A KEYBOARD FOR UNDERWATER PERFORMANCE ASSESSMENT BATTERY TESTING

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Summary

The report discussed a keyboard developed for collecting performance data from subjects submerged underwater. The keyboard is waterproof and has a simplified four button format, allowing divers to enter responses without looking at the keyboard and while wearing diving gloves. A testing session is discribed and appropriate software techniques are suggested.

Introduction

Cognitive function in divers submerged at various temperatures is of interest both in military and some civilian settings. Underwater cognitive testing has sometimes been done using waterproof paper and pencils (e.g., Bowen, 1968; Davis et al., 1975) or auditory problem presentation with manual signals for responses (e.g., Stang and Wiener, 1970). Some simple testing devices have been constructed (e.g.; Biersner, 1976; Stang and Wiener, 1970). At the other extreme, complex equipment, exactly simulating the underwater tasks of interest have been created (e.g., Vaughn and Anderson, 1973; Vaughn, 1977). However, none of these alternatives provide data which can be compared to results of the typical computer administered performance assessment batteries (PAB) most often used in laboratory studies. Baddeley et al. (1975) employed a device allowing recording of true or false responses to problems projected on a viewing screen placed at the observation port of a submersion tank. We describe here an underwater keyboard which allows computer administration of many typical PAB tasks in any submersion tank equipped with a window through which a computer screen can be displayed and viewed.

Equipment

The underwater keyboard is pictured in Figure 1. A simplified four button keyboard was chosen so that divers could manipulate two buttons with each thumb, with no need to look at the keyboard to find a specific button. A software technique to implement tasks involving more than four possible responses using only four buttons will be discussed later in this report.

The four button keyboard is made up of two two-button switch boxes (Daniel-Woodhead 2-button control, Part Number 4052). The Hypalon diaphragms which come with these switch boxes were used. The switches were placed parallel to each other with a one inch space between them and a specially machined single face plate of Detrin was used to tie the two switch boxes together. Screws pass through the faceplate and diaphragms into the switch boxes forming a water tight seal. The subject holds the keyboard with the switch boxes cupped in the palms and the fingers fitting into the gap between the boxes. This hand position allows easy access to the two buttons on each side with the thumbs. As only the thumbs are used, gloves without fingers (i.e. mittens) are not a limitation. The keyboard can be held firmly in one position, and the subject does not need to look at the keyboard to find a button.

The switch boxes are filled with Dow Corning DC200 100c.s viscosity dielectric fluid to further assure water exclusion. Initially, 1000c.s viscosity fluid was used. However, the higher viscosity fluid caused irregular slowing of switch opening after button release, interfering with measurement of response times in rapid sequential tasks. Changing to the lower viscosity fluid solved this problem.

Each switch boxes is connected to a 20 foot two conductor Hypalon jacketed underwater cable (Belden Wire and Cable, Belden 8424 QJ). The two cables are joined together at one foot intervals with shrink tubing to improve handling.

The wiring diagram is shown in Figure 2. *These keyboards currently are used* with Apple IIe computers for cognitive testing, but could easily be adapted for an IBM compatible type PC. To input data from this keyboard to the Apple IIe computers we use the powerful I/O 32 board manufactured by Applied Engineering. This four button underwater keyboard uses only a small portion of the boards capacity. The cable is connected to the I/O 32 board via a 25-pin connector (mated set), a 26-conductor ribbon cable (Warwick) and a 26-pin connector.

Testing

The keyboard was tested by a diver in a 3FFW, using open circuit SCUBA, wearing a dry suit (Viking Combat Swimmer Dry Suit, Model #3030). Two divers gloves manufactured by Divers Unlimited Inc., San Diego, California, were tested with the keyboard, a 5-finger, 1/8 inch neoprene glove (Model GWA-L) and an outer 3-finger, rettactable mit of 1/4 inch neoprene (Model GD3FMR-L). The keyboard was manipulated easily with both gloves.

