Effects of Graphic Cueing Strategies in Text-Based Instruction on Comprehension and Retention

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ABSTRACT

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This experiment compares the effect of different graphic cueing strategies in text-based instruction. Participants were undergraduate university students, none of whom had prior knowledge of the subject matter used. The subjects were randomly assigned to four treatments and administered the following cueing strategies: (1) redundant graphic cueing, where the material covered in the embedded graphic overlapped the material in the text; (2) non-redundant graphic cueing, where the material covered in the embedded graphic was different from the material in the text; (3) the graphic organizer treatment, where a schematic representation of the relationship between the concepts was offered; and (4) a text only group serving as the control condition, where no graphic cueing was offered .

Two posttests were administered, one immediately after the treatments, and the other was delayed for two weeks. A Cloze test was also administered before the treatment to evaluate reading ability of the participants, the results were use as a covariate to reduce error variability.

An ANCOVA statistical procedure using the four treatments and the result on the reading ability test, was used to evaluate the results of the experiment on immediate and delayed recall of the dependent measures.

The results revealed that the experimental conditions and the effect of time were both significant factors in the experiment. No interaction was significant between these factors.

The results also showed that the graphic cueing conditions provided significantly better scores on both comprehension tests. No significant difference was found between the redundant and non-redundant conditions.

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To all the teachers of the department, for making it a place where it feels good to learn.

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INTRODUCTION

Are effects of all pictures equal ?

Text-based instruction is one of the oldest and most widely used methods of training and education, yet there is still no clear methodology to clarify the use of different elements in printed instructional materials. Illustrations in this context are often accepted and used as persuasive tools in instruction by teachers, publishers, graphic artist and educational technologist, yet research does not clearly indicate how print-based instructional material should be constructed.

Due to the proliferation of print based instructional material as a primary mode of instruction, it becomes essential that educational technologist examine the different factors that might contribute to the effectiveness of such materials. Practitioners and designers should not have to rely only on intuition or common sense, but should be able to base instructional decisions on solid grounds (Brody, 1982).

The written and spoken words are so omnipresent in our everyday life that we tend to forget that all of language is learned convention. Words are so present that it is even hard to imagine communicating or even thinking without them. Yet as very young children, we structure the world through our sense without the use of words, that is, before we start to learn a language. So it is in this context that it becomes fascinating to study how we recognize, store and recall information through the use of graphic representation.

Chapter 2

REVIEW OF THE LITERATURE

An overall picture

A review of the research on the effectiveness of pictures in instructional print material indicates that results often tend to be conflicting (Brody, 1981). Samuels (1970) reported that, generally, experiments in which pictures were added to text instruction did not show any significant increase in reading comprehension. However, several reviews done since then show that the use of illustrations can have small facilitative effect on comprehension (Moore & Readence, 1981). A review by Levie and Lentz (1982) has shown that illustrations can provide significant support to text-based learning . Finally, in a recent meta-analysis of Levin, Anglin and Carney (1987), the text-relevant illustration treatment demonstrated significant results over and above those reported by Levie and Lentz (1982). The last two reviews of the literature are particularly interesting because of the diversity of people in the sample, ranging from the third grade to college students, and by the high diversity of the type of illustrations used.

The inconsistency of the results obtained might suggest that when we are using pictorials in instructional material we are dealing with a set of complex variables, where comprehension might depend on a sophisticated interaction among the text, the illustrations, the learning style of the reader and the type of content to be learned (Brody, 1981). Even if the literature can only provide inconsistent results, there is a growing need in the field of educational technology, for guidelines in the use of graphic aids, and particularly in print based instruction (Duchastel, 1978).

Providing a set of such guidelines will require that we review some basic questions about the possible use of illustrations. First, we must understand that the word "illustration" is a generic term that covers a vast field of graphic representation from simple black and white line drawings to glossy color photographs. Then we must also consider that these representations are almost always used with a variety of other characteristics, like captioning techniques, position according to the text, and whether they share information with the text (Brody, 1981) .

So if we are to account for all the combinations of all the possible characteristics and for all the different types of graphic representation, it becomes clear that under the definition of illustration there is a vast field of possibilities, some of which might lead to increased learning and some of which might not.

Another major dimension in studying the effect of pictures is the function that graphic element plays in the instructional objectives. Graphics can be used in a variety of roles and instructional uses, from a pure decorative state to information processing and information retention.

There have been a few attempts at classifying the different functions of illustrations (Knowlton, 1966). Duchastel (1978) was one of the first to propose a classification based purely on the instructional roles of illustrations. He defined three basic instructional functions of an illustration. First, he suggests that illustrations have an attentional role, where the illustrations are used for motivational purpose, mainly to make the material more attractive. Secondly, illustrations can have an explicative role, where aspects of the material is delivered by the illustrations or by the combination of illustrations and text. Finally, there is the retentional role that illustrations can fulfill, where the illustration is used like mnemonic tools, and the learner, by remembering the illustration, will recall more easily the material related to it. Of course, some illustrations might provide a combination of these functions, so a picture might get the learners attention and at the same time provide information.

Another difficulty, brought about by the incredible variety of graphic types, their specific characteristics and functions, is that it becomes difficult to compare different studies in this area. One study might use simple black and white line drawing without captions and another, color photographs with extensive captions. In this example, positive results could be attributed to the use of the illustration, color, realistic illustration (being photographs), captioning technique or to a complex combination of some of the above. Other characteristics not implicitly stated in the experiment could also become important and challenge the validity of the experiment. Ogunyemi (1983) suggests that some type of material might be more suitable to visual representation. He argues that some technical instructional material is greatly reinforced by the use of illustrations. To solve some of this complexity, there is a need to compare some of these characteristics, so a conclusion can be reached about their use.

Many studies have found no significant difference between groups using graphic aids and those in the control group. The effect of illustrations on recall is often qualified as a statistically small effect (Duchastel, 1980), but when we consider the high variety of types of pictorial and the variables that comprise them, we cannot be sure what is causing what effect.

Knowing that in many cases the use of illustrations have provided significant results, we should stop trying to figure out whether illustrations can be useful in instruction and concentrate on studies evaluating the variables or situations that will make illustrations more effective instructional tools.

There is a definite need to develop studies around these variables and this is the purpose of this study. There is some research in this direction; for example, it has been found that the use of pictures as purely decorative tools, have produced no significant improvement in learning (Levin, Anglin & Carney, 1987) .

The debate over redundancy

Redundancy, is in particular, a factor that requires careful scrutiny. The use of graphics is very often synonymous with the redundancy of instructional content because the material covered by the graphic often overlaps the material provided by the text. Stone and Glock (1981) in their research on the use of graphics in text-based instruction found that there was significant improvement of result when the text and graphics provided redundant material. In such cases, it becomes difficult to assess what is the real cause of the difference in results. In this particular case, the use of graphics with text or the redundancy of the material are both plausible explanations for the significant difference in results.

So careful planning of such an experiment is important to isolate the major confounding variables so that they will not shed doubts on the results of the experiment (Clark & Clark, 1984). In this case, where a complex variable like graphic cueing is used, it is important to take into account a variable like redundancy that is often closely associated with graphic cueing.

Graphic organizers: A different kind of illustration

Graphic organizers, in the form of "concept maps" or "trees", are a completely different type of graphic cueing technique from that just discussed. Graphic organizers are specific visual aids aimed at providing learners with the key concepts and their organization in the material (Brown, 1988). Graphic organizers, like Ausubel's (1963) advanced organizers are thought to reach the learner's prior knowledge and favor information encoding, which should lead to better comprehension and retention (Alvermann, 1981). Their focus on the structure of prior and new concepts is the main difference that separates graphic organizers from other illustrations (Bernard, Petersen & Ally, 1981).

Graphic organizers also differ from other classical content organizers such as outlines, because concepts are not necessarily presented in the sequence of presentation, they are also different from flow charting or mapping in that the relationship between or among concepts is not explicitly presented (Moore & Readence, 1984).

One of the problems with the use of graphic organizers, is that the learner might not know how to use or might not recognize the benefits of using graphic organizers (Bovy, 1981). It is proposed in the literature, that efforts should be made to direct the learners in the use of graphic organizers (Alvermann, 1988; Bernard, 1990b).

Another point that is important to address, is the type of information that will be recalled. In the literature it is suggested that in some situations, material or type of learning will offer better results with graphic organizers (Mayer, 1979). For example, it might be proposed that the structure and the concepts used might be recalled with more ease, but that the recall of specific information embedded in the material might suffer.

Problem statements

One of the purposes of this study is to assess the effect of different graphic cueing techniques on comprehension and retention. It is expected that all the treatments using graphic cueing will increase the learners' retention of the material presented over the control condition. Levie and Lentz (1982), in their review of the use of different types of illustrations and graphics in text book instruction, found generally significant results. The results were even better when only text-relevant illustrations were used (Levin, Anglin & Carney, 1987).

A few experiments in the literature showed significant effects when message redundancy was used, meaning that when the information delivered by the pictorial was completely redundant to the text material (Stone & Glock, 1981) . So It is expected that the treatments delivering both illustrations and text in this study, will provide a better exposure to the material and in a more diversified way. Subjects exposed to that treatment should produce better results on the posttests .

In some experiments on graphic cueing, it is suggested that some methods of graphic cueing might provide better results over time (Ogunyemi, 1983). So it is expected that the gap between the graphic cueing groups and the text only group will increase over time.

Chapter 3

METHOD

Sample

The experimental sample used consisted of sixty four subjects who are undergraduate university students, registered in the Communication Studies Department of Concordia University. Sixteen subjects were randomly assigned to each condition in this experiment. The sample was composed of forty-one women and of twenty-three men, ranging in age from nineteen to twenty-six years old.

Most of the research mentioned in the literature was done with young children (Anglin, 1986), so this experiment is trying to verify these findings with an older sample selection.

Design and data analysis

This study used a posttest only control group design with four levels of independent variable. This design may be characterized as a 4 x 2 factorial, with repeated measures on the second factor (see figure 1).

Figure 1

Experimental design

	The text only condition	The graphic organizer condition	The redundant text and graphic condition	The non-redundant text and graphic condition
Immediate posttest	n=16	n=16	n=16	n=16
Delayed posttest	n=16	n=16	n=16	n=16

The results of a reading ability test were used as a covariate on all four treatment groups, although in the end the covariate was removed from the design because it did not predict posttest results significantly. An ANOVA procedure was used to evaluate the results of the experiment on immediate and delayed recall of the information administered.

Materials

Duchastel (1980) proposes that the selection of the subject matter to be used in these experiments, should be considered. Some material might not need explicative illustrations, while others might really benefit from them. Ogunyemi (1983) in his review of black and white pictorial instruction, also found that some technical content areas were more favorably disposed towards the use of pictures than others.

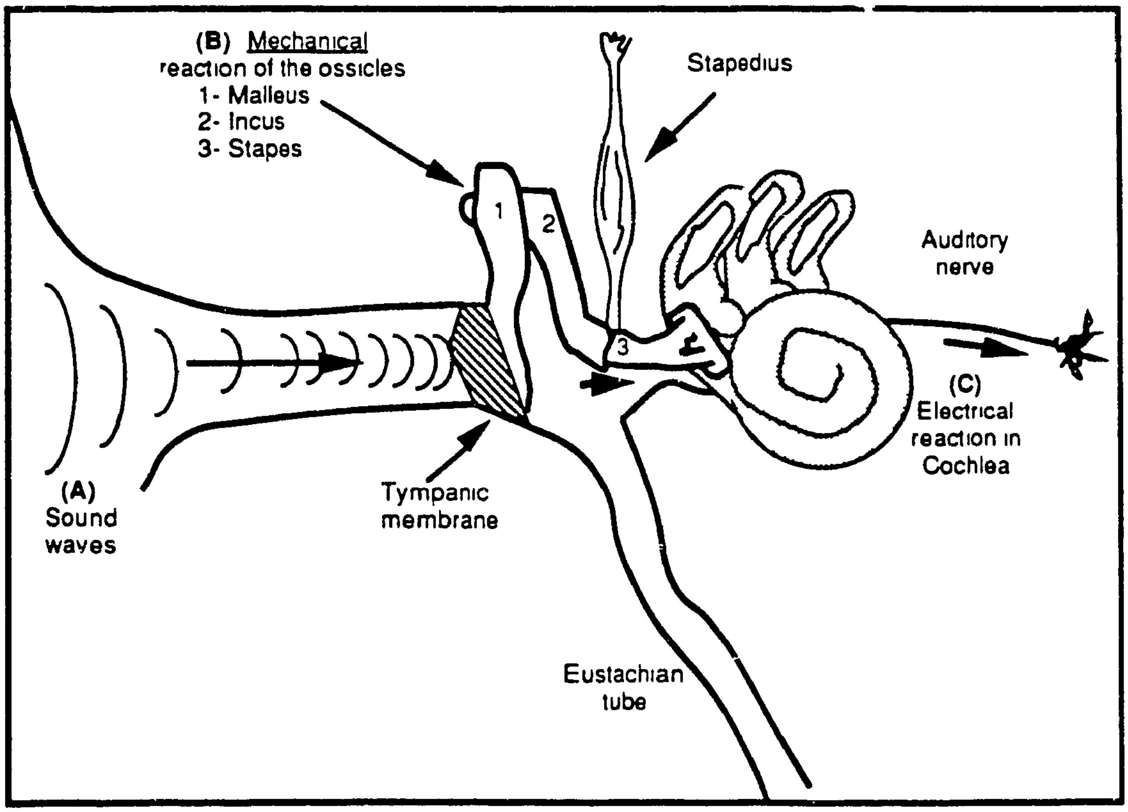
The experimental material that was used in this research, was a 1998 words unit of instruction entitled "The middle-ear muscles" adapted from an article by the same name published in the Scientific American of August 1989 (see appendix B). The instruction was selected and developed to match some of the interest of the sample and to increase the ecological validity of the experiment.

