A voice-activated key for the Apple Macintosh computer

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An interface circuit to connect a microphone to an Apple Macintosh computer is described. The Apple Macintosh mouse port is used as the input port, and the microphone activation simulates a mouse press.

One of the main drawbacks of the Macintosh Computer is its closed architecture, particularly with the 512K and the 1-MB versions, which do not have expansion slots. There are some systems (Chute, Gaeman, & Ziegler, 1987; Reed College, 1985) that break this closeness and offer a number of versatile possibilities at a high cost. We designed a simple circuit that uses the Macintosh input devices to enable a microphone to be connected to the computer. Although the circuit is not as versatile as some of the commercial, general purpose interfaces, it can be used to run experiments at low cost.

Circuit Description

In the design, we use the mouse input: that is, the serial RS232/RS242 port is used as an input port, and the circuit is designed so that a pulse coming from the microphone is interpreted as a mouse press by the computer hardware. In this arrangement, the interface is connected to the mouse port, and the mouse and the microphone are both connected to the interface circuit. Figure 1 shows an external diagram of the interface housing. An adjustable sensitivity dial allows the user to establish a reference level for triggering the circuit. Two additional on/off switches, one for the power supply and the other for the microphone connections, allow the circuit to be permanently connected, sometimes using the microphone, and at other times the mouse itself. Three diodes indicate when the interface is ready or activated.

Figure 2 is a diagram of the circuit, which is built around four operational amplifiers. The first amplifier is set in a noninverting configuration to attain a high input impedance and, with a gain of a factor of about 100, to set the signal at a usable level. A potentiometer is in the circuit to vary the sensitivity level. A second amplifier

Figure 1. Views of the interface box housing the circuit.

is set in an inverting configuration with a gain factor of 10. The third operational amplifier is set as a comparator. A variable resistor establishes the voltage reference level so that if the voltage of the other input goes above the reference level, the amplifier output goes positive, and this output is used to simulate the mouse press.

Test

To check the validity of the circuit, we wrote a program to test the use of the microphone in a naming experiment in which reaction time is measured when a subject sees two stimuli in sequence and must name the second one (Balota & Chumbley, 1984). The voice is de-

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Figure 2. Circuit diagram of the microphone interface to the Apple Macintosh.

tested simply as a mouse press. To make the process more understandable, we wrote a short program in Microsoft BASIC 3.0 to implement a real experiment, showing in this manner the use of the circuit.

The experiment consisted of 63 trials, in which a prime word was followed by a prime target that the subject had to pronounce. Twenty-one of those trials contained related pairs of words extracted from association norms. The remaining 42 trials comprised 21 control trials in which the prime word was always the word "NEUTRO" ("neutral"), and 21 in which the prime and the target were unrelated pairs of words. We used a stimulus onset asynchrony between prime and target of 250 msec, with a prime duration of 200 msec.

The appendix presents a listing of the program written to run the experiment. We used two previously published routine libraries: one for accurate stimulus exposure (Lane & Ashby, 1987), and the other to measure naming time (Westall, Perkey, & Chute, 1986). The listing is written in a modular manner and, after array definitions and main program specification are presented, the main experimental functions are included as subroutines. Of particular interest is the instruction "WHILE PEEK(&H172) < > 0: WEND," which checks whether the mouse has been pressed, or detects when the interface is connected. It is important to realize that PEEKing directly position &H172 avoids any false triggering of the circuit due to the Macintosh buffer that accumulates all mouse events. The same

function can be accomplished with the following instructions: "WHILE MOUSE(0) > -1: WEND." The use of this last instruction requires that the mouse event buffer be discharged during the intertrial interval; otherwise, the program would be triggered by spurious activations produced during the intertrial interval.

The results of our experiment parallel the results obtained by other investigators, and are within a range of values similar to others collected with different hardware.

