PART1 and PART2: Programs for determining reading thresholds and motor response latencies

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One of the most perplexing problems in designing research in the area of cognitive development is identifying developmentally sensitive tasks that measure similar cognitive processes. Quite often tasks need to be modified for different age groups to avoid ceiling effects in older subjects and floor effects in younger ones (Achenbach, 1978). When making such modifications, the experimenter must assume that equivalent cognitive processes are still being measured across age groups. However, empirical evidence to support this assumption is infrequently reported. The threshold calculation and stimulus presentation procedures incorporated in the present programs, PART1 and PART2, may be used to investigate cognitive processes in a developmentally sensitive manner. When utilizing certain stimuli—for example, overlearned simple arithmetic addition problems—it may be reasonable for an experimenter to assume that the same cognitive process—in this case single-digit arithmetic—is being measured across ages. That is, briefly presented stimuli may evoke similar processes for subjects beyond a certain age. Once a subject's reading threshold (i.e., the minimum duration of presentation necessary for the subject to accurately read a stimulus) has been determined, task difficulty may be altered by varying the duration of stimulus presentation without changing the task.

PART1 is a BASIC program designed to determine a subject's reading threshold for various stimuli, ranging from words to simple arithmetic problems. The threshold determination procedure used in this program is similar to procedures used in psychophysics to establish stimulus perception thresholds (e.g., Sturr, Church, Nuding, Van Orden, & Taub, 1986). PART2, also a BASIC program, uses information obtained in the running of PART1 to present stimuli for durations above and below a subject's reading threshold.

PART1 and PART2 are readily modifiable for use with a variety of stimuli if an investigator wishes to determine reading thresholds and subsequently present stimuli for different durations around the subject's threshold, thus varying task difficulty. An investigator might also wish to examine a subject's response accuracy as a function

of the duration of presentation or of the type of stimuli used, for instance, using familiar versus unfamiliar words.

Common Features. Both programs are fully interactive and have adequate internal documentation to aid in user modification. In addition, immediately after the running of a subject, each program prints out a hard copy of the data collected.

PART1. PART1 determines a subject's reading threshold for whatever stimuli are of experimental interest. The program controls the duration of visual processing through backward pattern masking (Seymour, 1979). The masking pattern consists of a 12×7 array of dollar signs (\$) displayed immediately after the target stimulus. The mask symmetrically covers the area surrounding the presented stimulus and remains illuminated for 800 msec.

The pattern mask will have an effect on both the formation and the stability of visual icons (Seymour, 1979). As a result of the short duration between the presentation of the target stimulus and mask, the mask will interfere with the formation of accurate icons. In addition, the long duration of the mask will lead to the formation of a new icon, eliminating the initial iconic representation.

A subject's reading threshold is established using a staircase method developed by Wetherill and Levitt (1965). The duration of the initial stimulus presentation is 1,000 msec. If the subject correctly reads the stimuli presented at speeds between 600 and 1,000 msec, then each subsequent presentation will be 100 msec faster than the previous one. If a subject reaches the 500-msec mark without making two consecutive errors, then each subsequent stimulus will be presented 50 msec faster. It should be noted that presentation times, increments, and decrements are easily modified to suit a particular experimenter's purposes. Following stimulus presentation, the experimenter types a "Y" from the keyboard to indicate a correct reading, an "N" otherwise.

When a subject has incorrectly read a stimulus, a second trial is presented at the same stimulus duration. An error is defined as two consecutive misread stimuli at a given presentation duration. If the subject reads the second stimulus correctly, then no error is recorded, and the next stimulus presentation will be appropriately shorter as described above. The duration of presentation following an error is identical to the stimulus duration of the last correct response. In the event that the task is too difficult for a subject and the subject fails to respond correctly, presentation duration will be incremented from 1,000 msec until a basal performance level is attained.

Subsequent stimuli are presented at decrements of 10 msec, until the subject can no longer read the stimuli. At this point, stimulus presentation time is increased by 10 msec until the subject correctly reads two consecutive stimuli at the same speed of presentation. This cycle is repeated eight times. The 2-to-1 hit-to-miss ratio produces a minimum accuracy of 71%, as opposed to 50% obtained

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through random guessing with a 1-to-1 ratio (Wetherill & Levitt, 1965).

In an attempt to control for the large variability of early responses, only the last six cycles are used in the calculation of the threshold. The reading threshold is defined as the average of the minimum speed necessary for reading and the maximum speed necessary for nonreading of particular stimuli over the last six trials. Similar techniques for establishing stimulus perception thresholds have frequently been used in psychophysics (e.g., Sturr et al., 1986).

