Effects of Background Music and Sleep on Semantic Interpretation

Lupe Chapa and Danielle Miller

San José State University
Abstract

The effects of music and sleep may interfere with semantic interpretation and can have an effect on academic performance. Sixty-five San José State University students read a passage in two conditions: condition one had no music and condition two had music playing in the background. Semantic interpretation was measured through correct responses to the probed and free recall tasks. Participants answered proportionally more questions correct on probed recall task without music compared to participants who listened to music. Sleep deprived participants the night prior to the study answered proportionally more questions correct on the probed recall task. The free recall task response yielded no significant difference in any condition. The interaction of music and sleep was not statistically significant among participants. Further research will be needed to investigate the interaction of Background Music and Sleep on semantic interpretation.
Effects of Background Music and Sleep on Semantic Interpretation

Today, music is incorporated into daily activities from jogging to academic study time. Listening to music is rated the most preferred leisure activity of older children and young adolescents (Nippold, Duthie, & Larsen, 2005). It is important to look at how this impacts students’ academic career. Many students listen to music while they are doing homework or studying for a test. Studies show that divided attention during the encoding process produces negative effects on conceptually driven and data driven direct memory tests as well as conceptually indirect memory tests (Mulligan & Hartman, 1996). Therefore this implicates possible ramifications for students on academic performances if music does indeed act as a distracter.

Evidence shows there is a growing epidemic of sleep deprivation among American adults and teens (Freberg, 2006). According to the Sleep in America Poll (National Sleep Foundation, 2002), American adults sleep an average of 6.9 hours during the weekday and 7.5 hours on the weekends. When the poll was taken again in 2009 respondents reported sleeping an average of 6.7 hours of sleep on weekdays as well as weekends, while reporting they required a minimum of 7.4 hours of sleep a night to function at their best (National Sleep Foundation, 2009). In other words the average American is getting less sleep than what they require to perform at their best.

Sleep is essential for everyone because it preserves energy and restores the human body. However, sleep can be especially beneficial for students. REM sleep has been observed to increase after learning has taken place and REM sleep deprivation may slow or prevent the consolidation of learning that occurred that day (Freberg, 2006). The first night of sleep after learning might be vital for retaining that knowledge (Stickgold, James, & Hobson, 2000). However, college students in many countries show patterns of sleep deprivation (Reid & Baker,
2008). When individuals are sleep deprived there is a profound negative effect on their behaviors and cognitive abilities. (Roche Laboratories, 1966). REM sleep loss and overall sleep loss in general, can produce irritability and difficulty with concentration.

*Text Comprehension*

Text comprehension is comprised of four parts. The first part is word recognition, the process by which the readers recognize and decipher the meaning of words. Readers who have more extensive vocabularies tend to comprehend words more efficiently (Caldwell, 2008). An important part of word recognition is decoding, that is being able to break long words down into useful parts (Davison & Green, 1988). More experienced readers with larger vocabularies, who know how to segment words into prefixes, suffixes, and syllables tend to find word recognition easier.

The second component of text comprehension is syntactic analysis or parsing, the process of analyzing the text and understanding the grammatical structure of the sentences. Most parsing strategies tend to favor the simplest interpretation of grouping words and sentences together (Davison & Green, 1988). Parsing also helps to explain why readers choose a particular understanding or interpretation of a sentence as opposed to another interpretation (Carpenter, Miyake & Just, 1995).

The third process, semantic interpretation, is when the reader interprets the words and sentences into concepts which he or she understands. At this stage of text comprehension the reader is making sense of the words and sentences he or she is reading (Davison & Green, 1988). The final process, knowledge integration, is when the reader uses prior knowledge to help in the other processes (Graesser, Millis, Zwaan, 1997). Knowledge integration makes the others processes more effective and helps the reader comprehend the text better overall.
Readers go through each of these four processes in order to understand what it is they are reading. The more skillful the readers are in each process, the more proficient they are in text comprehension. These processes take attention and focus. Therefore if the reader is distracted by background noise or cannot focus because he or she is sleep deprived then the readers may not be as effective at completing these processes as they would be if they were not distracted or sleep deprived.

*Semantic Interpretation*

Semantic interpretation is a component of reading comprehension. Semantic interpretation is when the reader identifies components of the sentence as the agent, the subject and the effected object of the sentence (Allen, 1995). The agent is the relationship between the action and the person. Then the reader uses that information to interpret the meaning of the sentence.

