Noice and its effect upon the movement during a reading task

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Abstract
Background noise levels have been shown to disrupt reading eye movements. This study was designed to investigate sound pressure level changes and the effect each change had upon the number of eye regressions made during a reading task. A 0dB sound pressure level was used as a control baseline and comparisons were made to 40dB, 60dB, and 80dB sound pressure levels. The results indicated that sound pressure level changes do cause a significant increase in the number of time the eye regressed. The highest significance was noted for the 40dB level and the least significance was noted for the 80dB level. This result may indicate an increase of concentration at the higher sound pressure level which is not present at the lower sound pressure level. These results support the competitive interaction interpretation of visual and auditory stimulation.

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NOISE AND ITS EFFECT UPON EYE
MOVEMENT DURING A READING TASK

Mattson

A Thesis
Presented to the
Optometry Faculty of the
Pacific University
College of Optometry

In partial fulfillment of
the requirements for the Degree of
Doctor of Optometry

by

Michael Dene Mattson,
Forest Grove, Oregon, 1959
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ABSTRACT

Background noise levels have been shown to disrupt reading eye movements. This study was designed to investigate sound pressure level changes and the effect each change had upon the number of eye regressions made during a reading task. A 0dB sound pressure level was used as a control baseline and comparisons were made to 40dB, 60dB, and 80dB sound pressure levels. The results indicated that sound pressure level changes do cause a significant increase in the number of times the eyes regressed. The highest significance was noted for the 40dB level and the lowest significance was noted for the 80dB level. This result may indicate an increase of concentration at the higher sound pressure level which is not present at the lower sound pressure level. These results support the competitive interaction interpretation of visual and auditory stimulation.
INTRODUCTION

Reading is made up of eye movements in the form of saccades, fixations pauses and regressions. According to Gibson and Levin, 94% of the actual time involved is spent in fixation pauses while the other 6% is spent in actual movement. During a voluntary saccadic movement there is an eighty percent reduction of the visual input, known as a saccadic suppression. The maximum amount of visual information is obtained during the fixation pauses. Regressions are made to go back to check a word or phrase that was previously read. They are sometimes considered indicative of faulty reading, especially if excessive.

Weinstein states that there is only fragmentary evidence to support the common belief that distracting noises can seriously disturb performance on intellectually demanding tasks. He suggested that the failure to detect any detrimental effects of noise is often due to the insensitivity of the experimental procedures. The subjects in the studies usually attempt to overcome the noise distraction by mobilizing additional effort and redistributing their attention. Ryan and Linton stated that their results "showed that regressive eye movements increased when reading was associated with increased levels of background sound." The increased regressions constitute additional efforts to maintain the reading comprehension. "Earlier studies by Sommer et al indicate that tracking eye movements can be disrupted by auditory stimulation."

The study done by Ryan and Linton was done using pure tones of varying frequencies. This is an unnatural condition, because pure tones are not found in the natural environment. Weinstein studied the effects of a
radio news broadcast on proofreading and found that students "initially performed more accurately during bursts of noise than during intervening quiet periods." He states that the explanation may be that: "students try to compensate for the deleterious effects they feel noise is having on their performance by taking extra care when the noise is present." If this hypothesis were true, then it may be expected that one indication of this may be an increase in the eye regressions. Another indication may be a decrease in words read.

Ryan and Linton stated that an increase in regressions was independent of the frequency of the sound and; "The effect was solely a result of sound pressure level." They found that the significant sound pressure level was between 60dB and 90dB. Weinstein used a sound pressure level of 70dB, which is considerably below levels generally required to produce impairment. The average background noise level in the typical elementary school classroom is 60dB, and therefore it is significant to study the sound pressure level associated with the conditions of the classroom. The background noise used in this study was taped from a FM radio station playing "easy listening" music, that music often found in stores and offices.

It was the purpose of this study to introduce periods of noise, after a baseline of no noise had been run, to a subject performing a reading task and to determine the effects the noise had upon the subject's reading, as determined by the number of eye regressions the subject made during the reading task.
MATERIALS AND METHODS:

Subjects: Fourteen university students, three women and eleven men, with an average age of twenty-one years, were selected as subjects. All subjects were required to pass an auditory and visual screening before the experiment was begun. The following criteria was used for the auditory screening: Normal hearing of at least 15dB in the frequency range of 250 Hz to 4000Hz. All subjects passed a visual screening test and were determined to have normal 20/20 visual acuity at the near point.

