The effect of content-related and unrelated break activities on test results

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THE EFFECT OF CONTENT-RELATED AND UNRELATED BREAK ACTIVITIES ON TEST RESULTS

by

Ryan D. Gentek

A Thesis

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Abstract

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THE EFFECT OF CONTENT-RELATED AND UNRELATED BREAK ACTIVITIES ON TEST RESULTS 2015-2016
Terri Allen, Ph.D.
Master of Arts in School Psychology

Researchers have recently explored using brief breaks to maintain performance during prolonged tasks (Ariga and Lleras, 2011). However, research has yet to fully explore the effect of break activity content on the performance of the primary task. The present study sought to explore the differing effects of two break activities that were respectively similar and different in content to the main task. The present researcher compared past studies of task-switching and interruption studies to theories of the vigilance decrement and hypothesized that a brief similar task should result in significantly different main-task performance than the brief dissimilar task. 20 participating Rowan students were randomly divided into two groups based on the break activity they would be assigned: content-related or content-unrelated. The participants were given a 20 minute quantitative reasoning test, followed by either a quantitative reasoning (content-related) or literacy-based (content-unrelated) break activity. After 5 minutes of this activity, participants were given a second 20 minute quantitative reasoning test. Scores of all tests were measured using a two-way ANOVA with repeated measures. Participants that participated in content-unrelated break activities were found to have significantly different test scores from those of participants given content-related activities.
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Chapter 1

Introduction

Need for Study

Research has shown that prolonged cognitive focus can result in attention failures (Head, Helton, 2014). In settings where focus is necessary for success, such as schools and workplaces, this “vigilance decrement” (Davies & Parasuraman, 1982) threatens an individual’s task progress and efficiency; for example, students with attention problems are at higher risk for low academic achievement (Polderman, Boomsma, Bartels, Verhulst, & Huizink, 2010; Sayal, Washbrook, & Propper, 2015). Regular breaks during cognitive tasks, however, have shown to reduce the impact of time on attentional resources (Ariga & Lleras, 2011). Ariga and Lleras’ study has gained popularity for providing a method of improving focus and productivity (New York Times, 2012). From this study a new question arose concerning which break activities are best for increasing overall efficiency. Multiple studies have observed various answers to this question; however, little research has touched on the topic of whether cognitively similar or different break activities would affect main task results. Studies of task switching have touched on the subject of relation between tasks but have mainly focused on multiple congruous tasks as opposed to the effects of a smaller task on a large one. In settings such as schools, where short breaks may be effective in keeping the attention of students, finding methods to both promote learning and provide students with a means of retaining attention is crucial to the success of those students. Therefore, expansions of Ariga and Lleras’ study are crucial for supplying educators with tools for increasing the efficiency of their classrooms.
Purpose

The current seeks to determine whether, for a main task requiring sustained attention, break activities similar to the main task in terms of their use of cognitive intelligence will produce significantly better results on that main task than an activity unrelated in its use of intelligence. The research completed in this paper is focused specifically on a main task involving quantitative reasoning and break activities involving quantitative reasoning and perceptual speed with literacy skills.

Hypothesis

The effects of different cognitively stimulating break activities interrupting a main activity have yet to be extensively researched. Studies of task-switching and cognitive transfer indicate that similar tasks, rather than different tasks, are more efficiently completed when paired (Arrington, Altman, & Carr, 2003; Gopher, Armony, & Greenshpan, 2000; Kiesel, Wendtm & Peters, 2007; Rubinstein, Meyer, & Evans, 2001; Singley & Anderson, 1989). Meanwhile, theories of the vigilance decrement would argue the opposite, with divergent activities lending themselves better to staving off attention deficits (Davies & Parasuraman, 1982). This researcher believes that a brief break activity involving use of the same cognitive ability will demonstrate significantly different effects on the results on the main task when compared to a break activity involving the use of a different cognitive intelligence. For the purposes of this study, this researcher will be specifically investigating whether subjects that perform a brief “KenKen” task in the middle of a quantitative reasoning achievement test will show different changes in score from the pre-test to post-quantitative reasoning tests when
compared to subjects that instead perform a “Boggle Brain Busters” task during that break.

**Operational Definitions**

*Vigilance decrement:* the progressive reduction in performance during tasks involving sustained attention (Davies & Parasuraman, 1982).

*CHC theory:* the Cattell-Horn-Carroll theory of intelligence. Named after its three most influential researchers, defines intelligence as a collection of cognitive abilities rather than a single factor (Cattell, 1941; Horn, 1965; Carroll, 1993). The categories of cognitive abilities are drawn from Schneider and Newman’s (2015) organization of the theory. Specific subjects observed by this study are quantitative reasoning, which falls within the category of quantitative knowledge, perceptual speed, and literacy, a form of crystallized intelligence.

*Content-related:* this researcher’s terminology referring to two tasks that are similar in regards to the cognitive processes used for completion. The cognitive processes cited in this study are taken from the CHC theory as organized by Schneider and Newman (2015).

*Content-unrelated:* this researcher’s terminology referring to two tasks that are different in regards to the cognitive processes used for completion.

**Assumptions**

This paper assumes the acceptance of the CHC theory of intelligence (Schneider & Newman, 2015). It was assumed that the break activity of KenKen was related to usage of quantitative reasoning while Boggle was unrelated to this form of intelligence. The first and second quantitative reasoning achievement tests were assumed to be
equivalent in difficulty. Participants were also assumed have knowledge of the high school mathematics required by the test presented.

Limitations

Students participated in the study class credit. This study in particular was worth 8 points, which was more than most other studies at the time. The greater number of points offered for participation could have attracted a particular crowd while the length of the study could have dissuaded others, resulting in a skewed sample. The inclusion of only Rowan University students also restricts the degree to which this study can be safely generalized to the general population.

This study assumed that any notable differences between individuals would be primarily created by differences in the break activities. However, participants came from a variety of backgrounds and likely had varying degrees of skill, leading to some obtaining higher average scores than others. Differences in individual abilities were partially controlled for by observing average change in scores as opposed to comparing scores of subjects directly. Additionally, participants may have had differing levels of interest in the main and break activities. As degree of interest is often a factor in one’s ability to maintain attention, this factor likely played a role in the expression of the vigilance decrement. These are just several of the many factors that could have had unintended influences on results.

Although the break activities had face validity as per the type of intelligence involved in their completion, the present study did not observe the actual validity of their intended content. In addition, the KenKen activity was assumed to be similar in content to the quantitative reasoning test while the Boggle Bran Busters activity was assumed to
be different. Similarly, the two break activities were assumed to be reasonably similar in method of response and difficulty while different in content.

**Summary**

The current study is an expansion of previous research into mental breaks and task switching. This research hopes to provide individuals with additional tools for increasing productivity and attention, as well as shed insight into the relationship between sustained attention and cognition. Should this study find that content-related break activities lend to better performance on the main task than content-unrelated activities, it would support future studies of ability-based attention. This research could in some regard provide individuals with essential information for increasing both task attention and efficiency in a variety of environments.

A pool of Rowan University students was assembled to participate in the present study. Each participant was randomly assigned to one of two experimental groups: content-related and content-unrelated. After a description of the test and break task procedures, all participants were first given a 22-item quantitative reasoning achievement test, which they had 20 minutes to complete. After this allotted time expired, tests were collected and break activities were distributed, with the content-related group receiving a quantitative reasoning-based KenKen task and the content-unrelated group receiving a perception speed and literacy-based Boggle task. This break task was performed for 5 minutes, after which these tasks were collected and the second 22-item quantitative reasoning achievement test was distributed. Participants were given another 20 minutes to complete this test. In addition to the test scores collected, two items of demographic data were collected, including collegiate major and gender.
Chapter 2

Literature Review

Ideally, simply putting one’s mind to a task would be sufficient for diligent completion of that task. Fitting with this ideal, recent research has suggested that most attentional resources are guided through an individual’s goal-setting (Dijksterhuis & Aarts, 2010; Pashler, Johnston, & Ruthruff, 2001). Unfortunately, for most individuals goal-setting itself does not allow for sustained attention throughout a prolonged task. Research into attention resources, the failure of vigilance, and methods of recovering attention can provide individuals with the tools they need to work efficiently and successfully.

