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DEVELOPMENT OF A MICROCOMPUTER BASED SYSTEM FOR PSYCHOACOUSTIC EXPERIMENTATION

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1. INTRODUCTION

The experimental facility described in this paper (and in more detail in Halford et al, 1980) has been developed for use in research into the effects of wearing hearing protection on the perception of warning sounds. In the context of this research it is necessary to control the presentation of a variety of sounds to subjects in the presence of background noise, and to monitor the subjects' responses to the sounds and their performance at a loading task. The number of experiments required in the research programme, the difficulties in controlling the stimulus variables, and the large amount of data generated by each experiment indicate the need for a semi-automated means of running the experiments. The recent advent of relatively cheap microcomputer systems lead to the development of the facility around one such system. Whilst the facility was tailored to the specific needs of this research programme, the flexibility inherent in the use of the microcomputer suggests that similar facilities could be used in a wide range of subjective experimentation.

2. GENERAL FEATURES

The sounds presented to the subject are tape recorded environmental sounds including both warning and other meaningful industrial sounds. The facility was designed such that six different sounds can readily be presented during one experimental session. The sounds used are generally discrete events having a duration of approximately six seconds, though within this time they may vary in both intensity and frequency content.

An additional feature of the facility is the ability to measure free-field or pressure field audiograms (Rendell, 1980). The pure tone signals for this are provided by a synthesiser and presented via a loudspeaker or headphones respectively.

It is necessary to control both the time of presentation of a particular sound and the relative intensity of the sounds. The sounds are presented individually in the presence of a background of noise throughout the experiment. The background noise can be provided from any external source such as a random noise generator or tape recorded industrial noise. The intensity of the noise can be adjusted prior to running an experiment, or varied during a session under the control of the microcomputer to simulate the effects of time varying noise.

The loading task used is a modified version of a TV-game. In the "football" mode the subject has control over the vertical position of two players, with the objective of directing a ball through a goal on one side of the display screen, whilst protecting the goal at the other end.

The data to be collected are measures of the subject's responses to the sound events, and his performance at the loading task. The subject indicates his responses by pressing a button which provides a measure of the number of responses and also the response time relative to the onset of the sound. The task performance is recorded as the points won and lost at particular times.

3. DESCRIPTION OF THE FACILITY

The role of the microcomputer within the facility is both as a process controller and as a data logger. Separately it is able to carry out much of the data processing and thereby reduces the dependence on other computing facilities for analysis of the data.

The diagram in Figure 1 indicates the main components of the facility. The microcomputer is a Cromemco Z-2D system which is made accessible to the user by a visual display unit (VDU), a teletype providing print-out and paper tape facilities, and a separate paper tape punch.

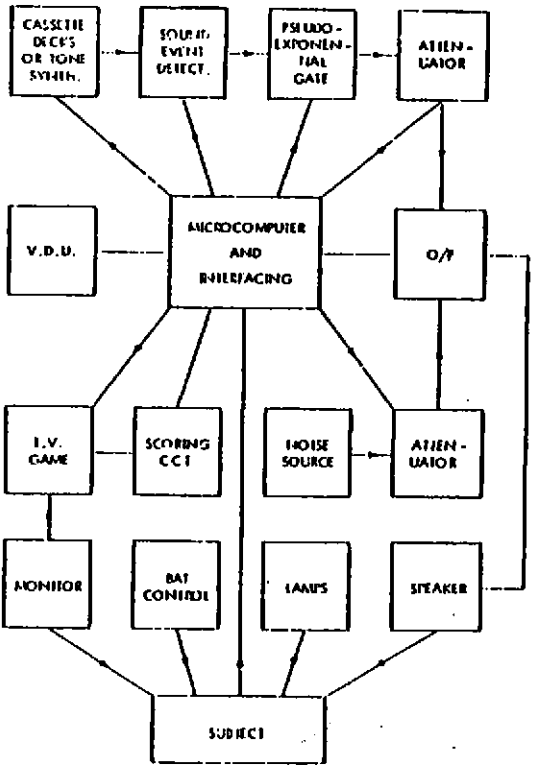

Figure 1. Components of the facility.