In the English language, there is a sentence process that depends on a system called word order. In this order the vast majority of English sentences use subject-verb-object order as basic structure (MacWhinney, Bates & Kliegl, 1984). Although there are many other rules that apply to this order the noun-verb-noun (NVN) process is one of the most commonly used. Even though this process is highly effective in the English language, it does not fully apply to other languages. The Competition Model holds that the forms of natural languages are created, governed, constrained, acquired and used in the service of communicative functions. This model is being proposed as a means of organizing our understanding of cross-linguistic differences in sentence processing, while focusing our attention on important and researchable issues in this field (MacWhinney, Bates & Kliegl, 1984).
The present study illustrates this claim in a test of sentence interpretation by German-, Italian-, and English-speaking adults. Subjects were presented with simple transitive sentences in which contrasts of (1) word order, (2) agreement, (3) animacy, and (4) stress were systematically varied. For each sentence, participants were asked to state which of the two nouns was the actor. The results indicated that Americans relied overwhelming on word order, using a first-noun strategy in NVN and a second-noun strategy in verb-noun-noun and noun-noun-verb sentences. Germans relied on both agreement and animacy. Italians showed extreme reliance on agreement cues. In both German and Italian speaking participants, stress played a role in terms of complex interactions with word order and agreement. The findings were interpreted in terms of the "competition model" (MacWhinney, Bates & Kliegl, 1984).

Understanding each process of semantic interpretation can be difficult. When readers engage in reading they need to be able to transform text information and by doing so, readers need to be pay attention and focus. Transformation of text comprehension can affect readers if background music is played and if readers are lacking sleep.

Effects of Music

College students may claim that auditory distractions such as music or television do not affect their study habits, however this is not necessarily true. Studies report that a substantial majority of students, 68 percent, study while listening to their radios (Cantril & Allport, 1935). The opinion of these researchers is that unless the radio is kept low in volume it serves as a distracter adversely affecting speed and comprehension in study.

Previous research shows conflicting results. Some studies have shown that music does have an effect on performance; other studies have shown that it does not. Studies that show there is no effect of music on reading comprehension task explains this may be a result of college aged
students having an increased exposure to music and a greater ability to adapt to repetitive auditory stimulation (Kiger, 1989).

Music preference can have an effect on comprehension tasks. Vocal music can be disruptive to participants who are unfamiliar with the lyrics, while show no effect on participants who express familiarity with the lyrics. That is, for those who are more familiar with the lyrics, there may be less impairment because there is less cognitive effort used to retrieve the lyrics from the long-term memory (Greene & Alley, 2008). Distraction levels vary depending on the type of music with instrumental music ranking as the least distracting and the vocal music condition ranking as the most distracting (Greene & Alley, 2008). Other researchers found that popular music reduced paragraph comprehension, but classical music did not (Boyle & Coltheart, 1996).

Research has also shown that music may cause arousal in listeners. The Yerkes and Dodson law states that the arousal level of an individual increases performance up to an optimal level, beyond this level the individual reaches a state of over-arousal which leads to a deterioration in performance (Hallam, Price & Katsarou, 2002). Stimulating music is expected to increase arousal and improve performance in simple tasks. However, if the task is complex, like reading challenging material, then the level of arousal may become too great and performance begins to deteriorate.

A study done by Henderson, Crews and Barlow (1945) tested participants on vocabulary and reading comprehension. Results show that popular music had a significant negative effect on reading comprehension. Classical music showed no evidence of distraction in either the vocabulary or reading sections of the test suggesting that music serves as distraction upon the complexity of the test materials.
However, previous research suggests that performance in the presence of familiar background music is higher than that in the presence of unfamiliar music (Hilliard & Tolin, 1979). When testing, background music can interfere and effect memory, in the case of music familiarity, auditory disruption may not impair cognitive performance.

Effects of Sleep

There are two states of sleep, each with its own function. One state of sleep is synchronized or non-rapid eye movement (NREM) sleep. The function of NREM is physical restoration. The other state is desynchronized sleep. This stage is also referred to as rapid eye movement (REM) sleep or active sleep and is thought to be specifically responsible for restorative function with respect to systems of the central nervous system. Such systems include focused attention and motivation (Hartmann, 1973). Therefore lack of sleep and quality of sleep affects an individual’s motivation to complete a required task such as reading for a class assignment while also decreasing their focused attention.

