasic
C) flexible
D) positive
E) protection

287. _____ ion channels allow ions to flow in or out of the neuron when a specific chemical binds to the receptor site.
A) Dendritic
B) Leak

C) Voltage-gated
D) Ligand-gated
E) Tonic

288. _____ packages DNA into small volumes to fit into the nucleus of a cell and protects the DNA structure and sequence.
A) Biopolymers
B) Tautomers
C) Chromatin
D) Pyrimidines
E) Helicase

289. The telencephalon during embryonic development gives rise to the cerebrum which contains the _____ .
A) peripheral nerves
B) pons
C) brain stem
D) medulla
E) cerebral cortex

290. _____ postsynaptic potentials occur when a neuron gets closer to the threshold of generating an action potential.
A) Stimulating
B) Inhibitory
C) Integrative
D) Excitatory
E) Increasing

301. Sepak _____ is similar to volleyball but players use anything but their hands to move the ball around.
A) bossaball
B) takraw
C) ecua-volley
D) footbag
E) newcomb ball

302. In _____, a popular game in Europe, competitors alternate between 11 rounds of chess and boxing.
A) strategy boxing
B) blitz chess
C) chess punch

D) boxing checkmate
E) chess boxing

303. _____ games involve toilet seat tossing, seed spitting, mud belly flops, and dumpster diving.
A) Hillbilly
B) Hick
C) Woodsmen
D) Country bumpkin
E) Redneck

304. The first woman to play in the NHL played _____ for the Tampa Bay Lightning in 1992-1993.
A) centerman
B) defenseman
C) goaltender
D) winger
E) power forward

305. _____ involves participants making homemade devices such as catapults, canons and centrifugals.
A) Potatoe launching
B) Melon catapult
C) Pumpkin shot
D) Melon launch
E) Pumpkin chucking

306. In the Scottish _____ toss, competitors toss a 20 foot pole so that it lands in the 12 o'clock position relative to them.
A) timber
B) beam
C) highland log
D) caber
E) timberland

307. In _____ players slide stones towards a target segmented into four concentric circles on sheets of ice.
A) bocce ball
B) broom ball
C) snow snake
D) curling

E) bandy

308. Cricket originally used the term _____ long before it was used in baseball.
A) hit and run
B) foul ball
C) power hitter
D) home run
E) grand slam

309. Tennis was the first sport in which _____ were invited to compete at the Olympics in 1900.
A) women
B) all countries
C) non-white players
D) doubles teams
E) physically disabled players

310. Originally a _____ was used to play basketball until 1929.
A) volley ball
B) soccer ball
C) foot ball
D) aluminum hoop
E) rubber ball

311. Hop, step, and jump are the three movements required for an athlete to successfully complete a _____.
A) broad jump
B) triple jump
C) long jump
D) fosbury flop
E) hurdle

312. The presidential ceremonial pitches in MLB originally started in 1910 beginning with _____.
A) Calvin Coolidge
B) William McKinley
C) Theodore Roosevelt
D) Woodrow Wilson
E) William Howard Taft

313. Before 1926, World Series winners received _____ instead of championship rings.
A) cars
B) individual trophies
C) pocket watches
D) gold medals
E) silver medallions

314. The sport that uses the heaviest ball, with a maximum of 16 pounds, is a tie between bowling and _____.
A) wireball
B) korfball
C) shot put
D) bocce
E) petanque

315. _____, located in Europe, has competed in the most summer Olympics without winning any medals.
A) Albania
B) Lithuania
C) Croatia
D) Romania
E) Liechenstein

316. A(n) _____ is a proper term for a person that fishes using a hook.
A) angler
B) caster
C) rodman
D) lurers
E) hook and liner

317. Most NASCAR teams use _____ in their tires instead of air.
A) helium
B) oxygen
C) nitrogen
D) argon
E) acetylene

318. After losing many players to WWII military service, the Pittsburgh Steelers and Philadelphia Eagles combined to become the _____.
A) Eaglers
B) Steel Eagles

C) Eagle Steelers
D) Steagles
E) Seaglers

319. In Thailand, _____ is considered a professional sport.
A) tag
B) yo-yoing
C) toe wrestling
D) kite flying
E) weight guessing

