DOCUMENT RESUME

ED 406 013 PS 025 231

AUTHOR	Irwin, Holly M.; Burns, Barbara M.
TITLE	Attention-Sharing in Middle Childhood: An Analysis of Performance Operating Characteristics.
PUB DATE	Apr 97
NOTE	21p.; Paper presented at the Biennial Meeting of the Society for Research in Child Development (62nd, Washington, DC, April 3-6, 1997).
PUB TYPE	Speeches/Conference Papers (150) -- Reports - Research/Technical (143)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Age Differences; Attention; *Attention Control; *Children; Data Analysis; Elementary Education
IDENTIFIERS	Dual Tasks

ABSTRACT

Two experiments investigated developmental differences in attention allocation and attention-sharing in a dual-task paradigm using Performance Operating Characteristics (POC) as an innovative data analysis method. In Experiment 1, attention allocation was assessed. Two visual detection tasks were presented to 20 second- and 11 fifth-graders who indicated whether a target on each display was present or absent. Baselines of single-task performance were equated for each individual. After practice trials in which tasks were presented concurrently, subjects received instruction for each of five experimental conditions, which had different emphasis ratios. Accuracy was measured for 12 practice and 48 test trials. Experiment 2 assessed attention-sharing. Again, second- and fifth-graders participated. Procedures were identical to Experiment 1 except that baseline durations were obtained while both tasks were presented, participants received practice trials for the concurrent task before they performed baseline procedures, and only one emphasis ratio was employed. Results indicated that fifth graders could allocate their attention to different emphasis levels, but second-graders did not. Second-graders had a significantly slower baseline than fifth-graders. However, there was no age difference in attention-sharing. The POC analysis, which used performance functions in which performance on one task was plotted as a function of performance on a second task, allowed a more precise assertion of attention allocation and demonstrated the need to equate the baselines in developmental studies. (Contains 20 references.) (KDFB)

Attention-Sharing in Middle Childhood: An Analysis of Performance Operating Characteristics

Holly M. Irwin
and
Barbara M. Burns

Overview

The goal of our research studies was to better characterize developmental differences in attention allocation (i.e., the ability to manipulate attention) and attention-sharing in a dual-task paradigm using Performance Operating Characteristics (POC) as an innovative way to analyze the data.

Past research using the dual-task paradigm has yielded conflicting results. As shown in Table 1, some research has suggested that developmental differences in both attention allocation and attention-sharing exist while others have not. Reasons for the mixed results include confusion of the terminology, methodological issues, and problematic statistical procedures. The terminology used for attention allocation has been metacognition, self-regulation, and executive control. Each has several different operational definitions which has led to different ways of measuring attention allocation and, not surprisingly, different conclusions. Ambiguous task instructions and the lack of controls for different individual capacity levels has been identified by Somberg and Salthouse (1982) and Guttentag (1989) as problematic. The use of difference scores in the dual-task paradigm has over-corrected for single-task ability (Ackerman, Schneider, & Wickens, 1984), been demonstrated to be less reliable than either of the original scores (Brainerd and Reyna, 1989), and likely to lead to regression-to-the-mean (Cohen & Cohen, 1975; Ackerman & Wickens, 1982).

Performance Operating Characteristics (POC) analysis was employed in our research in order to address dual-task performance. POC analysis uses performance functions in which performance on one task (e.g., Task A) is plotted as a function of performance on the second task (e.g., Task B). Typically, as the allocated resources increase for one task, the availability of resources for the other task decreases (Somberg & Salthouse, 1982). The benefits of using this alternative statistical procedure include: being able to explicitly measure attention allocation within the capacity sharing model with varying emphasis levels; accurately measuring the total potential performance region for divided attention; and obtaining a measure of dual-task cost without necessitating the use of difference scores.

The current research examines attention allocation and attention-sharing in second- and fifth-graders with a consideration of the issues discussed above. In this research, the baselines of single-task performance will be equated for each individual and POC analysis will be implemented as a statistical procedure which will allow a more careful examination of these attention control processes. Our predictions are: (1) attention-sharing will develop before attention allocation, and (2) developmental differences will exist in attention allocation.

Methods

Experiment 1: Attention Allocation

Participants

Twenty second- and eleven fifth-graders volunteered for participation from a local public elementary school.

Apparatus and Procedure

The procedure was adapted from Somberg and Salthouse (1982) in which two visual detection tasks were presented to participants who were required to respond whether a target on each display was present or absent. Each child was individually tested on a laptop computer using Microcomputer Experimental Laboratories (MEL) software. Accuracy was the dependent measure.

Task 1 (Task X). As shown in Figure 1, four X's appeared at each of the four corners of an imaginary rectangle centered on the computer screen. The target was a small line (.14 cm) extending from the vertex of one of the X's. The location of the target could be on any of the four vertices of the X or the four corners of the imaginary rectangle. Each of the sixteen possible target locations was an equally likely event.

Task 2 (Task +). As shown in Figure 2, four plus signs (+'s) appeared at each of the four corners of an imaginary rectangle centered on the screen which was concentric to the imaginary rectangle of Task X. The target was a small line (.10 cm) extending from one of the four vertices of the + or the four corners of the imaginary rectangle. Each position was equally likely to occur.