Some individuals do not consider themselves sleep deprived because they believe that they are getting at least eight hours of sleep. Quality of sleep is an important aspect of sleep and it is characterized by an inability to fall asleep or remain in a sleep state. Poor quality sleep reduces motivation in cognitive tasks such as reading comprehension and mathematics (Meijer & van den Wittenboer, 2004). Poor quality of sleep typically means there is a loss of REM sleep and this likely affects the willingness to perform rather than affecting cognitive ability (Wilkinson, 1968). The unwillingness to perform is when individuals receive insufficient stage 3 and stage 4 sleep, which usually occur in the first few hours of sleep (Blagrove, Alexander & Horne, 1995).
The research on the effects of sleep specifically on semantic interpretation is limited. There is substantially more research that focuses on the effects of sleep deprivation on other cognitive functions. As a way of testing cognitive function numerous studies look at text comprehension and semantic interpretation as part of the text comprehension process.

The research on sleep deprivation has yielded inconsistent results. Some studies show sleep deprivation does not significantly affect basic reading, writing, arithmetic, visual functions and intellectual functions (Dai-Jin et al., 2001). Other studies concluded that language tasks, such as reading comprehension, which require continued attention and higher level processing, were negatively affected by short-term sleep deprivation (Pilcher et al., 2007). The more attention a task requires the more impaired an individual’s performance on that task will be due to sleep loss (Swann, Yelland, Redman, & Rajaratnam, 2006). Long, complex tasks that require high attention, and do not provide feedback to the individual on his or her progress can be expected to be more sensitive to total sleep loss (Johnson, 1983).

Music, Sleep and Semantic Interpretation

Research on the relationship between background music and sleep is limited. There is little research on the effects of background music and sleep deprivation specifically on semantic interpretation. Previous studies show that background music impairs reading comprehension performance. Previous research also shows sleep affects a reader’s ability to focus on task on hand. Studies have shown that both background music and sleep, individually, have an effect on one’s academic performance. However, individuals are not sleep deprived and readers who are used to having background music there appears to be no effect of reading comprehension at all. The relationship of these factors and semantic interpretation require further study to better grasp a understanding on students who perform under these circumstances.
Closing

Previous research of sleep deprivation and background music suggest there is an effect of these two factors on semantic interpretation. A readers’ ability to effectively go through each processes of text comprehension may be comprised when the reader listens to music. If the process of text comprehension, as a whole, is incomplete then the reader is unable to understand the material he or she is reading. The reader is then incapable of storing that information in their long-term memory, and hence rendering themselves unable to recall that information at a later time. This study focuses on the effect of listening to music and sleep deprivation on text comprehension, more specifically semantic interpretation. College students face sleep deprivation and listen to music often; therefore it is important to see how these factors interfere with an individual’s academic careers.

Method

Participants

Sixty-five San José State University undergraduate students (36 female and 29 male) participated in this study. The ages of the participants ranged from 19 to 70 with a mean age of 24. The majors of the participants varied with psychology being the most common major. The sleep patterns of the participants also varied. Participants were recruited from upper division psychology, humanities and human sexuality courses.

Materials

The first stimulus was a 573 word reading passage originated from Dillinger 1994. The passage was a narrative text in first person point of view. The narrator described a visit to his friend, who is a nuclear scientist, at his place of work. This stimulus was presented in both
experimental conditions. The second stimulus was the song Lady Gaga’s (2008) The Fame, Just Dance. This stimuli was presented only in the with music experimental condition.

There were two response sheets. The first response sheet required the participants to replicate the passage (See Appendix C). The second response consisted of 15 multiple choice questions (See Appendix D) adapted from Harrington and Schmeisser, 2008. The questions were specifically targeted to test the participants use semantic interpretation. Participants in all experimental conditions received the same response sheets.

Participants responded to a background questionnaire (See Appendix A) consisting of 11 questions. The questionnaire asked participants about their study habits as well as their sleeping pattern. One of these items is 4-point Likert scale question and three items are 5-point Likert scale questions. The questionnaire also asked for gender, age and major. Participants in all conditions received the same background questionnaire.

