Temporal Judgments: The Effects of Sensory Interference and Limited Attention

David Jason Wyse

Abstract

Based on theories of sensory interference and limited attention and on the previous finding of Brown and Stubbs (1992), it was hypothesized that (a) timing judgments are more accurate when prospective rather than retrospective, (b) timing judgments and text comprehension are worse when both tasks must be done using the same sensory mode rather than different modes, and (c) text comprehension is worse when another task competes for attention. The results definitely confirm (c) and give mild support to (a). The validity of (b) is ambiguous, but a limited domain for sensory interference is proposed along with other explanations.

Two popular areas of study are dual task interference and limited attention. The concept of task interference was first proposed Stroop, and this involved recognition of the semantic meanings of words interfering with the naming of the physical colors of words. In the Stroop task, subjects were presented with lists of words printed in different colors of ink and asked to name the ink color for each word. The subjects had no difficulty with this task if the stimulus words were neutral, but if the words were semantic color words, the semantic meaning of the word and the actual color of the ink would interfere, causing the subject to slow down and generate more errors. Similar studies using both visual and auditory stimuli have been used to study task interference, and the prominent result has been that multiple tasks involving the same sensory modality lead to a general degradation of performance on the tasks.

Cherry initiated the research on limited attention in studying the "cocktail effect." Cherry demonstrated that when two different auditory messages were presented to a subject who shadowed one of the messages, his or her ability to recall anything about the unattended message was extremely limited. Subjects were completely unable to describe anything about the unattended message, and they did not even realize if the speaker switched to a foreign language. This led Cherry to propose that attention is a limited resource. Subsequent studies have demonstrated that attention is not quite as
limited as Cherry suggested: subjects are still able to detect a tone or non-verbal sound, and their attention will switch to the unattended message if they hear their name. Nonetheless, attention to more than one task usually leads to a greater frequency of errors on both tasks.

When both sensory interference and limited attention are considered, the question arises: "Is performance degradation a result of task interference, limited attention, or both?" Several studies (Kimchi, 1982; Proctor, 1978; Yuille & Ternes, 1975) have explored this specific question with two general conclusions. The first is that task performance can be predicted based on the demands that the task makes upon a common pool of capacity. The second is that a greater amount of this capacity is used when both tasks involve the same sensory modality; the result is destructive interference to both tasks. A more recent study by Brown and Stubbs (1992) explored the roles of interference and attention in the temporal perception. In this study the subjects were instructed to listen to either a short or a long tape of four contrasting pieces of music while proofreading a selection of text. Some of the subjects were informed that they would be asked to estimate the length of each musical selection (the prospective condition); others were kept uninformed (the retrospective condition). The experimenters found that prospective time judgments were more accurate than retrospective time judgments and that the proofreading task reduced the accuracy of both conditions. This study leaves unanswered the important question of what exactly causes the loss of accuracy in time estimates. Therefore, the present study is a modification of Brown and Stubbs (1992); it was designed with the goals of examining the effects of different sensory modalities on temporal perception and determining whether performance degradation is due to limited attention or due to task interference. In this study the proofreading task was replaced with a text comprehension task. This created the advantage of being able to present the text selection either visually or aurally.

Considering the goals of this study, I intended to test three hypotheses: (a) time judgments is better in the prospective condition than in the retrospective condition due to prior knowledge of the task, (b) time judgments and text comprehension are worse in the aurally presented text condition than in the visually presented text condition due to auditory interference between the two tasks, and (c) text comprehension is worse in the prospective condition than in the retrospective condition because attention is a limited resource divided between the time judgments and the text comprehension. Support for the first hypothesis replicates the original results from Brown and Stubbs (1992). Support for the second hypothesis but not the third indicates that the degradations in performance are due to sensory interference. Support for the third hypothesis but not the second indicates that the degradations in performance are due to limited attention. Support for both the second and third hypothesis indicates that both limited attention and sensory interference result in performance degradation.
Temporale Judgments

Method

Subjects

Nineteen male subjects and one female subject participated in this study. They were all undergraduate students at Carnegie Mellon University, and they participated as a favor to the experimenter.

Stimulus Materials

Time judgments. The stimuli for time judgments were four tape-recorded musical selections representing different musical styles (jazz, Eastern, movie soundtrack, and new age). The selections were drawn from uncommon sources so as to be unfamiliar to most subjects; none contain lyrics. The selections, in order of presentation, were Amanecer by Simon James (jazz, 186s), The Moon Mirrored in the Pool by Hua Yanjun (Eastern, 312s), Two Socks at Play by John Barry (movie soundtrack, 119s), and Tree in the Storm by Ralf Illenberger (new age, 258s).

Text selection. Some subjects were required to read a 2161 word excerpt from the short story “The Inhuman Condition” by Clive Barker. Other subjects were required to listen to the same excerpt presented aurally. The aurally presented text was spoken in a loud clear voice, with inflection determined by the material, and lasted the entire duration of the four music selection. In visual form the text was presented in single spaced, twelve point Carnegie font, with one inch margins.

Questionnaires. The reading comprehension questionnaire contained fifteen short-answer questions about the text excerpt. The questions were straightforward, requiring no inferences from the text, and they could be answered briefly. The music questionnaire containing four time judgment questions, four questions about the genre of each music selection, four questions about instrumentation, and five Lickert scales assessing the subject’s familiarity with the music and text selections.