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APPENDIX

Program Listing for Naming Demonstration Program

```

'***** CONSTANTS & ARRAYS *****
DEFINT a-z

FixPointTime=30      'fixation point time=500 msecs.
PrimeTime=12         'prime time= 200 msecs.
InterStimTime=3      'ISI time=50 ms
InterTrialTime=96    'ITI time=1600 ms

```

APPENDIX (Continued)

```

NTrials=63          'number of trials
NSessions=1         'number of sessions
Hpoint=220          'horizontal coordinates for stimulus presentation
Vpoint=150          'vertical coordinates for stimulus presentation
maxWordLen=12       'maximum length for stimulus words
True=1              'value needed to install the millicontrol routine
False=0             'value to deinstalled the millicontrol routine
MyTime=0            'starting time to measure naming
NewTime=0           'final naming time

```

```

DIM CountCode(11)      'MilliCount array
DIM ControlCode(85)    'MilliControl array
DIM prime$(NTrials,NSessions) 'prime stimuli
DIM target$(NTrials,NSessions) 'target stimuli
DIM condition(NTrials,NSessions) 'experimental condition codes
DIM TR(NTrials,NSessions) 'naming times

```

***** MAIN PROGRAM *****

```

RANDOMIZE TIMER
LIBRARY "PsychLib"      'routine library, see note 1
GOSUB InstallRoutines   'loading of machine language routines
GOSUB SubjetInformation 'subject information
StimFile$=FILES$(1,"TEXT") 'stimulus file name
GOSUB ReadStimFile      'get stimuli
GOSUB PrepareScreen     'screen blanking
GOSUB RandomSecuence    'randomization
GOSUB InitMilliTimer    'timer initialization
FOR session=1 TO NSessions 'session loop
    GOSUB InitSession    'session start
    FOR trial=1 TO NTrials 'trial loop
        GOSUB ExecTrial  'trial presentation
    NEXT trial
NEXT session
GOSUB DiscardMilliTimer 'timer deactivation
GOSUB FinalMessage     'end
GOSUB SaveResponses     'save naming times
END

```

***** SUBROUTINES *****

```

InstallRoutines:      'see note 2
    FOR KOUNT=0 TO 10
        READ CountCode(KOUNT)
    NEXT KOUNT
    FOR KOUNT=0 TO 84
        READ ControlCode(KOUNT)
    NEXT KOUNT
RETURN

```

```

SubjetInformation:
    INPUT " CODE:";SubjetCode$
    INPUT " NAME:";SubjetName$
    INPUT " AGE:";SubjetAge$
    CLS
RETURN

```

APPENDIX (Continued)

ReadStimFile:

```

  OPEN StimFile$ FOR INPUT AS #1
  FOR session=1 TO NSessions
    FOR trial=1 TO NTrials
      INPUT#1,prime$(trial,session)
      INPUT#1,target$(trial,session)
      INPUT#1,condition(trial,session)
    NEXT trial
  NEXT session
  CLOSE #1
RETURN
```

PrepareScreen:

```

  CALL BLS! 'black out the whole screen. See note 1
  WINDOW 1,"", (0,20)-(512,342),3 'white window
  HIDECURSOR
  TEXTFONT 4
  TEXTSIZE 12
RETURN
```

RandomSequence:

'see note 3

```

  FOR session=1 TO NSessions
    tempSession=INT(RND*(NSessions-session+1)+session)
    FOR trial=1 TO NTrials-1
      tempTrial=INT(RND*(NTrials-trial+1)+trial)
      SWAP prime$(trial,session),prime$(tempTrial,tempSession)
      SWAP target$(trial,session),target$(tempTrial,tempSession)
      SWAP condition(trial,session),condition(tempTrial,tempSession)
    NEXT trial
  NEXT session
RETURN
```

InitMilliTimer:

'see note 2

```

  Millicontrol!=VARPTR(ControlCode(0))
  CALL Millicontrol!(True)
RETURN
```

InitSession:

```

  WHILE INKEY$<>"":WEND 'empty keyboard buffer
  PRINT "Press the spacebar to begin the run";session
  WHILE INKEY$<>" ":WEND
  CLS
  CALL Waitic!(InterTrialTime) 'delay. See note 1

RETURN
```

ExecTrial:

```

  white$=STRING$(maxWordLen+2," ") 'Blank string to clear the
stimuli

  tempPrime$=prime$(trial,session)
  lenPrime=LEN(tempPrime$)
  tempPrime$=" "+tempPrime$+STRING$(maxWordLen-lenPrime+1," ")
' string length matching
```