Procedure

Testing took place in a classroom. As participants arrived they completed a consent form and were instructed their participation was completely voluntary and they could choose to leave the room and not participate. Participants were given oral instructions to read the passage handed to them. Participants were given five minutes to read the passage. The participants were given oral and written instructions to complete the free recall response in the allotted five minutes. Researchers collected the first response sheet and passed out the second the response sheet. Participants were once again give oral and written instructs to complete the probed recall response in the three minutes allowed. Upon completion of the second response sheet it was collected and the background questionnaire was passed out. The participants were reminded not to put their name on this questionnaire as all information would remain anonymous and
confidential. Participants had three minutes to complete the background questionnaire. After collecting all the material the participants were invited to ask any questions and instructed how to follow up if they would like to know the results.

Session two, with different participants, was conducted with the exact procedures as session one but background music was played while the participants read the passage. The experimental conditions were conducted in similar classroom settings.

**Design and Analyses**

The data were collected in four experimental conditions. Both Music (with music and without music) and Sleep (low sleep and high sleep) were between-subject factors. The Sleep condition was measured by self-report from the background questionnaire. The groups were defined by sleeping 6.9 hours of sleep or less (sleep deprived) or eight hours or more (not sleep deprived). The rejection level for all analysis was set at $p = .05$.

Semantic interpretation was measured using a free recall task and a probed recall task. To measure the free recall task the researchers scored the responses using a propositions key. To measure the probed recall task the researchers counted the number of correct responses. This data was used to assess the effects of Background Music and Sleep on Semantic Interpretation.

The Likert scale items in the background questionnaire were measured in millimeters from the left edge of the scale to the slash mark made by participants. The shorter the distance measured the more the participants agreed with the statement.

**Results**

This study evaluated the effects of music and sleep on semantic interpretation.

*Main effects of Music*
The probed recall response yielded a significant difference, $F(1, 44) = 4.913, p < .032$, between the proportion of correctly answered questions by participants not exposed to music ($M = .782, SD = .028$) and by participants who were exposed to music ($M = .687, SD = .032$).

The free recall response yielded no significant difference, $F(1, 44) = 2.178, p < .147$, between the number of details recalled from the original passage by participants exposed to music ($M = .059, SD = .015$) and participants not exposed to music ($M = .087, SD = .013$).

**Main effects of Sleep**

Participants who were sleep deprived the night prior to the study significantly answered proportionally more questions correctly ($M = .758, SD = .036$) on the probed recall response than did participants who were not sleep deprived the night prior to the study ($M = .654, SD = .037$), $F(1, 48) = 4.025 p < .05$.

The free recall response yielded no significant difference between the number of details recalled from the original passage by participants who were sleep deprived the night before the study ($M = .083, SD = .013$) and participants who were not sleep deprived the night before the study ($M = .058, SD = .013$), $F(1, 48) < 1$.

On the probed recall response there was no significant difference between participants who were sleep deprived the week before the study ($M = .739, SD = .028$) and participants who were not ($M = .731, SD = .032$), $F(1, 44) < 1$.

On the free recall there was no significant difference on number of correctly recalled facts from the original passage by participant described as sleep deprived the week before and ($M = .086, SD = .013$) and participants who were not ($M = .060, SD = .015$), $F(1, 44) = 1.885, p < .177$.

**Interactions**
There was no significant interaction of music and sleep on the number of correct responses on the probed recall, $F(1, 44) < 1$ or on the number of details recalled from the original passage, $F(1, 44) = 1.746, p < .193$.

Other factors, such as gender, preference of silent versus noisy study environment and frequency of studying with background noise, showed no significant effects.

Discussion

This study investigated the effects of background music and sleep on semantic interpretation. Although semantic interpretation has not been well documented, the broader process of reading comprehension had been. Previous research shows music and sleep deprivation, individually, each negatively affect reading comprehension. There has not been much research conduct that investigates the interaction of music and sleep on reading comprehension. This study measured semantic interpretation by using a probed recall task and a free recall task on a single narrative text.