Procedure

Subjects were told that the experimenter was studying different sensory modes and the performance of multiple tasks. The experimenter explained that they would listen to a tape consisting of four musical selections; they were told to listen carefully because they would later be asked to answer questions about the selections. At this time, half of the subjects were told that the music questions would include judging the duration of each musical selection (prospective condition). The other subjects did not learn about the
time judgments until they received the music questionnaire (retrospective condition). Additionally, half of the subjects were told that they would be listening to an excerpt from a short story (audio condition), and the remaining subjects were told that they would be reading the text selection (visual condition). Both groups were informed that they would be asked to answer a set of comprehension questions about the text selection. The experimenter emphasized that both the music listening and text comprehension tasks were equally important. Following the presentation, the subjects were given the text comprehension questionnaire. The experimenter waited until all of the subjects in the group were finished before handing out the music questionnaire. Finally, the subjects were debriefed and sworn to secrecy.

The experiment comprised a two (audio/visual) by two (prospective/retrospective) design. There were five subjects in each of the four conditions. Subjects were tested in groups of two to three people, and the groups were randomly assigned to conditions.

The time judgments were converted into seconds, and an accuracy ratio was computed for each music selection by dividing the absolute difference between the estimated and actual length of the selection by the actual length. The ratios assume that subjects have a proportional range of inaccuracy for their time judgments. Thus, a thirty second error is more significant relative to a two minute time span than to a ten minute time span. The ratios are always positive. The closer the value of the ratio is to zero, the more accurate the time judgment. The use of accuracy ratios was a modification of the original Brown and Stubbs study (1992); the original study used logarithmic regression on the assumption that time judgments followed classic stimulus-intensity curves. The experimenter felt that this was a conceptual and statistical error, and therefore replaced the regression with the accuracy ratios. The four accuracy ratios were averaged for each subject, producing a mean accuracy ratio.

Results

The dependent measures in this study were the average time accuracy ratio and the comprehension score. The scores for the time accuracy ratio ranged from .113 to 1.114 with a mean of .398 and standard deviation of .2493. The comprehension scores ranged from 8 to 15 (out of a possible 15) with a mean of 10.85 and standard deviation of 2.907. Table 1 shows the cell means for the dependent measures in each of the conditions.

The hypotheses were examined using a series of planned t-tests. Each t-test compared one of the dependent measures across one of the conditions. Before each test was performed, the condition means and standard deviations were checked to eliminate potential outliers for that comparison. The comparison between the prospective and retrospective conditions for accuracy ratios approached significance (one-tailed t=1.47, df=16, .10>p>.05),
Table 1

<table>
<thead>
<tr>
<th>Prospective Accuracy Ratio</th>
<th>Prospective Comp. Score</th>
<th>Retrospective Accuracy Ratio</th>
<th>Retrospective Comp. Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio Text</td>
<td>.4512</td>
<td>11.4</td>
<td>.4536</td>
</tr>
<tr>
<td>Visual Text</td>
<td>.2026</td>
<td>9.8</td>
<td>.4846</td>
</tr>
</tbody>
</table>

giving some support to the original hypothesis in Brown and Stubbs (1992) that people judge time more accurately when they are specifically trying to do so. A comparison between the audio and visual conditions for accuracy ratios showed a significant effect due to the sensory mode (one-tailed t=2.57, df=17, p=.01), supporting the sensory interference hypothesis. However, the corresponding test for comprehension was non-significant (one-tailed t = 1.156, df=18, ns), making any evaluation of the second hypothesis questionable. Finally, the comprehension was compared across the prospective and retrospective conditions, and this test was significant (one-tailed t=2.069, df=18, p<.05), confirming the limited attention hypothesis. Additionally, the correlation between the accuracy ratios and comprehension scores was determined to be significant (r=.528, two-tailed t=2.637, df=18, p<.02); this result supports the limited attention theory in that improving performance on one of the tasks required a corresponding decrease in performance on the other task.

Discussion

The results are clearly consistent with the hypothesis that attention is a limited resource and that performance on a task is directly related to the amount of attention devoted to that task. The sensory interference hypothesis received mixed support. A possible explanation for this result may be that only certain tasks are affected by sensory interference. Thus, the fact that sensory interference affect time judgments and not comprehension could have been caused by two factors: (a) time judgment is a less familiar and less well practiced task than text comprehension, (b) listening to music is more demanding task on the sensory system than hearing or reading text. The original results from Brown and Stubbs (1992) were weakly supported, suggesting that time judgments are easier and more accurate when prospective than when retrospective.

There are several possible problems with this study. The most obvious one is that only a small number of subjects were tested in each condition, and the effects might have been clearer with a greater number of subjects. Another potential methodological problem was the group testing of subjects; although the experimenter noticed no degradation in performance due to
group size, the error variance might have been reduced by testing the subjects individually. There also might have been a ceiling effect for the comprehension questionnaire. Although only one of the subjects scored perfectly, many of the subjects scored near-perfect and missed the same questions. Additionally, although most of the subjects in the visual conditions had the opportunity to read the text selection more than once, their comprehension scores showed no significant improvement over the audio text groups, which supports the hypothesis of a ceiling effect.

In conclusion, the study appears to support the limited attention theory. The study also gives some support to the sensory interference theory, but the mixed results and a ceiling effect on the comprehension questionnaire make it difficult to evaluate the sensory interference theory. Certainly, the sensory interference theory and the interaction effects between it and the limited attention theory require further research.

References