Apparatus: The setting for the project was the Pacific University Audiological Testing Suite that was soundproof. Subjects sat at a predetermined point where the sound pressure level produced by a Sansui 6060 amplifier, producing 37 watts RMS, had been calibrated for three sound pressure levels: 40dB, 60dB, and 80dB. The sound pressure level was calibrated using a Realistic Sound Pressure Level Meter, which had been calibrated one day before the study was begun. The range of the meter was 60dB to 126dB. The 40dB level was obtained by using the automute on the Sansui 6060 amplifier to decrease the sound pressure level by 20dB at all frequencies. The 60dB and the 80dB ranges were marked on the face of the amplifier. The cassette tape recorder used was a Wollensak 50w, 60Hz model 2551 AV and it was patched directly into the Sansui 6060 amplifier to produce the sound field. The subjects were given the audiological screening on a Beltone Audiomiter model 10D calibrated to 1964 ISO values.

Reading material consisted of one reading selection standardized for college freshman level reading difficulty. The story was photocopied and cut into sections approximately 250 words in length and glued onto plain white 6X8 index cards. The eye movements were recorded by use of a
Biometrics Inc. Eye Trac Visual Measurement system. The eye trac records eye position via an infrared reflection technique. Two photocell sensors detect the amount of infrared light reflected from the limbal region of the eye. More infrared light is reflected from the sclera than from the cornea, and the position of the limbus, relative to the photocell, determines the amount of infrared light detected by the sensor. As a result, the amount of infrared light reflected into the photocell is a function of the eye position.

Procedure: Subjects underwent the visual and auditory screening procedures before entering the experimental environment. The subject was given a standardized set of instructions verbally and asked to sign a subject release form prior to the screenings.

The subject was moved into the experimental environment and seated at the eye trac monitor. After calibrating the eye trac monitor, a control reading of one minute was done in the absence of produced sound. This was used as a baseline over which the average increase of regressions for each of the subsequent conditions was calculated. After the initial baseline reading was done, the noise was introduced into the system. The three sound pressure levels used were chosen to correspond to those sound pressure levels used in previous studies. One minute recordings were done at each of the three sound pressure levels. One minute time clocks were used to minimize startle tendencies and to allow enough time to get a good sample, without causing subject fatigue.

Comprehension of the material was maintained by giving the subject a short true-false test following the testing procedure. This was also de-
signed to increase subject attentiveness, and to decrease attempts to read excessively fast, with a probable decrease in comprehension. The subject was given time to ask the experimenter any questions he had and was then released.
RESULTS:

The number of eye regressions for each minute of reading was tabulated and the data was in the form of a percent increase in regressions over the average number found in the control. A one way analysis of variance for repeated measures was applied to the data obtained. Significant effects at the .05 level were found for the increased sound pressure levels, over the baseline control of OdB. See Table I page 8.

Using the Newman-Keuls Multiple Range Test it was found that the average percent increase in the regressions was significant for all the sound pressure levels when compared with the OdB no noise condition. The average increase was not found to be significant between the sound pressure levels above OdB, when they were compared with one another. The most significant result was found between the sound pressure level of OdB and 40dB, with the lowest significance found between Od3 and 80dB. See Table II page 9.

Table I. Mean values from within group measures of the total number of eye regressions at the four sound pressure levels. Comparison between the sound pressure levels results in the S value, see Table II.

<table>
<thead>
<tr>
<th>Sound Pressure Level</th>
<th>Within Group Total Regress.</th>
<th>Sample Number</th>
<th>Mean X</th>
</tr>
</thead>
<tbody>
<tr>
<td>OdB</td>
<td>445</td>
<td>13</td>
<td>34.23</td>
</tr>
<tr>
<td>40dB</td>
<td>543</td>
<td>13</td>
<td>41.77</td>
</tr>
<tr>
<td>60dB</td>
<td>525</td>
<td>13</td>
<td>40.35</td>
</tr>
<tr>
<td>80dB</td>
<td>512</td>
<td>13</td>
<td>39.38</td>
</tr>
</tbody>
</table>
Table II.