Overview of Attention

Knudsen (2007) describes the four fundamental processes involved in attention as “working memory, top-down sensitivity control, competitive selection, and automatic bottom-up filtering for salient stimuli”. Working memory acts as storage for attended information and determines what stimuli should be consciously attended to. Top-down sensitivity control refers to processes used to gather information, such as hearing and sight, and how they are manipulated to focus on specific stimuli and ignore others. Working memory and top-down sensitivity control both play a role in activating specific brain regions in accordance to the type of information being attended to (Corbetta, Miezin, Dobmeyer, Shulman, & Peterson, 1991; Mesulam, 1999; Shomstein & Behrmann, 2006). However, bottom-up salience filters also work to manage information stored in working memory; input from environmental stimuli is unconsciously compared with input gathered from top-down control for importance (Baddeley, 2003). Stimuli
deemed strong enough to make it past the initial attentional filter can take precedent over consciously attended stimuli, claiming space in working memory. The selection of what stimuli to store information from is based on the unexpected nature or strength of the environmental stimuli and the strength of the consciously and currently attended stimuli (Desimone & Duncan, 1995). The information stored in working memory deemed most important, gathered through stimuli observed via either top-down or bottom-up procedures, then acts as a foundation for proceeding top-down sensitivity control. In this way, outside stimuli can interfere with an individual’s goal-directed attention.

Attention has been known to be crucial for successful performance since the early years of psychology (James, 1890). Many essential human functions, such as learning, have been linked to one’s ability to attend to specific information. The link between attention and learning is specifically crucial in school environments, where the success of a student depends on demonstrations of achievement in learning. When attention is blocked in some way, learning is weakened accordingly (Kruschke, 2005). Further, failure to learn present information due to inattention can prevent future learning through a conditioned inattentive response (Kruschke & Blair, 2000; Mackintosh 1975; Mackintosh & Turner 1971) which is exemplified in the correlation between inattention at younger ages and lower achievement in future schooling (Polderman, Boomsma, Bartels, Verhulst, & Huizink, 2010). Outside of learning, attention is predictor of efficient multitasking (Konig, Buhner, & Murling, 2005) and, because attention determines future top-down control procedures (Knudsen, 2007), attention facilitates the gathering of perceptual information (Carrasco & McElree, 2001).
Finding ways of increasing attention is crucial for environments where inattention can negatively affect an individual’s success. Inattention among school children, for example, places them at higher risk for academic underachievement (Sayal, Washbrook, & Propper, 2015). With attention being such a crucial factor of performance, possible causes of inattention have been explored. Davies and Parasuraman (1982) describe a “vigilance decrement” as the gradual decrease in awareness during prolonged attention tasks. Due to this growing lack of attention, performance on the task suffers. In most work-related settings, such as schools and businesses, efficiency is crucial for the timely and accurate completion of work. Therefore, several attempts to explain and thereby solve the vigilance decrement have arisen in recent years. The main cause of the decrement has proven difficult to observe, however research has provided two main theories (Helton & Russell 2012). The first and most dominant of these theories is that of cognitive overload and mental fatigue. Supporters of the cognitive overload theory propose that the observed attention failure occurs due to cognitive resources “running out” or being strained for too long of a time. When an individual spends a lengthy amount of time using cognitive functions, those functions may become “tired” much like a muscle (Head & Helton, 2014). Working memory may be the executive function most affected by such prolonged activity (Caggiano & Parasuraman, 2006). The second theory proposed maintains the opposite view; that the vigilance decrement occurs due to cognitive underload and boredom, commonly referred to as the “mindlessness” theory. Here, observing the same stimuli repetitively causes habituation to those stimuli, resulting in a wandering mind seeking other stimulation (Cheyne, Solman, Carriere, &
Taking a Break as a Means of Sustaining Attention

A study by Ariga and Lleras (2011) provides a method of deferring the vigilance decrement that is reportedly as beneficial as it is attractive to the common worker: take a break. In their study, subjects were presented with images of longer or targeted shorter lines and asked to respond when a target line appeared. These images would cycle at a constant rate for 1200 trials across a 40 minute time frame. One group performed only this vigilance task. A No-switch group performed an additional memory task, in which the screen presented a set of four numbers for five seconds before the vigilance task and asked to memorize them. At the end of the vigilance task, a single digit was presented. Subjects were asked to respond if the digit presented was one of the four numbers shown before the vigilance task began. A Switch group was given the same procedure as the No-switch group, except that these subjects were tested for the memory task several times throughout the vigilance task, interrupting the main task. A final Digit-ignored group was presented the same procedure as the Switch group but was told to ignore all numbers, performing only the vigilance task.

The results demonstrated that the Switch group, which had occasionally stopped their vigilance task, scored significantly higher than those groups that continued working for the entirety of the 40 minutes. Ariga and Lleras (2011) maintain that the intermittent restarting of the main-task “preempted” the vigilance decrement, avoiding attention failure and resulting in more accurate completion of the main task. The researchers argue that their findings present evidence for the “goal-habituation” or mindlessness theory of
the vigilance decrement. Although this study has met with some opposition (Helton & Russell, 2012), it has garnered a significant amount of popular attention, promoting scheduled break activities in order to increase productivity (Korkki, 2012). Because attention is an essential factor of performance, attempts to maintain the attention of individuals (Maag & Reid, 1993) and efficiently schedule around the depletion and renewal of attentional resources (Klein, 2004) look to benefit from strategies such as Ariga and Lleras’ (2011) proposal. In an effort to increase attentional resources, methods based on their findings is currently being tested for usage in the workplace, schools, and elsewhere (Howie, Beets, & Pate, 2014; Zacher, Brailsford, & Parker, 2014; Fritz, Ellis, Demsku, Lin, & Guros, 2013). Observation of various break activities and their effect on the main task yield numerous possibilities for increasing productivity. Exercise during breaks, in addition to encouraging healthy physical activity, strengthen academic performance in 4th and 5th grade students (Howie, Schatz, & Pate, 2015). Short midday naps also prove beneficial for learning (Mednick, Nakayama, & Stickgold, 2002).

However, the wealth of options available to the break-time individual opens the discussion of the values of different break activities and which activities may be best for certain situations. For example, a study by Schlichting and Preston (2014) found that complete “rest” or a break from cognitive activity created a sudden surge in subjects’ abilities to encode new information. However, this discovered benefit is only applicable when the individual is capable of ceasing activity.

**The Significance of Secondary Task Content**

Many individuals may find themselves in situations where attention is dropping but cognitive activity is necessary to continue a desired task. Methods of continuing
cognitive activity while still reducing decrements to vigilance are therefore more likely to be useful to such individuals. Any supplementary task presented alongside a main task, especially one involving sustained cognitive processing, would involve the phenomenon of task-switching. Diverting attention away from one task and towards another has a negative impact on performance of the new task, called the “switching cost” (Monsell, 2003). However, the content of the new task dictates the magnitude of that cost. Tasks that are similar in content to the main task have shown to lower task-switching costs (Arrington, Altman, & Carr, 2003). Similarly, anticipated task-switching accompanied by minimal change in the strategies used for task completion result in a lesser reduction of productivity (Gopher, Armony, & Greenshpan, 2000). Cognitive tasks that require similar responses also receive faster and more accurate answers (Kiesel, Wendt, & Peters, 2007; Rubinstein, Meyer, & Evans, 2001). This previous research shows a preference for similar rather than different break activity content. Meiran, Chorev, and Sapir (2000) suggest three component parts contributing to task-switching costs: passive dissipation of the previous task set, preparation for the new task, and the residual preparedness for the new task if it is being repeated. Over time, the brain reduces cognitive processes related to the previous time. Information about the new task then overrides the old information, allowing for better completion of the new task and lowering switching costs. These components are congruent with aforementioned studies of similar and different task pairings and provide a theory for the innate preference for similarity found in task-switching research.

With task-switching costs being partially determined by similarity, the criteria for determining similarity and difference between tasks need to be established. Such criteria
may include task difficulty, perceived task importance, method of response, and others. One method of differentiating tasks is by identifying the cognitive processes associated with those tasks. The multidimensional theory of intelligence proposes a number of cognitive domains with which to categorize tasks and mental processes (Carroll, 1993; Schneider & Newman, 2015). According to this framework, similar tasks would primarily focus upon the same category of intelligence as each other. Conversely, unrelated tasks would focus upon different categories of intelligence. Observing tasks from the viewpoint of cognitive processes introduces the concept of transferring learning. Singley and Anderson (1989) describe transference of learning as the process by which prior information influences current and future performance. These researchers expand upon the former “transfer of practice” theory (Thorndike & Woodworth, 1901) to state that when one task is stopped and another begins, elements of the former task that are common with the new task will assist in the completion of the new task. By this logic, tasks similar in regards to their primary cognitive category should allow for transference of skill. Similarity between tasks can also lead to inappropriate usage of previous information where it is not truly applicable (Lee, 1998). This interference has been observed in programming and language studies and tends to occur more in the case of tasks mastered over a lifetime interfering with new tasks (Kroll, Hell, Tokowicz, & Green, 2010; Lee & Pennington, 1994); in the context of Ariga and Lleras’ study (2011) the chance of interference would likely depend on the type and presentation of main and break tasks presented.

The effect of task difficulty on attention may also influence task performance. Tasks requiring high perceptual load seem to block the influence of bottom-up stimuli
due to the individual’s inability to deviate perceptual tools to those distracters (Lavie, 2010). However, difficult tasks appear to suffer more from distracters due to their dependence on working memory (Kiyonaga & Egner, 2014; Sanders & Baron, 1975). Regardless of a task’s actual difficulty, perception of a task as difficult can increase anxiety and reduce vigilance (Tiwari, Singh, & Singh, 2009). Perceived task difficulty may also indirectly affect performance through goal setting, which has a strong relationship with attention. A study by Horvath, Herleman, and McKie (2006) observed an inverse relationship between task difficulty and the goals set for that task; people tend to set higher goals for perceived easier tasks and vice versa. For simple tasks, specific and difficult goals preempt greater task performance. Meanwhile, more difficult goals may hinder performance on difficult tasks (Garland, 1984), possibly due to a greater degree of anxiety created by the pressure of such a combination of difficulties (Locke, Shaw, Saari, & Latham, 1981). The impact of task goals and difficulty on efficiency may be influenced by the type of task presented; the aforementioned correlations between goal setting and performance were found using algorithmic tasks, where heuristic tasks do not appear to be affected in the same way (Huber, 1985).

Task difficulty plays a specific role in the context of multiple tasks relevant to Ariga and Lleras’ study (2011). However, little research has observed the effects of switching between tasks of various difficulties. Interruption of a cognitively straining main task has shown to cause overload and reduce efficiency for that task (Altmann & Trafton, 2002). Meanwhile, more simple main tasks may benefit from interruption, as they provide stimulus during a period of low cognitive load (Speier, Vessey, & Valacich, 2003; Teigen, 1994). These findings are similar to both the cognitive overload and
mindlessness theories of attention. Vigilance was not considered as a factor of the results of these studies, however the congruence between the findings of interruption studies and vigilance decrement theories warrants further exploration. Schneider and Anderson (2011) claim that the sequence in which tasks of asymmetric difficulty are presented dictates switch costs; specifically that primary completion of difficult tasks increased switch costs for subsequent tasks regardless of difficulty. The researchers propose that this increase is due to a depletion of executive control and working memory resources. Interestingly, a depletion of these resources affecting performance would coincide with the aforementioned study by Knudsen (2007), which maintains that perceptual control and working memory are crucial pieces of attention. Both executive control functions and working memory have shown to be limited resources, supporting the theory (Daily, Lovett, & Reder, 2001; Lorist, Klein, Nieuwenhuis, Jong, Mulder, & Meijman, 2000).

The topic of increasing task efficiency has been a major focus of psychology research for some time. Methods of increasing task efficiency can both provide the general population with tools to ease their workload and grant individuals with greater need for improving productivity the means by which to do so. Toward this end, studies of task switching and transfer of practice provide their share of information. Ariga and Lleras (2011) offer the suggestion of break tasks in order to stave off inattention. However, the term “break task” leaves an arguably significant amount of room for clarification; researchers observing the completion of multiple tasks have demonstrated that the content of that break task is likely to be relevant to its effects on the main task. As Ariga and Lleras’ study offers a useful tool for both the general and atypical population’s usage, further investigation of the dynamics of that tool appear justified.
Chapter 3
Methodology

Participants

Twenty American undergraduate students participated in the study. These students were recruited and selected via the standard procedures of the Rowan University subject pool. Students are offered psychology course credit in exchange for participation in a number of research studies. Participants were randomly assigned to one of two testing groups: Content-Related (n=10) and Content-Unrelated (n=10).

Materials

The two quantitative reasoning tests used consisted of the multiple choice questions pulled from two sections of a GRE quantitative reasoning practice exam. The maximum score available for each quantitative reasoning test was 22. Academic achievement is a factor in the completion of GRE exams; the GRE’s quantitative reasoning tests, however, are generally similar to the broad ability of quantitative reasoning described by the CHC theory of intelligence (Dwyer, Gallagher, Levin, & Morley, 2003). The practice tests were deemed sufficient for use in the present study because of this commonality between definitions in conjunction with popular acceptance of the GRE as a measure of aptitude. In order to have one content-related and one content-unrelated break activity, possible break activities were determined using both the GRE and CHC theory’s definitions of quantitative reasoning. A grouping of KenKen puzzles was chosen as a content-related activity as KenKen involves basic mathematical calculations and quantitative reasoning. A Boggle activity was chosen for the content-unrelated sample as it does not require any significant mathematical or quantitative
reasoning abilities. Both activities were visually similar and required responses to be written by hand, ensuring that the most prominent difference between the two activities was in the content rather than the structure.

**Design**

The dependent variable in this experiment was the type of break activity presented (Content-Related or Content-Unrelated) while the independent variables were the quantitative reasoning test results before and after the break. Results of the pre- and post-tests were calculated and compared using a two-way ANOVA with repeated measures.

**Procedure**

Before testing, one of two colored stickers was placed at the top of each copy of Quantitative Reasoning Test A. These stickers corresponded to the Content-Related and Content-Unrelated testing groups respectively. These tests were then shuffled in order to randomize the placement of the stickers. Each test was also marked with a number to indicate the specific desk that the test would be delivered to. Groups of no more than 20 participants entered the designated room for testing, signed in strictly for the purpose of receiving credit via the Rowan Subject pool, and read the consent page presented to them. Participants were seated according to a randomly-generated seating chart. Calculators and scrap paper were distributed to each subject. The marked copies of the test were distributed to the participants, thereby separating the subjects into the two testing groups. Without further instruction, the participants were then given 20 minutes to complete Quantitative Reasoning Test A. After the allotted time had passed, the tests were collected. Participants that had a particular colored sticker on their test were given the KenKen activity, while those with the other colored sticker were given the Boggle
activity. The participants were given five minutes to work on these activities, after which these activities were also collected. The participants were then given copies of Quantitative Reasoning Test B, which had also been marked to which designate specific seats should receive which test. Another 20 minutes was given to complete this test, after which the tests were collected and the participants were dismissed. The quantitative reasoning tests were graded using the same methods as the official GRE, with only correct answers counting towards the final score and incorrect or omitted answers having no impact. No data was collected from the break activities, as the activities were more important for their consideration than their accurate completion.
Chapter 4

Results

The present study observed the effects of two simple break activities on a longer and more difficult quantitative reasoning test. Participants were randomly assigned to one of two groups. The participants in Group 1 were given the quantitative reasoning-related break activity titled “KenKen” while Group 2 was given the literacy-based activity titled “Boggle Brain Busters”.

Hypothesis

The quantitative reasoning-related break activity will have a significantly different effect on the results of the quantitative reasoning post-test as opposed to the use of the literacy-based break activity.

A one-way repeated measures ANOVA was conducted to compare the effect of break activity content on prolonged activity performance, where KenKen and Boggle acted as break activities and a quantitative reasoning test was the prolonged activity. There was a significant effect of break activity content \((F(1,18)=7.056, \ p<0.05; \ \text{Wilk’s Lambda}=0.718)\), with the participants completing the Boggle activity demonstrating a significantly greater increase in mean test scores between the pre-and post tests when compared to the mean test scores of the group performing the KenKen activity.

Figure one demonstrates the observed differences between the scores of the two groups.
Figure 1. Mean Scores of Content-Related and Unrelated Groups on Pre and Post-Tests
Chapter 5
Discussion

Summary

Comparisons of post-test scores between the content-related and content-unrelated groups revealed a significant difference between the scores of participants given the content-unrelated activity “Boggle Brain Busters” and those given the content-related activity “KenKen”. Those given the content-unrelated activity on average achieved a small increase in scores from the pre-test to the post-test, while the participants given the content-related activity demonstrated a decrease in average score. This decrease in score is likely a demonstration of the vigilance decrement in action, while the increase in score of the content-unrelated group demonstrates an avoidance of the vigilance decrement similar to the findings of Ariga and Lleras (2011). Prior studies have shown other content-unrelated tasks to produce similar effects to present results, however the break activities utilized in those studies were too different from the primary task to specifically evaluate any main effect of content (Howie, Schatz, & Pate, 2015; Zacher, Brailsford, & Parker, 2014; Fritz, Ellis, Demsku, Lin, & Guros, 2013).

The present study in part acted as a comparison between the effects of task switching and the vigilance decrement. Task switching research would suggest that similar tasks allow for more efficient transfer of strategies (Singley & Anderson, 1989) and therefore would result in higher performance when the switch task was related to the primary task. However, both the mindlessness and cognitive overload theories of the vigilance decrement argue the opposite: these theories hold that similar tasks result in a failure to maintain attention, either due to monotony or straining of a single cognitive
skill, leading to less efficient performance (Head, Helton, 2014; Helton & Warm, 2008). Both of these topics are involved in the act of switching to and from a break activity, and therefore it is necessary to identify the extent to which each plays a role in determining the effectiveness of a break task. The results gathered from the present study suggest that although task switching may have a role in determining that effectiveness, the effects of the vigilance decrement surpass those of information and strategy transfer.

In addition, the present results suggest that the maintenance of attention is tied to the sustained usage of a type of intelligence. The content-related KenKen task was less challenging and different in method from the main quantitative reasoning task. Despite the differences between the two tasks, their quantitative reasoning base proved too significant to effectively avoid the drop in performance associated with the vigilance decrement. Meanwhile, while the Boggle task was similar in difficulty and method to the KenKen task, its difference in the type of intelligence used appeared significant for avoiding that decrement. According to these findings, replenishing attentional resources requires an individual to break from the type of intelligence that they are currently using. People may even have sets of attentional resources separated by factors like intelligence usage to allocate differentially, although this implication requires more research. The present study did not explore whether it was the actual content of these activities or the perceived similarities or differences that affected results, however the involvement of perception can be safely inferred by the overt nature of the content of the activities presented.

Break activities are common tools for maintaining attention to main tasks in a variety of environments. Schools are one common example. In kindergarten, tasks are
frequently switched in order to sustain the attention of young students. Some teachers choose to have these tasks pertain to a single subject; for example, a teacher may choose to have all morning activities relate to reading and all afternoon activities relate to mathematics. This method is meant to reinforce material. However, the present study suggests that this method may not be reinforcing material to the degree that teachers would prefer, as even if the activity is different in method the similarity in content means that attentional resources will not be maintained or regained via those break activities. Ideally, teachers should be interspersing their lessons with material that is different in type of intelligence from their primary lesson or switching subjects entirely. Doing so would allow students to recover the attentional resources relevant to the teacher’s intended primary material.

Limitations

The sample may not accurately represent the intended population due to its small sample size (n=20). Although the findings were significant, the sample’s results could have been influenced by individual differences between participants.

The scope of the present study had limitations due to sampling bias. The usage of the Rowan Subject Pool is particularly notable. Students participated in the study class credit. This study in particular was worth 8 points, which was more than most other studies at the time. The greater number of points offered for participation could have attracted a particular crowd while the length of the study could have dissuaded others, resulting in a skewed sample. The inclusion of only students also restricts the degree to which this study can be safely generalized to the general population. Usage of this system
also restricted the proper representation of age, gender, race, and other demographic factors.

This study assumed that any notable differences between individuals would be primarily created by differences in the break activities. However, participants came from a variety of backgrounds and likely had varying degrees of skill, leading to some obtaining higher average scores than others. Differences in individual abilities were partially controlled for by observing average change in scores as opposed to comparing scores of subjects directly. Additionally, participants may have had differing levels of interest in the main and break activities. As degree of interest is often a factor in one’s ability to maintain attention, this factor likely played a role in the expression of the vigilance decrement. These are just several of the many factors that could have had unintended influences on results.

Although the break activities had face validity as per the type of intelligence involved in their completion, the present study did not observe the actual validity of their intended content. In addition, the KenKen activity was assumed to be similar in content to the quantitative reasoning test while the Boggle Bran Busters activity was assumed to be different. Similarly, the two break activities were assumed to be reasonably similar in method of response and difficulty while different in content.

**Future Direction**

Expansions of and corrections to the present study would have significant implications for school and workplace environments as well as for individuals attempting to increase their personal productivity. To reiterate the importance of this research, the 2011 study of Ariga and Lleras has garnered significant popularity (Korki 2012), with
scheduled breaks being tested as methods of increasing both efficiency and comfort. Determining the method by which the vigilance decrement is avoided is distinctly related to the success or failure of such strategies and is therefore critical to their creation and implementation for public use.

Future studies replicating this study should ensure the validity of relationships between the content-related and unrelated break activities and the main task to ensure that the types of tasks being assigned are actually related and unrelated to their intended subsets of intelligence. Construct validity should be determined for each activity individually. Then, the intended content-related break activity and its matching primary task should be tested for their positive correlation; the break activity should be different enough in method to constitute a theoretical break of monotony while still similar in content and intelligence usage. To test the present hypothesis, the content of the unrelated break activity does not necessarily need to be specific, although it should be similar in form to the other break activity while as different as possible from the main task’s targeted intelligence subset.

The present study specifically observed quantitative reasoning as the related intelligence subset with literacy as the unrelated secondary task. As such, the results were binary in their scope, with break activities being deemed either effective or ineffective. In reality, because difference in activity content was found to be significantly beneficial, differing degrees of “difference” may evince degrees of effectiveness more similar to a spectrum than a binary “yes” or “no”. Therefore, future replications may seek to explore the precise dynamics between intelligence subsets and attention by including more break activities of a wider range of intelligence subsets. For example, instead of only
quantitative reasoning and literacy-based break activities, researchers could include tasks involving reading comprehension and/or visual reasoning. Doing so would observe the precise degree of difference necessary to constitute a true “break task” and may evince further information about the relationship between attentional resources and intelligence usage.

In addition to the aforementioned suggestions, future research should account for and correct the limitations of this study, specifically for the purpose of better representing the general population. Researchers should increase the sample size and account for the identifying demographics of their sample. Researchers should also take steps to eliminate or alleviate effects from differences in individual motivations to perform.
References


Thorndike, E. & Woodworth, R. (1901). The influence of improvement in one mental function upon the efficiency of other functions. *Psychological Review, 8*, 247-261


Appendix A

Alternative Consent Form

I am/we are inviting you to participate in a research survey entitled “The effects of content-related and unrelated break activities on test results”. We are inviting you because you are a Rowan University student. In order to participate in this survey, you must be 18 years or older.

The survey may take approximately 1 hour to complete. Your participation is voluntary. If you do not wish to participate in this survey, do not respond to this paper survey. The number of subjects to be enrolled in the study will be 100.

The purpose of this research study is to determine whether break activities that are similar or different in content result in better performance on a longer main task.

Completing this survey indicates that you are voluntarily giving consent to participate in the survey.

There are no risks or discomforts associated with this survey. There may be no direct benefit to you, however, by participating in this study, you may help us understand the complexities of the human attention system and provide future individuals with tools for increasing productivity.

Your response will be kept confidential. We will store the data in a secure computer file and the file will destroyed once the data has been published. Any part of the research that is published as part of this study will not include your individual information. If you have any questions about the survey, you can contact me at the address provided below, but you do not have to give your personal identification.

Co-Investigator: Ryan Gentek
Email: gentekr8@students.rowan.edu
Appendix B

Quantitative Reasoning Tests

Quantitative Reasoning Test A

MAJOR ______________________

GENDER _____________________

Quantitative Reasoning - Test A

22 Questions.

Section Directions

For each question, indicate the best answer, using the directions given.

Notes: All numbers used are real numbers.

All figures are assumed to lie in a plane unless otherwise indicated.

Geometric figures, such as lines, circles, triangles, and quadrilaterals, are not necessarily drawn to scale. That is, you should not assume that quantities such as lengths and angle measures are as they appear in a figure. You should assume, however, that lines shown as straight are actually straight, points on a line are in the order shown, and more generally, all geometric objects are in the relative positions shown. For questions with geometric figures, you should base your answers on geometric reasoning, not on estimating or comparing quantities from how they are drawn in the geometric figure.

Coordinate systems, such as x y planes and number lines, are drawn to scale; therefore, you can read, estimate, or compare quantities in such figures from how they are drawn in the coordinate system.

Graphical data presentations, such as bar graphs, circle graphs, and line graphs, are drawn to scale; therefore, you can read, estimate, or compare data values from how they are drawn in the graphical data presentation.
For each of Questions 1 through 9, compare Quantity A and Quantity B, using the additional information given, if any. Select one of the following four answer choices. A symbol that appears more than once in a question has the same meaning throughout the question.

A. Quantity A is greater.
B. Quantity B is greater.
C. The two quantities are equal.
D. The relationship cannot be determined from the information given.

Example 1:

Quantity A: \((2)(6)\) 2 times 6
Quantity B: \(2 + 6\)

Solution: Quantity A is equal to 12 and Quantity B is equal to 8, so the correct answer for Example 1 is answer choice A, Quantity A is greater.

Example 2:

Refer to the figure.

![Figure for Example 2](image)

Begin skippable figure description.

The figure shows triangle \(PQR\), where \(P\) is the leftmost vertex of the horizontal base \(PR\) and vertex \(Q\) is above \(PR\). Point \(S\) lies on horizontal base \(PR\) and appears to be the midpoint of \(PR\). Line segment \(QS\) is drawn from vertex \(Q\) to point \(S\). The lengths of \(PS\) and \(SR\) appear to be equal.

End skippable figure description.
Quantity A: $PS$
Quantity B: $SR$

**Solution:** The correct answer for Example 2 is answer choice D. The relationship between $PS$ and $SR$ cannot be determined from the information given since equal measures cannot be assumed, even though $PS$ and $SR$ appear to be equal in the figure.

**Question 1.**

Refer to the figure.

![Figure for Question 1](image_url)

*Begin skippable figure description.*

The figure shows two right triangles. One of the triangles has a leg of length 4 and a leg of length $x$, and a hypotenuse of length 8. The other triangle has two legs, each of which is of length 4, and a hypotenuse of length $y$.

*End skippable figure description.*

Quantity A: $x$
Quantity B: $y$

A. Quantity A is greater.
B. Quantity B is greater.  
C. The two quantities are equal.  
D. The relationship cannot be determined from the information given.  

From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.

**Question 2.**

It is given that  
\[(x - 2y)(x + 2y) = 4\]  
open parenthesis, x minus 2y, close parenthesis, times open parenthesis, x plus 2y, close parenthesis, = 4

Quantity A: \(x^2 - 4y^2\) x squared, minus, 4 times the quantity y squared  
Quantity B: 8  
A. Quantity A is greater.  
B. Quantity B is greater.  
C. The two quantities are equal.  
D. The relationship cannot be determined from the information given.  

From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.

**Question 3.**

A certain recipe requires \(\frac{3}{2}\) three halves cups of sugar and makes 2 dozen cookies.  
(1 dozen = 12)  
Quantity A: The amount of sugar required for the same recipe to make 30 cookies  
Quantity B: 2 cups  
A. Quantity A is greater.  
B. Quantity B is greater.  
C. The two quantities are equal.  
D. The relationship cannot be determined from the information given.
From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.

**Question 4.**

A power station is located on the boundary of a square region that measures 10 miles on each side. Three substations are located inside the square region.
Quantity A: The sum of the distances from the power station to each of the substations
Quantity B: 30 miles
A. Quantity A is greater.
B. Quantity B is greater.
C. The two quantities are equal.
D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.

**Question 5.**

It is given that

\[ 6 < x < 7 \]

6 is less than x, which is less than 7,
and
\[ y = 8 \]

Quantity A: \( \frac{x}{y} \) the fraction \( x \) over \( y \)
Quantity B: 0.85
A. Quantity A is greater.
B. Quantity B is greater.
C. The two quantities are equal.
D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.

**Question 6.**

Refer to the figure.
Begin skippable figure description.
The figure accompanying this question consists of a circle and triangle $BOA$, where $O$ is the center of the circle and $A$ and $B$ are points that lie on the circle. In the triangle, the measure of angle $BOA$ is 60 degrees.
End skippable figure description.

It is given that $O$ is the center of the circle and the perimeter of triangle $BOA$ is 6.
Quantity A: The circumference of the circle
Quantity B: 12
A. Quantity A is greater.
B. Quantity B is greater.
C. The two quantities are equal.
D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.

Question 7.
Quantity A: The standard deviation of a set of 5 different integers, each of which is between 0 and 10
Quantity B: The standard deviation of a set of 5 different integers, each of which is between 10 and 20
A. Quantity A is greater.
B. Quantity B is greater.
C. The two quantities are equal.
D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.

Question 8.

It is given that \( x \) is greater than 1.

Quantity A: \( x \left( x^2 \right)^4 \) \( x \) times, the fourth power of, open parenthesis, \( x \) squared, close parenthesis

Quantity B: \( \left( x^3 \right)^3 \) open parenthesis, \( x \) cubed, close parenthesis, to the third power

A. Quantity A is greater.
B. Quantity B is greater.
C. The two quantities are equal.
D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.

Question 9.

It is given that \( x \) is not equal to 0.

Quantity A: \( |x| + |-2| \) the absolute value of \( x \) + the absolute value of negative 2

Quantity B: \( |x - 2| \) the absolute value of the quantity \( x \) minus 2

A. Quantity A is greater.
B. Quantity B is greater.
C. The two quantities are equal.
D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.
For Questions 10 through 22, select answers from the list of answer choices according to the instructions provided with the question.

Question 10.
This question has five answer choices, labeled A through E. Select the best one of the answer choices given.
The system of equations

\[ 7x + 3y = 12, \text{ and} \]
\[ 3x + 7y = 6 \]

is given.

If \( x \) and \( y \) satisfy the system of equations given, what is the value of \( x - y \)?

A. \( \frac{2}{3} \) two thirds
B. \( \frac{3}{2} \) three halves
C. 1
D. 4
E. 6

Select and indicate the best one of the answer choices given.

Question 11.
This question has five answer choices, labeled A through E. Select all the answer choices that apply.
In triangle \( ABC \), the measure of angle \( A \) is 25° and the measure of angle \( B \) is greater than 90°. Which of the following could be the measure of angle \( C \)?
Indicate all such measures.

A. 12°
B. 15°
C. 45°
D. 50°
E. 70°
Select and indicate all the answer choices that apply. The correct answer to a question of this type could consist of as few as one, or as many as all five of the answer choices.

**Question 12.**
This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

What is the least integer \( n \) such that \( \frac{1}{2^n} \) the fraction with numerator 1, and denominator 2 to the power \( n \) is less than 0.001?

A. 10
B. 11
C. 500
D. 501
E. There is no such least integer.

Select and indicate the best one of the answer choices given.

**Question 13.**
This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

In the sunshine, an upright pole 12 feet tall is casting a shadow 8 feet long. At the same time, a nearby upright pole is casting a shadow 10 feet long. If the lengths of the shadows are proportional to the heights of the poles, what is the height, in feet, of the taller pole?

A. 10
B. 12
C. 14
D. 15
E. 18

Select and indicate the best one of the answer choices given.

**Question 14.**
This question has five answer choices, labeled A through E. Select the best one of the answer choices given.
If \( k \) is the smallest prime number greater than 21 and \( b \) is the largest prime number less than 16, then \( kb = \)

A. 299  
B. 323  
C. 330  
D. 345  
E. 351  

Select and indicate the best one of the answer choices given.

**Question 15.**

This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

List \( R \): 28, 23, 30, 25, 27  
List \( S \): 22, 19, 15, 17, 20  

The median of the numbers in list \( R \) is how much greater than the median of the numbers in list \( S \)?

A. 8  
B. 10  
C. 12  
D. 13  
E. 15  

Select and indicate the best one of the answer choices given.

**Questions 16 through 18 are based on the following data.**

Refer to the figure.
Corporate Support for the Arts by Sector in 1988 and 1991

Total for 1988: $630 million
Total for 1991: $520 million

Data for Questions 17 through 20

**Begin skippable data description.**

The data is given in a bar graph. The title of the graph is Corporate Support for the Arts by Sector in 1988 and 1991. Under the title are two statements: “Total for 1988: $630 million” and “Total for 1991: $520 million”.

There are six sectors listed along the horizontal axis of the graph. Horizontal gridlines are drawn at 0%, 10%, 20%, 30%, and 40%.

For each of the six sectors the bars in the graph are as follows.


**End skippable data description.**

**Question 16.**

This question has five answer choices, labeled A through E. Select the best one of the answer choices given.
How many of the six corporate sectors listed each contributed more than $60 million to the arts in both 1988 and 1991?

A. One
B. Two
C. Three
D. Four
E. Five

Select and indicate the best one of the answer choices given.

**Question 17.**

This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

From 1988 to 1991, which corporate sector decreased its support for the arts by the greatest dollar amount?

A. Services
B. Manufacturing
C. Retail
D. Wholesale
E. Other

Select and indicate the best one of the answer choices given.

**Question 18.**

This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

Of the retail sector’s 1991 contribution to the arts, \( \frac{1}{4} \) one fourth went to symphony orchestras and \( \frac{1}{2} \) one half of the remainder went to public television.

Approximately how many million dollars more did the retail sector contribute to public television that year than to symphony orchestras?

A. 5.2
B. 6.3
C. 10.4
D. 13.0
Select and indicate the best one of the answer choices given.

**Question 19.**

This question has three answer choices, labeled A through C. Select all the answer choices that apply.

The total number of recording titles distributed by music distributors L and M is 9,300. The number of recording titles distributed by L is 7,100, and the number of recording titles distributed by M is 5,200. Which of the following statements must be true? Indicate all such statements.

A. More than half of the titles distributed by L are also distributed by M.
B. More than half of the titles distributed by M are also distributed by L.
C. No titles are distributed by both L and M.

Select and indicate all the answer choices that apply. The correct answer to a question of this type could consist of as few as one, or as many as all three of the answer choices.

**Question 20.**

This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

If $c$ and $d$ are positive integers and $m$ is the greatest common factor of $c$ and $d$, then $m$ must be the greatest common factor of $c$ and which of the following integers?

A. $c + d$
B. $2 + d$
C. $cd$
D. $2d$
E. $d^2$

Select and indicate the best one of the answer choices given.

**Question 21.**
This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

Of the 750 participants in a professional meeting, 450 are female and \( \frac{1}{2} \) one half of the female and \( \frac{1}{4} \) one fourth of the male participants are less than thirty years old. If one of the participants will be randomly selected to receive a prize, what is the probability that the person selected will be less than thirty years old?

A. \( \frac{1}{8} \) one eighth  
B. \( \frac{1}{3} \) one third  
C. \( \frac{3}{8} \) three eighths  
D. \( \frac{2}{5} \) two fifths  
E. \( \frac{3}{4} \) three fourths

Select and indicate the best one of the answer choices given.

Question 22.

This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

In the \( x \ y \) plane, what is the slope of the line whose equation is \( 3x - 2y = 8 \)?

A. \( -4 \) negative 4  
B. \( -\frac{8}{3} \) negative 8 thirds  
C. \( \frac{2}{3} \) two thirds  
D. \( \frac{3}{2} \) three halves  
E. 2
Select and indicate the best one of the answer choices given.

This is the end of the first quantitative reasoning test. Please wait for the co-investigator to give further instructions.
Quantitative Reasoning Test B

MAJOR ______________________

GENDER ______________________

Quantitative Reasoning – Test B

22 Questions.

Section Directions
For each question, indicate the best answer, using the directions given.

Notes: All numbers used are real numbers.

All figures are assumed to lie in a plane unless otherwise indicated.

Geometric figures, such as lines, circles, triangles, and quadrilaterals, are not necessarily drawn to scale. That is, you should not assume that quantities such as lengths and angle measures are as they appear in a figure. You should assume, however, that lines shown as straight are actually straight, points on a line are in the order shown, and more generally, all geometric objects are in the relative positions shown. For questions with geometric figures, you should base your answers on geometric reasoning, not on estimating or comparing quantities from how they are drawn in the geometric figure.

Coordinate systems, such as x y planes and number lines, are drawn to scale; therefore, you can read, estimate, or compare quantities in such figures from how they are drawn in the coordinate system.
Graphical data presentations, such as bar graphs, circle graphs, and line graphs, are drawn to scale; therefore, you can read, estimate, or compare data values from how they are drawn in the graphical data presentation.

**For each of Questions 1 through 9, compare Quantity A and Quantity B, using the additional information given, if any. Select one of the following four answer choices. A symbol that appears more than once in a question has the same meaning throughout the question.**

A. Quantity A is greater.
B. Quantity B is greater.
C. The two quantities are equal.
D. The relationship cannot be determined from the information given.

**Example 1:**

Quantity A: \((2)(6)\) 2 times 6

Quantity B: 2 + 6

Solution: Quantity A is equal to 12 and Quantity B is equal to 8, so the correct answer for Example 1 is answer choice A, Quantity A is greater.

**Example 2:**

Refer to the figure.
Figure for Example 2

*Begin skippable figure description.*

The figure shows triangle $PQR$, where $P$ is the leftmost vertex of the horizontal base $PR$ and vertex $Q$ is above $PR$. Point $S$ lies on horizontal base $PR$ and appears to be the midpoint of $PR$. Line segment $QS$ is drawn from vertex $Q$ to point $S$. The lengths of $PS$ and $SR$ appear to be equal.

*End skippable figure description.*

Quantity A: $PS$
Quantity B: $SR$

Solution: The correct answer for Example 2 is answer choice D. The relationship between $PS$ and $SR$ cannot be determined from the information given since equal measures cannot be assumed, even though $PS$ and $SR$ appear to be equal in the figure.

**Question 1.**

It is given that $x$ is a positive integer and $y$ is a negative integer.

Quantity A: $x - y$  $x$ minus $y$
Quantity B: $y - x$  $y$ minus $x$

A. Quantity A is greater.
Question 2.
The probability that events $E$ and $F$ will both occur is 0.42.

Quantity A: The probability that event $E$ will occur
Quantity B: 0.58

A. Quantity A is greater.
B. Quantity B is greater.
C. The two quantities are equal.
D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.

Question 3.
Refer to the figure.
Figure for Question 3

Begin skippable figure description.
The figure accompanying this question consists of a large triangle $PQR$. Side $PR$ is horizontal, with point $R$ to the right of point $P$, and vertex $Q$ lies above side $PR$. Point $S$ lies on side $PR$ and line segment $QS$ divides the large triangle $PQR$ into two smaller triangles, $PQS$ and $QRS$. The measure of angle $PQS$ is $x$ degrees, and the measure of angle $QRS$ is $y$ degrees.

End skippable figure description.

It is given that the length of line segment $PS$ is equal to the length of line segment $SR$.

Quantity A: $x$

Quantity B: $y$

A. Quantity A is greater.

B. Quantity B is greater.

C. The two quantities are equal.

D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.

Question 4.

It is given that $a$ and $b$ are positive integers.

Quantity A: $\frac{a}{b}$ The fraction $a$ over $b$
Quantity B: \( \frac{a + 3}{b + 3} \) The fraction with numerator \( a + 3 \) and denominator \( b + 3 \)

A. Quantity A is greater.
B. Quantity B is greater.
C. The two quantities are equal.
D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.

**Question 5.**
The arithmetic mean of 100 measurements is 23, and the arithmetic mean of 50 additional measurements is 27.

Quantity A: The arithmetic mean of the 150 measurements
Quantity B: 25

A. Quantity A is greater.
B. Quantity B is greater.
C. The two quantities are equal.
D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.

**Question 6.**
Refer to the figure.
Begin skippable figure description.
The figure accompanying this question consists of an $xy$ plane in which there is a line $k$ that extends upward from the lower left part of the plane, through the origin, to the upper right part of the plane. In addition, the point with coordinates 3 comma 4 is shown. This point lies in the upper right quadrant below line $k$ and above the $x$ axis. The horizontal axis of the $xy$ plane is labeled $x$, the vertical axis is labeled $y$, and the origin is labeled $O$.

End skippable figure description.

Quantity A:  The slope of line $k$
Quantity B:  1

A. Quantity A is greater.
B. Quantity B is greater.
C. The two quantities are equal.
D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.
**Question 7.**

One of the roots of the equation \( x^2 + kx - 6 = 0 \) is 3, and \( k \) is a constant.

Quantity A: The value of \( k \)

Quantity B: \(-1\) negative 1

A. Quantity A is greater.
B. Quantity B is greater.
C. The two quantities are equal.
D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.

**Question 8.**

The original price of a suit was 30 percent less than the suit’s $250 suggested retail price. The price at which the suit was sold was 20 percent less than the original price.

Quantity A: The price at which the suit was sold

Quantity B: 50% of the suit’s suggested retail price

A. Quantity A is greater.
B. Quantity B is greater.
C. The two quantities are equal.
D. The relationship cannot be determined from the information given.

From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.
Question 9.
Refer to the figure.

Figure for Question 9

*Begin skippable figure description.*
The figure accompanying this question consists of rectangle $ABCD$ and trapezoid $EFGH$.

In rectangle $ABCD$, the length of horizontal side $AD$ is 8 and the length of vertical side $CD$ is 3. In trapezoid $EFGH$, the leftmost side, $EF$, is a vertical line segment with endpoint $F$ lying above endpoint $E$. Side $EF$ meets the two horizontal sides, $FG$ and $EH$, at right angles. The length of horizontal side $FG$ is 5 and the length of horizontal side $EH$ is 7. The length of vertical side $EF$ is 4 and the length of side $GH$ is not given.

*End skippable figure description.*

Quantity A: The area of rectangular region $ABCD$
Quantity B: The area of trapezoidal region $EFGH$

A. Quantity A is greater.
B. Quantity B is greater.
C. The two quantities are equal.
D. The relationship cannot be determined from the information given.
From the answer choices given, select and indicate the one that describes the relationship between quantity A and quantity B.

For Questions 10 through 22, select answers from the list of answer choices according to the instructions provided with the question.

Question 10.
This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

If \( j \) and \( k \) are integers and \( j - k \) minus \( k \) is even, which of the following must be even?

A. \( k \)
B. \( jk \)
C. \( j + 2k \)
D. \( jk + j \)
E. \( jk - 2j \) \( jk \) minus \( 2j \)

Select and indicate the best one of the answer choices given.

Question 11.
This question has five answer choices, labeled A through E. Select all the answer choices that apply.
Last year Kate spent between \( \frac{1}{4} \) one fourth and \( \frac{1}{3} \) one third of her gross income on her mortgage payments. If Kate spent $13,470 on her mortgage payments last year, which of the following could have been her gross income last year?

Indicate all such gross incomes.

A. $40,200
B. $43,350
C. $47,256
D. $51,996
E. $53,808

Select and indicate all the answer choices that apply. The correct answer to a question of this type could consist of as few as one, or as many as all five of the answer choices.

**Question 12.**

This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

In State X, all vehicle license plates have 2 letters from the 26 letters of the alphabet followed by 3 one digit numbers. How many different license plates can State X have if repetition of letters and numbers is allowed?

A. 23,400
B. 60,840
C. 67,600
D. 608,400
Select and indicate the best one of the answer choices given.

**Question 13.**

This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

If \( p \) is a negative number and \( 0 < s < |p| \), 0 is less than \( s \), which is less than the absolute value of \( p \), which of the following must also be a negative number?

A. \((p + s)^2\) open parenthesis, \( p + s \), close parenthesis, squared

B. \((p - s)^2\) open parenthesis, \( p \) minus \( s \), close parenthesis, squared

C. \((s - p)^2\) open parenthesis, \( s \) minus \( p \), close parenthesis, squared

D. \(p^2 - s^2\) \( p \) squared minus \( s \) squared

E. \(s^2 - p^2\) \( s \) squared minus \( p \) squared

Select and indicate the best one of the answer choices given.

**Question 14.**

This question has five answer choices, labeled A through E. Select the best one of the answer choices given.
If \(\frac{1}{2^k} + \frac{1}{2^k} = \frac{1}{2^x}\) the sum of the two fractions \(\frac{1}{2}\) raised to the power \(k\) and \(\frac{1}{2}\) raised to the power \(k\) equals the fraction \(\frac{1}{2}\) raised to the power \(x\), then \(x\) expressed in terms of \(k\) is

A. \(\frac{k}{2}\) the fraction \(k\) over 2

B. \(k - 1\) \(k\) minus 1

C. \(k + 1\)

D. \(2k\)

E. \(k^2\) \(k\) squared

Select and indicate the best one of the answer choices given.

**Question 15.**

This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

Refer to the figure.

![Figure for Question 16](image-url)

**Begin skippable figure description.**
The figure accompanying this question consists of a graph of a normal distribution with mean \( m \) and standard deviation \( d \). The graph shows a bell-shaped curve drawn above a horizontal axis. On the horizontal axis, from left to right, are the 5 equally spaced numbers; \( m - 2d \), \( m - d \), \( m \), \( m + d \), and \( m + 2d \). Vertical line segments above each of these numbers divide the normal distribution into 6 regions. The approximate percents of the distribution in each of the six regions are given as follows. To the left of the number \( m - 2d \) is 2%; between the number \( m - 2d \) and the number \( m - d \) is 14%; between the number \( m - d \) and the number \( m \) is 34%; between the number \( m \) and the number \( m + d \) is 34%; between the number \( m + d \) and the number \( m + 2d \) is 14%; and to the right of the number \( m + 2d \) is 2%.

**End skippable figure description.**

The figure shows a normal distribution with mean \( m \) and standard deviation \( d \), including approximate percents of the distribution in each of the six regions shown.

For a population of 800,000 subway riders, the numbers of subway trips taken per rider last January are approximately normally distributed with a mean of 56 trips and a standard deviation of 13 trips. Approximately how many of the riders took between 30 and 43 trips last January?

A. 60,000  
B. 110,000  
C. 160,000  
D. 210,000
Questions 16 through 19 are based on the following data.

Refer to the figure.

STUDENT ENROLLMENT AT A SMALL COLLEGE

Distribution of Enrollment by Class and Gender
Total Enrollment: 1,400

<table>
<thead>
<tr>
<th>Class</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshmen</td>
<td>303</td>
<td>259</td>
</tr>
<tr>
<td>Sophomores</td>
<td>215</td>
<td>109</td>
</tr>
<tr>
<td>Juniors</td>
<td>182</td>
<td>88</td>
</tr>
<tr>
<td>Seniors</td>
<td>160</td>
<td>84</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>860</strong></td>
<td><strong>540</strong></td>
</tr>
</tbody>
</table>

Percent of Total Enrollment Majoring in Selected Academic Areas

<table>
<thead>
<tr>
<th>Area</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humanities</td>
<td>33%</td>
</tr>
<tr>
<td>Social sciences</td>
<td>30%</td>
</tr>
<tr>
<td>Physical sciences</td>
<td>24%</td>
</tr>
</tbody>
</table>

Note: No student is majoring in more than one area.

Data for Questions 17 through 20
Begin skippable data description.
The data is given in two tables. The title of the data is “STUDENT ENROLLMENT AT A SMALL COLLEGE.”