Figure 2

Example of the graphic treatments used in this study

Diagram of the mechanic of perceived sound:

Study this diagram carefully.
Locate all the parts and follow the process presented (A-B-C).



All graphic treatments used in this experiment were composed of line drawing and text, and all were in black and white (see an example in Figure 2). In all of these cases, instructive oral captions as defined by Bernard (1990a), were used to aid in the processing of the illustrations and graphic cueing techniques. Alvermann (1988) proposed that such guidance can make a difference when using graphic organizers or illustrations. All the graphic used were text-relevant representations of the material to be covered; none of the graphic were used for pure attentional or motivational purposes (Duchastel, 1978).

Graphic Treatments

All the treatments used in this experiment included the same number of instructional objectives. These objectives were also used to prepare the questions for the posttests. The only difference in the instructional packages provided as treatment in this experiment was the graphic strategy used to aid learner recall of the information in the lesson. A copy of the complete experimental packages is found in the appendix B.

Redundant graphic cueing: Learners in this group received a text-based lesson, where graphic cues were embedded throughout the lesson. The graphics used were redundant with the adjacent text in the lesson. The graphic and the text adjacent material in this treatment were presenting the same instructional content. Five graphics were embedded in the material in this condition.

Non-redundant graphic cueing: Learners in this group received a text-based lesson, where graphic cues were also embedded throughout the lesson. The graphics used in this case were not redundant with the adjacent text in the lesson, so that some of the instructional objectives in this treatment were covered by the text, and others by graphics. There was no overlap of information delivery between the two forms of content. The graphic and captions used for this condition were an exact copy of the ones used in the redundant cueing condition.

The graphic organizer treatment: Learners in this group received a text-based lesson where no graphic cues were embedded in the lesson. The graphics used in this treatment was an organizer, where a schematic representation of the concepts used was provided to the subject. This graphic aid was positioned at the beginning to act as an advance organizer, and was also placed at the end of the text-based lesson to act as a summarization tool. There is evidence that organizers of this type can function in both encoding and review (Mayer, 1979).

Text only group: Learners in this group received a text-based lesson covering the same instructional objectives as the previous treatments, but no graphic cueing strategies was used. This group was used as the control condition.

Instrumentation

Reading ability is the potential in an individual to comprehend written material. It can be measured in a variety of ways, one of which is a Cloze test. This was the measure used in this experiment. A Cloze test was administered prior to the treatment to evaluate reading ability of the participants. The reading ability test consisted of a one-page text entitled "Bad faith in counseling therapy" where the participants were asked to fill in fifty-five blank spaces with the adequate word while taking into account the content and structure of the text. This Cloze procedure was developed by a student of the educational technology department of Concordia University according to the methodology proposed by Rye (1982). The results of a pilot test, done with undergraduate students, showed a coefficient reliability of .64 when compared to the Form C of the Nelson-Denny Reading Test which is meant for college and undergraduate university students. The results that were obtained from this testing procedure were to be used as a covariate in the final analysis.

Two comprehension tests were the dependent measures used to investigate the effects of cueing in this study. For each comprehension test, fourteen multiple-choice questions were developed, one question for every instructional objective presented in the text. For each of these questions, five multiple choices were offered. Answers to these questions could not be found by just using the graphic organizer. No graphic were used in the comprehension tests to insure that no bias from this source would favor the graphic conditions. In such a case, subjects might only recall the images but not necessarily the content or processes presented in the material.

It is suggested in the literature that the effects of illustration have a tendency to become more effective over time (Ogunyemi, 1983). To test this assertion, a delayed test was administered two weeks after the treatment. This test used the same fourteen multiple choice questions, but the order of the questions and of the multiple choices for each question were randomly modified.

A formative evaluation of the complete experimental material was conducted with five undergraduate students from the target population and with four volunteers of mixed origins. This was done to ensure the readability of the material developed, and to estimate the time to complete each part of the experimental packages.

To ensure that no interaction would occur between each step of this experiment, the three main sections of the experiment were separated by putting them in separate envelopes. These envelopes were then identified by a stamped number, from one to three, identifying their sequence of use.

In the first envelope, the package consisted of a personal identification sheet that would be used again in the delayed posttest and would assure that adequate matching of immediate and delayed posttest was possible. The Cloze test providing the reading ability measure was also included in the first envelope.

In the second envelope, the experimental conditions were introduced. At the end of this section, another exercise was given to the subjects that had finished reading the material presented and did not want to go over the text again. This exercise consisted of twelve mathematical equations to solve which served as a distractor to fill in the time remaining. The mathematical test was considered to be content neutral. The immediate posttest was the only element in the third envelope.

The first page of each of the three sections was stamped with a four digit identification number, where the first digit identified the four experimental conditions and the last two digits were sequential numbers, from one to twenty, and would help match the three section completed by a specific subject. The three envelopes were then stapled to each other to insure that no mixing of the envelopes would occur.

Procedure

This experiment was conducted in a normal class setting. Two classes of unequal size were used in the sample. The experimental materials were randomly distributed to subjects. Aside from the number identifying each of the three envelopes, no external identification of the material was used, thus making it impossible for the subjects to discriminate between treatments. The packages from each condition were alternately placed in a box so that when distributed no adjacent subject would have the same treatments.

The subjects were informed prior to the start of the experiment, that they would receive three brown envelopes stapled together, and that each of these envelopes was identified with a number from one to three, that number representing a section of this experiment. Subject were asked to follow the specific instructions of the instructors and that they would be informed of the specific envelopes to open and of all the time constraints for each of the three parts of the experiment. They were also informed that they would be asked to place back each section of the package in the predetermined envelope after each step without having the possibility to refer back to it in the later steps. Finally subject were asked to work through the material in complete silence and that all questions should be referred directly to the instructor.

In the first part of the experiment, the subjects were asked to complete a personal information sheet that was later used to match immediate and delayed testing results. Upon completion of this sheet, the subject were given ten minutes to complete the Cloze test that evaluated the reading ability of the participants. Subjects were informed of the time remaining, half-way through this section to permit them to pace their efforts.

When the time limit was reached, subjects were instructed to return the first package to the first envelope and to open the second envelope. They were informed that there was a twenty minute limit for the second section. Again the subjects were informed of the time remaining, half-way through.

Two weeks after the treatment, the delayed test was administered in the same class settings. The delayed posttest package consisted of a personal information sheet, the same one that was used in the first part of the experiment, and of the delayed posttest. Fifteen minutes was the alloted time to complete this posttest.

Chapter 4

RESULTS

The purpose of this study was to determine the relative effectiveness of different cueing strategies as enhancements to learning. In order to do so an analysis of covariance (ANCOVA) procedure was intended to evaluate the results on immediate and delayed recall of the information administered. The analysis of covariance with repeated measure, was done using a MANOVA procedure on SPSS. In this way the comprehension variable used as a covariate could be used to evaluate and adjust the posttest results.

It was hypothesized that undergraduate students exposed to graphic cueing strategies would demonstrate superior recall and comprehension than those exposed to the same text-based lesson, but with no graphic cueing strategy. To insure that the results could be more generalizable, three types of graphic cueing strategies were used in this comparison. A comparison between certain types of graphic cueing strategies was also proposed in this study.

Drop outs

The delayed measure was gathered two weeks after the initial treatment. Six subjects of the initial sample did not attend the second class session. To keep the results of the covariate and of the immediate posttest, the means obtained by their specific group on the posttest were used as replacement of this measure. The replacement data used in this case, could not influence the magnitude or the variability of the group means either positively or negatively, but increased the sensitivity of the experiment by retaining the original sample size. The drop outs were distributed among all groups, two of these groups had two mean replacements and the other two groups had only one.

Assumptions of analysis of covariance.

Statistical analysis were performed on the data to test the assumptions of homogeneity of regression. The assumption states that the slopes of the regression lines (b_y) for all treatments are not significantly different from chance. Both immediate and delayed test were used with the four experimental conditions in this analysis.

Analysis of this data showed that the Cloze test results were not significantly different among the groups and that the homogeneity of regression for the two independent measures was not violated ($p > .05$). However, the results of this analysis also showed that the covariate used, did not explain enough of the posttest variance to be significant. In this case, the means of each group were not adjusted as normally done in an analysis of covariance, and one degree of freedom was returned to the error term and analysis of variance performed. It is presumed that the Cloze test was not significant because it varied radically in both form and content from the posttests. The Cloze test was designed for a nursing audience, which means that the terminology and content may have been insufficiently familiar to the Communication Studies students. In addition, the Cloze test is specifically intended to measure reading comprehension. The posttests, by contrast, measure recall and comprehension of the passage content.

Test of the design

Analysis of variance was conducted to test the difference due to the main effect for graphic cueing strategies, the main effect for time and their interaction. All hypotheses were confirmed or rejected using an alpha $\leq .05$ as this is considered an appropriate level for testing the significance of learning strategies.

Graphic cueing effect. Analysis on the main effect for the graphic conditions disclosed a significant difference among the different treatments, F (3, 60) = 7.53, $p < .05$ (see Table 4). Further inquiries can be found in the planned comparison section, where more information is provided about the difference between the different experimental conditions.

Time effect. Analysis on the main effect for the time (immediate and delayed posttest) also showed significant difference between the scores obtained between the immediate and delayed measures, F (1, 60) = 75.65, $p < .05$ (see Table 4).

Graphic cueing strategies x time effect. Analysis on the interaction of the different graphic cueing strategies with the factor of time showed no significant interaction between these two variables, F (3, 60) = 1.03, $p > .05$ (see Table 4).

Analytical comparisons

Analytical comparisons as defined by Keppel and Saufley (1980), were then used to test the different hypotheses involving differences among treatment groups.

The first comparison tested the hypothesis that the presence of a graphic cueing strategy in general is preferable to no graphic cueing strategy. Results showed that there was a significant difference between the average of the three graphic conditions and the control group, $F(1, 60) = 22.29$, $p < .05$ (see Table 5). A second comparison showed that there was no significant difference between the condition using the redundant graphics and the non-redundant graphics, $F(1, 60) = .007$, $p > .05$ (see Table 5).

Table 1

Means and Standard Deviation for the Comprehension Covariate

Cloze test (N= 64)

Strategy	M	SD
Text Only Group (Control)	27.25	9.22
Graphic organizer Group	29.94	6.88
Redundant Graphic Group	29.38	6.64
Non-Redundant Graphic Group	27.06	7.17
Entire Sample	28.41	7.48

Note: Scores are out of a total of 55.

Table 2

Means and Standard Deviation for the Immediate Posttest

(N= 64)

Strategy	M	SD	ES*
Text Only Group (Control)	6.13	1.86	------
Graphic organizer Group	8.25	2.36	1.14
Redundant Graphic Group	8.69	2.02	1.38
Non-Redundant Graphic Group	8.75	2.52	1.41
Entire Sample	7.95	2.41	------

* ES= effect size (M_T - M_C / SD_C)

Note: Scores are out of a total of 14.