Session 1: Equating the Baselines. Participants were presented with each task in a single-task environment to familiarize them with each task. Baseline durations for the task were assessed using Task X alone. Stimulus durations were manipulated (+/- 100 msec) until each participant was operating at an accuracy level between 75 and 80% for detection in one task. Individual baselines control for different levels of capacity among participants in the second- and fifth-grades.

Session 2: Experimental Trials. Participants received 32 practice trials in which both tasks were presented concurrently. Trials resembled Figure 3 in which both Tasks X and + were presented. Following practice, participants received instructions for each of the five experimental conditions with emphasis ratios of 4:0, 3:1, 2:2, 1:3, and 0:4. Figure 4 depicts how this was employed. Twelve practice and 48 test trials were presented for each of the five experimental conditions and accuracy was measured. Conterbalancing was achieved by giving half the subjects in each age group the emphasis order mentioned above while the other half received the reverse order.

Experiment 2: Attention-Sharing

Participants

Twenty second- and 20 fifth-graders volunteered for participation from a local public elementary school.

Apparatus and Procedure

The apparatus and procedure were identical to the previous experiment except for three things: (1) the baseline durations for the task were obtained while both tasks were presented, (2) participants received practice trials for the concurrent task before they performed the baseline procedure, and (3) only the 2:2 ratio condition was employed.

Results

Experiment 1: Attention Allocation

Performance Operating Characteristics (POC) Analysis

POC analysis is a method in which divided attention cost is determined in a dual-task environment. First, accuracy data from the two tasks are plotted along the x- and y-axes ranging from the minimum to maximum values. If there are no divided attention costs, then the three intermediary points would be located at the upper-right corner of the POC graph. To the extent that there are divided attention costs, the three intermediary points would be located down and to the left of the upper-right point. As shown in Figure 5, the area of this region is the divided attention cost (DAC). The total area of the entire rectangle is termed the functional performance region (FPR). The area of the FPR is calculated by computing the area of the rectangle produced in the graphs. The FPR signifies the potential dual-task performance.

The POC graphs for second- and fifth-graders are shown in Figures 6 and 7. The areas of the FPR and DAC were calculated for each group. The FPR regions were 193.20 and 1183.82 units for second- and fifth-graders, respectively. The relative DAC regions were 78.36 and 68.40 units of FPR, which is in the expected direction.

In a study conducted on age differences among younger and older adults (Somberg & Salthouse, 1982), young adults were found to have 1330.7 FPR units and 42.00 DAC units of FPR while the older adults were found to have 1296.7 FPR units and 42.00 units of FPR. Figure 8 illustrates data for a recently conducted experiment on young adults, where it was found that they were operating with 2310 FPR units and 90.12 DAC units of FPR. In comparing the FPRs, although the data from Somberg and Salthouse (1982) are similar to the data of the fifth-graders, data from recent adult participants demonstrate a larger range in the FPR. In comparing the DAC regions, it appears that the data from Somberg and Salthouse (1982) exhibit less cost than either the second- or fifth-graders. However, in our study with adults, there appears to be more cost. Further comparisons could not be made as the individual data did not meet the assumption of being a "monotonically increasing function of the amount of capacity allocated to a process" (Kantowitz & Weldon, 1985, p. 532).

Analysis of Variance

A two factor ANOVA for each task was also employed on the data (Grade X Condition). For both Tasks X and +, respectively, there was a Condition main effect, $F_{(4,116)} = 6.96$, $p < .0001$; $F_{(4,116)} = 14.26$, $p < .0001$, and an interaction of Grade X Condition, $F_{(4,116)} = 2.62$, $p < .05$; $F_{(4,116)} = 5.10$, $p < .001$. Further analysis revealed no differences among any of the emphasis levels for either task for second-graders. However, there were several significant differences among the emphasis levels for the fifth-graders in both tasks. As illustrated in Figure 9, it appears that the fifth-graders were able to manipulate their attention to emphasis levels. In contrast, second-graders in both Tasks X and + did not demonstrate differential attention performance as a function of the emphasis levels.

Figure 10 shows the results of the adults for Tasks X and +. As expected, adults were also able to manipulate their attention to emphasis levels on both tasks (Task X: $F_{(4,172)} = 23.82$, $p < .001$; Task +: $F_{(4,172)} = 29.83$, $p < .001$. All comparisons were significant except for one for Task X (25:0) and two for Task + (50:25, 25:0).

Baselines

Different levels of capacity for the two grades was examined using a t-test comparing the baseline durations. Second-graders were found to have a significantly slower baseline (M = 1725.00) than fifth-graders (M = 1344.44), $t_{(29)} = 4.57$, $p < .001$. Figure 11 depicts the baselines for the adults (M = 1006.25) in relation to the baselines for the second- and fifth-graders, $F_{(2,43)} = 28.09$, $p < .001$. The baseline for adults was faster than for either the second- or fifth-graders.