The presentations were in 40-column mode (characters 50 mm high). The screen was 3 inches outside the dive tank window and the divers face mask was 12-18 inches inside the window. The dive subject had 20/40 uncorrected vision and had no difficulty reading the screen. Since Navy divers are required to have 20/20 vision initially, it is anticipated that most of them should have no difficulty working with this apparatus.

Software Techniques

Some potential applications for this keyboard are straight forward, such as simple response times, choice reaction times with no more than four possible choices, logical reasoning or any other type of problem or question allowing four or fewer types of response. However, its use is not limited to these situations. Performance assessment batteries often include questionnaires with more than 4 possible answers to a given question. It is possible to modify such software to function with this keyboard by using a visual analog scale presentation. An example of such a presentation is diagrammed in Figure 3. This figure presents one question from the Naval Health Research Center Profile of Mood States Scale, in original and visual analogue scale formats. This scale consists of a series of words reflecting various moods. The subject responds to each word by stating how much it applies to his/her present mood on a scale of zero to four. In the visual analog scale set up, the subject is presented with a scale from zero to four, with a pointer sitting at the midpoint "2". To respond, the two upper buttons are used to move the pointer right or left, as appropriate. The right lower button is then pushed to register the answer.

Some types of tasks are difficult or impossible to set up on a keyboard with only four buttons. Mathematical calculations cannot be performed except with a multiple choice or odd/even type answer format. Digit symbol substitution could conceivably be set up on a sliding scale format. However, it would be cumbersome and very slow, and the display would be somewhat complex given the visual limitations of a subject looking through the air-water interfaces of a mask, water, and a glass window.

For users of Apple hardware, it should be mentioned that clock boards which use interrupts for timing small intervals (e.g., Timemaster II H.O., by Applied Engineering) require special programming to work with the I/O 32 board. If the boards are accessed directly from Apple Basic with the clock in the interrupt mode (the only mode in which the Timemaster II H.O measures time in units smaller than 1 second) the system will freeze up. This problem can be solved by using an assembly language program to access the I/O 32 board and the clock. An assembly language program which facilitates the combination of the I/O 32 board and the Timemaster II H.O. used in conjunction with Applied Engineering's BIN.MILLISEC assembly routines (Applied Engineering, 1988) is presented in the Appendix. This program will work with either the enhanced or the unenhanced version of the Apple IIe.

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APPENDIX: ASSEMBLY LANGUAGE PROGRAM TO RUN I/O 32 AND TIMEMASTER II H.O., IN CONJUNCTION WITH BIN.MILLISEC ROUTINE RICHARD BOOTH 1989**

BUTTON SET ROUTINE

```
        LDX   #$20          ;load slot number
1$:     LDA   $C084,X       ;read Port A* bits
        BEQ   1$            ;if none set, check again
        STA   $3B0          ;return port A contents - PEEK(944)
        RTS                 ;done
```

BUTTON CLEAR ROUTINE

```
        SEI                 ;disable interrupts
        LDX   #$20          ;lcad slot number
2$:     LDA   $C084,X       ;read Port A*  bits
        BNE   2$            ;if any set, check again
3$:     STA   $3B0          ;return port A*  contents - PEEK(944)
        RTS                 ;done
```

ENTRY POINTS

CALL 945	invokes "button set" routine
X=PEEK (944)	returns Port A* contents stored by most recent call to "button set" or "button clear" routines
CALL 956	invokes "button clear" routine and disables timing interrupts
CALL 957	invokes "button clear" routine but permits interrupts and response timing to continue

APPLE BASIC CODE TO ENTER THIS ASSEMBLY LANGUAGE

```
NN=945
FOR M=0 TO 22: READ X: POKE NN + M, X: NEXT M
DATA  162,32,189,132,192,240,251,141 176,3,96,120
DATA  162,32,189,132,192,208,251,141.176,3,96
```

* The keyboard is connected to Port A on the I/O 32 board. A button

press sets the corresponding Port A bit, button release clears it.