PART2. The second program presents stimuli for durations above and below a subject's reading threshold as determined in PART1. As the program is currently written, stimuli are presented at two different durations. Half are presented at the subject's reading threshold plus one standard deviation. The other half are presented at the subject's reading threshold minus one standard deviation. This manner of presentation ensures that the subject will be able to see and process approximately half of the stimuli presented. This manipulation allows for the determination of feeling-of-knowing accuracy, which PART2 was originally designed to investigate. That is, a subject who cannot accurately perceive a stimulus should not report a high "feeling of knowing" of what the stimulus was. Reaction times are recorded from the offset of the stimulus until the subject makes a manual response (e.g., depressing a game paddle). These reaction times permit comparisons of responses made about varying aspects of the stimuli or task. At the beginning of PART2, two sample trials are presented, along with two meaningless stimuli, that measure each subject's motor response time. PART2 is easily modified to present any stimuli of interest for any desired durations above or below a subject's reading threshold.

Limitations. Since these programs involve an interactive sequence with each subject, subjects must be run one at a time. In addition, an experimenter must be present to enter subject information as well as to pace the experiment itself. Following the subject's verbal responses, the experimenter makes the determination of whether or not a subject accurately perceived the stimulus. This information is manually entered by the experimenter immediately following the subject's response.

Language and Devices Needed. Both programs are written in Applesoft BASIC and require 64K of RAM under the PRODOS operating system. The program is written to be used with the Proclock by Practical Peripherals, 31245 La Baya Drive, Westlake Village, CA 91362; however, it can be modified to work with similar clocks. Finally, game paddles (or analogous devices) are needed.

Program Availability. PART1 and PART2 are available on disk by sending \$6 to Jeffrey J. Walczyk. Requests from outside the United States should include \$8 for costs and airmail delivery. Program listings are available free of charge.

REFERENCES

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Listing of PART1

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1 REM Part I, a program by Jeffrey J. Walczyk
3 DIM RT(2,8): DIM P0$(60): DIM MM(12):QQ = 1
5 IF PEEK(768) < > 8 THEN PRINT CHR$(4);"BRUN MSRTN"
7 GOSUB 1000: REM Jump to subroutine to load problems.
10 HOME
13 PRINT
15 PRINT "1. RUN A SUBJECT THROUGH THE ENTIRE"
16 PRINT "  EXPERIMENTAL SESSION.": PRINT
20 PRINT "2. EXIT THIS PROGRAM.": PRINT
35 PRINT : INPUT "ENTER A SELECTION (1 OR 2)":SE
40 IF SE < 1 OR SE > 2 THEN PRINT "INVALID SELECTION; TRY AGAIN!": GOTO
   35
45 IF SE = 2 THEN END
50 IF SE = 1 THEN GOTO 100
90 GOTO 10
99 END
100 REM This subroutine is a driver, calling the appropriate sub-
102 REM routines coming later in the program in their proper order.
105 GOSUB 1200: REM Get student data
107 GOSUB 1400: REM Clear screen
108 DL = 1000
110 LC = 1000
115 GOSUB 900
120 IF AN$ = "1" AND DL < = 500 THEN LC = DL:NC = 0:DL = DL - 50
125 IF AN$ = "1" AND DL > 500 THEN LC = DL:NC = 0:DL = DL - 100

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Listing of PART1 (Continued)