Table 3

Means and Standard Deviation for the Delayed Posttest

(N= 58 *)

Strategy	*M*	SD	ES**
Text Only Group (Control)	3.94	2.11	------
Graphic organizer Group	6.94	2.52	1.42
Redundant Graphic Group	7.25	1.77	1.57
Non-Redundant Graphic Group	7.06	2.21	1.48
Entire Sample	6.30	2.52	------

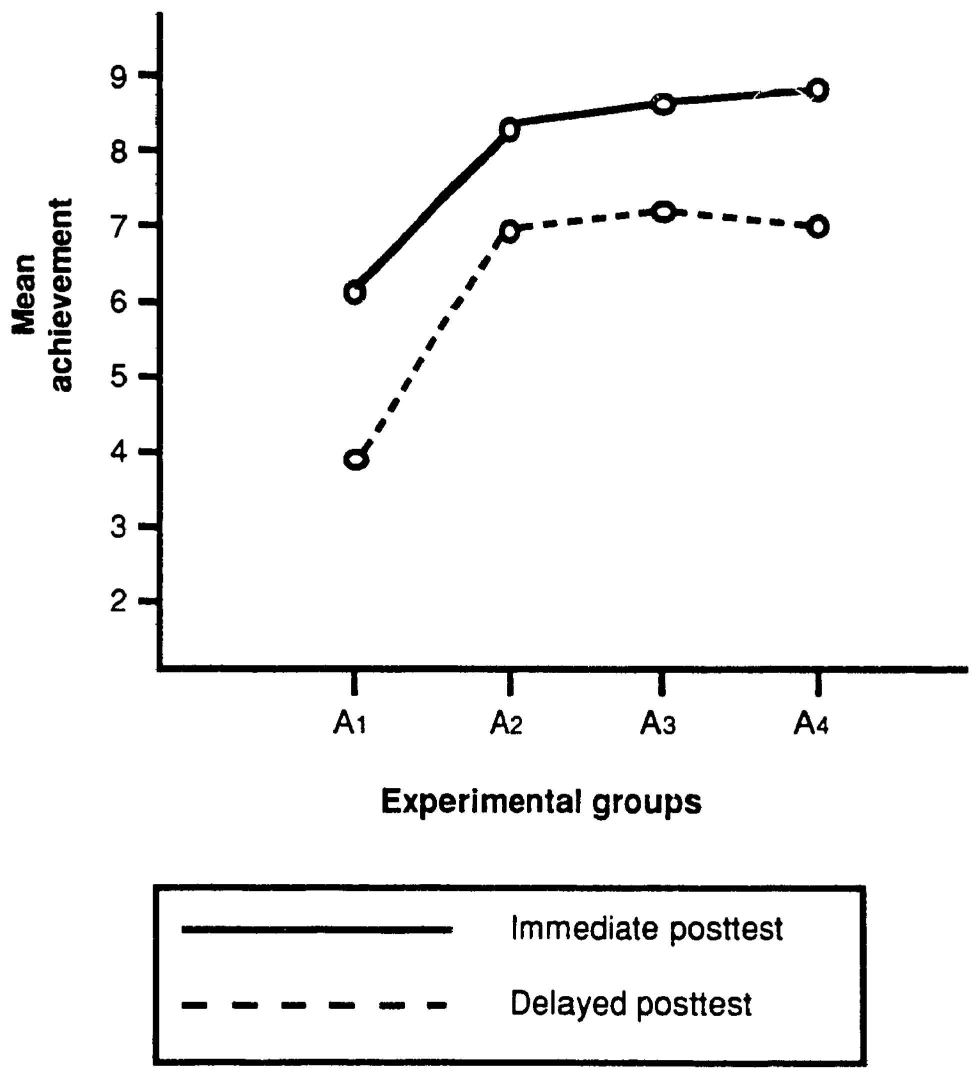
* Six subjects from the original sample did not show up for the delayed posttest. The means of their respective group was used in the following analysis.

** ES= effect size (M_T - M_C / SD_C)

Note: Scores are out of a total of 14.

Figure 3

Graph of the Means for the Immediate and Delayed Posttest



A1 is the text only condition
A2 is the graphic organizer condition
A3 is the non-redundant text and graphic condition
A4 is the redundant text and graphic condition

Table 4

Summary of the Analysis of Variance with Repeated Measures

Source	SS	df	MS	F	P
Groups	189.63	3	63.21	7.53	< .001
Error (1)	503.38	60	8.39		
Time	87.78	1	87,78	75.65	< .001
Group X Time	3.59	3	1.20	1.03	.385
Error (2)	69.62	60	1.16		

Table 5

Summary of the Analytical Comparisons

Source	SS	df	MS	F	P
A_1 vs A_2 & A_3 & A_4	187.04	1	187.04	22.29	$< .05$
A_3 vs A_4	.06	1	.06	.007	$> .05$
Error	503.38	60	8.39		

A_1 is the text only condition
A_2 is the graphic organizer condition
A_3 is the non-redundant text and graphic condition
A_4 is the redundant text and graphic condition

Chapter 5

DISCUSSION

This study was designed to isolate some of the factors that are relevant for instructional designers and practitioners who want to use illustrations as learning tools in text-based instruction.

The Covariate

The fact that the covariate was not a significant factor in this experiment was unexpected. It was expected that the covariate could explain some of the variance obtained thereby reducing the error associated with the dependent measure. Many hypotheses could explain the lack of discrimination offered by this instrument.

Since the time available for the Cloze test was restricted to ten minutes, this may have been a factor. More then half (about 55%) of the subjects in the experiment, did not complete the reading ability test. It is possible that that this factor reduced some of the discriminating power of the test.

Another variable that might be an important contributor to these results, is the subject matter used in the test. The passage entitled "Bad faith in counseling therapy" did not match the interest of the sample population. Anecdotal reactions collected after the delayed posttest indicated that some of the subjects in the sample felt awkward about the material offered in the reading ability measure. Rye (1982) suggest that it is important to keep the restricted test population in mind when constructing a teacher-made Cloze test. He also proposes that the Cloze procedure relies heavily on the passage itself to motivate the subject into filling in the gaps in a meaningful way. There was also the problem mentioned earlier of the mismatch between the intention of the Cloze test and the dependent measures. The Cloze test is designed to measure comprehension while the multiple-choice dependent measures primary assessed, content recall.

The graphic cueing conditions

The general hypothesis put forward in this study was that different cueing techniques would improve the comprehension and retention in text-based instruction. Since no interaction was found to be significant in the analysis of the data, we can draw conclusions directly from the main effects obtained and make specific comparison between groups, without the interference of a statistical interaction.

It was expected that the graphic conditions would be found to be a very significant factor in the experiment. Analytical comparisons as defined by Keppel and Saufley (1980) were used to test some of the different hypotheses and to identify some of the sources of this variance.

The result of a comparison involving all three graphic cueing groups and the control group, clearly indicates that an important source of these significant results may result from the effect of the graphic conditions. The outcome of this comparison is also consistent with the results of previous reviews in the literature (Levie & Lentz ,1982; Levin, Anglin & Carney, 1987).

Close inspection of group means reveals that all the groups using graphic cueing techniques achieved better scores on both the immediate and delayed posttest than the one using no cueing method (see Table 2 and 3). The effect size obtained for the immediate and delayed measures were substantially larger then those reported by Levie and Lentz (1982) in their review on the effects of text illustrations (about .4). Normally a graph of the means is used only to demonstrate a significant interaction, in this case, the graph in Figure 3, is presented to show the similarity of the patterns of the posttest measures obtained across the two week delayed testing interval. Therefore, it seems reasonable to suggest that there are some underlying common factors in all these conditions that may help the processing and the retention of the information found in text-based lesson.

These results also indirectly contribute to the hypothesis that the use of relevant illustrations will help comprehension and recall (Levin, Anglin & Carney, 1987).

The effect of time

Another hypothesis of this experiment was that methods of graphic cueing might increase the significance of the results over time (Ogunyemi, 1983). The result showed that there was a significant drop in the scores for all group, but that there was no significant interaction when comparing the difference between the immediate and posttest scores of each group.

A plausible explanation for this result, may be that the period of two weeks between the immediate and delayed comprehension test, might not be sufficient to reveal significant differences between the scores of the graphic cueing conditions and the scores of the text only group. It would be interesting to run the same experiment and to add another delayed test a few weeks later. Then we might have a better understanding of the effect of time in these circumstances. Even better, but not possible, in these instances would be a longitudinal field study of pictures and prose where the results could be evaluated on a regular basis and with a larger sample.

Another possibility for explaining that result, may be in the fact that many other confounding factors that might also be contributors to this type of effect, were under control in this experiment. The fact that only text-relevant illustrations were used, and that careful planning went into insuring that all the treatments had the same amount of elements to recall might have reduced the impact of this effect (Anglin,1987).

The effect of redundancy

One of the most interesting result obtained in this experiment was the comparison between the redundant and the non-redundant groups. No significant differences were found between these conditions throughout the experiment. The hypothesis that redundancy would increase recall and comprehension proposed by Stone and Glock (1981) is not confirmed in this experiment. One of the plausible explanations for this result, may be that the material used in that study was for very specific technical training, being the assembly of a model of a loading cart, and not targeted for conceptual retention and comprehension like in this study. The difference in results may be caused by the difference in content and instructional objectives.

This experiment clearly shows that information redundancy is not always a required factor in the success of graphic cueing. It is not easy to determine what is the cause of such a result but we could hypothesize that one or many contributing factors might replace or minimize the importance of information redundancy. Again factors like the strict use of text-relevant illustrations might minimize or replace the impact of the information redundancy.

The results of this experiment also suggest that the amount of information delivered to the subjects was not a significant factor. A confounding explanation closely related to the concept of redundancy is the amount of information provided to the subjects. Graphic cueing techniques often offer a larger amount of information to the subject because they are usually added to the basic text used in the control condition. This affirmation remains true if we were only to compare the graphic organizer and the redundant graphic conditions to the control group. There is more information provided to the subjects by both of this graphic cueing techniques then in the text only condition. So in this context, the amount of informations provided to the subject might still be a reasonably confounding explanation of the effect.

The results of the non-redundant condition clearly helps to reject this hypothesis. This condition delivered about the same amount of information as in the control group yet it obtained results closely match to the condition delivering more information. The only other explanation of the difference in that case, remains the means by which the information is provided to the subjects, either with or without a graphic cueing strategies.

Suggestions for improving this type of study

From the experience gathered in this study, there are a few things that would need to be corrected if someone would want to replicate this study. First it would be important to select a subject matter to be used in the Cloze test that is more closely related to the interest of the target population, so that the ecological validity of the measure would increase. The time suggested to complete the Cloze test needs also to be revised, ten minutes is clearly not enough. It would also be interesting to add a second delayed measure to verify if the posttest results would be different for a longer period of time.

More research on contributing factors is also needed to understand the impact of variables like, clarity of the graphic material, the importance of the visual aspects of certain subject matters and the types of testing used, just to mention just a few.

Conclusion

Graphic cueing strategies can be of major interest to teacher and instructional designers who rely heavily on text-based instruction. These techniques are easy to use and can be adapted to many situations. Depending on the nature of an educator's objectives, graphic cueing strategies tend to modify the processing and recall activities in a very direct way.

Further studies are required to explain the different facets of this complex of experimental variables. There is a great need to explain some of the attributes of illustrations, and to confront some of the confounding variables, so that clearer guidelines can be usefully provided to practitioners in the field.

Although the present study did not identify any major new strategies for incorporating illustrations in learning material, it does suggest that the use of some types of illustrations might provide very significant result in educational and training material. The results of this experiment add to the ones already in the literature that acknowledge the important role of text-relevant illustrations as an effective conveyor of information.

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APPENDICES

Note: All the material presented in this section was reduced to 80% of the size of the originals.

APPENDIX A:

The material in the first envelope.

Content:
-The personal identification sheet.
-Directions.
-The Cloze test.

(Step #1)

Directions : Please complete the following questionnaire.

Name or ID number: ____________________________

Age: _______

Sex: ( ) Female ( ) Male

Mother tongue: ( ) English ( ) French ( ) Other _______

Directions : When you have finished writing, please wait for instructions, before moving to next page.

(Step #2)

Directions : -Please complete the following sentences with the appropriate words.

-When you have finished writing, please wait for instructions, before moving to following step.

-Please, do not do anything else until you are told to do so

Bad faith in counseling therapy

The occurrence of bad ______

The question I should ______ to raise in this ______ is this: Can counseling ______ effective when the counselor ______ a person of bad ______ ? I am using the ______ "bad faith" in exactly ______ sense made famous by Sartre. ______ particular forms of bad ______ I have in mind ______ are those in which ______ person either deceives himself ______ deceives others. In either ______, of course, bad faith ______ a generalized form of ______ .

The point I wish ______ emphasize is that the ______ who operates in bad ______ is soon detected by ______ patient and that his ______ thereafter becomes nil. In ______, one might say that ______ counselor who shows bad faith ______ actually reinforce those patterns ______ behavior in the patient ______ prompted the latter to ______ help in the first ______ This would occur if ______ patient became cynical ______ the advice received, ______ is very likely to ______ when the counselee or ______ senses that the actions ______ by the counselor would ______. be part of the ______ own behavior pattern if ______ roles and contexts of ______ counselee and counselor were ______ . It is also likely ______ happen if the counselee ______ the strong impression that ______ values the counselor stresses ______ not genuinely part of ______ warp and woof of ______ counselor's own inner being

______ effect, if there is ______ law of diminishing returns ______ counseling, it would surely ______ in shortly after the ______ had become unmistakably aware ______ the bad faith of ______ counselor There are a ______ of situations in which ______ counselor can show bad ______ .

APPENDIX B:

The material in the second envelope.

For each of the experimental conditions:

Content:

-Directions.

-The experimental conditions.

-The exercise consisting of mathematical equations.

THE TEXT ONLY CONDITION

(Step #3)

Directions :	- Carefully read the following text. -When you have finished reading this text, you may re-read it as often as you wish in the alloted time. -A questionnaire on this text will be administered shortly after this section.