The noise is provided by an external random noise generator, whereas the signals are either reproduced on a set of six cassette decks or generated by a pure tone synthesiser. The presentation of the signals is controlled by a pseudo-exponential gate with rise and fall times of approximately 50 ms. The intensities of the noise and the signals are controlled by two digital attenuators of ISVR design. The signal and noise are electronically mixed and then amplified prior to being fed either to a single loudspeaker located in the test room or to either the left or right side of a pair of headphones.

The loading task is based on an integrated circuit chip, but has extensive additional circuitry to make the task accessible to the computer. The visual display from the task is fed to two television sets, one a monitor for the experimenter, and the other the display for the subject. The subject has control via a potentiometer over the position of his two players.

In addition, the subject has a response button with which to indicate his decision that a sound has occurred. Two lamps, one red and the other green, located above the subject's TV screen can be used to indicate to the subject the progress of the experimental session.

The functions of the microcomputer as a process controller are:

(i) selection and timing of the presentation of a particular sound:- frequency synthesiser or cassette decks, gate, left or right channel,

(ii) setting of signal attenuator,

(iii) setting of noise attenuator,

(iv) starting, stopping or resetting the task,

(v) switching on and off the two indicator lamps.

The functions of the microcomputer as a data logger are to record the time of occurrence of the following events:

(i) start of a signal (a sound event)

(ii) subject's response

(iii) points won and lost at the task

4. INTERFACING WITH THE MICROCOMPUTER

The Cromenco Z-2D system has 48 Khytes of memory, a disc controller board, a single mini-floppy diskette drive, and a Twin Universal Asynchronous Receiver/Transmitter (TUART) board for interfacing to peripheral devices. This configuration provides the minimum requirements for a flexible system capable of controlling experimental variables and the logging of data. It represents a relatively standard microcomputer system and will not be described in detail here. Of note, however, is the strategy adopted in interfacing the computer to the peripheral devices and in programming the computer to provide a time base for the experiment.

The interfacing is achieved using the two parallel input/output ports on the TUART board. The controlling functions of the microcomputer are achieved via a two stage process. The output of an appropriate eight bit number to one of the parallel ports provides an instruction for one of the control functions. The subsequent output of an appropriate number to the other parallel port directs the instruction to one of the controlling functions listed above.

The data logging function of the microcomputer is achieved by inputting an eight bit number to one of the parallel ports. Five of the eight bits were used to represent one each of the events game in progress, point lost, point won, subject response and sound event. The simultaneous occurrence of more than one event can therefore be indicated by appropriate setting of the bits.

An essential requirement of the facility is the provision of a time base both for the sequencing of the sound events, and for the measurement of the subjects' response times. This cannot, however, be achieved using the available set of instructions within the BASIC language. It was however intended that the facility could be operated with BASIC as its use would minimize the programming (software) development time. This objective was achieved by patching into the BASIC package two assembly language subroutines. The first subroutine, QTIM initiates a cyclical interrupt procedure whereby at approximately 4 ms intervals the program being run in BASIC is interrupted and part of the subroutine reads the input port. If the input port value indicates that an event has occurred the value and its time of occurrence are entered into a buffer memory. At the end of the subroutine the computer returns to the next step in the BASIC program. The second subroutine stops the interupts and is called at the end of the experimental session.

This programming strategy makes use of one of the ten timers on the TUART board which is programmed to count up to approximately 4 ms before causing an interrupt to occur. In addition it relies on the USR function in Cromemco 16K Extended BASIC which makes it possible to call up the assembly language subroutines. The BASIC program is transparent to the interrupts, that is provided that certain precautions are taken the BASIC program is not disturbed in any way by the subroutine processing which occurs after every interrupt.

5. CONCLUSION

A microcomputer based experimental facility has been built and commissioned which is suitable for a wide range of psychoacoustic experimentation. The facility is capable of presenting complex sound stimuli or pure tones to a subject, either under free field or pressure field conditions. The facility can also provide one of a range of loading tasks derived from a set of television games. The microcomputer can control these events, and also log their occurrence in conjunction with the subject's responses to the sound stimuli and the subject's performance at the loading task. The microcomputer also has the ability to manipulate and analyse the data.

The facility was specifically designed for a programme of research into the effects of wearing hearing protection on the perception of warning sounds. However, the range of its features suggests that it is suitable for many different experiments in psychoacoustics. It is of a flexible design and therefore amenable to modifications and additions to meet future requirements.

6. REFERENCES

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