320. The highest rank one can achieve in sumo wrestling is called _____.
A) chonmage
B) sekitori
C) yokozuna
D) makuuchi
E) sandanme

321. The first modern Olympic games were held in _____ in 1896 with no female competitors.
A) Athens
B) Berlin
C) Florence
D) Paris
E) Vienna

322. _____ were originally used as the innertube in rugby balls.
A) Pig stomachs
B) Cow stomachs
C) Bull bladders
D) Pig bladders
E) Lamb stomachs

323. Golf was banned in England in 1457 because it was considered a distraction from the serious pursuit of _____.
A) fencing
B) english football
C) archery
D) poetic writing
E) tennis

324. The _____ are the only team to neither play in nor host a super bowl.
A) Washington Redskins
B) Atlanta Falcons
C) Jacksonville Jaguars
D) Cleveland Browns
E) Tampa Bay Buccaneers

325. The javelin throw involves throwing a _____ as far as possible while running.
A) large wooden pole
B) spear
C) flying disc
D) metal ball
E) heavy stone

326. _____, otherwise known as "radball" is a game of soccer played only on bicycles.
A) Cycleball
B) Wheelball
C) Footvolley
D) Roller soccer
E) Bmxball

327. _____ involves running, jumping, and climbing with the aim of getting from one point to another as quickly as possible.
A) Triathlon
B) Abseiling
C) Parkour
D) Sport climbing
E) Free running

328. _____ involves spining in a circle, while swinging a metal ball, to increase the distance of the throw once released.
A) Hammer throwing
B) Sheaf toss
C) Stone put
D) Steinstossen
E) Flail throw

329. _____ involves a male competitor racing through an obstacle course while carrying a female teammate.
A) Wife carrying

B) Ball and chain race
C) Jock and juliet
D) Conan and eve race
E) Hercules competition

330. _____ is a recreational sport involving rolling down a hill in a transparent plastic orb or "hamster ball".
A) Zorbing
B) Buddy bumper ball
C) Sphere trek
D) The orb roll
E) Human bubble racing

331. In competitive diving, scores are based in part on the _____ from the athlete's overall performance.
A) degree of accuracy
B) artistic impression
C) technicality of skill
D) code of points
E) degree of difficulty

332. _____ occurs in an octagonal space where players slap a ball attempting to hit an opponent at the waist or below.
A) Dodgeball
B) Slapball
C) Gaga ball
D) Grounders
E) Hand ball

333. _____ involves a member of one team running to an opposing team's side tagging out as many players without being tackled.
A) Extreme tag
B) Kabaddi
C) Freeze tag
D) Bishop tackle
E) Tackle touch

334. Fierljeppen is similar to _____ but rather than jumping for height one must make it the furthest distance over a body of water.
A) high jump
B) competitive trampolining

C) pole vaulting
D) hurdles
E) steeplechase

335. The state sport of Maryland is _____.
A) kayak racing
B) tug-of-war
C) cycling
D) canoe paddling
E) jousting

336. A _____ in billiards occurs when one hits the cue at an extremely steep angle in order to curve it around an obstruction.
A) jump shot
B) run the table
C) masse shot
D) snooker hit
E) shadow hit

337. In Colorado _____ racing, or humans running alongside a donkey, is a summer heritage sport.
A) mule
B) ass-pair
C) pack burro
D) the donkey trot
E) burro duo

338. _____ is rubbed on every Major League baseball to allow for better grip.
A) Mud
B) Pine tar
C) Vaseline
D) Dirt
E) Rosin

339. Hockey pucks are _____ before each game so that they glide smoother and don't bounce during the game.
A) heated to 300 degrees
B) covered in silicone
C) compressed
D) soaked in liquid nitrogen
E) frozen

340. Tennis courts were once a(n) _____ shape before becoming a rectangular shape.
A) hour-glass
B) octagon
C) figure-8
D) square
E) oval

341. The first televised sporting event was the 1936 _____.
A) Berlin Olympics
B) World Series
C) the Ashes cricket test
D) York and Liverpool rugby union
E) Wales vs Manchester football game

342. While rugby is very similar to American football, one major way it differs is _____ is not allowed.
A) handoffs
B) blitz
C) conversions
D) interceptions
E) forward passing