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130 IF AN$ = "2" THEN NC = NC + 1
135 IF NC = 2 THEN GOTO 160: REM Jump to 1 through 8 loop.
137 IF DL < 20 THEN DL = 20: GOTO 160
140 GOTO 115
160 DL = LC
165 FOR KK = 1 TO 8
170 GOSUB 900
175 IF AN$ = "1" THEN YC = YC + 1
180 IF YC = 2 THEN RT(2, KK) = DL: YC = 0: GOTO 195
185 IF AN$ = "2" THEN YC = 0: DL = DL + 10: GOTO 170
190 GOTO 170
195 DL = DL - 10: GOSUB 900
200 IF AN$ = "2" THEN RT(1, KK) = DL: GOTO 210
205 GOTO 195
210 DL = DL + 10: NEXT KK
212 GOSUB 2000: REM Branch to subroutine to save subject data to disk
215 HOME : PRINT "INFO IS ABOUT TO BE PRINTED FOR": PRINT "THIS SUBJECT.
    IS PRINTER READY?"
216 GOSUB 1400: GOSUB 3500
290 HOME : PRINT "The first phase of data collection": PRINT "is through
    !"
292 GOSUB 1400
300 END : REM END OF PROGRAM
900 REM This subroutine will print a math problem, PR$, at the center
    of the computer's screen
905 REM for the numberr of milliseconds specified in the variable DL.
910 REM The delay subroutine is called from this one.
911 PR$ = PO$(QQ): QQ = QQ + 1: IF QQ = 61 THEN QQ = 1
915 HOME : REM Clear the screen
918 FOR GG = 1 TO 2000: NEXT GG
920 VTAB 11: HTAB 19: PRINT PR$
925 GOSUB 1300: REM Call timing routine
926 VTAB 11: HTAB 15: PRINT "$$$$$$$$$$"
927 VTAB 10: HTAB 15: PRINT "$$$$$$$$$$"
928 VTAB 12: HTAB 15: PRINT "$$$$$$$$$$"
929 VTAB 9: HTAB 15: PRINT "$$$$$$$$$$"
930 VTAB 13: HTAB 15: PRINT "$$$$$$$$$$": VTAB 8: HTAB 15: PRINT "$$$$
    $$$$$$": VTAB 14: HTAB 15: PRINT "$$$$$$$$$$"
932 VTAB (24): HTAB (1)
934 GET AN$
935 IF AN$ < > "1" AND AN$ < > "2" THEN PRINT CHR$ (7): GOTO 934
945 RETURN : REM End of subroutine
1000 REM This routine loads the PO$ array with 60 math problems.
1010 D$ = CHR$ (4): PRINT D$; "OPEN PROBLEMS"
1015 PRINT D$; "READ PROBLEMS"
1020 FOR X = 1 TO 60: INPUT PO$(X)
1025 NEXT X: PRINT D$; "CLOSE PROBLEMS"
1030 RETURN : REM End of routine
1200 REM This routine obtains the subject's name, class, age, number,
1205 REM and the date.
1210 HOME
1215 INPUT "Enter subject's name "; NA$
1220 INPUT "Enter subject's class "; CL$
1225 INPUT "Enter subject's age "; AG
1230 INPUT "Enter subject number "; SN
1235 INPUT "Enter date "; DT$
1240 PRINT : PRINT "The subject's name is "; NA$
1245 PRINT "The subject's class is "; CL$
1250 PRINT "The subject's age is "; AG
1255 PRINT "The subject's number is "; SN
1260 PRINT "The date is "; DT$
1265 PRINT : INPUT "IS THE ABOVE INPUT CORRECT (Y or N) "; AN$
1270 IF AN$ < > "Y" THEN 1210
1275 RETURN : REM End of routine
1300 REM This routine causes a delay to occur for the number of
1305 REM milliseconds specified in the global variable DL.
1310 CALL 640: REM INITIALIZE MSRTN

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Listing of PART1 (Continued)

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1315 CALL 785: REM RESET COUNTER AND START
1320 A = PEEK (974):B = PEEK (975):MS = INT ((B + A * 256) * 1000 / 10
    24)
1325 IF MS < DL THEN 1320
1330 CALL 795: REM STOP COUNTER
1335 RETURN
1400 REM This routine clears the screen and instructs the experimenter
1402 REM to press any key to continue.
1403 VTAB (23): HTAB (10)
1405 PRINT "PRESS ANY KEY TO CONTINUE!"
1410 GET A$: IF A$ = "" THEN 1410
1412 HOME
1415 RETURN : REM End of subroutine
2000 REM This routine appends another subject's data to the datafile.
2010 PRINT CHR$ (4);"APPEND SUBJDAT"
2012 PRINT CHR$ (4);"WRITE SUBJDAT"
2015 PRINT NA$: PRINT CL$: PRINT AG: PRINT SN: PRINT DT$
2020 FOR X = 1 TO 2: FOR Y = 1 TO 8: PRINT RT(X,Y): NEXT Y: NEXT X
2025 PRINT CHR$ (4);"CLOSE SUBJDAT"
2030 RETURN : REM End of subroutine
3500 REM This routine prints out a single subject's information.
3502 GOSUB 6000: REM JUMP TO SUBROUTINE WHICH CALCULATES MEDIAN
3503 HOME : PRINT "INFO IS ABOUT TO BE PRINTED!"
3504 PRINT "MAKE SURE THE PRINTER IS READY!": GOSUB 1400
3505 PR# 1: PRINT "SUBJECT NAME ";NA$
3510 PRINT "SUBJECT CLASS ";CL$
3515 PRINT "SUBJECT AGE ";AG
3520 PRINT "SUBJECT NUMBER ";SN
3535 PRINT "DATE OF EXPERIMENT ";DT$
3537 PRINT "THE MEDIAN REACTION TIME IS ";MD
3540 FOR X = 1 TO 2
3545 IF X = 1 THEN PRINT "EIGHT BASAL REACTION TIMES"
3550 IF X = 2 THEN PRINT "EIGHT CEILING REACTION TIMES"
3555 FOR Y = 1 TO 8: PRINT RT(X,Y);" ";: NEXT Y: PRINT
3560 NEXT X: PRINT : PRINT
3653 PR# 0
3670 RETURN
6000 REM SUBROUTINE TO DETERMINE MEDIAN
6002 CC = 1
6005 FOR X = 1 TO 2: FOR Y = 3 TO 8
6010 MM(CC) = RT(X,Y):CC = CC + 1
6015 NEXT Y: NEXT X
6020 FOR X = 1 TO 12: FOR Y = 1 TO 12
6025 IF MM(Y) < MM(X) THEN CC = MM(X):MM(X) = MM(Y):MM(Y) = CC
6030 NEXT Y: NEXT X
6035 MD = (MM(6) + MM(7)) / 2
6040 RETURN