The main effects of music on the probed recall task were statistically significant, but were not statistically significant on the free recall task. These results are inconsistent with some previous research that shows music was a distracting factor that lowered reading test performance (Fogelson, 1973). These differences could be a result of the disparity between technological advancements between current day and the 1970’s. Technology has enabled music to become mobile and more integrated into everyday activities. In 2006 as many as 1 in 5 Americans over the age of 12 had their own MP3 players (Kleinschmit, 2006). This statistic does not include cellular devices or other music players. This statistic regarding youth and music players may contribute to youth today being more exposed to music, than youths of previous generations, and less susceptible to the interference in academic activities, such as reading.
The current study found no significant effect of the frequency of reading or studying with music. These results are inconsistent with previous research. Etaugh and Ptasnik (1982) found that subjects who seldom studied with background music showed better comprehension in a laboratory study when they learned in silence while those who frequently studied with music performed better when in the presence of music (Kiger, 1989). This difference could be due to the type of music played during the reading task. Previous research allowed participants to bring their preferred type of music to listen to during the reading task. Since participants who were familiar with the music played during the study did not have an effect, the unexpected outcome could be because all participants exposed to music were exposed to the same song. Participants’ preference was not considered in the music selection. In addition participants were given a time constraint; all participants were allotted five minutes to read the passage, which may have negatively influenced their scores on the task.

The main effects of sleep deprivation the night before the study on semantic interpretation on probed recall were statistically significant, but were not statistically significant on the free recall. These results were inconsistent with previous research (Webb, 1986). These differences may be due to possible actions taken by the participants prior to the study to compensate for their lack of sleep. Such compensating acts could include ingesting large doses of caffeine or energy drinks.

A second explanation of these inconsistent outcomes could have been due the scoring methods used for scoring the free recall. The free recall task for this study displayed a floor effect i.e. the scores for the free recall task were tightly clustered around the low end of the scoring scale. This reduced the variance of the participants’ score on this task.
Average sleep deprivation for the week before the study showed no statistical effects. This is consistent with previous research (Webb, 1986). A possible reason for this is that participants may have become accustomed to working on little sleep due to work, school or other social activities.

There is limited research studying the effects of music and sleep on semantic interpretation. The current study showed there was no statistically significant effect of this interaction on either the probed recall task or the free recall task. This current study suggests there is no interaction between lack of sleep and background music on semantic interpretation. However more research should be conducted to correlate this finding.

Overall the disparities between results of the current study and results of previous research studying the effect of music and sleep can be attributed to the part of reading comprehension being studied. The current study focuses on a specific component of reading comprehension, semantic interpretation. Previous research focuses on the broad action of reading comprehension. The lack of participants’ interest in the materials may have influenced these findings, too. These unexpected outcomes could be due to the difficulty of the text used or lack of response of participants’ during the free recall.

This study investigated how music and sleep may impact semantic interpretation. The study yielded mixed results which entices more research into the field. Future research can focus on the effects of different music types. In previous studies researchers found that popular music reduced paragraph comprehension, but classical music did not (Boyle & Coltheart, 1996). In addition, further researchers can focus on different age groups such as high school students or even elementary students. This may influence students to adopt better study habits early in life. Studying the effects of caffeine and other energy boosting supplements on reading
comprehension may also yield useful information. Since previous research on music and sleep have shown inconsistent results it is important to continue studying this topic until the effects become consistent. Consistent results or understanding why the results are inconsistent may lead to better understanding academic difficulties.
References


Appendix A: Background Questionnaire
1) How old are you? ______________________________

2) Are you a male or female? ________________________

3) What is your major? _____________________________

4) How many hours of sleep did you get last night? _______________________________

5) How many hours of sleep did you get each night last week?

<table>
<thead>
<tr>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
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</tbody>
</table>

For the following three items please place a diagonal slash mark across the horizontal line at the position that best reflects your preferences.

Example:
I prefer apples more than oranges.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

6) How often do you read or study with background noise (e.g. music, television, talking, etc.).

<table>
<thead>
<tr>
<th>Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Never</th>
</tr>
</thead>
</table>

7) I prefer to study in a silent environment.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

8) I prefer to study in an environment with background noise.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

Please turn over questionnaire and continue to questions on the back side.

9) I prefer to study in a quiet environment, but I do not mind studying with music present.
10) What kind of music do you prefer to listen to when you are studying? __________________

11) What is your current GPA? ________________________________
Appendix B: Narrative Text

I have a friend named Alex who is a nuclear physicist, but he works in a public hospital instead of at some big university’s reactor. He spends a lot of his time shooting protons at glucose and other things. Alex makes several different isotopes with the old cyclotron which is in his lab, and he often helps one of the computer programmers who works in the hospital’s brain scanning center. Yesterday I visited Alex at the hospital.