343. In roller derby, a player called a _____ can score points by lapping members of the opposing team.
A) jammer
B) blocker
C) flyer
D) pivot
E) sprinter

344. _____ is considered to be the second oldest sport in the world.
A) Wrestling
B) Chariot racing
C) Hockey
D) Discuss throwing
E) Gymnastics

345. The bag that archers use to hold their arrows is called a _____.
A) crest

B) fletcher
C) nook
D) stave
E) quiver

346. Splitting the arrow of a competitor is called a(n) _____.
A) crest shot
B) shaft splice
C) ace shot
D) robin hood
E) fletched shot

347. The second most popular sport in the world is _____.
A) soccer
B) lacrosse
C) volleyball
D) cricket
E) ping pong

348. _____ has more fans around the world than basketball, baseball or American football.
A) MMA
B) Formula 1 racing
C) Table tennis
D) Motorcycle racing
E) Ice skating

349. Legal serving during badminton must be hit in an upwards direction from anywhere below the _____.
A) elbow
B) belly button
C) neck
D) armpit
E) waist

350. There are 2 forms of competitive rowing, sweep oaring where each rower has 1 oar and _____ where each rower has 2 oars.
A) swing
B) repechage
C) power stroke
D) sculling
E) gliding

351. The first intercollegiate sport in the United States was _____ and was held in 1852 between Yale and Harvard.
A) baseball
B) football
C) track and field
D) golf
E) rowing

352. Wimbledon is the only major tennis championship still being played on _____.
A) wood
B) packed down clay
C) higher altitudes
D) weekdays only
E) grass

353. In ancient Greece most of the gymnastics competitions were done _____.
A) while wearing masks
B) by young boys
C) at night
D) by slaves
E) in the nude

354. When a bowler gets four strikes in a row this is called a _____.
A) turkey
B) quadruple
C) solid run
D) ham bone
E) line-up

355. Skateboard wheels were originally made of metal or clay until _____ wheels came onto the market.
A) rubber
B) silicone
C) carbon fiber
D) pneumatic
E) polyurethane

356. The most well known and popular skateboard trick is called the _____.
A) superman

B) x-up
C) ollie
D) royal
E) indy backside

357. The Super Bowl is America's second largest food consumption day, behind _____.
A) Fourth of July
B) Labor Day
C) Easter
D) Thanksgiving
E) Cinco de Mayo

358. The NFL season is the _____ professional sports season of any big major American sport.
A) longest
B) least viewed
C) shortest
D) second most viewed
E) warmest

359. The women's equivalent of the male tennis competition known as Davis Cup is the _____.
A) Claret Jug
B) Grey Cup
C) women's Federation Cup
D) Fed Cup
E) Calder Cup

360. _____ is a very old martial arts technique created in the Philippines.
A) Krav maga
B) Jujutsu
C) Arnis
D) Judo
E) Capoeira

361. Another name for bowling is _____.
A) kingpin
B) kegler
C) decaball
D) tenpins
E) pins

362. _____ involves rolling biased balls so that they stop close to a smaller ball called a jack.
A) Croquet
B) Spikeball
C) Lawn bowling
D) Camogie
E) Jackball

363. The only NFL team to go a whole season undefeated, including the Super Bowl, is the _____.
A) New England Patriots
B) Miami Dolphins
C) San Francisco 49ers
D) Denver Broncos
E) New Orleans Saints

364. The _____ is a long distance cross-country skiing race held in Australia.
A) Fourth of July
B) 40 km relay
C) ski marathon
D) kangaroo hoppet
E) sprint classic

365. In badminton, players hit a cork-like object with feathers attached known as a _____.
A) wood shot
B) flick
C) shuttlecock
D) rubberstock
E) feathertip

366. In boxing, a _____ is a blow to the back of the head or to the base of the skull and are illegal hits.
A) rabbit punch
B) caught cold
C) blow back
D) low blow
E) sucker punch

367. _____ is a term used for boxers who faced repeated dazing punches to the head over long periods of time.
A) Blow-by-blow
B) Glass jaw
C) Punch drunk
D) Haymaker
E) Southpaw

368. NASCAR is an acronym for the national association for _____ racing.
A) speed car auto
B) sprint course auto
C) stock car auto
D) super craft auto
E) speedway circle auto