Experiment 2: Attention-Sharing

Analysis of Variance

A one-way ANOVA was performed on accuracy for Task X and Task + in which the 50:50 condition was compared between second- and fifth-graders. There was no difference found for either task, $F_{(2,49)} < 1$. Figure 12 compares the result of this experiment to the 50:50 condition from experiment 1 for both second- and fifth-graders as well as the 50:50 condition from the adults. It should be noted that these data for attention-sharing (50:50) were obtained from one condition of the five experimental conditions.

Baselines

Different levels of capacity for the two grades were examined using a t-test between the baseline durations for second- and fifth-graders. Second-graders had a slower baseline duration (M = 1775.00) than the fifth-graders (M = 1417.65), $t_{(35)} = 4.28$, $p < .001$. Figure 13 illustrates the baseline durations for second- and fifth-graders and compares them to the baselines obtained from adults. In a one-way ANOVA, baselines were found to be significantly different, $F_{(2,49)} = 36.52$, $p < .001$, where the baseline for adults was faster than for either the second- or fifth-graders.

General Discussion

The results of these studies on attention-sharing and attention allocation demonstrate the existence of developmental differences in attention allocation and no developmental differences in attention-sharing. Performance Operating Characteristics analysis allowed a more precise assertion of attention allocation and demonstrated the necessity of individually equating the baselines in developmental studies. Future studies which build on these findings are needed to identify the mechanisms and strategies underlying the ability to successfully manipulate the allocation of attention.

References

Ackerman, P.L., & Wickens, C.D. (1982, March). Individual differences in time-sharing ability: A critical review and analysis (Report No. 8102). Champaign IL: University of Illinois, Human Attention Research Laboratory.

Ackerman, P.L., Schneider, W., & Wickens, C.D. (1984). Deciding the existence of a time-sharing ability: A combined methodological and theoretical approach. Human Factors 26(1), 71-82.

Birch, L.L. (1976). Age trends in children's time-sharing performance. Journal of Experimental Child Psychology 22, 331-345.

Birch, L.L. (1978). Baseline differences, attention, and age differences in time-sharing performance. Journal of Experimental Child Psychology 25, 505-513.

Bjorklund, D.F., & Harnishfeger, K.K. (1987). Developmental differences in the mental effort requirements for the use of an organizational strategy in free recall. Journal of Experimental Child Psychology 44, 109-125.

Brainerd, C.J., & Reyna, V.F. (1989). Output-interference theory of dual-task deficits in memory development. Journal of Experimental Child Psychology 47, 1-18.

Cohen, J., & Cohen, P. (1975). Applied multivariate regression/correlation analysis for the behavioral sciences. Hillsdale, NJ: Erlbaum.

Guttentag, R.E. (1984). The mental effort requirement of cumulative rehearsal: A developmental study. Journal of Experimental Child Psychology 37, 92-106.

Guttentag, R.E. (1989). Age differences in dual-task performance: Procedures, assumptions, and results. Developmental Review 9, 146-170.

Halford, G.S., Maybery, M.T., & Bain, J.D. (1986). Capacity limitations in children's reasoning: A dual-task approach. Child Development 57, 616-627.

Hiscock, M., & Kinsbourne, M. (1978). Ontogeny of cerebral dominance: Evidence from time-sharing asymmetry in children. Developmental Psychology 40, 486-500.

Hiscock, M., Kinsbourne, M, Samuels, M., & Krause, A.E. (1985). Effects of speaking upon the rate and variability of concurrent finger tapping in children. Journal of Experimental Child Psychology 40, 486-500.

Kamhi, A.G., & Masterson, J.J. (1986). The reliability of the time-sharing paradigm. Brain and Language 29, 324-341.

Kantowitz, B.H., & Weldon, M. (1973). On scaling performance operating characteristics: Caveat emptor. Human Factors 27(5), 531-547.

Kee, D.W., & Davies, L. (1988). Mental effort and elaboration: A developmental analysis. Contemporary Educational Psychology 13, 221-228.

Lane, D.M. (1979). Developmental changes in attention-deployment skills. Journal of Experimental Child Psychology 28, 16-29.

Manis, F.R., Keating, D.P., & Morrison, F.J. (1980). Developmental differences in the allocation of processing capacity. Journal of Experimental Child Psychology 29, 156-169.

Schiff, A.R., & Knopf, I.J. (1985). The effect of task demands on attention allocation in children of different ages. Child Development 56, 621-630.

Somberg, B.L., & Salthouse, T.A. (1982). Divided attention abilities in young and old adults. Journal of Experimental Psychology: Human Perception and Performance 8(5), 651-663.

White, N., & Kinsbourne, M. (1980). Does speech output control lateralize over time? Evidence from verbal-manual time-sharing tasks. Brain and Language 10, 215-223.