APPENDIX (Continued)

```

tempTarget$=target$(trial,session)
lenTarget=LEN(tempTarget$)
tempTarget$=" "+tempTarget$+STRING$(maxWordLen-lenTarget+1," ")

                                'string length matching
FixPoint$=">"+STRING$(lenPrime," ")+"<"

MOVETO Hpoint,Vpoint
CALL Waitic!(1)
CALL DrawText!(FixPoint$)

MOVETO Hpoint,Vpoint
CALL Waitic!(FixPointTime)
CALL DrawText!(tempPrime$)

MOVETO Hpoint,Vpoint
CALL Waitic!(PrimeTime)
CALL DrawText!(white$)

MOVETO Hpoint,Vpoint
CALL Waitic!(InterStimTime)

Millicount!=VARPTR(CountCode(0))
CALL Millicount!(VARPTR(MyTime))

CALL DrawText!(tempTarget$)

'*****
WHILE PEEK(&H172)<>0:WEND      'Mouse reading. When zero, the
                                'microphone is inactive
'*****

CALL Millicount!(VARPTR(NewTime))      'naming time

CLS

TR(trial,session)=NewTime-MyTime-9      'this is the final naming time
                                        '(corrected for compile
version)
                                'If the program is written with the interpreter, the
                                'final time must be corrected by 17 ms. which is
                                'the error introduced by the interpreter in command
execution

CALL Waitic!(InterTrialTime)
RETURN

DiscardMilliTimer:                'See note 2
    Millicontrol!=VARPTR(ControlCode(0))
    CALL Millicontrol!(False)
RETURN

FinalMessage:
    WHILE INKEY$<>"":WEND
    BEEP
    PRINT "This is the end of the experiment"

```

APPENDIX (Continued)

```

PRINT "Thank you for your collaboration"
PRINT "Press the spacebar to end"
WHILE INKEY$<>" ":WEND
INITCURSOR
RETURN

```

SaveResponses:

```

FileName$=StimFile$+SubjetCode$
OPEN FileName$ FOR OUTPUT AS#1
PRINT#1,SubjetCode$
PRINT#1,SubjetName$
PRINT#1,SubjetAge$
FOR session=1 TO NSessions
    PRINT#1,"SESSION";session
    FOR trial=1 TO NTrials
        PRINT#1,condition(trial,session); 'Experimental
                                           'condition codes
        PRINT#1,CHR$(9);TR(trial,session)
    NEXT trial
NEXT session
CLOSE#1
RETURN

```

'***** DATA MACHINE CODE *****

'machine code for "Millicount!"

```

DATA &H226F,&H0004,&H41F8,&H0192,&H2068,&H0018,&H32A8,&HFFFA
DATA &H2257,&H508F,&H4ED1

```

'machine code data for "Millicontrol!"

```

DATA &H2F0A,&H2478,&H01D4,&H157C,&H0040,&H1C00,&H102A,&H0800
DATA &H2078,&H02A6,&H2278,&H02AA,&H45FA,&H0074,&HB3C8,&H6F1E
DATA &HB548,&H66F4,&H7006,&HB588,&H56C8,&HFFFC,&H6704,&H5988
DATA &H60E6,&H91FC,&H0000,&H0026,&H42A8,&H0008,&HA41F,&H0C6F
DATA &H0000,&H0008,&H6740,&H7026,&HA51E,&H4A40,&H6638,&H5088
DATA &H2478,&H01D4,&H002A,&H0040,&H1600,&H022A,&H007F,&H1600
DATA &H43F8,&H0192,&H2348,&H0018,&H157C,&H000B,&H0800,&H157C
DATA &H0003,&H0A00,&H700E,&H43FA,&H0016,&H30D9,&H51C8,&HFFFC
DATA &H157C,&H00C0,&H1C00,&H245F,&H225F,&H548F,&H4ED1,&H1029
DATA &H0800,&H41FA,&HFFF2,&H5298,&H5290,&H0C90,&H0000,&H0708
DATA &H6B06,&H4290,&H53A8,&HFFFC,&H4E75

```

1. Routines BLS!, Waitic! (), and DrawText! () are part of the PsychLib library (Lane & Ashby, 1987). This library is required to be able to use those instructions.

2. Routines MilliControl and MilliCount were adapted from Westall, Perkey, and Chute (1986).

3. Adaptation from routines presented in Sanmartin (1986).

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