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Listing of PART2

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5 REM Part II, a program by Jeffrey J. Walczyk
7 DIM PP(2): DIM CA$(36):SW$ = "N"
10 DIM RT(2,8): DIM R1(36): DIM R2(36): DIM RP$(36)
15 DIM P2$(36)
35 PRINT CHR$ (4);"OPEN PROB2": PRINT CHR$ (4);"READ PROB2"
40 FOR X = 1 TO 36: INPUT P2$(X): NEXT X
45 PRINT CHR$ (4);"CLOSE PROB3"
50 GOSUB 1000: REM Call to subroutine which will read subject data from
    PART I
53 HOME
61 GOSUB 3000: GOSUB 800
62 HOME : PRINT "PART II IS TO BEGIN!": GOSUB 1400
63 SW$ = "Y"
65 FOR QQ = 1 TO 36
68 HOME : FOR GG = 1 TO 2000: NEXT GG

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Listing of PART2 (Continued)

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70 PP$ = P2$(QQ): GOSUB 900
72 R2(QQ) = RR
75 IF QQ = 12 OR QQ = 24 THEN PRINT "END OF A BLOCK OF 12": INPUT "PRES
    S RETURN KEY TO CONTINUE.";WW$
80 NEXT QQ
82 GOSUB 4000
85 HOME : PRINT "PART II IS OVER."
90 PRINT "INFORMATION IS ABOUT TO BE SENT TO THE"
95 PRINT "PRINTER! MAKE SURE IT IS READY!": GOSUB 1400
100 GOSUB 2500
130 END
800 REM SUBROUTINE WHICH DISPLAYS SAMPLE PROBLEMS
801 HOME :CO$ = "N"
805 PP$ = "1 + 0": HOME : PRINT "SAMPLE PROBLEMS ARE TO BE DISPLAYED!"
807 GOSUB 1400: HOME
808 FOR GG = 1 TO 2000: NEXT GG
809 CO$ = "N"
810 DL = 1000: GOSUB 905: FOR GG = 1 TO 3000: NEXT GG:CO$ = "N":PR$ = "0
    + 1": GOSUB 905
815 RETURN : REM End of subroutine
900 REM Screen print subroutine
902 IF LEFT$(PP$,1) = "F" THEN DL = FT
903 IF LEFT$(PP$,1) = "S" THEN DL = ST
904 CO$ = "N":PP$ = RIGHT$(PP$,5)
905 HOME : VTAB 11: HTAB 19: PRINT PP$
941 GOSUB 1350
942 IF SW$ = "Y" THEN GOSUB 1500
943 HOME
950 RETURN
1000 REM This subroutine reads student data from PART 1, calculates
1005 REM that subject's mean and standard deviation, etc.
1010 HOME : INPUT "ENTER THE SUBJECT'S NUMBER ";NS
1015 PRINT : PRINT "THE SUBJECT'S NUMBER IS ";NS
1020 INPUT "IS THIS CORRECT (Y OR N)";AN$: IF AN$ < > "Y" THEN 1010
1025 PRINT CHR$(4);"OPEN SUBJDAT"
1030 PRINT CHR$(4);"READ SUBJDAT"
1035 INPUT NA$: INPUT CL$: INPUT AG: INPUT SN: INPUT DT$
1040 FOR X = 1 TO 2: FOR Y = 1 TO 8
1045 INPUT RT(X,Y): NEXT Y: NEXT X
1050 IF SN < > NS THEN 1035: REM If not proper subject, read the next
    subject record.
1055 PRINT CHR$(4);"CLOSE SUBJDAT"
1065 GOTO 1080
1070 PRINT "THE SUBJECT NUMBER ENTERED IS ": PRINT "NOT IN THE DATA FILE
    ."
1072 PRINT "PLEASE TRY AGAIN!"
1073 GOSUB 1400
1075 GOTO 1000: REM Jump back and try again.
1080 ME = 0: REM Set Subject mean score to 0
1085 FOR X = 1 TO 2: FOR Y = 3 TO 8:ME = ME + RT(X,Y): NEXT Y: NEXT X
1090 ME = ME / 12
1095 SD = 0: REM Set standard deviation to 0
1100 TT = 0: FOR X = 1 TO 2: FOR Y = 3 TO 8:TT = TT + (RT(X,Y) - ME) ^ 2:
    NEXT Y: NEXT X
1105 SD = (TT / 12) ^ .5
1110 FT = ME - SD:ST = ME + SD
1115 RETURN
1350 REM This subroutine is responsible for taking reaction times till
1355 REM the red button is pressed.
1360 CALL 640: CALL 785
1365 A = PEEK (974):B = PEEK (975):MS = INT ((B + A * 256) * 1000 / 10
    24)
1366 IF MS > = DL AND CO$ = "N" THEN GOSUB 5000
1367 IF PEEK ( - 16286) > 127 THEN GOTO 1380
1370 GOTO 1365
1380 PRINT CHR$(7):RR = MS: CALL 795: RETURN
1400 REM Press any key to continue subroutine