TABLE 1

Methodological Issues and Developmental Differences

Study	Subject ages	Tasks: 1 & 2	Task baselines	Task emphasis	Equation of baselines	Time-sharing dev. diff.	Attn allctn dev. diff.
Birch (1976)	7, 10, 13	Sa-diff Tracking	YES YES	*1 Task & *Equal	NO	YES	YES & NO
Birch (1978)	8, 13	Sa-diff Tracking	YES YES	Equal	YES (practice)	NO	N/A
Hiscock & Kinsbo. (1978)	3-12	Recitation Tap	NO YES	Ambiguous	Indirectly (practice)	YES	N/A
Lane (1979)	7, 9, college	Visual mem. Auditory tracking	YES YES	Tsk 1&2 Stimuli	YES amt of stimuli	NO	YES
Manis Keating & Morrison (1980)	8, 12, 20	Sa-diff Probe detection	YES NO	Only 1 Task	YES, but not systematic	YES	N/A
White & Kinsbo. (1980)	3-12	Recitation Tap	NO YES	Ambiguous	NO	YES	N/A
Guttent. (1984)	7, 8, 11	Recall Tap	NO YES	Only 1 Task	NO	E1:YES E2&3: NO	N/A
Hiscoc. Kinsbo. Samuels & Krause (1985)	6-10	Recitation Tap	YES YES	Ambiguous	Indirectly (practice)	YES: Tsk1 vs 1&2 NO:Tsk2 vs 1&2	N/A
Schiff & Knopf (1985)	9-13	Detection Visual memory	YES YES	Only 1 Task	YES pilot data	YES	N/A
Kamhi & Masters. (1986)	3, 5, 7, 9	Speech Tap	YES YES	Ambiguous	NO	YES	N/A
Halford Maybery & Bain (1986)	3-5	Transcript-ion reasoning Color recall	YES NO	Ambiguous	Indirectly (practice)	YES (E2)	N/A
Bjorklu. & Harnish. (1987)	9, 12, 21	Recall Tap	NO YES	Ambiguous	NO	NO	N/A
Kee & Davies (1988) Exp 1	11, college	Tap Memorization (aloud)	YES NO	Ambiguous	NO	NO	N/A
Kee & Davies (1988) Exp 2	Same	Tap Memorization (silent)	Same	Same	Same	YES	N/A

BEST COPY AVAILABLE

Figure 1

Figure 2

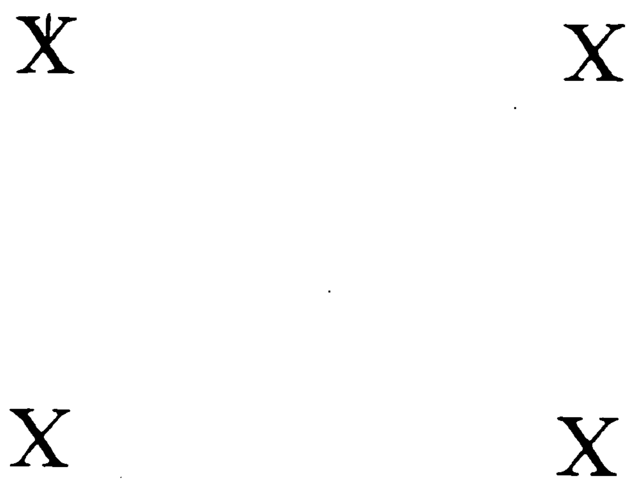
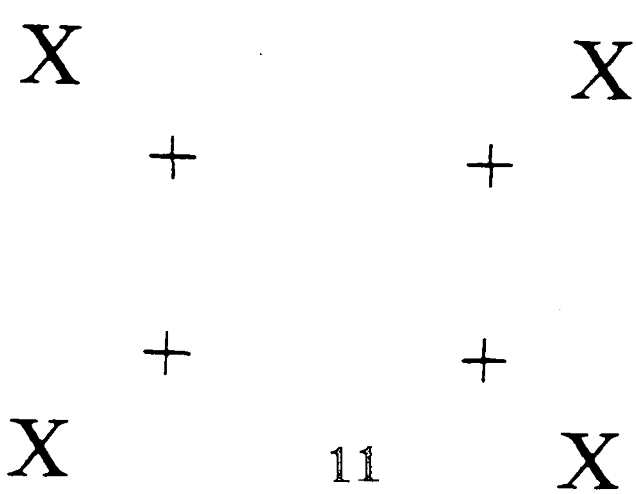