THE MIDDLE-EAR MUSCLES

Adapted from an article published in American Scientific of august 1989 by Erik Borg and Allen Counter

Tiny muscles behind the eardrum contract involuntarily when a person vocalizes or is exposed to a loud noise. This neuromuscular control system prevents sensory overload and enhances sound discrimination

Modern industry has produced a noisy world. The din of jackhammers, the whine of jet engines and the blare of amplified electric guitars have become all too common. It was therefore considerate of nature to have equipped the human ear with a rather sophisticated noise-reduction system: two small muscles that are attached to the ossicles, the tiny bones that connect the eardrum to the cochlea (the structure that houses the sound-receptor cells). When the muscles contract, they dampen the vibrations of the ossicles, thereby reducing the acoustic signal that ultimately reaches the inner ear.

Although they are skeletal muscles, (in fact they are smallest skeletal muscles in the human body), the middle-ear muscles are not under voluntary control. They contract reflexively about a tenth of a second after one or both ears are exposed to loud external sounds. Indeed, the characteristics of the reflex have become so well known that deviations from the normal response serve as a basis for diagnosing various hearing disorders and neurological conditions

The muscles of the middle ear contract not only in response to loud external sounds but also immediately before a person vocalizes This prevocalization reflex operates even when one speaks, sings or cries as softly as possible. Yet most evidence suggests that it is meant to protect the inner ear from the fatigue, interference and potential injury caused by one's own louder utterances, which can result in high sound levels in one's head. The shouting and wailing of children or babies, for example, can reach their own ears with the same intensity as the sound of a train passing nearby.

The middle-ear muscles do more than just indiscriminately attenuate internal or loud external sounds in humans. The muscles muffle primarily a loud sound's lower frequencies, which tend to overpower its higher frequencies. The net result of this frequency selectivity is to improve hearing-particularly of those sounds that contain many high-frequency components, such as human speech. In fact, the middle-ear muscles are what enables one to hear other people talking even while one is speaking.

Perceived sounds are air-pressure waves that have been funneled to the tympanic membrane, or ear-drum, causing it to vibrate. The vibrations are transmitted through the three ossicles in the middle ear (the malleus, incus and stapes) to the cochlea. The middle-ear mechanism-the eardrum and ossicle linkage-serves to convert the movements of low-density air into analogous movements of the higher-density fluid in the cochlea. The movements of the fluid are transmitted to fine hairlike receptor cells on the cochlea's basilar membrane. These cells trigger electrical impulses in the auditory nerve that are then interpreted by the brain as sound.

Attached to the ossicles are the two middle-ear muscles: the tensor tympani and the stapedius. The stapedius is the muscle under investigation in this study. The stapedius originates in the wall of the middle-ear cavity and ends near the articulation point between the stapes the incus.

The function of the muscles in human hearing was a subject of speculation until this century, when laboratory experiments on animals and clinical observation made a comparative analysis of their physiology possible. One of the most specialized middle-ear-muscle systems is seen in echolocating bats. Their powerful stapedius muscle contract at very high repetition rates as the bats make the rapid-fire click sounds that are their hunting cry. During each click a bat's middle-ear muscles reach peak tension quickly, but they relax just as suddenly so that the bat's ears will be sensitive to the click's echo from potential prey. The contraction-relaxation cycle lasts for only a few milliseconds (thousandths of a second) and can be repeated more than 100 times a second as the bat closes in on its prey. Studies have confirmed that the bat's middle-ear muscles contract reflexively several milliseconds before the start of vocalization and, when contracted, can dampen the sound energy reaching the inner ear by more than 20 decibels.

Experiments on individuals who have perforated eardrums show that the middle-ear muscles are active during vocalization in human beings as well. By inserting a harmless needle electrode through the perforation and into the stapedius, one can make an electromyogram (EMG) of the muscle as the subject vocalizes. An EMG records the electrical activity of muscle fibers, which increases as the fibers contract. Such EMG's have revealed that the electrical activity of the stapedius begins just before the subject makes a vocal sound; the activity increases as the vocalization becomes louder.

In most mammals both the tensor tympani and the stapedius muscles are subject to such a reflex, but in humans only the stapedius is. For that reason the middle-ear response to loud sounds in humans is called the acoustic stapedius reflex (ASR).

The ASR causes the stapes (the ossicle directly attached to the cochlea) to move some 50 microns (millionth of a meter) from its resting position, thereby increasing the stiffness of the ligaments reducing sound transmission to the inner ear by 20 decibels or more. Like the pupillary reflex (the contraction of both pupils in response to light shone in one eye), the ASR is normally observed in both ears, even if only one is stimulated acoustically The reflex is generally elicited by sounds that are between 80 and 90 decibels above a person's hearing threshold-about as loud as the sound of a noisy street.

The importance of the middle-ear muscles in human hearing has been a matter of considerable debate over the years. Several single function theories have been advanced, but the findings of many studies suggest that nature has been economical: it has given the muscles several separate but interrelated functions. Animal-model studies have made it fairly clear that the human stapedius is capable of protecting the inner-ear receptor cell from sustained, loud noise that might otherwise cause hearing loss. It offers specific protection in the frequency range that is most important for speech communication. Such hearing loss occurs when the inner ear suffers an acoustic battering that fractures the hairlike receptor cells.

The stapedius cannot protect the inner ear from the damage that can be caused by an exceedingly sharp and intense sound pulse. The stapedius requires between 100 and 200 milliseconds to contract fully-a response time that is too slow to muffle, say, the sound of a gunshot before it reaches the inner-ear receptors. (Actually, one can probably reduce the risk of inner-ear damage from the bang of a gunshot by humming before shooting, since the middle-ear muscles are activated automatically during vocalization).

The stapedius can attenuate loud, abrupt sounds only if they come in quick succession, since the muscle then has a chance to build up tension. Apparently, the middle-ear muscles evolved to cope with the sounds of nature, such as thunder and loud animal sounds, which tend to rise slowly. Nevertheless, they do a remarkable job of protecting one's hearing from much of the noise of modern industrial society.

Other recent investigations have shown that the stapedius muscle has an even more sophisticated role in human communication. Audiologists have noted that people with nonfunctional stapedius muscles tended to have some difficulty in distinguishing speech sounds when loud background noise was present or when the sounds were amplified greatly. The lack of functional stapedius muscles appeared to have hampered the subjects' ability to discriminate spoken words. How could that be ?

The answer becomes clear when one considers the way a sound wave is broken down into component frequencies in the long, spiral cavity of the cochlea. A sound wave propagating in the inner-ear fluid generates a traveling wave along the basilar membrane, which partitions the cochlear duct from beginning to end. Low-frequency sound components induce undulations in the membrane from the stapes all the way to the tip of the cochlear spiral, whereas the undulations of high-frequency components die out much more quickly and are confined to the area near the stapes. Because the low-frequency components dominate the undulations of the basilar membrane in the cochlea, low-pitched sounds of high intensity can drown out high-frequency sounds and even make them imperceptible.

Such "masking" of high-frequency sounds by low-frequency sounds is minimized by the ASR, since increasing the stiffness of the middle-ear linkage attenuates the low-frequency components of a complex sound more than it does the high-frequency components. Because many key speech sounds are generally high-pitched, the middle-ear muscles can actually enhance the perception of speech when they contract.

The ability of the stapedius muscle to maintain the ear's sensitivity to the frequencies encompassed by most speech sounds in spite of high sound levels was demonstrated experimentally . It was shown that the ASR can improve the threshold for the detection of high-frequency sound in noise by as much as 50 decibels. The stapedius also enhances one's ability to hear while speaking. A speaker's own ears are subjected to intense low-frequency vibrations that arise primarily from the enunciation of vowels. Fortunately, the prevocalization contraction of the middle-ear muscles prevents one's own speech from masking ambient high-frequency sounds. Indeed, the muscles are what makes it possible to hear soft sounds while one speaks.

The neural circuits that control the ASR and the prevocalization reflex are only now beginning to be understood. Modern techniques for the visualization of neurons in combination with the physiological studies have helped chart the intricate neuronal network that activates the middle-ear muscles

The neuronal pathway that controls the activation of the middle-ear muscles during self-vocalization has not been completely identified in mammals, but it probably has elements in common with the pathway that controls the muscles of the larynx, or voice box, during speech. Indeed, a reflex circuit from laryngeal receptors to the stapedius muscles has been found in some mammals.

In patients afflicted with Bell's palsy (facial paralysis), the ASR is reduced or blocked entirely in one ear if the lesion lies between the facial nerve's origin and the branch innervating that ear's stapedius. In such a case, the patients who have a paralyzed stapedius muscle as a result of Bell's palsy have helped elucidate the muscle's role in human hearing: they complain that their ears are hypersensitive to loud sounds and that what they hear is often distorted.

Conclusion

The evolution of the middle-ear cavity and its associated structures endowed vertebrates with an increased sensivity to sound. Yet that sensitivity, in turn, created a need for an efficient mechanism for coping with intense noises that would otherwise interfere with the perception of the sounds on which an animal's survival depends

The middle-ear-muscle system is nature's elegant solution. This system of sound mufflers and tuners effectively suppresses loud internal and external noise, allowing relevant soft sounds to be separated from irrelevant loud ones. Specifically, the muscle's reflexive contractions prevent desensitization of the auditory receptors, interference between high and low frequencies in the perception of sound, and injury to the inner ear. It is quite likely that the significant evolutionary advantage conferred by the middle-ear muscles accounts for their existence throughout the evolutionary scale, from the lower vertebrates to human beings.

The built-in reflexes of the middle-ear muscles have both enhanced the hearing of human beings and proved to be a reliable tool for determining the integrity of the ear and the neuronal circuits of the brain stem. It is likely that the application of the ASR will become even more important in the future for identifying individuals who are susceptible to noise-induced hearing loss as well as for rehabilitating those who have been outfitted with hearing aids.

Directions : -You have finished reading the text, you may re-read it as often as you wish in the alloted time.

-If you feel you do not need to re-read the text, you can turn to the next page and follow the instructions.

-Please, do not do anything else until you are told to do so.

Please complete the following equations.
(You may use a separate sheet for the calculations)

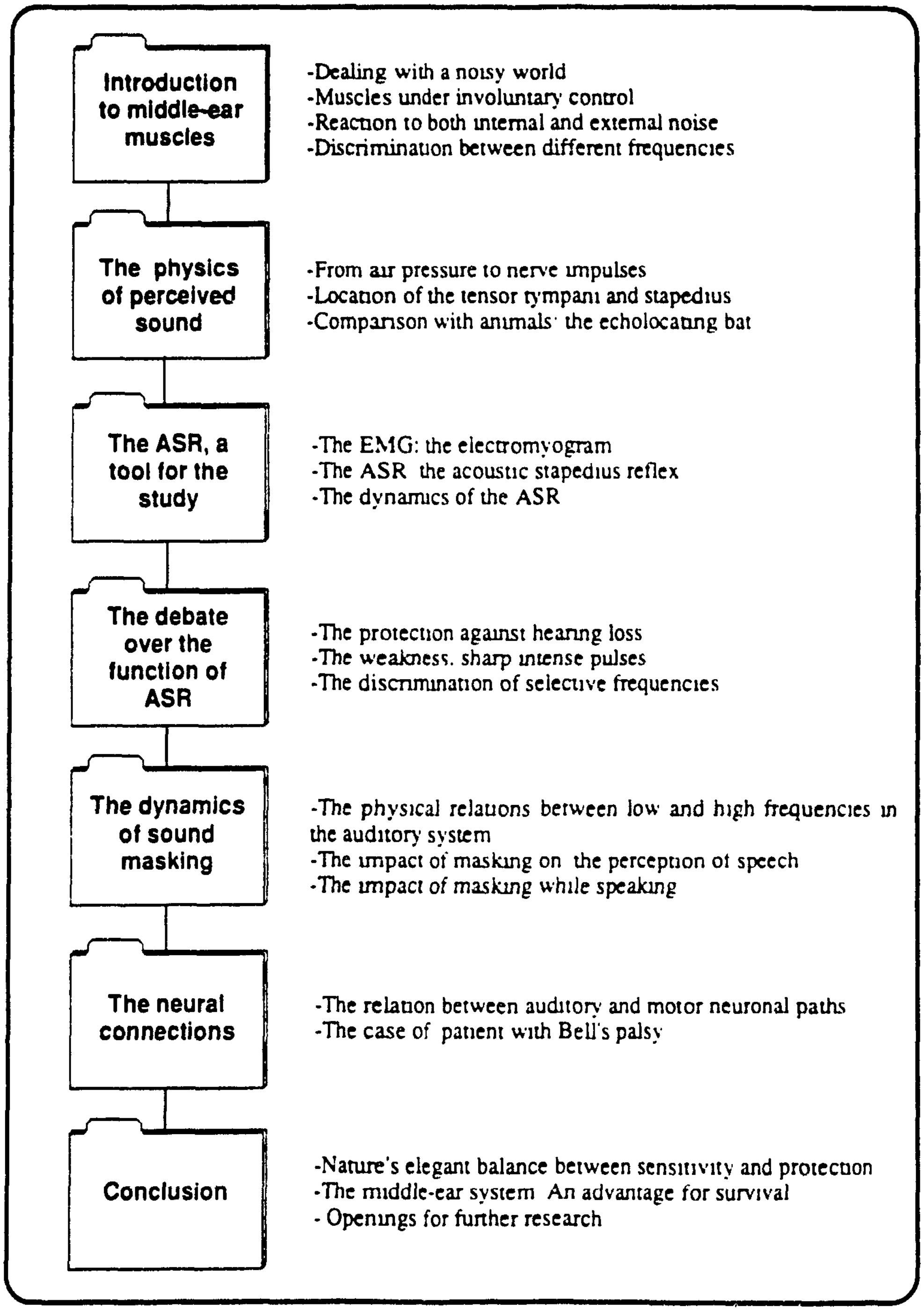
76465 + 96843 - 7676	67436 - 4575 + 7676	476576 + 423 - 54575	56756 - 7868 + 7676
12 X 17	29 X 12	73 X 42	92 X 12
125 /17	576 / 12	6544 / 85	92 / 12

THE GRAPHIC ORGANIZER CONDITION

(Step #3)

Directions :	- Carefully read the following text. -When you have finished reading this text, you may re-read it as often as you wish in the alloted time. -A questionnaire on this text will be administered shortly after this section

This diagram presents the key concepts and the way that they relate to each other in this text. Study this diagram carefully. This diagram will also be presented at the end of the text to help you review.



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This diagram presents the key concepts and the way that they relate to each other in this text. Study this diagram carefully

Introduction to middle-ear muscles	-Dealing with a noisy world -Muscles under involuntary control -Reaction to both internal and external noise -Discrimination between different frequencies
The physics of perceived sound	-From air pressure to nerve impulses -Location of the tensor tympani and stapedius -Comparison with animals: the echolocating bat
The ASR, a tool for the study	-The EMG: the electromyogram -The ASR: the acoustic stapedius reflex -The dynamics of the ASR
The debate over the function of ASR	-The protection against hearing loss -The weakness: sharp intense pulses -The discrimination of selective frequencies
The dynamics of sound masking	-The physical relations between low and high frequencies in the auditory system -The impact of masking on the perception of speech -The impact of masking while speaking
The neural connections	-The relation between auditory and motor neuronal paths -The case of patient with Bell's palsy
Conclusion	-Nature's elegant balance between sensitivity and protection -The middle-ear system: An advantage for survival - Openings for further research

Directions : -You have finished reading the text, you may re-read it as often as you wish in the alloted time.

-If you feel you do not need to re-read the text, you can turn to the next page and follow the instructions.

-Please, do not do anything else until you are told to do so.

Please complete the following equations.
(You may use a separate sheet for the calculations)

76465 + 96843 - 7676	67436 - 4575 + 7676	476576 + 423 - 54575	56756 - 7868 + 7676
12 X 17	29 X 12	73 X 42	92 X 12
125 /17	576 / 12	6544 / 85	92 / 12

THE REDUNDANT GRAPHIC CUEING CONDITION

(Step #3)

Directions :	- Carefully read the following text. -When you have finished reading this text, you may re-read it as often as you wish in the alloted time. -A questionnaire on this text will be administered shortly after this section.

THE MIDDLE-EAR MUSCLES

Adapted from an article published in American Scientific of august 1989 by Erik Borg and Allen Counter

Tiny muscles behind the eardrum contract involuntarily when a person vocalizes or is exposed to a loud noise. This neuromuscular control system prevents sensory overload and enhances sound discrimination

Modern industry has produced a noisy world The din of jackhammers, the whine of jet engines and the blare of amplified electric guitars have become all too common It was therefore considerate of nature to have equipped the human ear with a rather sophisticated noise-reduction system two small muscles that are attached to the ossicles, the tiny bones that connect the eardrum to the cochlea (the structure that houses the sound-receptor cells) When the muscles contract, they dampen the vibrations of the ossicles, thereby reducing the acoustic signal that ultimately reaches the inner ear.

Although they are skeletal muscles, (in fact they are smallest skeletal muscles in the human body), the middle-ear muscles are not under voluntary control. They contract reflexively about a tenth of a second after one or both ears are exposed to loud external sounds Indeed, the characteristics of the reflex have become so well known that deviations from the normal response serve as a basis for diagnosing various hearing disorders and neurological conditions

The muscles of the middle ear contract not only in response to loud external sounds but also immediately before a person vocalizes This prevocalization reflex operates even when one speaks, sings or cries as softly as possible. Yet most evidence suggests that it is meant to protect the inner ear from the fatigue, interference and potential injury caused by one s own louder utterances, which can result in high sound levels in one s head The shouting and wailing of children or babies, for example, can reach their own ears with the same intensity as the sound of a train passing nearby

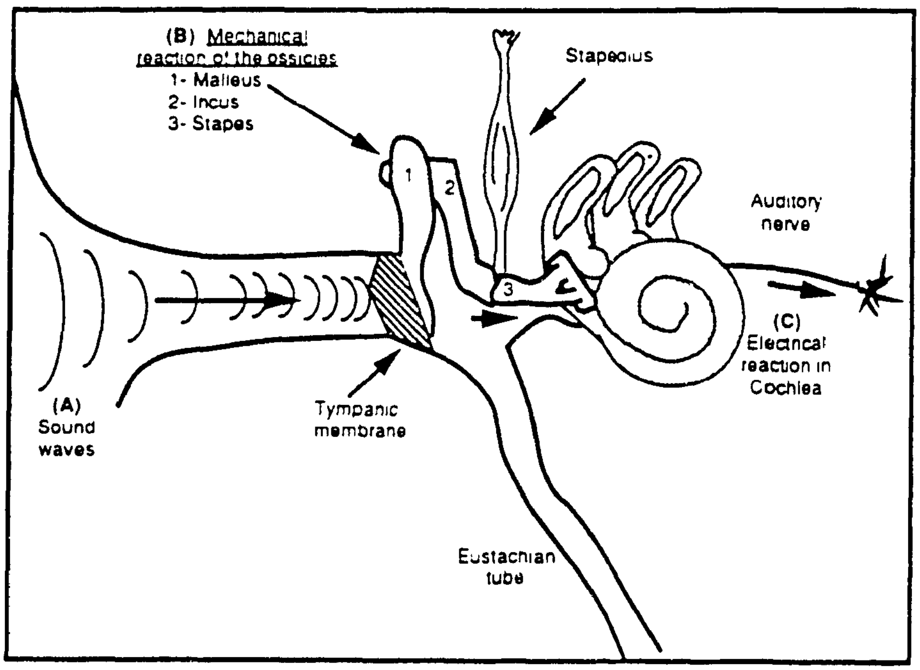
The middle-ear muscles do more than just indiscriminately attenuate internal or loud external sounds in humans. The muscles muffle primarily a loud sound s lower frequencies, which tend to overpower its higher frequencies The net result of this frequency selectivity is to improve hearing-particularly of those sounds that contain many high-frequency components, such as human speech. In fact, the middle-ear muscles are what enables one to hear other people talking even while one is speaking

1

Perceived sounds are air-pressure waves that have been funneled to the tympanic membrane, or ear-drum, causing it to vibrate. The vibrations are transmitted through the three ossicles in the middle ear (the malleus, incus and stapes) to the cochlea. The middle-ear mechanism-the eardrum and ossicle linkage-serves to convert the movements of low-density air into analogous movements of the higher-density fluid in the cochlea. The movements of the fluid are transmitted to fine hairlike receptor cells on the cochlea's basilar membrane. These cells trigger electrical impulses in the auditory nerve that are then interpreted by the brain as sound.

Diagram of the mechanic of perceived sound.

Study this diagram carefully. Locate all the parts and follow the process presented (A-B-C).



Attached to the ossicles are the two middle-ear muscles: the tensor tympani and the stapedius. The stapedius is the muscle under investigation in this study. The stapedius originates in the wall of the middle-ear cavity and ends near the articulation point between the stapes the incus.

The function of the muscles in human hearing was a subject of speculation until this century, when laboratory experiments on animals and clinical observation made a comparative analysis of their physiology possible. One of the most specialized middle-ear-muscle systems is seen in echolocating

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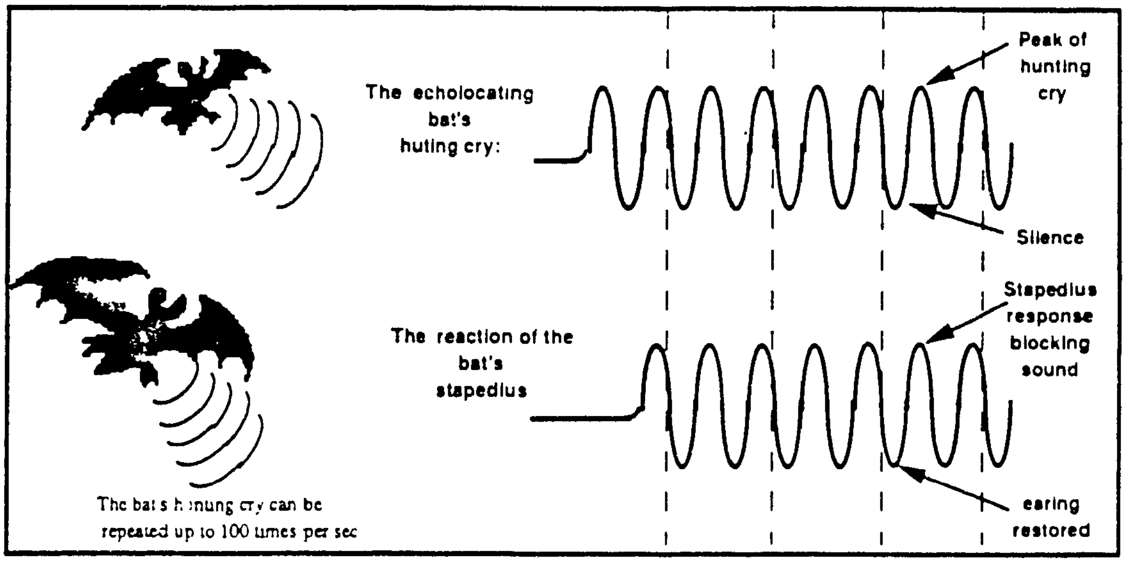
bats. Their powerful stapedius muscle contract at very high repetition rates as the bats make the rapid-fire click sounds that are their hunting cry. During each click a bat's middle-ear muscles reach peak tension quickly, but they relax just as suddenly so that the bat s ears will be sensitive to the click's echo from potential prey. The contraction-relaxation cycle lasts for only a few milliseconds (thousandths of a second) and can be repeated more than 100 times a second as the bat closes in on its prey. Studies have confirmed that the bat's middle-ear muscles contract reflexively several milliseconds before the start of vocalization and, when contracted, can dampen the sound energy reaching the inner ear by more than 20 decibels

Diagram of the reaction of the bat's stapedius to the hunting cry it produces.

Study this diagram carefully. Compare the reaction of the stapedius to the production of bat's hunting cry. Draw conclusions from this comparaison.



Experiments on individuals who have perforated eardrums show that the middle-ear muscles are active during vocalization in human beings as well. By inserting a harmless needle electrode through the perforation and into the stapedius, one can make an electromyogram (EMG) of the muscle as the subject vocalizes. An EMG records the electrical activity of muscle fibers, which increases as the fibers contract. Such EMG's have revealed that the electrical activity of the stapedius begins just before the subject makes a vocal sound; the activity increases as the vocalization becomes louder.

3

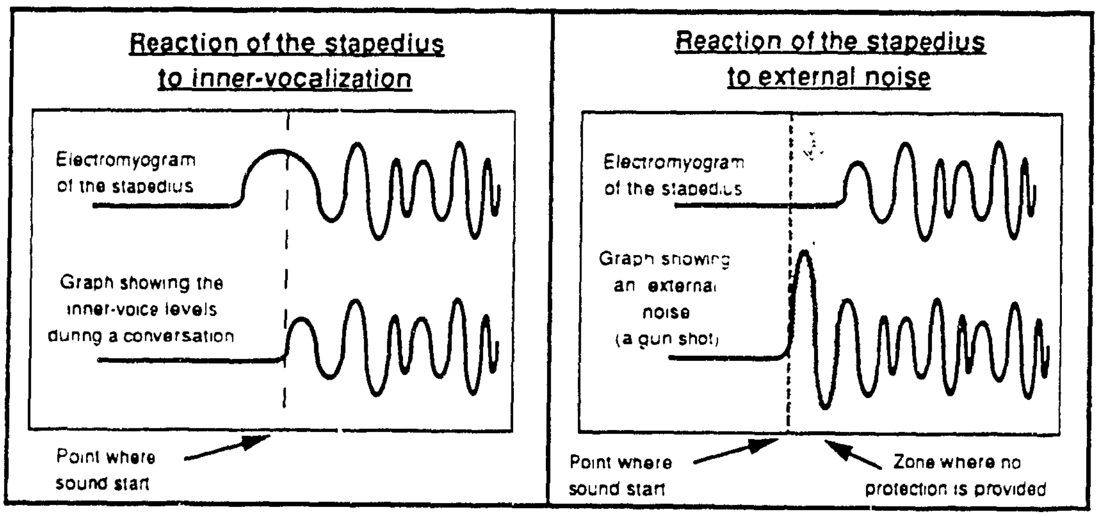
threshold-about as loud as the sound of a noisy street.

The importance of the middle-ear muscles in human hearing has been a matter of considerable debate over the years. Several single function theories have been advanced, but the findings of many studies suggest that nature has been economical: it has given the muscles several separate but interrelated functions. Animal-model studies have made it fairly clear that the human stapedius is capable of protecting the inner-ear receptor cell from sustained, loud noise that might otherwise cause hearing loss. It offers specific protection in the frequency range that is most important for speech communication. Such hearing loss occurs when the inner ear suffers an acoustic battering that fractures the hairlike receptor cells.

The stapedius cannot protect the inner ear from the damage that can be caused by an exceedingly sharp and intense sound pulse The stapedius requires between 100 and 200 milliseconds to contract fully-a response time that is too slow to muffle, say, the sound of a gunshot before it reaches the inner-ear receptors (Actually, one can probably reduce the risk of inner-ear damage from the bang of a gunshot by humming before shooting, since the middle-ear muscles are activated automatically during vocalization)

Diagram comparing the reaction of the stapedius reflex (ASR) to internal and external noise:

Study all the parts of this diagram carefully Compare when the stapedius is activated for each situation Draw conclusions on the protection offered from this comparaison



5

The stapedius can attenuate loud, abrupt sounds only if they come in quick succession, since the muscle then has a chance to build up tension. Apparently, the middle-ear muscles evolved to cope with the sounds of nature, such as thunder and loud animal sounds, which tend to rise slowly. Nevertheless, they do a remarkable job of protecting one's hearing from much of the noise of modern industrial society.

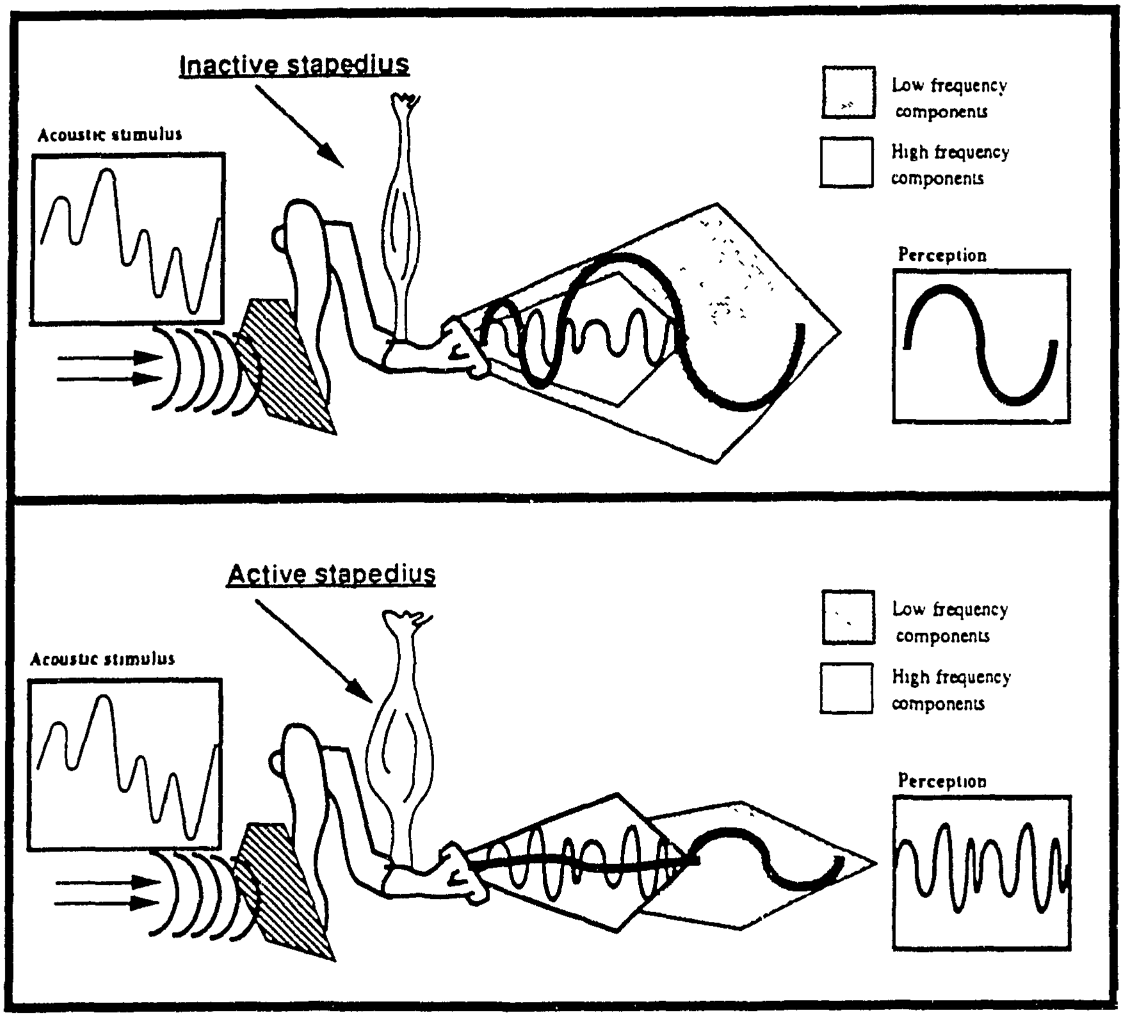
Other recent investigations have shown that the stapedius muscle has an even more sophisticated role in human communication. Audiologists have noted that people with nonfunctional stapedius muscles tended to have some difficulty in distinguishing speech sounds when loud background noise was present or when the sounds were amplified greatly The lack of functional stapedius muscles appeared to have hampered the subjects' ability to discriminate spoken words. How could that be ?

The answer becomes clear when one considers the way a sound wave is broken down into component frequencies in the long, spiral cavity of the cochlea A sound wave propagating in the inner-ear fluid generates a traveling wave along the basilar membrane, which partitions the cochlear duct from beginning to end Low-frequency sound components induce undulations in the membrane from the stapes all the way to the tip of the cochlear spiral, whereas the undulations of high-frequency components die out much more quickly and are confined to the area near the stapes Because the low-frequency components dominate the undulations of the basilar membrane in the cochlea, low-pitched sounds of high intensity can drown out high-frequency sounds and even make them imperceptible.

Such «masking» of high-frequency sounds by low-frequency sounds is minimized by the ASR, since increasing the stiffness of the middle-ear linkage attenuates the low-frequency components of a complex sound more than it does the high-frequency components. Because many key speech sounds are generally high-pitched, the middle-ear muscles can actually enhance the perception of speech when they contract

Diagram presenting the frequency discrimination effect of the stapedius reflex (ASR):

Study all the parts of this diagram carefully. Compare the results obtained when the stapedius is activate and inactivate. Draw conclusions from this comparaison.



The ability of the stapedius muscle to maintain the ear's sensitivity to the frequencies encompassed by most speech sounds in spite of high sound levels was demonstrated experimentally . It was shown that the ASR can improve the threshold for the detection of high-frequency sound in noise by as much as 50 decibels. The stapedius also enhances one's ability to hear while speaking. A speaker's own ears are subjected to intense low-frequency vibrations that arise primarily from the enunciation of vowels. Fortunately, the prevocalization contraction of the middle-ear muscles prevents one's own speech from masking ambient high-frequency sounds. Indeed, the muscles are

7

what makes it possible to hear soft sounds while one speaks.

The neural circuits that control the ASR and the prevocalization reflex are only now beginning to be understood. Modern techniques for the visualization of neurons in combination with the physiological studies have helped chart the intricate neuronal network that activates the middle-ear muscles

The neuronal pathway that controls the activation of the middle-ear muscles during self-vocalization has not been completely identified in mammals, but it probably has elements in common with the pathway that controls the muscles of the larynx, or voice box, during speech Indeed, a reflex circuit from laryngeal receptors to the stapedius muscles has been found in some mammals.

In patients afflicted with Bell's palsy (facial paralysis), the ASR is reduced or blocked entirely in one ear if the lesion lies between the facial nerve's origin and the branch innervating that ear's stapedius In such a case, the patients who have a paralyzed stapedius muscle as a result of Bell's palsy have helped elucidate the muscle's role in human hearing They complain that their ears are hypersensitive to loud sounds and that what they hear is often distorted

Conclusion

The evolution of the middle-ear cavity and its associated structures endowed vertebrates with an increased sensivity to sound Yet that sensitivity, in turn, created a need for an efficient mechanism for coping with intense noises that would otherwise interfere with the perception of the sounds on which an animal's survival depends

The middle-ear-muscle system is nature's elegant solution. This system of sound mufflers and tuners effectively suppresses loud internal and external noise, allowing relevant soft sounds to be separated from irrelevant loud ones. Specifically, the muscle's reflexive contractions prevent desensitization of the auditory receptors, interference between high and low frequencies in the perception of sound, and injury to the inner ear It is quite likely that the significant evolutionary advantage conferred by the middle-ear muscles accounts for their existence throughout the evolutionary scale, from the lower vertebrates to human beings

The built-in reflexes of the middle-ear muscles have both enhanced the hearing of human beings and proved to be a reliable tool for determining the integrity of the ear and the neuronal circuits of the brain stem. It is likely that the application of the ASR will become even more important in the future for identifying individuals who are susceptible to noise-induced hearing loss as well as for rehabilitating those who have been outfitted with hearing aids.

Directions : -You have finished reading the text, you may re-read it as often as you wish in the alloted time.

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(You may use a separate sheet for the calculations)

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12 X 17	29 X 12	73 X 42	92 X 12
125 /17	576 / 12	6544 / 85	92 / 12

THE NON-REDUNDANT GRAPHIC CUEING CONDITION

(Step #3)

Directions :	- Carefully read the following text. -When you have finished reading this text, you may re-read it as often as you wish in the alloted time. -A questionnaire on this text will be administered shortly after this section.

THE MIDDLE-EAR MUSCLES

Adapted from an article published in American Scientific of august 1989 by Erik Borg and Allen Counter

Tiny muscles behind the eardrum contract involuntarily when a person vocalizes or is exposed to a loud noise. This neuromuscular control system prevents sensory overload and enhances sound discrimination

Modern industry has produced a noisy world. The din of jackhammers, the whine of jet engines and the blare of amplified electric guitars have become all too common. It was therefore considerate of nature to have equipped the human ear with a rather sophisticated noise-reduction system: two small muscles that are attached to the ossicles, the tiny bones that connect the eardrum to the cochlea (the structure that houses the sound-receptor cells). When the muscles contract, they dampen the vibrations of the ossicles, thereby reducing the acoustic signal that ultimately reaches the inner ear.

Although they are skeletal muscles, (in fact they are smallest skeletal muscles in the human body), the middle-ear muscles are not under voluntary control. They contract reflexively about a tenth of a second after one or both ears are exposed to loud external sounds. Indeed, the characteristics of the reflex have become so well known that deviations from the normal response serve as a basis for diagnosing various hearing disorders and neurological conditions.

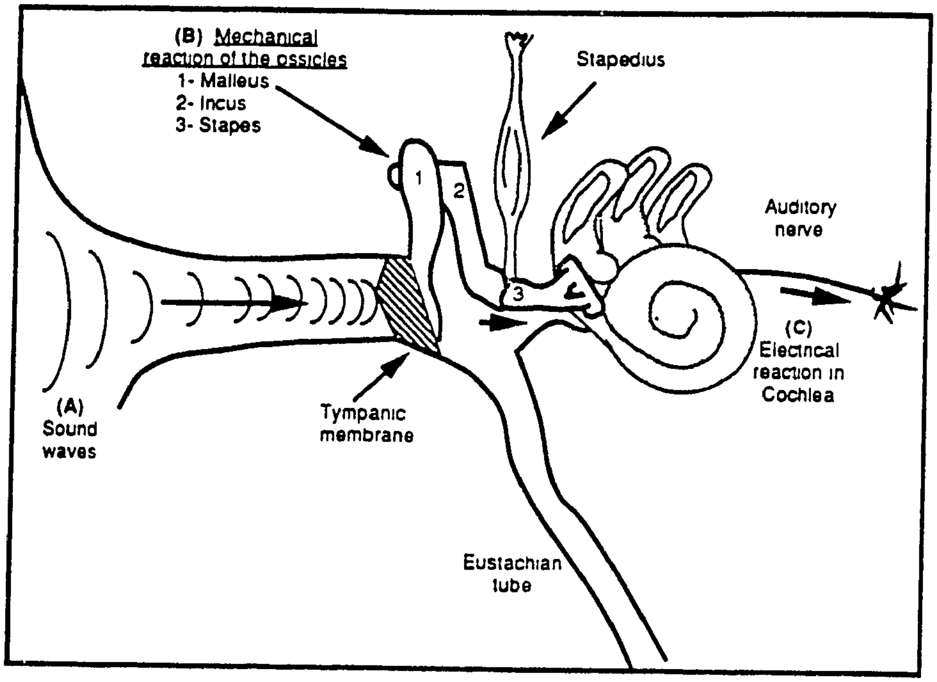
The muscles of the middle ear contract not only in response to loud external sounds but also immediately before a person vocalizes. This prevocalization reflex operates even when one speaks, sings or cries as softly as possible. Yet most evidence suggests that it is meant to protect the inner ear from the fatigue, interference and potential injury caused by one's own louder utterances, which can result in high sound levels in one's head. The shouting and wailing of children or babies, for example, can reach their own ears with the same intensity as the sound of a train passing nearby.

1

The middle-ear muscles do more than just indiscriminately attenuate internal or loud external sounds in humans. The muscles muffle primarily a loud sound's lower frequencies, which tend to overpower its higher frequencies. The net result of this frequency selectivity is to improve hearing-particularly of those sounds that contain many high-frequency components, such as human speech. In fact, the middle-ear muscles are what enables one to hear other people talking even while one is speaking.

Diagram of the mechanic of perceived sound:

Study this diagram carefully. Locate all the parts and follow the process presented (A-B-C).



The stapedius is the muscle under investigation in this study. The stapedius originates in the wall of the middle-ear cavity and ends near the articulation point between the stapes the incus

The function of the muscles in human hearing was a subject of speculation until this century, when laboratory experiments on animals and clinical observation made a comparative analysis of their physiology possible.

Diagram of the reaction of the bat's stapedius to the hunting cry it produces:

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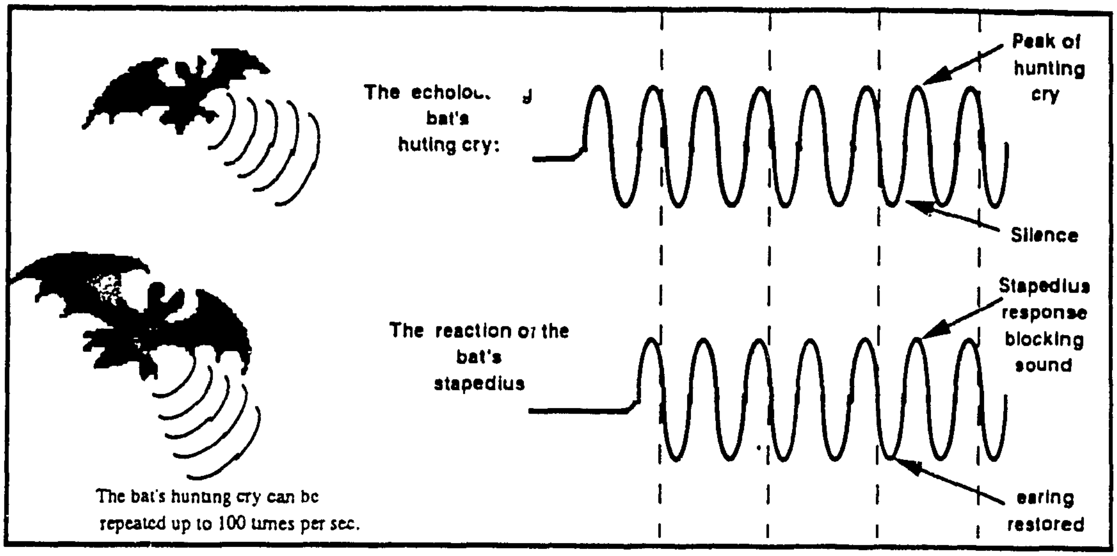


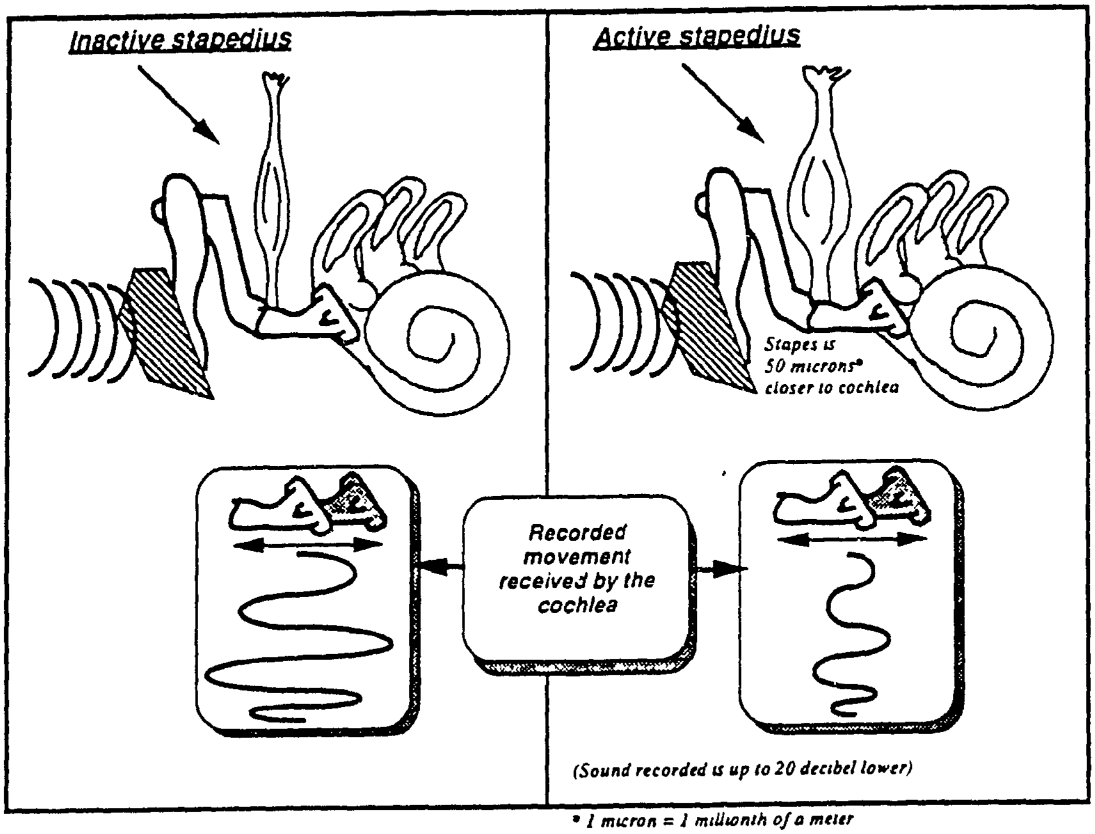
Studies have confirmed that the bat's middle-ear muscles contract reflexively several milliseconds before the start of vocalization and, when contracted, can dampen the sound energy reaching the inner ear by more than 20 decibels.

Experiments on individuals who have perforated eardrums show that the middle-ear muscles are active during vocalization in human beings as well. By inserting a harmless needle electrode through the perforation and into the stapedius, one can make an electromyogram (EMG) of the muscle as the subject vocalizes. An EMG records the electrical activity of muscle fibers, which increases as the fibers contract. Such EMG's have revealed that the electrical activity of the stapedius begins just before the subject makes a vocal sound; the activity increases as the vocalization becomes louder

In most mammals both the tensor tympani and the stapedius muscles are subject to such a reflex, but in humans only the stapedius is. For that reason the middle-ear response to loud sounds in humans is called the acoustic stapedius reflex (ASR).

Diagram showing the impact of activating the acoustic stapedius reflex (ASR):

Study this diagram carefully. Compare the results obtained when the stapedius is active and inactive. Draw conclusions from this comparaison.



Like the pupillary reflex (the contraction of both pupils in response to light shone in one eye), the ASR is normally observed in both ears, even if only one is stimulated acoustically. The reflex is generally elicited by sounds that are between 80 and 90 decibels above a person's hearing threshold-about as loud as the sound of a noisy street.

The importance of the middle-ear muscles in human hearing has been a matter of considerable debate over the years. Several single function theories have been advanced, but the findings of many studies suggest that nature has been economical: it has given the muscles several separate but interrelated functions. Animal-model studies have made it fairly clear that the human stapedius is capable of protecting the inner-ear receptor cell from sustained, loud noise that might otherwise

4

cause hearing loss. It offers specific protection in the frequency range that is most important for speech communication. Such hearing loss occurs when the inner ear suffers an acoustic battering that fractures the hairlike receptor cells.

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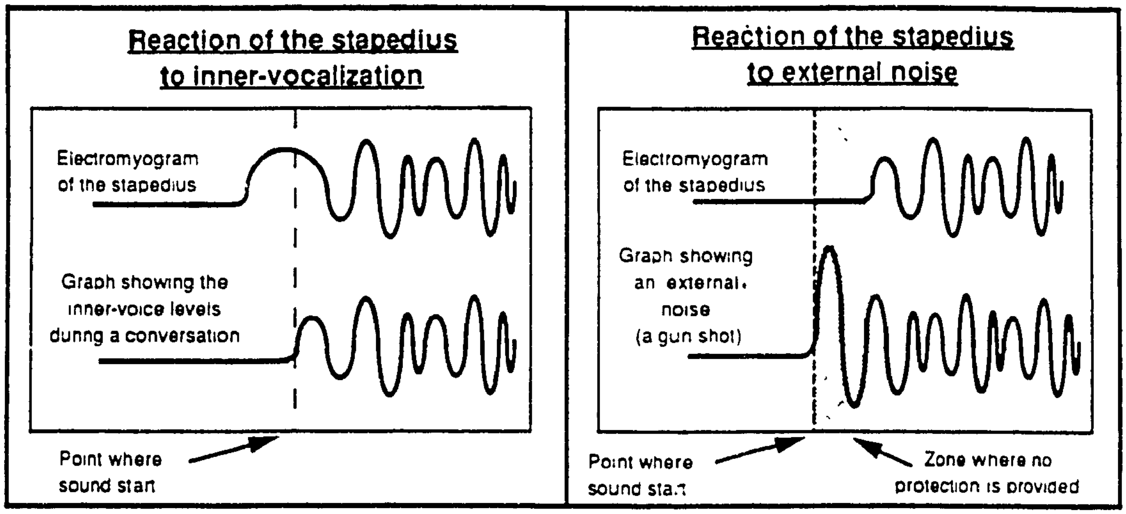

The stapedius can attenuate loud, abrupt sounds only if they come in quick succession, since the muscle then has a chance to build up tension. Apparently, the middle-ear muscles evolved to cope with the sounds of nature, such as thunder and loud animal sounds, which tend to rise slowly Nevertheless, they do a remarkable job of protecting one's hearing from much of the noise of modern industrial society

Other recent investigations have shown that the stapedius muscle has an even more sophisticated role in human communication. Audiologists have noted that people with nonfunctional stapedius muscles tended to have some difficulty in distinguishing speech sounds when loud background noise was present or when the sounds were amplified greatly. The lack of functional stapedius muscles appeared to have hampered the subjects' ability to discriminate spoken words How could that be ?

The answer becomes clear when one considers the way a sound wave is broken down into

5

component frequencies in the long, spiral cavity of the cochlea. A sound wave propagating in the inner-ear fluid generates a traveling wave along the basilar membrane, which partitions the cochlear duct from beginning to end

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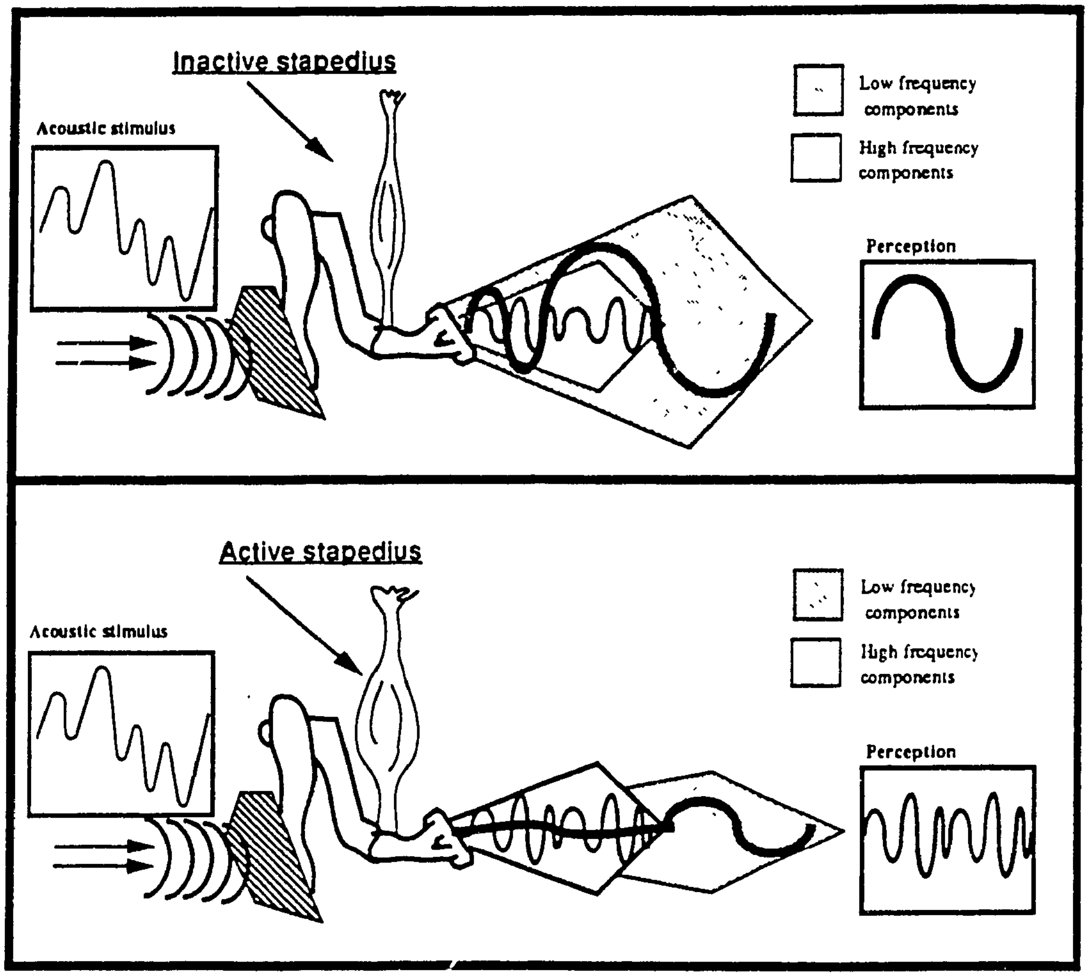

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The neural circuits that control the ASR and the prevocalization reflex are only now beginning to be understood. Modern techniques for the visualization of neurons in combination with the physiological studies have helped chart the intricate neuronal network that activates the middle-ear muscles.

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Conclusion

The evolution of the middle-ear cavity and its associated structures endowed vertebrates with an increased sensivity to sound. Yet that sensitivity, in turn, created a need for an efficient mechanism for coping with intense noises that would otherwise interfere with the perception of the sounds on which an animal's survival depends.

The middle-ear-muscle system is nature's elegant solution This system of sound mufflers and tuners effectively suppresses loud internal and external noise, allowing relevant soft sounds to be separated from irrelevant loud ones Specifically, the muscle's reflexive contractions prevent desensitization of the auditory receptors, interference between high and low frequencies in the perception of sound, and injury to the inner ear. It is quite likely that the significant evolutionary advantage conferred by the middle-ear muscles accounts for their existence throughout the evolutionary scale, from the lower vertebrates to human beings.

The built-in reflexes of the middle-ear muscles have both enhanced the hearing of human beings and proved to be a reliable tool for determining the integrity of the ear and the neuronal circuits of the brain stem. It is likely that the application of the ASR will become even more important in the future for identifying individuals who are susceptible to noise-induced hearing loss as well as for rehabilitating those who have been outfitted with hearing aids.

7

Directions : -You have finished reading the text, you may re-read it as often as you wish in the alloted time.

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-Please, do not do anything else until you are told to do so.

Please complete the following equations.
(You may use a separate sheet for the calculations)

76465 + 96843 - 7676	67436 - 4575 + 7676	476576 + 423 - 54575	56756 - 7868 + 7676
12 X 17	29 X 12	73 X 42	92 X 12
125 /17	576 / 12	6544 / 85	92 / 12

APPENDIX C:

The material in the third envelope.

<u>Content:</u>

-The immediate posttest.

Directions :	-For each of the following questions, choose the **BEST** answer based on the text you have read -Please do not refer back to the text section to answer to these questions.

1- Nature has provided humans with a sophisticated noise reduction system to cope with our noisy world. What are the key components of this system Select the best answer.

A- The EMG and the ASR.
B- The stapedius' reaction on the ossicles
C- The ligaments of the tympanic membrane
D- The electrical reaction in the Cochlea.
E- None of the above

The best answer is _____

2- What is one particularity of the middle-ear muscles ?

A- They are skeletal muscles that they are not under voluntary control
B- They are directly connected to the auditory nerve
C- They are directly connected to the tensor tympani
D- They are the only facial muscles that are under voluntary control
E- None of the above.

The best answer is _____

3- The middle-ears muscles are designed to react to

A- Loud external noise.
B- Sharp and intense pulse.
C- Sound during vocalization.
D- Both A and C.
E- Both B and C.

The best answer is _____

4- Which of the following best describe the mechanics of perceived sound ?

A- The transformation of mechanical vibration in the cochlea triggering electrical impulses in the auditory nerve .
B- Air-pressure waves causing the ear-drum to vibrate.
C- The mechanical transmission of vibrations through the ossicles to the cochlea.
D- All of the above.
E- None of the above

The best answer is _____

5- What are the names of the two middle-ear muscles ?

A- Incus and stapedius
B- Tympanic membrane and stapedius
C- Tensor tympani and stapedius
D- Incus and Malleus
E- Stapes and stapedius

The best answer is _____

6- What is so special about the middle-ear muscles of the echolocating bats ?

A- They increase sound sensitivity by 30 decibels.
B- They help keep the bat's balance during flight.
C- They mask the extremely rapid rate of the bat's hunting cry
D- All of the above.
E- None of the above.

The best answer is _____

7- What is an EMG ?

A- The recorded mechanical activity of the tympanic membrane.
B- An electromyogram.
C- The recorded electrical activity of the stapedius muscle.
D- Both A and B.
E- Both B and C.

The best answer is _____

8- What is the acoustic stapedius reflex (ASR) ?

A- The reaction of the stapedius while yawning.
B- The middle-ear reaction to loud noise in human.
C- The reaction of the stapedius in patient with perforated ear- drums.
D- The reaction of the stapedius in patient suffering of Bell's palsy.
E- None of the above.

The best answer is _____.

9- What happens when the stapedius is contracted ?

A- It increases the stiffness of the tympanic membrane, thus increasing sound transmission.
B- It increases the stiffness of the tympanic membrane, thus decreasing sound transmission.
C- It increases the stiffness of the ligament between the stapes and incus , thus decreasing sound transmission.
D- It increases the stiffness of the ligament between the stapes and incus , thus increasing sound transmission.
E- None of the above

The best answer is _____

10- What is the type of sound that the stapedius cannot protect the inner-ear against ?

A- Very Sharp and intense sound pulse.
B- Noise over 80 decibels.
C- Vibration from internal vocalization.
D- Both A and B
E- A, B and C

The best answer is _____

11- What happens when the stapedius is contracted ?

A- High frequencies are masked.
B- Mid-range frequencies are masked.
C- Low frequencies are masked.
D- Both A and C.
E- None of the above.

The best answer is _____

12- In speech recognition, the stapedius acts like:

A- An amplifier, increasing your own voice while speaking.
B- A resistance, blocking the electrical impulses in the auditory nerve.
C- A filter, reducing the ambient and background noise coming from the environment.
D- All of the above.
E- None of the above.

The best answer is _____

13- What happens to patient suffering from the paralysis of the nerve innervating the stapedius ?

- A- The patient becomes hypersensitive to loud noise and complains about sound distortion.
- B- The patient complains from headaches and about sound distortion.
- C- The patient complains about a constant buzzing sound.
- D- All of the above.
- E- None of the above.

The best answer is _____

14- how do the authors of this article qualify the solution provided by the middle-ear system ?

- A- It is nature's elegant solution, suppressing loud noise, yet allowing relevant sound to be understood.
- B- The middle-ear system has no impact on the survival and evolution of species.
- C- The middle-ear system provides a great way to suppress high frequency noise.
- D- All of the above.
- E- None of the above.

The best answer is _____

Directions :

-When you have finished answering these questions, you may go over this questionnaire as often as you wish in the alloted time.

-Upon completion of this questionnaire you may return it to the instructor.

-Another questionnaire on the same material will be administered one week from now.

Thank you for your cooperation

APPENDIX D:

The delayed measure.

<u>Content:</u>

-The personal identification sheet.

-The delayed posttest.

Directions : Please complete the following questionnaire.

Name or ID number: ______________________________

Age: ________

Sex: ( ) Female ( ) Male

Mother tongue: ( ) English ( ) French ( ) Other _______

Directions : When you have finished writing, please wait for instructions, before moving to next page.

Directions : -For each of the following questions, choose the **BEST** answer based on the tex* you have read two weeks ago.

1- What is the type of sound that the stapedius cannot protect the inner-ear against ?

A- Noise over 80 decibels.
B- Vibration from internal vocalization.
C- Very Sharp and intense sound pulse.
D- Both A and B
E- A, B and C

The best answer is _____

2- What happens to patient suffering from the paralysis of the nerve innervating the stapedius ?

A- The patient complains from headaches and about sound distortion.
B- The patient complains about a constant buzzing sound.
C- The patient becomes hypersensitive to loud noise and complains about sound distortion.
D- All of the above.
E- None of the above.

The best answer is _____

3- What is an EMG ?

A- An electromyogram.
B- The recorded electrical activity of the stapedius muscle
C- The recorded mechanical activity of the tympanic membrane.
D- Both A and B.
E- Both B and C.

The best answer is _____

4- What is the acoustic stapedius reflex (ASR) ?

A- The reaction of the stapedius in patient suffering of Bell's palsy.
B- The reaction of the stapedius while yawning.
C- The reaction of the stapedius in patient with perforated ear- drums.
D- The middle-ear reaction to loud noise in human.
E- None of the above.

The best answer is _____

5- Which of the following best describe the mechanics of perceived sound ?

A- Air-pressure waves causing the ear-drum to vibrate.
B- The transformation of mechanical vibration in the cochlea triggering electrical impulses in the auditory nerve .
C- The mechanical transmission of vibrations through the ossicles to the cochlea.
D- All of the above.
E- None of the above

The best answer is _____

6- How do the authors of this article qualify the solution provided by the middle-ear system ?

A- The middle-ear system has no impact on the survival and evolution of species.
B- It is nature's elegant solution, suppressing loud noise, yet allowing relevant sound to be understood.
C- The middle-ear system provides a great way to suppress high frequency noise.
D- All of the above.
E- None of the above.

The best answer is _____

7- What happens when the stapedius is contracted ?

A- It increases the stiffness of the ligament between the stapes and incus , thus decreasing sound transmission

B- It increases the stiffness of the tympanic membrane, thus decreasing sound transmission.

C- It increases the stiffness of the ligament between the stapes and incus , thus increasing sound transmission.

D- It increases the stiffness of the tympanic membrane, thus increasing sound transmission.

E- None of the above

The best answer is _____

8- Nature has provided humans with a sophisticated noise reduction system to cope with our noisy world. What are the key components of this system. Select the best answer.

A- The ligaments of the tympanic membrane.

B- The EMG and the ASR.

C- The electrical reaction in the Cochlea.

D- The stapedius' reaction on the ossicles.

E- None of the above.

The best answer is _____

9- What is so special about the middle-ear muscles of the echolocating bats ?

A- They mask the extremely rapid rate of the bat's hunting cry

B- They increase sound sensitivity by 30 decibels

C- They help keep the bat's balance during flight.

D- All of the above.

E- None of the above.

The best answer is _____

10- What happens when the stapedius is contracted ?

A- Low frequencies are masked.
B- High frequencies are masked.
C- Mid-range frequencies are masked.
D- Both A and C.
E- None of the above.

The best answer is _____

11- What are the names of the two middle-ear muscles ?

A- Tympanic membrane and stapedius
B- Incus and stapedius
C- Incus and Malleus
D- Tensor tympani and stapedius
E- Stapes and stapedius

The best answer is _____

12- In speech recognition, the stapedius acts like:

A- A filter, reducing the ambient and background noise coming from the environment.
B- A resistance, blocking the electrical impulses in the auditory nerve.
C- An amplifier, increasing your own voice while speaking.
D- All of the above.
E- None of the above.

The best answer is _____

13- The middle-ears muscles are designed to react to

A- Loud external noise.
B- Sound during vocalization.
C- Sharp and intense pulse.
D- Both A and B.
E- Both B and C.

The best answer is _____

14- What is one particularity of the middle-ear muscles ?

A- They are directly connected to the tensor tympani.
B- They are directly connected to the auditory nerve.
C- They are skeletal muscles that they are not under voluntary control.
D- They are the only facial muscles that are under voluntary control
E- None of the above.

The best answer is _____

Directions :

-When you have finished answering these questions, you may go over this questionnaire as often as you wish in the alloted time.

-Upon completion of this questionnaire you may return it to the instructor.

Thank you for your cooperation