369. In 1967, the _____ were the first team to win the NFL's first Super Bowl.
A) Pittsburgh Steelers
B) Green Bay Packers
C) Detroit Lions
D) New York Jets
E) New York Giants

370. In bobsledding, individual runs down the course are known as _____.
A) heats
B) matches
C) races
D) scrimmage
E) pickups

371. In _____ grooves in the ice at the initial push make it unnecessary for a pilot to steer until leaving the start area.
A) bobsledding
B) speedskating
C) ski jumping
D) Alpine skiing
E) luge

372. In badminton in order to win a _____, or otherwise known as a game, a player must obtain 21 points.
A) set
B) rally

C) match
D) pitch
E) bout

373. The modern game of field hockey grew out of Scotland and was originally called _____.
A) bahooky
B) hokin
C) shinty
D) peely wally
E) drookit

374. In fencing, prior to electronic scoring, players wore white uniforms because touches were scored from _____ on the weapons.
A) a clay powder
B) brown chalk
C) charcoal
D) ink-soaked tips
E) a dark oil

375. _____, also called skibiking, involves the use of skis and a bike-frame where the rear ski is fixed and the front ski steers.
A) Snowbike
B) Bike plowing
C) Snow cycling
D) Skibobbing
E) Skipeddling

376. Clay pigeon shooting involves shooting clay disks projected from a device called a _____ at various angles, speeds, and distances.
A) skeet slingshot
B) launcher
C) disc sling
D) trap
E) catapult

377. The game of lacrosse was devised by _____ as a method for toughening up young men in preparation for war.
A) the French
B) British soldiers
C) the Scottish

D) Native Americans
E) India

378. Wakeboarding was originally called _____.
A) water skating
B) skurfing
C) water planing
D) aquaski
E) hydroboarding

379. Before the invention of celluloid and other new-age plastics, some billard balls were made out of _____ in the 17th century.
A) phenolic resin
B) polished quartz
C) ivory
D) bakelite
E) lucite

380. A _____ (PWC) can be used for riding while seated or while standing up, which are used for tricks or racing.
A) private water car
B) personal watercraft
C) primary water car
D) personal wakecraft
E) piloted wakecraft

381. Personal watercrafts (PWC) are often referred to by their trademarked names, such as Jet Ski, WaveRunner, or _____.
A) Sea-runner
B) Jetboat
C) Aquajet
D) Runabout
E) Sea-doo

382. Raquet balls are designed for different kinds of play indicated by different colors; for instance _____ balls are the fastest.
A) blue
B) black
C) purple
D) green
E) red

383. Snowboarding was originally termed _____ and incorporated a rope to the nose of a board for snow-surfers to hold onto.
A) skiboarding
B) skoarding
C) iceboard
D) sled-boarding
E) snurfing

384. In the game pickleball, players use solid paddles to hit a ball that is similar to a _____ over a net.
A) Wiffle ball
B) ping pong ball
C) netball
D) corfball
E) squash ball

385. The letters in the acronym SCUBA stand for _____ breathing apparatus.
A) super closed unique
B) self-contained underwater
C) self collective uniform
D) solid contained unique
E) strictly closed underwater

386. The outer shell of a paintball is made from a _____ capsule.
A) petroleum
B) polycarbonate
C) gelatin
D) polypropylene
E) polyactic acid

387. In bull riding, a qualified ride is 8 seconds long and ends when _____, the rider touches the ground, or his free arm touches the bull.
A) one hand grabs their hat
B) the hand comes out of the rope
C) they wave at the rodeo clowns
D) both hands grab the rope
E) one hand touches their thigh

388. In shot put, if at any time the shot loses contact with _____ then it is technically an illegal put.
A) both hands
B) the ground
C) the rope
D) the chest
E) the neck

389. In gymnastics, a male gymnast will use his legs skills on a _____, usually swinging both legs in a circular motion.
A) pommel horse
B) vault
C) uneven bars
D) balance beam
E) still rings

390. _____ involves riders performing acrobatic stunts on dirt bikes while jumping man-made dirt tracks.
A) Supercross
B) Sidecarcross
C) Freestyle motocross
D) Supermoto
E) Motocross jump