Figure 3



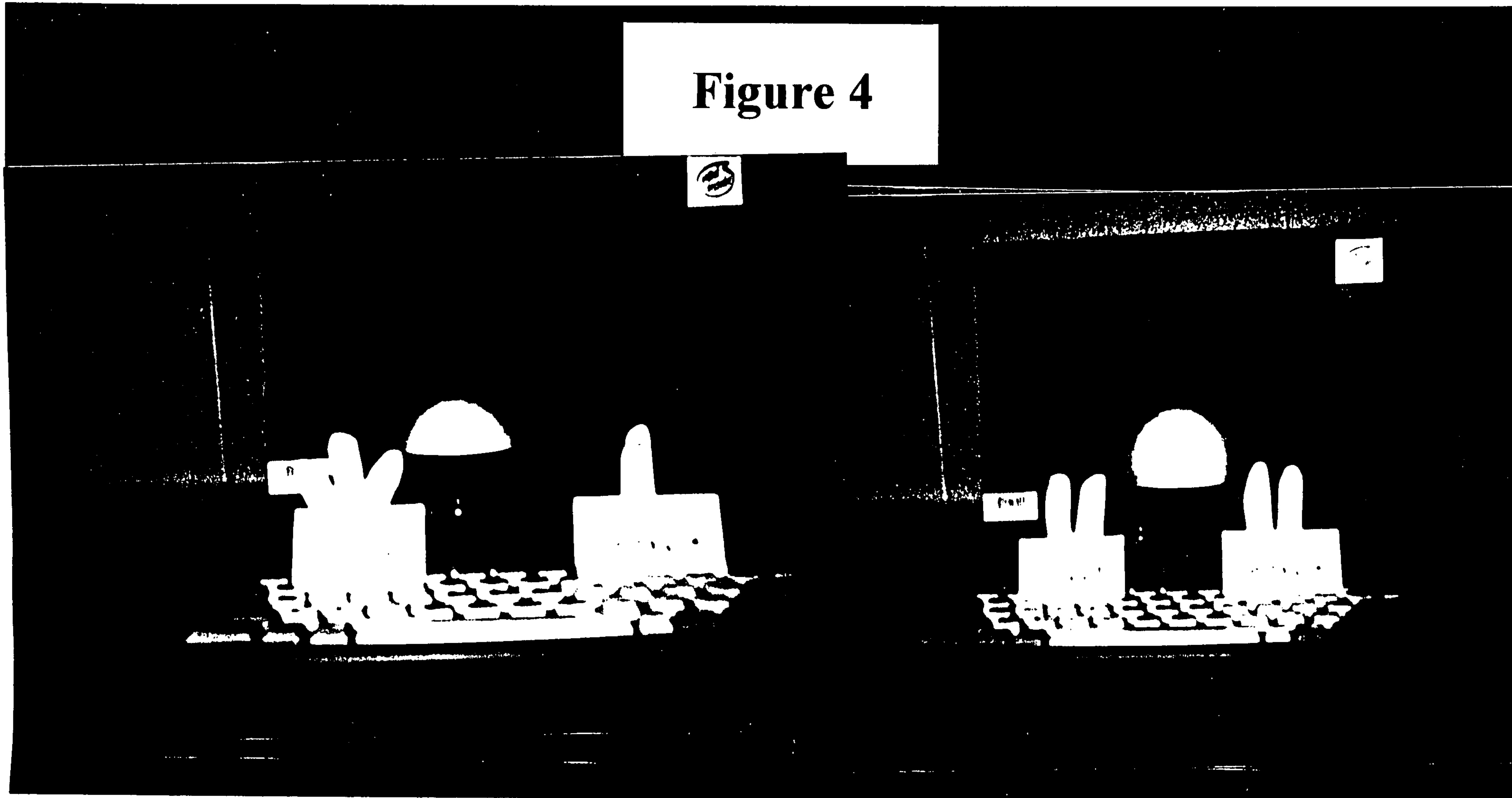


Figure 4

BEST COPY AVAILABLE

Figure 5

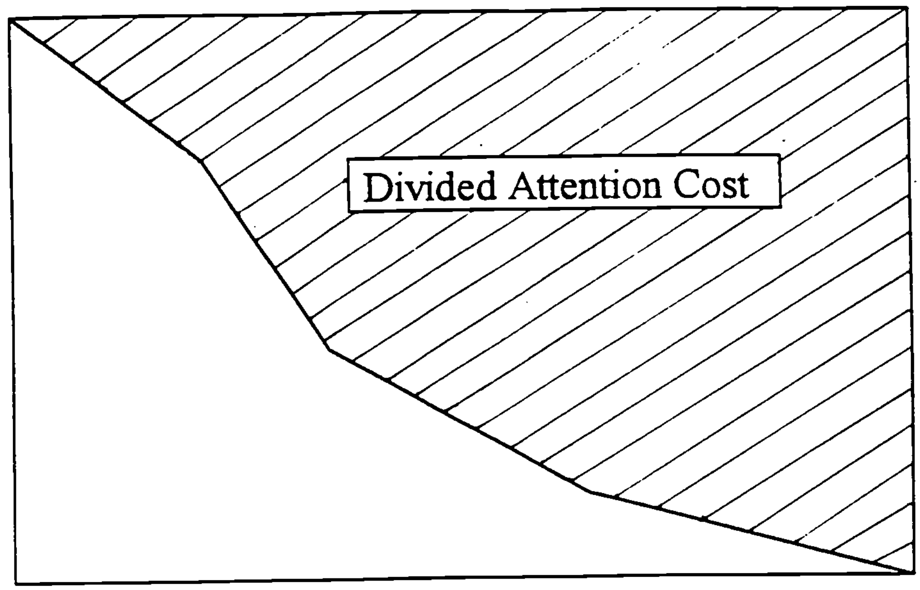
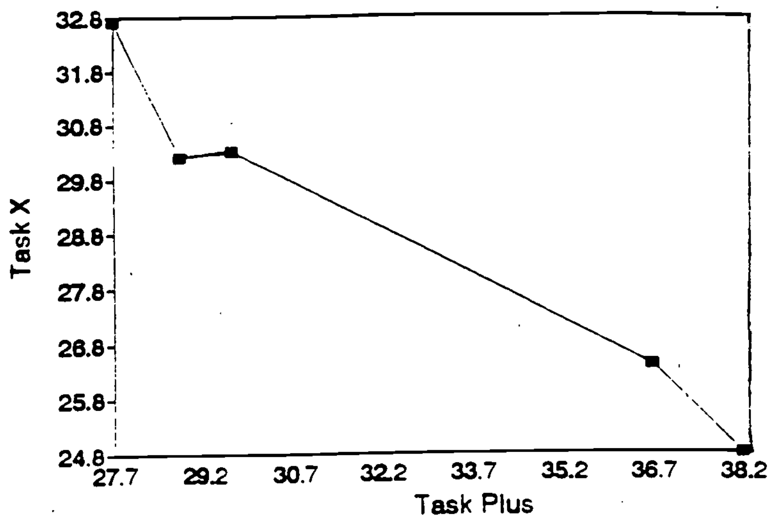