When I found the right office, it was already 10 o’clock. Alex was reading a collection of technical articles, but he put his book on a nearby shelf when I arrived and he showed me all around the lab. He turned on the small cyclotron which was in one corner and made some fluorine isotope to demonstrate how simply it worked. The small machine made noises while Alex explained what it was doing. Afterwards, Alex made some terrible coffee. We talked about the local news for a little while, until a staff doctor asked for some carbon-eleven glucose in a hurry. He said he would call as soon as he was ready for it. Then he prepared the next patient for her scan. Alex explained that since the glucose isotope was only hot (or radioactive) for about a half an hour, he could just set up what was in the lab. He would only start to make the isotope itself when the doctor called again. Not long after Alex was all ready, the doctor called back to confirm his previous request and Alex began to prepare his magic potion right away. When he had finished it, he checked whether it was hot (or radioactive) enough for the scanner. Then we ran up to the scanner room on the third floor, with the solution in a lead bucket.

The scanner was a big aluminum ring with millions of wires connecting it to a big computer in the next room. The patient was waiting nervously for an injection on a long table, with her head inside the ring. As we walked back down the stairs together, Alex explained that scanners detect gamma rays coming from inside the patient’s brain. I didn’t really understand very much of what he was talking about. It sounded really crazy to me.

After lunch, Alex checked in at the lab. Then we visited his friend Yoshio who ran the brain scanner’s computer system. Even before he greeted us, Yoshio pointed at the two TV screens on a large desk and then asked which image was clearer. Yoshio was working on a new program to make the images sharper. Then he pointed at another screen with the same brain image, but it had two handles connected to it, like a video game. He suggested how we should play around with the handles, and when we moved them, the image changed in color and brightness. Yoshio explained that it was better for the doctors to manipulate the color and brightness of the important parts of the image.

The telephone rang, interrupting him. The call was for Alex. He had to go back to the lab, and it was time I left, too. We thanked Yoshio for his explanation of the new program, and walked to the main entrance together. Then Alex went to make some other kind of isotope and I went to the bank to pay some bills. It was a very interesting visit.
Appendix C: Response Sheet for Free Recall

*Please reproduce as much of the original text as possible. Focus on keeping the events in the same order as the original text and identifying who is doing the actions.*
Appendix D: Response Sheet for Probed Recall

1) Which of the following sentences was in the original passage?
   a) ran with the solution in a lead bucket
   b) spilled the solution in a lead bucket
   c) poured the solution in a lead bucket

2) Who made terrible coffee?
   a) The narrator
   b) Yoshio
   c) Alex

3) Who was the phone call for?
   a) Yoshio
   b) Alex
   c) Randy

4) Which of the following sentences was in the original passage?
   a) the staff doctor asked for some carbon-eleven glucose
   b) Alex asked for some carbon-eleven glucose
   c) The narrator asked for some carbon-eleven glucose

5) Who called to confirm the request?
   a) The doctor
   b) Yoshio
   c) Alex

6) Alex began to prepare his magic potion. When he had finished it, he checked whether it was hot enough for the scanner. What did Alex do next?
   a) He visited his friend Yoshio
   b) Alex and his friend went and had lunch
   c) Alex and his friend ran up to the scanner room on the third floor

7) Who ran the brain scanner's computer system?
   a) The doctor
   b) Alex
   c) Yoshio

8) Who went to the bank to pay some bills?
   a) Alex
   b) The narrator
   c) Yoshio

Please turn over and continue to questions on the back side

9) Who is the nuclear physicist?
a) Yoshio
b) The radiologist
c) Alex

10) What happened first?
   a) Alex prepared his magic potion
   b) Alex turned on the cyclotron
   c) Alex checked in at the lab

11) What did the staff doctor ask for?
   a) Carbon-eleven glucose
   b) An isotope
   c) A cup of coffee

12) Where does Alex work?
   a) public hospital
   b) university
   c) private hospital

13) What Yoshio doing when the narrator found him?
   a) playing a video game
   b) working on new program
   c) reading a collection of technical articles

14) Which of the following sentences was in the original passage?
   a) the narrator was waiting nervously for an injection
   b) the staff doctor was waiting nervously for an injection
   c) the patient was waiting nervously for an injection

15) What did Alex explain to the narrator?
   a) since glucose isotope was only hot (or radioactive) for about half an hour, he could just
   set up what was in the lab
   b) that it was better for the doctors to manipulate the color and brightness of the
   important part of the image
   c) that scanners detect gamma rays coming from inside the patient’s brain