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Listing of PART2 (Continued)

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1405 VTAB (23): HTAB (5): PRINT "PRESS ANY KEY TO CONTINUE!"
1410 GET A$: IF A$ = "" THEN 1410
1415 RETURN : REM End of subroutine
1500 REM This subroutine is called to record the subject's
1505 REM answers.
1510 GET AA$: IF AA$ < > "1" AND AA$ < > "2" AND AA$ < > "3" THEN PRINT
      CHR$ (7): GOTO 1510
1515 CA$(QQ) = AA$: RETURN
2500 REM This subroutine prints out data collected during PART 2.
2502 PR# 1: PRINT "PHASE II, PART 1": PRINT
2510 PRINT "SUBJECT NAME ";NA$
2515 PRINT "SUBJECT NUMBER ";SN
2520 PRINT "MOTOR RESPONSE TIMES"
2525 PRINT PP(1);" ";PP(2)
2527 PRINT "THE MEAN IS ";ME;" THE STANDARD DEVIATION IS ";SD
2530 PRINT "36 REACTION TIMES"
2535 FOR X = 1 TO 36: PRINT R2(X);" ";
2540 IF X / 6 = INT (X / 6) THEN PRINT
2545 NEXT X
2547 PRINT "36 YES/NO/MAYBE RESPONSES"
2550 FOR X = 1 TO 36: PRINT CA$(X);" ";
2555 IF X / 6 = INT (X / 6) THEN PRINT
2560 NEXT X: RETURN
3000 REM This subroutine gets motor response times!
3005 HOME : PRINT "MOTOR RESPONSES ARE TO BE MEASURED": GOSUB 1400
3010 FOR X = 1 TO 2
3012 HOME
3015 FOR Y = 1 TO 2500: NEXT Y
3020 VTAB 11: HTAB 19: PRINT "*****"
3025 GOSUB 1350:PP(X) = RR
3030 NEXT X: RETURN
4000 PRINT CHR$ (4);"APPEND SUBJDAT2"
4005 PRINT CHR$ (4);"WRITE SUBJDAT2"
4010 PRINT NA$: PRINT SN
4015 FOR X = 1 TO 36: PRINT R2(X): NEXT X
4020 FOR X = 1 TO 36: PRINT CA$(X): NEXT X
4025 PRINT CHR$ (4);"CLOSE SUBJDAT2"
4030 RETURN
5000 REM SUBROUTINE TO PRINT MASK
5004 VTAB 11: HTAB 15: PRINT "$$$$$$$$$$"
5005 VTAB 10: HTAB 15: PRINT "$$$$$$$$$$"
5010 VTAB 12: HTAB 15: PRINT "$$$$$$$$$$"
5015 VTAB 9: HTAB 15: PRINT "$$$$$$$$$$"
5020 VTAB 13: HTAB 15: PRINT "$$$$$$$$$$"
5025 VTAB 8: HTAB 15: PRINT "$$$$$$$$$$"
5030 VTAB 14: HTAB 15: PRINT "$$$$$$$$$$"
5032 CO$ = "Y"
5035 RETURN

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