Catch Questions list:
601. To cut food, you would usually use a _____
A) spoon
B) fork
C) knife
D) hammer
E) coffee cup

602. The type of tableware you would use to eat cereal is a _____
A) cup
B) plate
C) coffee mug
D) dessert plate
E) bowl

603. If one wanted to eat beef, they could eat a _____

A) steak
B) chicken
C) egg
D) turkey
E) bacon

604. To bake a cake, you would need to heat it in a(n) _____
A) freezer
B) blender
C) toaster
D) oven
E) microwave

611. The human body contains an outer protective layer of _____ .
A) plastic
B) skin
C) feathers
D) metal
E) electrical wire

612. The part of the body that is used for decision making is the _____ .
A) brain
B) liver
C) stomach
D) kindeys
E) lungs

613. Food is broken down and digested in the _____.
A) lungs
B) brain
C) heart
D) bladder
E) stomach

621. Baseball is a sport in which players attempt to hit a ball with _____.
A) a lacrosse stick
B) a tennis racket
C) their feet
D) a bat
E) a hockey stick

622. In soccer, players will use their _____ to kick a ball.
A) feet
B) hands
C) butt
D) wrist
E) elbows

623. American football players will wear _____ to protect their head from injury.
A) shin guards
B) wrist guards
C) a helmet
D) a cup
E) shoes

Appendix B

Demographic questionnaire

Q1 What is your current gender identity?

- Female
- Male
- Non-binary/Third gender
- Prefer to specify:

Q2 Age:

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65-74
- 75+

Q3 Please indicate your ethnicity/race? (Select all that apply)

- American Indian/Alaska Native
- Asian
- Black/African American
- Hispanic/Latino
- Native Hawaiian/Pacific Islander
- White (including European, Middle Eastern, or North African decent)
- Other, please specify your ethnicity/race here:

Q4 Highest level of education:

- High school
- Currently enrolled in college
- Associates Degree
- Bachelor's Degree
- Master's Degree
- Advanced degree (e.g. MD, DDS, DVM, PhD, JD)

Q5 What is you total household income from all sources?

- Less than $20k
- $20,000- $34,999
- $35,000- $49,999
- $50,000- $74,999
- $75,000- $99,999
- Over $100,000

Q6 Is English your primary language?

- Yes
- No

Q7 On a numerical scale, how much would you say you enjoy learning about new things:

Not really					Somewhat					As much as I can
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

Q8 Do you participate in any trivia related events in your local community?

- Every week
- Once a month
- Every once in a while
- Rarely ever

- Not interested in trivia

Q9 On a numerical scale, how much expertise do you have regarding cooking/baking?

No knowledge					Decent amount of knowledge					Advanced knowledge
0	1	2	3	4	5	6	7	8	9	10

Q10 How often would you say that you cook or bake?

- I cook/bake all the time
- I cook/bake a few times a week
- I cook/bake every once in a while
- I rarely ever cook/bake
- Not interested in cooking/baking

Q11 On a numerical scale, how much expertise do you have regarding human biology?

No knowledge					Decent amount of knowledge					Advanced knowledge
0	1	2	3	4	5	6	7	8	9	10

Q12 Have you taken any biology/kinesiology/other human physiology courses?

- I have a degree in one of the fields
- I am currently learning about this field
- I took one/a few course(s) recently
- I took one/a few course(s) a long time ago
- I never took a course

Q13 On a numerical scale, how much expertise do you have regarding sports?

No knowledge					Decent amount of knowledge					Advanced knowledge
0	1	2	3	4	5	6	7	8	9	10

Q14 Do you currently watch any sport(s)?

- All the time
- A few times a week
- Every once in a while
- Rarely Ever
- Not interested in sports

Q15 Which of the following sports have you played in an organized or semi-organized competitive setting (select all that apply):

- Football
- Baseball/Softball
- Basketball
- Tennis
- Waterpolo
- Lacrosse
- Hockey (ice or roller)
- Rugby
- Soccer
- Wrestling/Fighting/Boxing
- Running
- Snowboarding
- Surfing
- Table Tennis
- Skateboarding
- Golf
- Skiing

- [ ] Swim
- [ ] Bowling
- [ ] None of the above
- [ ] Other, please specify what other sport(s) you play here: