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THE EFFECTS OF MUSIC ON SHORT-TERM AND LONG-TERM MEMORY

by

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A thesis submitted in partial fulfillment of the requirements
for graduation with Honors in the Psychology

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The Effects of Music on Short-term and Long-term Memory

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Abstract

Recent research has suggested that there could be a benefit for learning verbal information with songs rather than spoken word; also, retrieval practices have been well documented as a beneficial learning strategy. The interaction between the two, however, has not been investigated. In this project, undergraduate students were assigned to one of four groups and listened to several complex sentences. Two groups had sentences that were spoken (Speech-Restudy, and Speech-Retrieval) and two had sentences that were sung (Song-Restudy, and Song-Retrieval). The restudy groups listened to the sentences four times, whereas the retrieval groups listened to the sentences twice, and then they were required to complete each sentence back out loud, twice as well, after being given the first part of the sentence as a cue. All participants' memory of the sentences was tested with a cued-recall and multiple-choice test immediately after and after one week following the initial listening. Results indicated that using retrieval learning strategies can lead to significantly better recall immediately after and one week later. The scores for participants in the musical groups were slightly higher than those in the speech groups, but the difference was not statistically significant.

Keywords: learning strategy, retrieval, music and memory

The Effects of Music on Memory in the Short and Long Term

Educators and students are constantly searching for simple, effective ways to remember textual information. Of the existing techniques, one of the most popular is using mnemonics. An example of this technique, the method of loci, uses familiar spaces to provide structure for new material. By assigning each piece of information to another object in the room, the participant remembers the information by imagining those objects when the information needs to be recalled. Regardless of the strategy that is used, intentional learning by adding some kind of structure to the information should improve memory capacity (Kilgour, Jakobson, & Cuddy, 2000).

Of the learning techniques that are currently in use, Dunlosky, Rawson, Marsh, Nathan, and Willingham (2013) demonstrated that some, like practice testing, are more effective than others for retention, both in the short and long term. In practice testing, a student actively retrieves information from memory, as would be done on an exam. Through calling information to mind, as it happens in a test, memory for that information is strengthened and forgetting is less likely (Roediger & Butler, 2011).

Many versions of these retrieval practices can promote retention including free response, cued-recall, fill-in-the-blank, and multiple-choice. Free or cued recall testing, where the student actively tries to remember the material with little help from outside cues, has been demonstrated as the most beneficial method of the practice test formats. Glover (1989) investigated this effect by having undergraduates read and study a passage about a fictional nation for ten minutes. The students in the experimental condition also received instructions asking them to return to the lab in two days to complete a free-recall test where they wrote as much information about the essay that they could remember.

Those in the control condition returned four days later without any additional study material. Those who were given the free-recall test performed better on the subsequent exam than those who did not.

Roediger and Butler (2011) also reported that retrieving information from memory produces better retention than restudying the same information for the same amount of time. They named this phenomenon *the testing effect*. One theory about why the testing effect is so helpful is because the act of retrieving elaborates on the information and creates multiple retrieval routes that make accessing that information easier.

Even though the testing effect is prevalent when the students do not have any feedback on the correct answers, providing feedback does increase the benefits of this learning strategy. The feedback enables the learner to correct their errors and subsequently remember those correct responses. Additionally, Roediger, Putnam, and Smith (2011) note that this feedback should be given whether or not the original answer was correct.

Though more research is needed to determine the effects of testing on a wide array of learning material, the evidence from the literature suggests that practice tests that require more retrieval (recall or short answer) promote better retention than tests that require less retrieval (e.g. fill-in-the-blank or recognition).

In addition, as Kilgour et al. (2000) implied, adding any structure to students' study time is preferable than none at all to increase retention. If adding structure to textual information can enhance memory, it is possible that music can be used as that structure. Music can implement a tempo, add rhythm and melody, and create repetition

within the material. Music presents the information in a way that can be more easily learned and retrieved from memory because it provides the listener many other cues in addition to verbal information (Hyman & Rubin, 1990). Wallace (1994) concluded that music does, indeed, contribute more than just rhythmical information to aid recall of information. Wallace (1994) chose two ballads from the *Frank C. Brown Collection of North Carolina Folklore* and recorded them in spoken and sung versions. The researcher who recorded the ballads emphasized rhythmically stressed syllables while a metronome played in the background. Participants heard one of the ballads five times through and were required to recall the text of each ballad in writing after the first, third, and fifth time. Twenty minutes after the last repetition, the participants recalled the ballad one more time. The sung verses were recalled better and retained longer than those that were rhythmically spoken. Additionally, rhythmical and syllable information was easier for participants in the sung condition to remember than in the spoken condition.

Calvert and Tart (1993) asked undergraduate students to remember a song from School House Rock that contained the words to The Preamble and recite them verbatim. Students were then asked whether they sang or spoke the words to be able to recall The Preamble. The students who reported that they had heard the song more frequently in their past were more likely to sing to recall the lyrics. Those who did use singing to recall the lyrics were able to remember more text and recall it more accurately. Additionally, 83% of the participants reported that they believed music to be helpful as a mnemonic, whether or not they had used singing to remember the words of The Preamble. Exposure to musical learning improved recall of information immediately after and the effect was even more pronounced after 5 weeks. These results indicate that adding music to textual

information can be used as an aid for learning and memory and that many participants believe it is a worthwhile mnemonic to use.

Kilgour et al. (2000) demonstrated that when undergraduates were presented with sung or spoken lyrics, the recall for the sung lyrics was superior to the spoken lyrics. They assigned participants to listen to the spoken, sung, or sung with piano prelude condition and were asked to recall material after the first, second, and fourth presentation of the material. Immediately after, they completed an unrelated number search task and then gave a final recall of the material. Results did indicate that both sung conditions performed significantly better than the spoken condition. However, after controlling for presentation rate of the lyrics in a subsequent experiment, the sung lyrics had no advantage over the spoken lyrics.

The possible benefit of musical learning has also been extended to the verbatim recall of foreign languages (Ludke, Ferreira, & Overy, 2014). In Ludke et al., participants listened to paired phrases in both English and Hungarian (an unfamiliar language to them). The phrases were spoken, spoken in rhythm, or sung. Participants listened to the English-Hungarian paired phrases and were asked to repeat the Hungarian words out loud. Then, they were required to reproduce the Hungarian words in recall, recognition, and vocabulary tests. To reproduce an important feature from Kilgour et al. (2000), the three conditions were controlled for duration and presentation rate. Singing was found to be more effective than speaking or rhythmic speaking when participants reproduced a list of the Hungarian words. This result implies that duration and presentation rate of the musical stimuli cannot explain the effect of music.

Thus, retrieval practices strengthen memory and make forgetting less likely (Roediger & Butler, 2011), and a memory benefit is also observed for verbal information learned through songs rather than through hearing speech (Ludke et al., 2014). Yet, nobody has investigated the interactive effects of retrieval practice and singing in memory. The goal of the current experiment was to determine whether or not there is an interaction between the use of musical melodies and type of learning technique for the recall of verbal information. We hypothesized that the text assigned to music paired with the retrieval learning strategy would increase students' recall in the short and long term and would result in the highest recall scores compared to the use of only music or only retrieval or none of those strategies.

Method

Participants. 81 undergraduate students from the University of Iowa participated in this study. The only requirement of the participants was that they were native English speakers. The students were recruited from an Elementary Psychology course and were rewarded 1.5 research credits for fully participating in the study. The study was advertised as “Listen & Remember,” a study that would investigate how music could help learning. Participants were randomly assigned to each of the groups (Song-Restudy, $n = 20$; Song-Retrieval, $n = 21$; Speech-Restudy, $n = 20$; Speech-Retrieval, $n = 20$).

Stimuli. Sixteen sentences were constructed with correct English grammar. They depicted unusual situations or deviated from the expected, for example, “Last summer, I went to Italy and took a picture with a dog drinking from a fountain” (see all sentences in Appendix A).

Participants listened to each sentence while looking at a blue computer screen. The participants were instructed to click an arrow on the screen to continue and listen to the next sentence. In all groups, the 16 sentences were presented in random order; once all of the sentences had been listened to, they were all presented again for a second time. After this second time, participants listened to all sentences two more times, but differently depending on whether they were in the restudy groups or the retrieval groups (see Design below).

The sentences were recorded by one of the researchers. Kilgour et al. (1999) demonstrated that one possible explanation for enhanced recall of information set to music is that there are differences in rate of presentation for spoken and sung conditions. This variation could influence the performance of participants. To control for natural variations in presentation rate, both sung and spoken phrases were timed to be the same length as their counterpart; that is, 1 spoken would be the same length as Sentence 1 sung. The sentences were an average of 30 seconds in length. The sung phrases were recorded first; then the spoken sentences were recorded in time with the same rhythmic pulse as the sung words. For the retrieval condition, the third and fourth repetition of the sentences were split to create time for the retrieval of the information. The sentences were divided by clauses to determine the location of the silence. Musical notation of the stimuli is available in Appendix B.

Design and Procedure. The participants were randomly assigned to each of the four groups in a 2 (music: sung or spoken) x 2 (learning strategy: retrieval or restudy) between-subjects design. In the initial learning phase, half of the participants were presented with spoken sentences and the other half with sung sentences. In the second

phase, participants in the spoken condition were divided into two groups: Speech-Restudy (they kept listening to the speech sentences) and Speech-Retrieval (they listened to the first part of the sentence and were asked to produce the second half). Similarly, participants in the singing condition were divided into two groups: Song-Restudy (they kept listening to the sung sentences) and Song-Retrieval (they listened to the first part of the sentence and were asked to sing aloud the second half). Thus, for participants in the restudy groups, the first and the second phase were identical. In the retrieval groups, only the first part of the sentence was given in the second phase, and the correct second half of the sentences were played aloud after an interval of 10 seconds in which the participants had to provide that second part of the sentence. In this 10-s pause, the participants were instructed to repeat as much as the sentence as they could remember out loud. If they were in a singing condition, they were asked to sing it out loud. If in the speech condition, they were asked to speak out loud. The sentences were presented in a random order each time through.

After listening to the sentences, they completed both the cued-recall test and the multiple-choice test (Immediate Test). The cued-recall test was given to the participants first. It provided the participants the first half of the sentence and then required them to write the second half of the sentence as best they could remember (Appendix C). Then, the forced multiple choice test gave participants the first half of the sentence and asked them to choose the correct second half from 3 options (Appendix D). Of the three options, one was the correct second half, one was the second half of one of the other sentences, and the last shared keywords with the correct sentence.

The participants were told that this experiment would consist of two parts separated by exactly one week. The first part of the experiment took approximately 45 minutes, as described above. During the second session, participants only had to complete the tests again: the cued-recall and multiple-choice (Delayed Test). This second session lasted approximately 15 minutes. Both sessions were held in the same quiet laboratory space, and were completed individually.

Data Analysis

Multiple-Choice Test. Participants' responses to this test were scored with a correct answer receiving one point and an incorrect answer receiving zero points. A total score of 16 points was possible.

Cued-Recall Test. Participants' answers on this test were scored individually for each sentence. The sentences were graded by word type: nouns and verbs were worth two points and adjectives, adverbs, and any other words were one point. The total points missed were deducted from each sentence's total. Points were not taken off if the words were the same but in different tenses; for example, "talking" could be substituted with "talked" or "talk".

Participants' data were excluded from this study if they left five or more cued-response questions blank on the immediate test. Participants were not excluded if multiple questions were left blank on the delayed cued-recall test. No data were excluded based on the multiple-choice scores.

Results

Twelve students were excluded from the study because they did not repeat the sentences out loud, they did not complete five or more blanks on the cued-recall test, or

they did not show up to the second part of the experiment. The remaining 69 students completed the entire experiment (Song-Restudy, $n = 16$; Song-Retrieval, $n = 18$; Speech-Restudy, $n = 18$; Speech-Retrieval, $n = 17$).

We predicted that the participants in the music condition would remember more words than the spoken condition and, additionally, those in the retrieval group would have better sentence recall than those in the restudy group, in both the immediate and delayed test, but especially in the latter one.

Immediate Test. As it can be seen in Figure 1, accuracy in the cued-recall test was very similar in the two retrieval groups, and accuracy in both of them was higher than in the two restudy groups. Overall, the song groups had a slightly higher average test score ($M= 211.29$, $SE= 3.92$) than the speech groups ($M= 209.09$, $SE= 3.87$). For the learning strategies, the retrieval conditions had significantly higher scores ($M= 216.53$, $SE= 3.81$) than the restudy conditions ($M=203.86$, $SE= 3.98$).

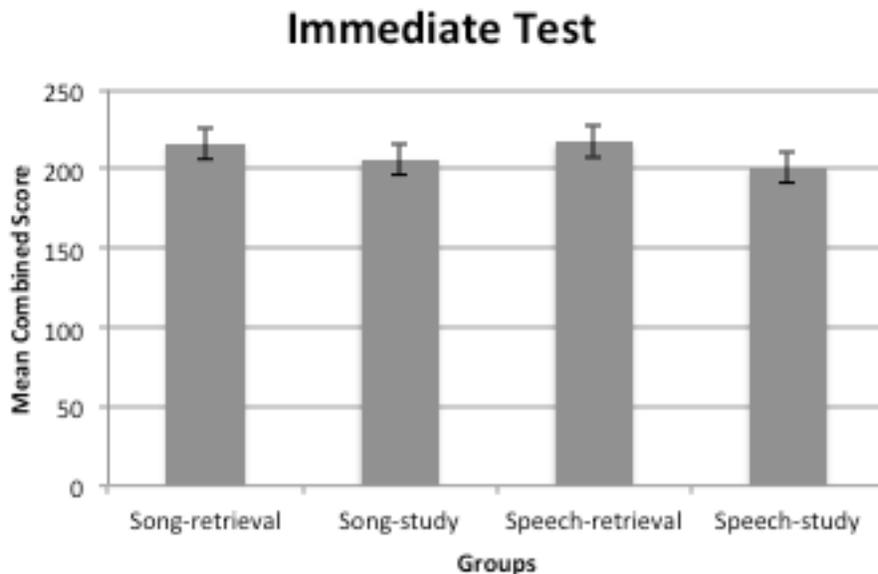


Figure 1. Mean accuracy for each of the experimental groups in the Immediate condition. Error bars represent the standard error of the mean.

A 2 (music: sung or spoken) x 2 (learning strategy: retrieval or restudy) mixed effects analysis of variance (ANOVA), with participant as a random effect, on the accuracy scores for the cued-recall test revealed no main effect of music, $F(1,65) = .16, p = .69$, but there was a main effect of learning strategy, $F(1,65) = 5.28, p = .02$. The interaction between the two variables was not statistically significant, $F(1,65) = .26, p = .61$.

The results for the immediate multiple-choice test indicated no differences among the groups. All groups had a perfect (or almost perfect, above 15.9 out of 16) score in this test.

Delayed Test. For the delayed test, the overall average scores were lower than in the immediate test. As it can be seen in Figure 2, accuracy was the highest in the Song-Retrieval group, followed by the Speech-Retrieval group; accuracy was the lowest in both restudy groups. Overall, the song groups had a slightly higher average test score ($M = 189.61, SE = 6.97$) than the speech groups ($M = 185.32, SE = 6.87$). For the learning strategies, the retrieval groups had overall higher scores ($M = 199.42, SE = 6.77$) than the restudy groups ($M = 175.52, SE = 7.07$).

A 2 (music: sung or spoken) x 2 (learning strategy: retrieval or restudy) mixed effects analysis of variance (ANOVA), with participant as a random effect, on the accuracy scores for the cued-recall test revealed no main effect of music, $F(1,65) = .19, p = .66$, but there was a main effect of learning strategy, $F(1,65) = 5.96, p = .02$, as in the immediate test. The interaction was not statistically significant, $F(1,65) = .18, p = .67$.

The results for the delayed multiple-choice test indicated no differences among the groups. All groups had a perfect (or almost perfect, above 15.8 out of 16) score in this test.

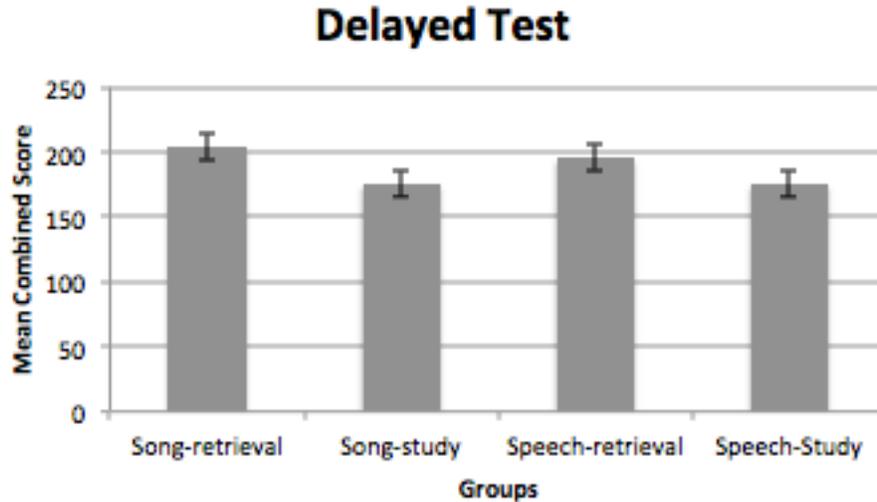


Figure 2. Mean accuracy for each of the experimental groups in the Delayed condition. Error bars represent the standard error of the mean.

Discussion

The purpose of this study was to examine if the interaction between musical presentation and retrieval practice would be beneficial for student learning of verbal information in the short and long term. Overall, the Song-Retrieval group had the highest accuracy scores, whereas the Speech-Restudy group had the lowest average test scores. However, only the learning strategy turned out to yield a statistically significant difference.

By integrating the representations of music and text, learning is encouraged and facilitated by music because of the expanded number of retrieval cues (Serafine, Crowder, & Repp, 1984). The advantage of musical learning, though supported by

previous literature, was not found in our study. Still, even though the results indicate that there was no significant difference between the musical and spoken group scores, the musical groups' average test scores were slightly higher than those in the spoken group. Some participants in the song groups expressed anxiety when informed that they were required to sing out loud. This may be a reason that the scores were only slightly higher than the spoken; they did not participate to the fullest capacity because they were anxious.

In previous studies, Wallace (1994) and Calvert et al. (1993) had results that supported the advantage of melodies for recall of information, but Kilgour et al. (1999) did not report any advantage. Our results were consistent with Kilgour et al. (1999) and reported that melody did not seem to be a useful mnemonic for recall of the verbal information. The differences in these studies may be attributed to rate of presentation of the verbal material. In contrast with this study, the advantage of music was previously shown when the materials were not purposely presented at a consistent rate between the spoken and sung conditions.

Although music did not have the strong influence that we had predicted, the learning strategy did. Previous research has determined that practice testing is more effective than restudying in the short and long term (Glover et al., 1999). In accordance with this research, groups using the retrieval learning strategy performed better than those who used the restudy method on the immediate and delayed post-test.

In line with Roediger et al. (2011), the testing effect was particularly strong. The differences in average scores of the retrieval and restudy groups increased from the immediate test to the delayed test with the retrieval group performing significantly better.

Up to this point, the testing effect has been thoroughly supported with written material, but not with auditory material and music. This finding expands the domains in which this learning strategy can be applied.

A possible limitation of this study was the way in which we required participants to respond to the music manipulation. Because it was required that they speak or sing out loud in the retrieval conditions, several participants reported that they were uncomfortable performing the task, singing in particular, while the experimenters were in the room (although they were behind a divider that allowed the participants some level of privacy). This situation may have reduced the accuracy of the participants' memory of the information because they were hesitant to perform to their full potential. In the future, this study could be run in a room with a separate office space with a door that can be shut to ease participants' anxiety. The environment should be conducive to the experiment while easing participant's nerves.

Additionally, Rawson and Dunlosky (2011) demonstrated that increasing the number of sessions that participants relearn material does increase the amount that can be accurately recalled. However, as the number of sessions increases there is a diminishing return for long-term retention. Because participants heard each sentence four times each, it is likely that the differences between the retention in both groups was small because they had more than enough "relearning" sessions.

To conclude, we showed that retrieval is indeed an efficient learning strategy, also with auditory materials; this strategy should be very easy to implement in the classroom or in any other learning environment. It is still an open question whether music could increase even more the benefits of retrieval. Future research will address this question.

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Appendix A. The 16 sentences used in the experiment.

1. The magazine is on the floor underneath the big, brown, sleeping dog
2. When I go to the grocery store, I get a call from my mother who lives in Ohio.
3. Down the street from my house they sell screwdrivers and hammers at the clothing store.
4. My best friend from California likes to ski in the mountains in spring and summer.
5. I never leave my house without my blanket, my apple, and my stuffed animal.
6. After I graduate from college, I want to be a professional clown in London.
7. Last summer, I went to Italy and took a picture with a dog drinking from a fountain.
8. In a golf course in Minnesota, I learned how to speak French with my friend.
9. Yesterday I saw a fish in a rain puddle on the to the post office.
10. In the middle of winter last year, there was a thunderstorm that affected the Midwest.
11. When I am sleeping, I go to the kitchen and drink cold water from the tap.
12. My favorite place to read is in a concert hall next to a nice, old lady.
13. I like to eat salsa in a green bowl full of mangoes and pineapple.
14. Tomorrow I will put on my pants and go to sleep and dream about my summer trip.
15. As I walked through town, I got to pet a monkey that was eating some peanuts.
16. My back was feeling sore, so later in the day I purchased ice cream.

Appendix B. Musical Notation

♩=120

The ma-ga-zine is on the floor un-der-neath the-big brown sle-ping dog

5

My best friend from Cal-i-for-nia likes to skii in the mount-ains in spring and sum-mer

9

After I grad-u-ate from col-lege I want to be a pro-fes-sion-al clown in Lon-don

14

In a golf course in Min-ne-sot-a I learned how to speak French with my friend

As I walked through town I got to pet a mon-key that was eat-ing some pea-nuts

64

My back was feel-ing sore so lat-er in the day I pur-chased ice-cream

When I am sleep - ping I walk to the kit - chen and drink cold wa - ter from the tap

This system contains measures 20 through 23. The melody is written in a treble clef with a key signature of one flat (B-flat). The lyrics are: "When I am sleep - ping I walk to the kit - chen and drink cold wa - ter from the tap".

24

I like to eat salsa in a green bowl full of man - goes and pine - ap - ple

This system contains measures 24 through 27. The melody continues in the same key signature. The lyrics are: "I like to eat salsa in a green bowl full of man - goes and pine - ap - ple".

28

Down the street from my house they sell screw - drivers and ham - mers from the cloth - ing store

This system contains measures 28 through 30. The melody continues. The lyrics are: "Down the street from my house they sell screw - drivers and ham - mers from the cloth - ing store".

31

I ne - ver leave my house with out my blank - et my ap - ple and my stuffed a - ni - mal

This system contains measures 31 through 34. The melody continues. The lyrics are: "I ne - ver leave my house with out my blank - et my ap - ple and my stuffed a - ni - mal".

35

When I go to the groc - ery store I get a call from my mo - ther who lives in O - hi - O

This system contains measures 35 through 38. The melody concludes. The lyrics are: "When I go to the groc - ery store I get a call from my mo - ther who lives in O - hi - O".

Appendix C. Cued-Recall Test

Please complete the sentences below according to what you have just heard. Please try to be as accurate as possible. If you do not remember the exact words, try the closest wording that comes to your mind.

- Yesterday I saw a fish _____
- In the middle of winter last year _____
- My favorite place to read _____
- My back was feeling sore _____
- When I go to the grocery store _____
- I like to eat salsa _____
- The magazine is on the floor _____
- My best friend from California _____
- I never leave my house without _____
- After I graduate from college _____
- In a golf course in Minnesota _____
- When I am sleeping _____
- Tomorrow I will put on my pants and _____
- As I walked through town _____
- Down the street from my house _____
- Last summer I went to Italy _____

Appendix D. Multiple Choice Test

Please circle the answer that correctly completes the sentence.

1. The magazine is on the floor...
 - a. In the refrigerator in the egg carton
 - b. Underneath the big, brown, sleeping dog
 - c. Next to the refrigerator by the dog

2. My best friend from California...
 - a. Likes to ski in the mountains in spring and summer
 - b. Takes pictures with her dog in the mountains
 - c. And took a picture with a dog drinking from a fountain

3. After I graduate from college...
 - a. I want to be a professional clown in London
 - b. I will assemble a five hundred piece puzzle in only twenty minutes
 - c. I will be a clown who can do puzzle tricks

4. In a golf course in Minnesota...
 - a. I got to pet a monkey that was eating some peanuts
 - b. I learned how to speak French with my friend
 - c. I heard a golfer speaking French to his monkey

5. When I am sleeping...
 - a. I often listen to rock and eat a snack in the kitchen
 - b. My upstairs neighbors blast rock music
 - c. I walk to the kitchen and drink cold water from the tap

6. I like to eat...
 - a. Salsa in a green bowl full of mangoes and pineapple
 - b. Fruit salad with apples, pineapple, and grapes
 - c. My blanket, my apple, and my stuffed animal

7. Down the street from my house...
 - a. I go to sleep and dream about my summer trip
 - b. I fell asleep after buying new clothes
 - c. They sell screw drivers and hammers from the clothing store

8. I never leave my house without...
 - a. Salsa in a green bowl full of mangoes and pineapple
 - b. My blanket, my apple, and my stuffed animal
 - c. Lots of fruit, a pillow, and a sweatshirt

9. When I go to the grocery store...
 - a. They sell screw drivers and hammers in the clothing area

- b. I call my boyfriend to see if he needs a hammer or clothing
 - c. I get a call from my mother who lives in Ohio
10. Tomorrow I will put on my pants...
- a. And go to sleep, and dream about my summer trip
 - b. And ski in the mountains in the spring and summer
 - c. And sleep before I go to ski
11. My favorite place to read...
- a. Is in a blue concert hall with a zebra statue
 - b. Is in a concert hall next to a nice old lady
 - c. Was zebra print and bright blue and John really liked it
12. Yesterday I saw a fish...
- a. Underneath the big, brown, sleeping dog
 - b. By a dog next to the post office
 - c. In a rain puddle on my way to the post office
13. In the middle of winter last year...
- a. There was a thunderstorm that affected the Midwest
 - b. I walked to the kitchen and drank cold water from the tap
 - c. I drank cold water in the middle of a thunderstorm
14. Last summer I went to Italy...
- a. And took a picture with a dog drinking from a fountain
 - b. And later in the day I would purchase ice cream
 - c. And took pictures of the different types of ice cream
15. As I walked through town...
- a. I got to pet a monkey that was eating some peanuts
 - b. There was a thunderstorm that affected the Midwest
 - c. I saw a monkey before it started to thunderstorm
16. My back was feeling sore...
- a. After stepping in a rain puddle on the way to the post office
 - b. So later in the day I purchased ice cream
 - c. And dropped my ice cream in a rain puddle

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