Figure 6

Performance Operating Characteristics
Second-Graders



Performance Operating Characteristics
Fifth-Graders

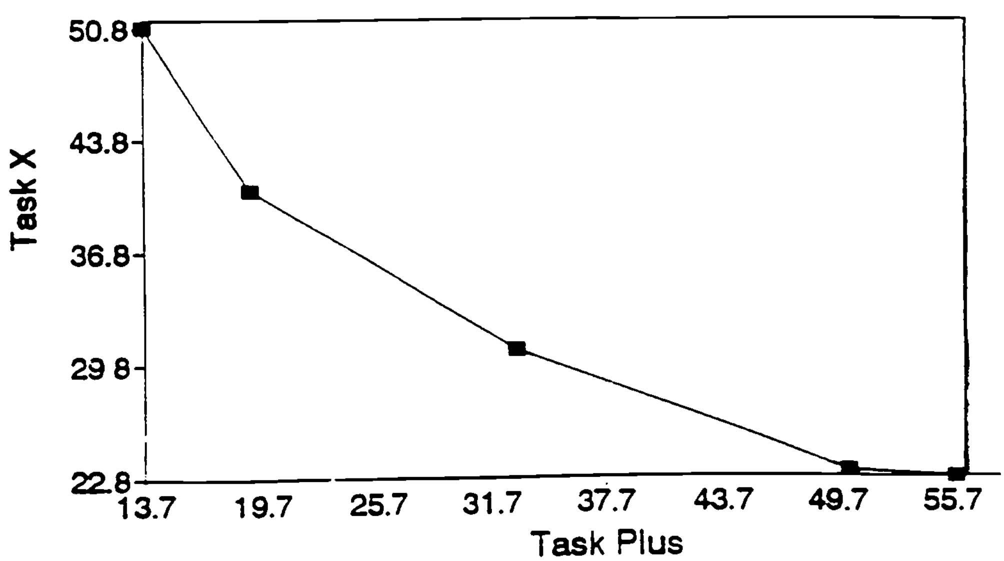


Figure 7

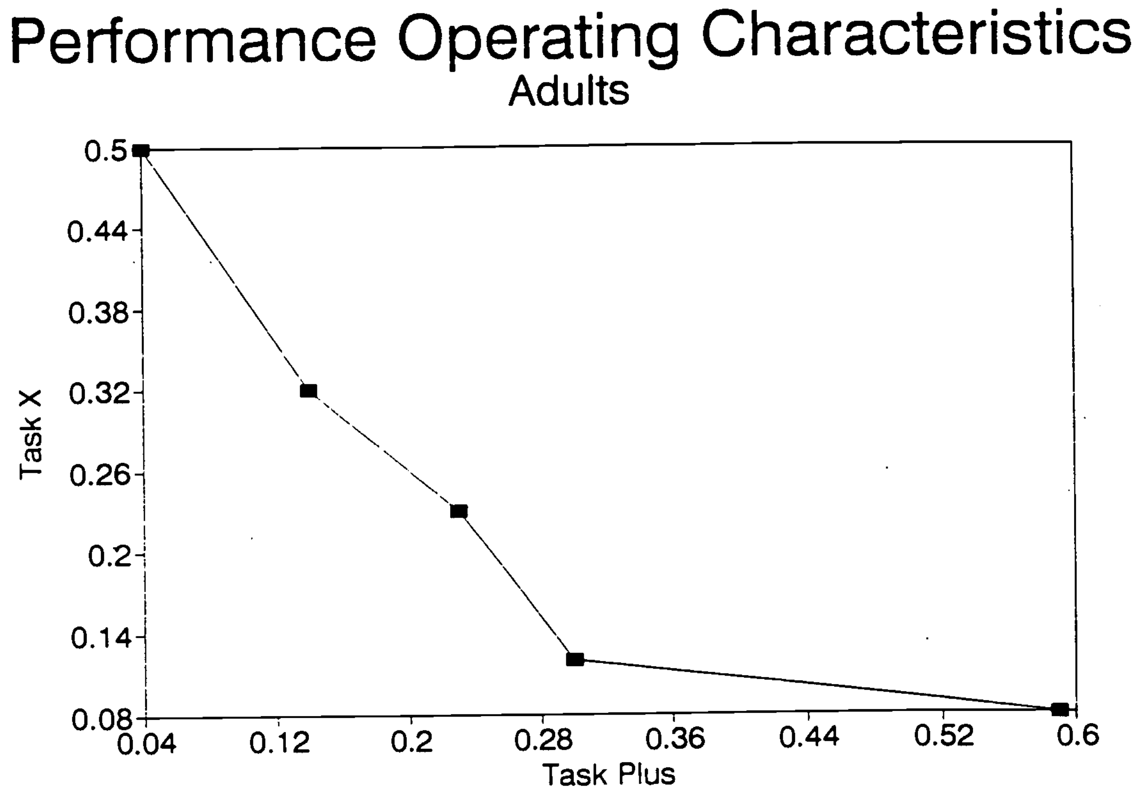
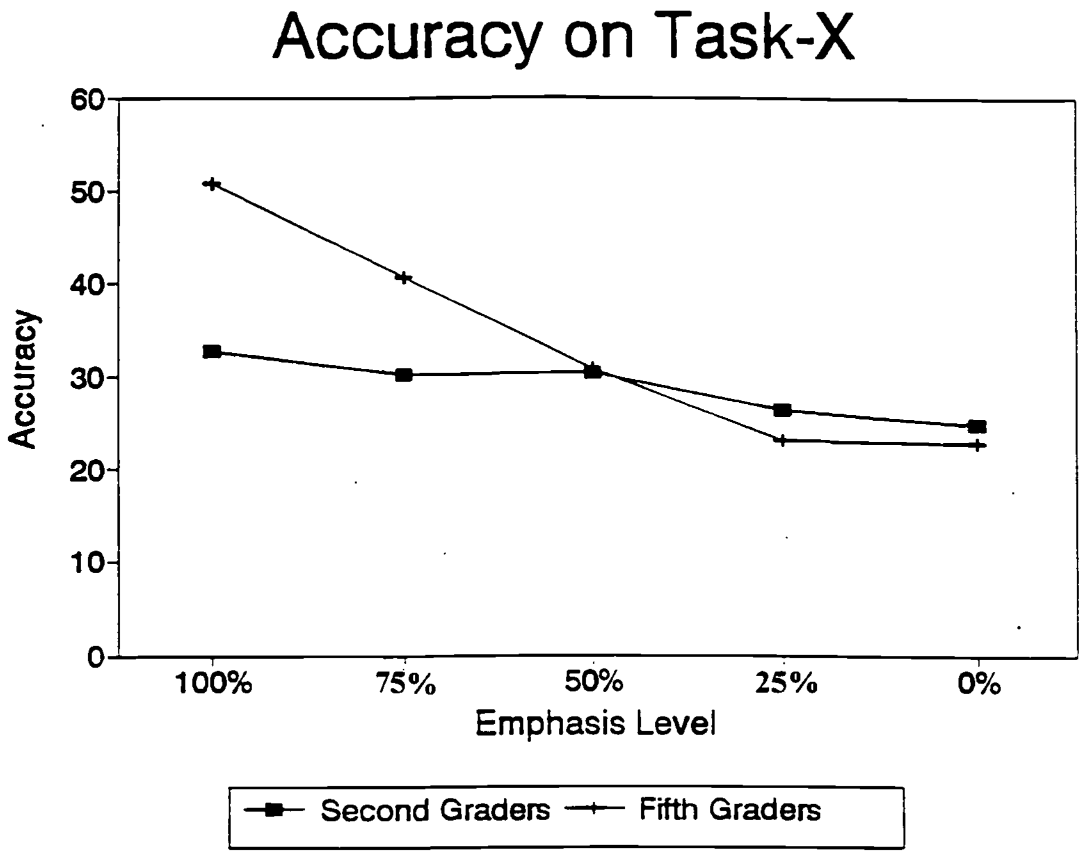

Performance Operating Characteristics
Adults
0.5
0.44
0.38
0.32
0.26
0.2
0.14
0.08
Task X
0.04
0.12
0.2
0.28
0.36
0.44
0.52
0.6
Task Plus

Figure 8


Accuracy on Task-X
Accuracy
60
50
40
30
20
10
0
100%
75%
50%
25%
0%
Emphasis Level
Second Graders
Fifth Graders