** Applied Engineering assembly language program.

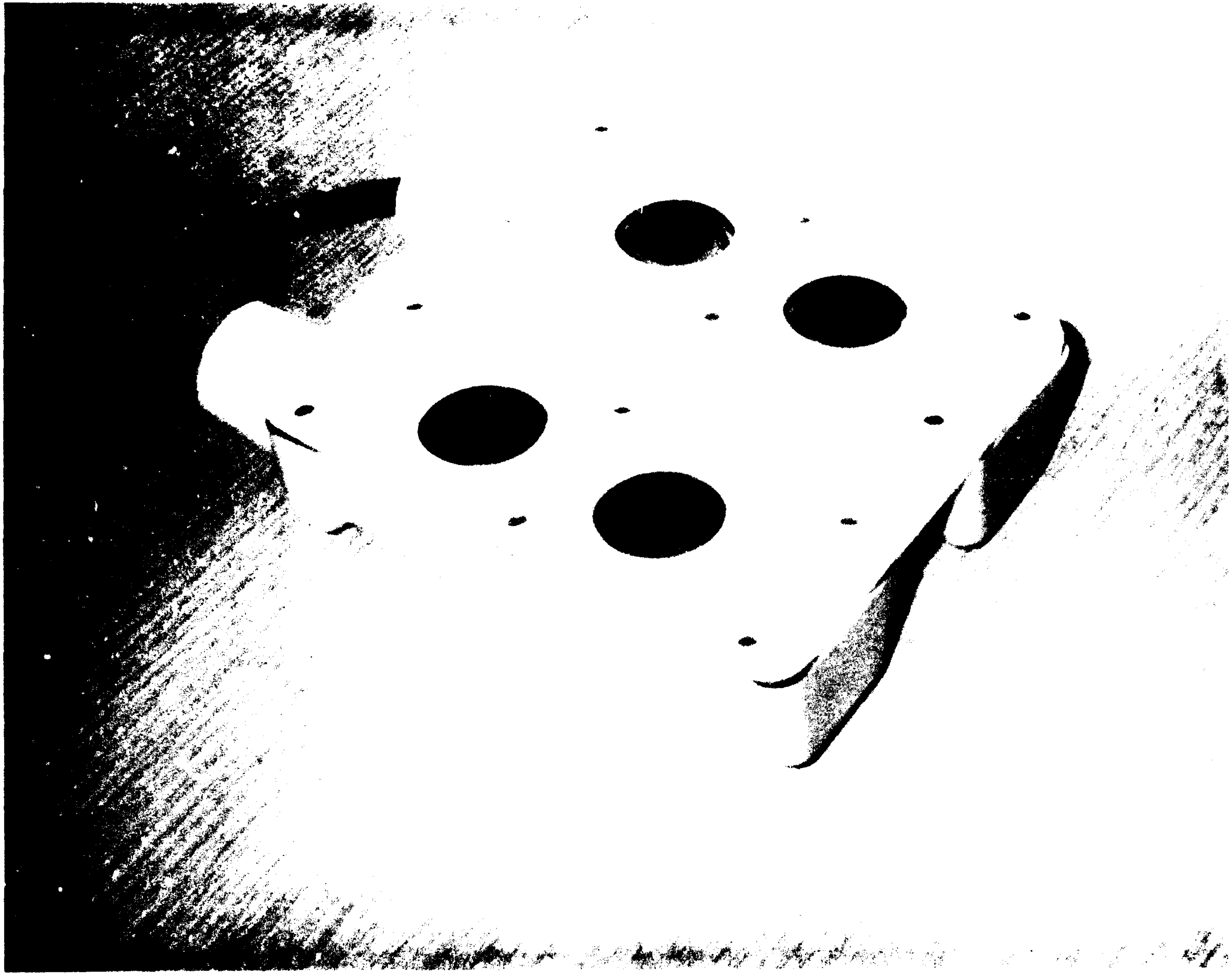

FIGURE 1. UNDERWATER KEYBOARD

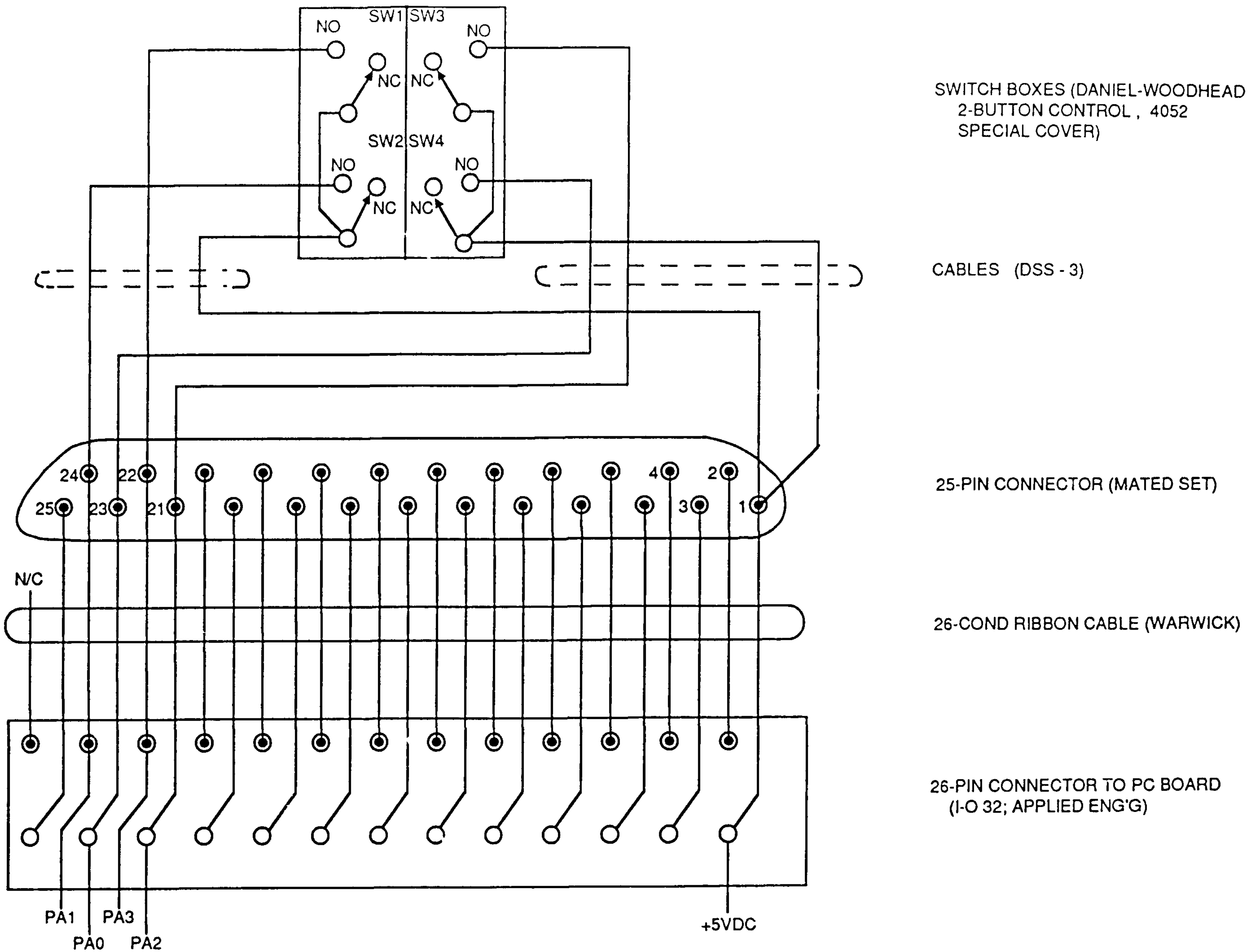

Figure 2. Wiring diagram for underwater keyboard

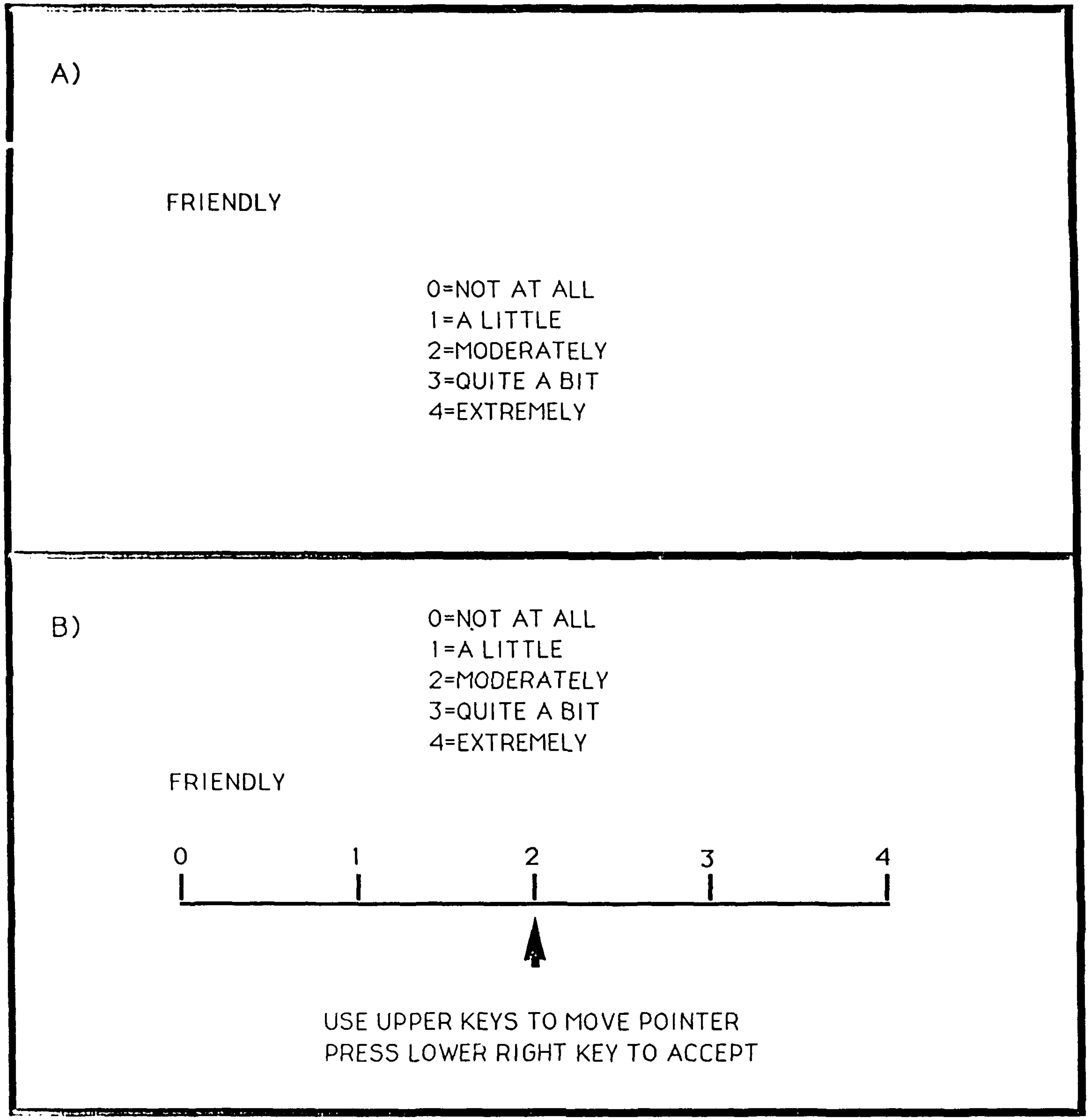

Figure 3. Formats for Profile of Mood States questions: A) standard keyboard format; B) four-button keyboard format.

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A waterproof keyboard has been developed. This allows collection of cognitive performance data from divers submerged in a tank. Cognitive tasks are presented to the divers on a computer screen placed at the tank viewing window. The four button keyboard can be easily manipulated while wearing standard diving gloves. Software techniques for adapting various types of tasks to the four-button response format are discussed.

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