<table>
<thead>
<tr>
<th>Sound Pressure Level</th>
<th>C Value</th>
<th>C Diff</th>
<th>Significance at .05 level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-40dB</td>
<td>7.54</td>
<td>4.12</td>
<td>sign</td>
</tr>
<tr>
<td>0-60dB</td>
<td>6.15</td>
<td>4.12</td>
<td>sign</td>
</tr>
<tr>
<td>0-80dB</td>
<td>5.15</td>
<td>4.95</td>
<td>sign</td>
</tr>
<tr>
<td>40-60dB</td>
<td>1.39</td>
<td>4.95</td>
<td>not sign</td>
</tr>
<tr>
<td>60-80dB</td>
<td>1.00</td>
<td>4.12</td>
<td>not sign</td>
</tr>
<tr>
<td>40-80dB</td>
<td>2.39</td>
<td>5.46</td>
<td>not sign</td>
</tr>
</tbody>
</table>

Newman-Keuls Multiple Range Test value, C Value, above the C Diff value is significant at the .05 level. The table compares the sound pressure levels and the significance between them. The C Diff value is the comparison of the within group data to the between group data and establishes the significance at the .05 level.
DISCUSSION:

Auditory stimulation introduced while a person is reading has been shown to disrupt eye movements. Noise has also been shown to effect other intellectual pursuits. The frequency of pure tone noise does not effect the eye movements as found by Ryan and Linton. Pure tone noise is not found in a natural environment and therefore this study was designed to determine the effects of noise which is more natural to a reading environment. Often there is background music in a reading environment and this is why "easy listening" music taped from a FM station was used. The music may be found in stores, offices and in homes where much reading is done.

The reading material used was standardized for the college freshman level and was of a sufficient interest level that the contributions of factors such as: reader intelligence, readiness, purpose of reading and interest were kept to a minimum.

The results of this study showed that noise introduced into the reading environment increases the regressive eye movements, thus supporting many earlier studies. The increase was due entirely to the sound pressure level of the noise. This is a further indication that the visual and auditory systems are competitive in nature. Reading speed did not show a decrease when each subject was asked to point out where he stopped reading, after each minute of reading, but remained approximately the same or slightly higher. This finding was supported by Weinstein's study. It was found that there was a decrease in regressions for each increase in sound pressure level. This finding, coupled with the reading
speed remaining approximately the same indicate the possibility that the
subjects were able to compensate for the increased auditory stimulation
and may indicate that the visual system overrode the auditory system.
Weinstein stated that:

Participants in a laboratory experiment are usually challenged
by the onset of noise and attempt to overcome the distraction
by mobilizing additional effort and redistributing their at-
tention. They express this complex and little understood pro-
cess by the simple statement "I tried to concentrate more." ¹³

The results of this study indicate that as the noise sound pres-
sure level was increased there may have been increased concentration by
the subject leading to a decrease in the eye regressions. The results
contradict Weinstein's statement that; "Unless the task is particularly
difficult, their coping strategy is successful and no effects of noise
are observed." ¹³ However, in other studies quoted by other researchers,
noise has improved, impaired or left unchanged the work of subjects. In
this study, increased concentration upon the visual task under increased
auditory stimulation was generally the rule and not the exception. This
may be an indication that the lower levels of sound were more relaxing
and the concentration level was decreased, while the highest sound pres-
sure level was very disruptive and the concentration level of the sub-
ject was increased to overcome the stimuli to a greater degree. Sub-
jectively, this was the indication from subjects.

Further studies should be done, particularly on younger age groups.
The subjects for this study were all college students with many years of
reading experience. Their reading skills were well developed and estab-
lished. Studies on younger children may indicate areas that will reveal
learning disabilities or possible difficulties. Comprehension studies and eye movement patterns would be helpful to determine proper or better eye movement patterns, leading to increased comprehension or comfort while reading. Extended reading time and its effects upon eye movement patterns may be studied. A more indepth study of reading rate and noise, comprehension and eye movements is needed. Subjects' interpretations of the task, their feedback about their work and the demands should be studied as to indicate areas that need further study. Their reports are a valuable source of information. Each study will reveal areas that should be pursued.
REFERENCES:


