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ABSTRACT

This study investigated the sensitivity of the pupillary response as an indicator of average mental load during three language processing tasks of varying complexity. The tasks included: (1) listening (without any subsequent comprehension testing); (2) speech shadowing (repeating a message in the same language while listening to it); and (3) simultaneous interpreting into the subjects' dominant language. It was predicted that if pupillary dilation adequately reflects average mental load, the simple listening task should be associated with the lowest dilation levels, the highly complex simultaneous interpreting task should be associated with the highest dilation levels, and the shadowing task should fall between the two. Subjects were nine native Finnish-speaking third- and fourth-year students in the University of Turku (Finland), department of translation. All were highly fluent in English and had had a minimum of 1 year's training in simultaneous interpreting. Three English language texts were used as source texts. Pupillary responses were filmed. Dilation was associated with task difficulty as predicted. Mental load also appeared to be greatest at the beginning of each task. The measurement technique is seen as promising for describing interpreters' use of processing resources and the factors affecting real-time performance. (MSE)

MENTAL LOAD IN LISTENING, SPEECH SHADOWING AND SIMULTANEOUS INTERPRETING: A PUPILLOMETRIC STUDY

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The paper reports an experiment in which the variations in mental load during simultaneous interpreting and two other language processing tasks were measured with the technique of pupillometry. Results suggest that the method reliably differentiates between the average levels of mental load created by tasks of different complexity. Pupillometry therefore seems to hold some promise for on-line investigations of the comprehension and production of spoken language.

1. Introduction

This paper reports an experimental study on the mental load experienced by the simultaneous interpreter. The central question is methodological: the validity of a psycholinguistic research technique in investigations of interpreting and other language processing tasks.

Although the cognitive processes related to translation have not been extensively studied by experimental psycholinguists, a number of studies have investigated the process of simultaneous interpreting. Gerver (1976) and Moser (1978) present information-processing models of the performance. Treisman (1965) and Lawson (1967) investigate the performance from the point of view of attention research. Empirical studies reviewed and described by Goldman-Eisler

(1972, 1980), Gerver (1976), Barik (1973, 1975), Chernov (1979), Lambert (1983) and others deal with various aspects of input and output, such as the overlap between comprehension and production, the length of the ear-voice span, the effect of source text delivery rates or hesitation pauses, and the recall performance of simultaneous interpreters. Tommola and Niemi (1986) report an experiment on the effects of source text syntax on interpreting. A body of research has also been developing on simultaneous interpretation with sign languages (e.g. Ingram 1985). Furthermore, a number of studies deal with pedagogical and professional aspects.

Simultaneous interpreting is a highly complex discourse performance where language perception, comprehension, translation, and production operations are carried out virtually in parallel and under severe time pressure. It is clear that such a complex activity is possible only by virtue of the independence, automaticity, and subconscious nature of many of the component processes. Yet the task involves several conscious processes, and is likely to create a heavy processing load. The sources and variations of mental load during interpreting present a question of some theoretical and empirical interest.

Methodologically, the investigation of mental load during language processing requires a technique with which one can monitor the interpreter's performance 'on line'. In other words, the technique should be sensitive to the process as it evolves in real time. A number of such on-line methods have been developed during recent years for the purposes of psycholinguistic research (cf. Carlson & Tanenhaus 1989), but many of these involve subsidiary tasks that affect the actual language processing under study. The focus of the experiment reported below is a psychophysiological response, pupil dilation, which seems to offer some promise for on-line investigations of interpreting processes. The pupillary response has long been known to be associated with increased mental activity. Several studies during the last two decades or so have also presented evidence that human cognitive processes, such as problem solving or language comprehension, are accompanied by pupillary dilations (cf. reviews by Janisse 1977, and Beatty 1982). The measurement of task load through the pupillary response has the advantage that the researcher does not have to tamper with the language processes themselves. So far it seems that no previous studies have applied the method to the study of cognitive processing in interpreting. Research on the validity of the technique applied to interpreting situations thus appears well justified.

The experiment reported here investigates the sensitivity of the pupillary response as an indicator of average mental load in language processing by comparing three tasks which are self-evidently different in complexity. The tasks are (1) listening (without any subsequent comprehension testing), (2) speech shadowing (repeating back a message in the same language while listening to it), and (3) simultaneous interpreting into the subjects' dominant language. If pupillary dilation adequately reflects average mental load, the simple listening task should be associated with the lowest dilation levels, the highly complex simultaneous interpreting task should be associated with the highest dilation levels, and the shadowing task should fall between the two.

2. Method*

2.1. Subjects

Nine subjects participated. All were 3rd to 4th-year students at the University of Turku Department of Translation studies, and had Finnish as their native language. The subjects were highly fluent

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speakers of English, and all had received a minimum of one year's instruction in the techniques of simultaneous interpreting as one part of their study programme.

2.2. Materials and design

Three English-language texts (500-600 words) were employed as source texts. The materials had been written to simulate opening presentations in an international conference. Each task thus involved the comprehension of the non-dominant language (English). Task 2, shadowing, involved speech production in English, while in the simultaneous interpreting task production was in Finnish. This change in the language of speech production works to increase the conservativeness of the design, since the supposedly more complex interpreting task involves production in the language which the subjects master best.

The texts were recorded by a native speaker of English. Three types of stimulus tape, in which the order of presentation of the three passages was systematically varied, were constructed from the recordings. The nine subjects were assigned randomly to one of the three versions of the stimulus tape, three subjects per version. Task order was always the same: listening, followed by shadowing and interpreting. If there were a practice effect, the task performed last, simultaneous interpreting, would benefit most, which would again increase the conservativeness of the design.

Thus, for each task, the design allowed an estimate of average mental load to be obtained on the basis of three texts, each of which were processed by three subjects.

2.3. Procedure

The subject was seated facing the screen of a computer which was connected to an Applied Science Laboratories eye movement camera. The computer was programmed to record the diameter of the subject's left pupil at the frequency of 50 Hz, i.e., every 20 ms. The pupil data was temporally synchronised with the stimulus text by connecting the computer to the tape recorder which presented the source text into the interpreter's headphones and preserved the interpreter's output. The subject was instructed to fixate his or her gaze on a graphic pattern shown on the screen during the performance of the tasks.

Three short warm-up texts preceded the actual experiment; during these, the subject practised each of the three tasks in the same order as that followed in the experiment proper. A 30-second silence preceded and followed each practice text and experimental text. During this silence, a baseline measurement of pupil size was taken.

The total duration of subject performance (3 warm-up texts and 3 experimental texts) was approximately 19 minutes. A total of over 55,400 measurements per subject were taken during this time.

3. Results

Prior to analysis, all eye-blinks were removed from the data. Secondly, the data were compressed into mean pupil size values corresponding to 3 seconds of the performance. Such a mean value for a 3-second window was calculated for every running second of the performance. The transformed data were fed into a spreadsheet program for the calculation of various statistics.

Figure 1 describes the average pupil dilation level for the three tasks (three texts, three subjects per text). It is apparent that the pupillometric estimate of mental load is consistent with the hypothesised difference in task difficulty. The analysis of variance computed from the data yielded a highly significant effect of Task ($F(2,16)=21.76$, $p<0.001$). **Pairwise contrasts between the tasks were significant (all p's<0.003).**

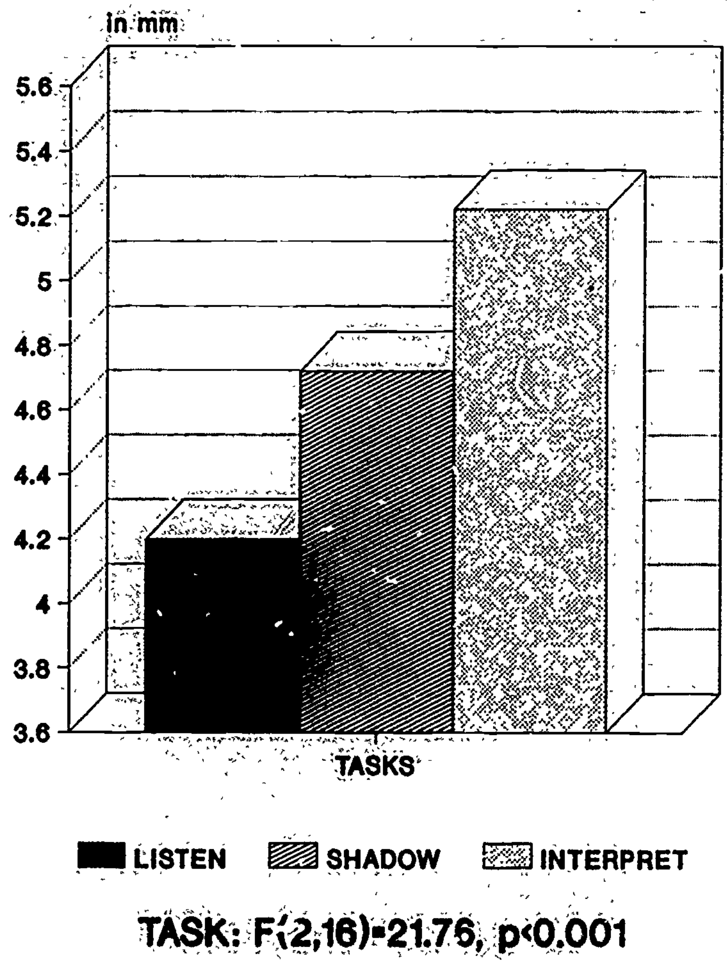

Figure 1. Average pupil dilation levels in three tasks

Figure 2 shows a rough estimate of task-internal variation in mental load. This effect, termed 'Order' in Figure 2, was measured in broad terms by dividing the three tasks into beginning, middle, and end sections. The analysis of variance computed on the data yielded a significant Order effect (F(4,32)=8.02, p=0.004). Mental load is highest during the beginning of the task, after which there is a statistically significant reduction, as indicated by a Beginning-Middle contrast computed accross tasks (F(1,8=16.13, p=0.004). Thus there seems to be a familiarity effect: the subject gets acquainted with the conceptual content and other properties of the texts. In this set of data the interaction between Task and Order is, however, nonsignificant.

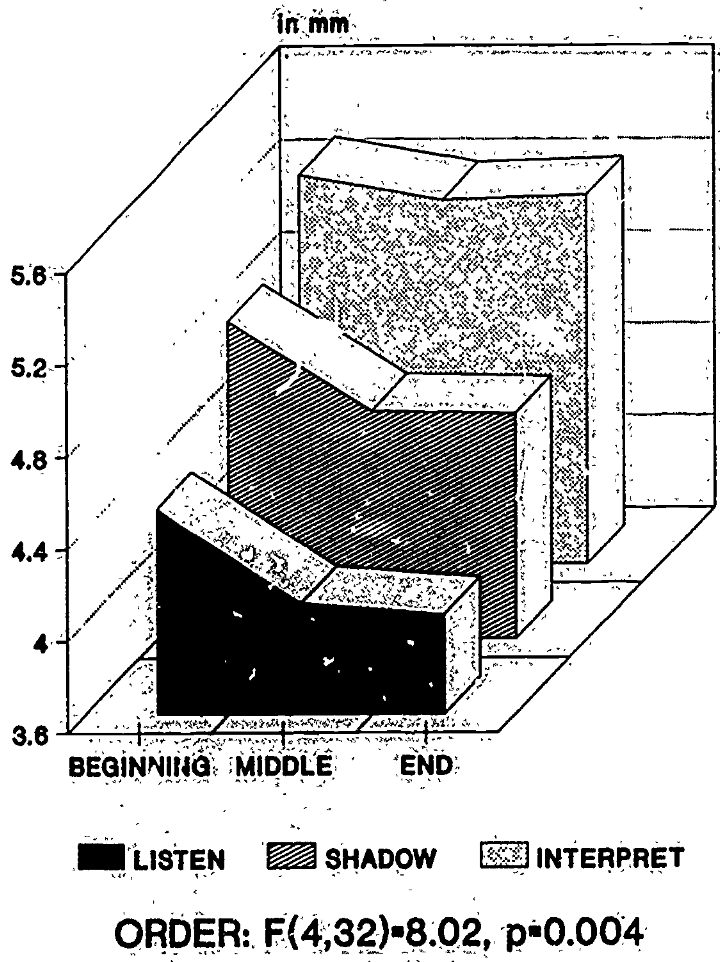

Figure 2. **Task-internal variation in pupil dilation level**

An analysis of the data from the practice texts indicated that the task effect is not restricted just to the three experimental texts, but also emerges with the shorter texts the subjects processed prior to the experiment proper.

4. Discussion

Analyses of simultaneous interpreting conventionally yield an audio record of interpreter output, which can be further processed into a visual representation for the purpose of measuring speech rates, ear-voice spans, and pauses. The purpose of the experiment reported above was to study the validity of a technique which yields, in addition to these, measures, an estimate of mental load during the on-going performance of simultaneous translation.

The study indicated that the pupil record accurately reflects hypothesised differences in the average complexity of three language processing tasks. The technique therefore seems to hold some promise for studies which aim to describe how the interpreter utilises his or her processing resources, and what factors affect the real-time performance.

Experiments in progress deal with two further questions concerning the technique: the latency of the pupillary response in language processing tasks, and 'load threshold'. Information on latency is important for studies where the response must be associated with a semantic or structural feature appearing at a given point in the stimulus materials. It is also useful to know more about how complex the language processing task must be to cause a load increase detectable with the method.

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