The title of the first table is “Distribution of Enrollment by Class and Gender. Total Enrollment: 1,400”. Four classes are listed in the table: Freshmen, Sophomores, Juniors, and Seniors. The rows in the table are as follows:

Freshmen: the number of males is 303, and the number of females is 259.

Sophomores: the number of males is 215, and the number of females is 109.

Juniors: the number of males is 182, and the number of females is 88.

Seniors: the number of males is 160, and the number of females is 84.

The total number of males is 860, and the total number of females is 540.

The title of the second table is “Percent of Total Enrollment Majoring in Selected Academic Areas,” and under the table is the note “No student is majoring in more than one area.” Three academic areas are listed in the table: Humanities, Social Sciences, and Physical Sciences.

The rows in the table are as follows:

Humanities: 33 percent.

Social Sciences: 30 percent.

Physical Sciences: 24 percent.

End skippable data description.

Question 16.
This question has five answer choices, labeled A through E. Select the best one of the answer choices given.
The ratio of the number of male freshmen to the number of female sophomores is approximately

A. 2 to 1
B. 3 to 1
C. 3 to 2
D. 4 to 1
E. 5 to 3

Select and indicate the best one of the answer choices given.

**Question 17.**

This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

If the total enrollment is 12 percent greater than it was five years ago, what was the total enrollment five years ago?

A. 1,180
B. 1,192
C. 1,220
D. 1,232
E. 1,250

Select and indicate the best one of the answer choices given.

**Question 18.**
This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

How many students are either juniors or males or both?

A. 678  
B. 766  
C. 948  
D. 1,130  
E. 1,312  

Select and indicate the best one of the answer choices given.

**Question 19.**

This question has three answer choices, labeled A through C. Select all the answer choices that apply.

Which of the following statements must be true?

Indicate all such statements.

A. The number of males majoring in physical sciences is greater than the number of females majoring in that area.

B. Students majoring in either social sciences or physical sciences constitute more than 50 percent of the total enrollment.

C. The ratio of the number of males to the number of females in the senior class is less than 2 to 1.

Select and indicate all the answer choices that apply. The correct answer to a question of this type could consist of as few as one, or as many as all three of the answer choices.

**Question 20.**
This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

The quantities $S$ and $T$ are positive and are related by the equation \( S = \frac{k}{T} \). $S$ equals the fraction $k$ over $T$, where $k$ is a constant. If the value of $S$ increases by 50 percent, then the value of $T$ decreases by what percent?

A. 25%

B. \(33 \frac{1}{3}\)% 33 and 1 third percent

C. 50%

D. \(66 \frac{2}{3}\)% 66 and 2 thirds percent

E. 75%

Select and indicate the best one of the answer choices given.

**Question 21.**

This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

If $x$ and $y$ are the tens digit and the units digit, respectively, of the product 
\[725,278 \times 67,066,\] \(725,278 \text{ times } 67,066\) what is the value of $x + y$?

A. 12

B. 10

C. 8

D. 6

E. 4
Select and indicate the best one of the answer choices given.

**Question 22.**

This question has five answer choices, labeled A through E. Select the best one of the answer choices given.

A developer has land that has $x$ feet of lake frontage. The land is to be subdivided into lots, each of which is to have either 80 feet or 100 feet of lake frontage. If \( \frac{1}{9} \) one ninth of the lots are to have 80 feet of frontage each and the remaining 40 lots are to have 100 feet of frontage each, what is the value of $x$?

A. 400
B. 3,200
C. 3,700
D. 4,400
E. 4,760

Select and indicate the best one of the answer choices given.

This is the end of this quantitative reasoning test. Please wait for the co-investigator to give further instructions.
Appendix C

Break Activities

KenKen Activity

Inky #1

6 \times 1 - \\
7 + \\
1 -

Inky #2

6 \times 9 \times 5 +

Inky #3

1 - 3 \times \\
3 \times 7 +

Inky #4

3 \times 1 - \\
1 - 8 +

Fill in the blank squares so that each row and each column contain all of the digits 1 thru 3.

The heavy lines indicate areas (called cages) that contain groups of numbers that can be combined (in any order) to produce the result shown in the cage, with the indicated math operation. For example, 12+ means you can multiply the values together to produce 12.

Numbers in cages may repeat, as long as they are not in the same row or column.
Fill in the blank squares so that each row and each column contain all of the digits 1 thru 3.

The heavy lines indicate areas (called cages) that contain groups of numbers that can be combined (in any order) to produce the result shown in the cage, with the indicated math operation. For example, $12+$ means you can multiply the values together to produce 12.

Numbers in cages may repeat, as long as they are not in the same row or column.
Inky #9

7 + 1 -
2 x
1 -

Inky #10

1 - 3 x
18 x 1 -

Inky #11

1 - 3 x
7 +
3 x

Inky #12

1 -
2 x 7 +

Fill in the blank squares so that each row and each column contain all of the digits 1 thru 3.

The heavy lines indicate areas (called cages) that contain groups of numbers that can be combined (in any order) to produce the result shown in the cage, with the indicated math operation. For example, 12+ means you can multiply the values together to produce 12.

Numbers in cages may repeat, as long as they are not in the same row or column.
Answers 10 to 18

Inky #10

2 1 3
1 3 2
3 2 1

Inky #11

2 3 1
1 2 3
3 1 2

Inky #12

3 2 1
1 3 2
2 1 3

Inky #13

3 2 1
2 1 3
1 3 2

Inky #14

2 3 1
1 2 3
3 1 2

Inky #15

3 2 1
1 3 2
2 1 3

Inky #16

1 3 2
2 1 3
3 2 1

Inky #17

2 1 3
3 2 1
1 3 2

Inky #18

2 3 1
1 2 3
3 1 2
Boggle Brain Busters Activity

INSTRUCTIONS: Find as many words as you can by linking letters up, down, side-to-side and diagonally, writing words on a blank sheet of paper. You may only use each letter box once within a single word. Play with a friend and compare word finds, crossing out common words.

<table>
<thead>
<tr>
<th>BOGGLE POINT SCALE</th>
<th>YOUR BOGGLE RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 letters = 1 point</td>
<td>151+ = Champ</td>
</tr>
<tr>
<td>4 letters = 2 points</td>
<td>101-150 = Expert</td>
</tr>
<tr>
<td>5 letters = 3 points</td>
<td>61-100 = Pro</td>
</tr>
<tr>
<td>6 letters = 4 points</td>
<td>31-60 = Gamer</td>
</tr>
<tr>
<td>7 letters = 8 points</td>
<td>21-30 = Rookie</td>
</tr>
<tr>
<td>8 letters = 10 points</td>
<td>11-20 = Amateur</td>
</tr>
<tr>
<td>9+ letters = 15 points</td>
<td>0-10 = Try again</td>
</tr>
</tbody>
</table>

Boggle BrainBusters Bonus
We put special brain-busting words into the grid of letters. Can you find them?
Find FOUR SIX-LETTER FRUITS in the grid of letters. Write your answers below.

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Answers to Saturday’s Boggle BrainBusters: LONDON BOGOTA DUBLIN BERLIN BEIRUT
INSTRUCTIONS: Find as many words as you can by linking letters up, down, side-to-side and diagonally, writing words on a blank sheet of paper. You may only use each letter box once within a single word. Play with a friend and compare word finds, crossing out common words.

BOGGLE® POINT SCALE

3 letters = 1 point
4 letters = 2 points
5 letters = 3 points
6 letters = 4 points
7 letters = 5 points
8 letters = 6 points
9+ letters = 7 points

YOUR BOGGLE® RATING

151+ = Champ
101-150 = Expert
61-100 = Pro
31-60 = Gamer
21-30 = Rookie
11-20 = Amateur
0-10 = Try again

By David L. Hoyt and Jeff Knurek

Boggle® BrainBusters Bonus

We put special brain-busting words into the puzzle grid. Can you find them?

Find SEVEN EUROPEAN CAPITALS in the grid of letters. Write your answers below.

____________________
____________________
____________________

Answers to Last Sunday’s Boggle® BrainBusters:
APE BAT GOAT CAMEL ZEBRA BADGER COUGAR

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