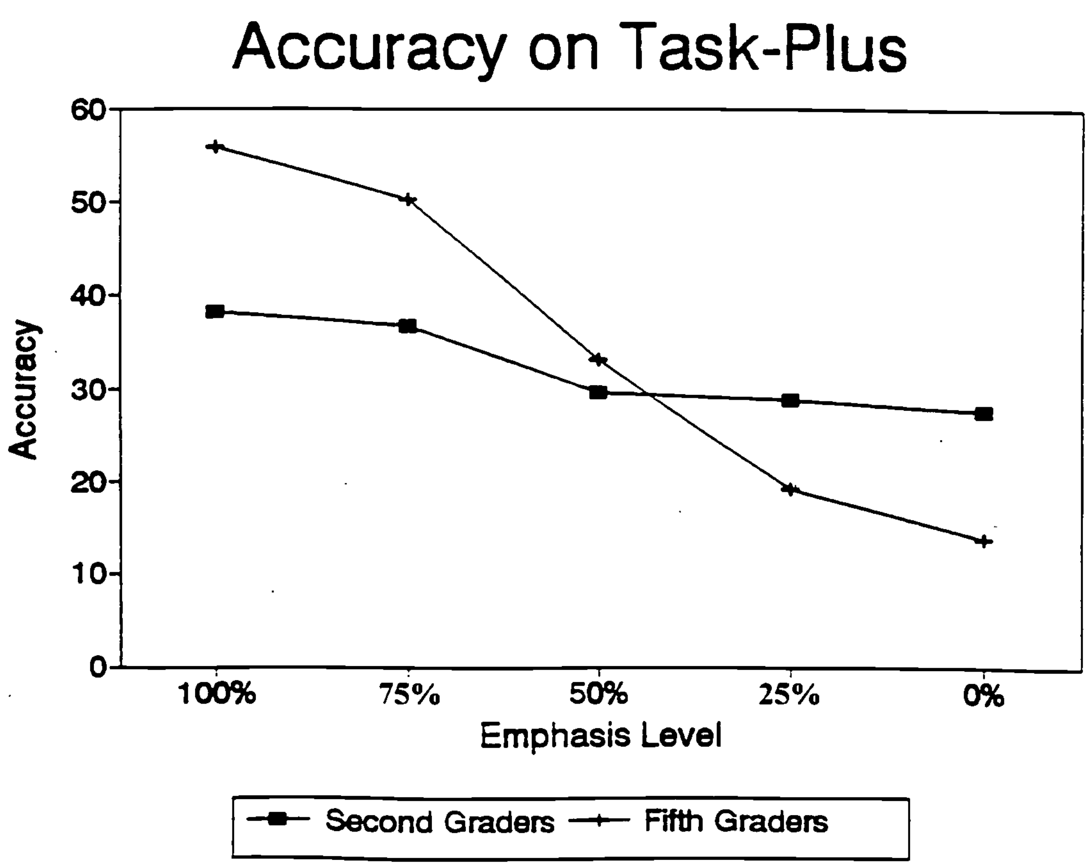
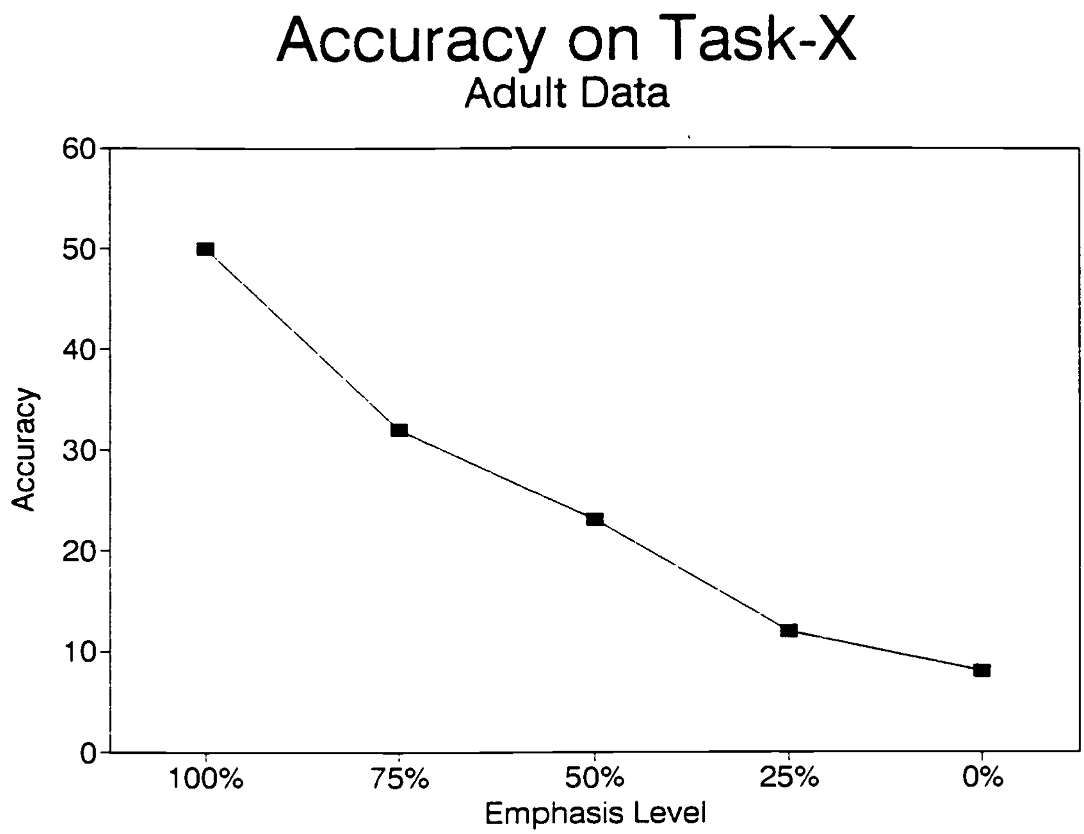

Accuracy on Task-Plus
Accuracy
60
50
40
30
20
10
0
100%
75%
50%
25%
0%
Emphasis Level
Second Graders
Fifth Graders

Figure 9


Accuracy on Task-X
Adult Data
60
50
40
30
20
10
0
Accuracy
100%
75%
50%
25%
0%
Emphasis Level

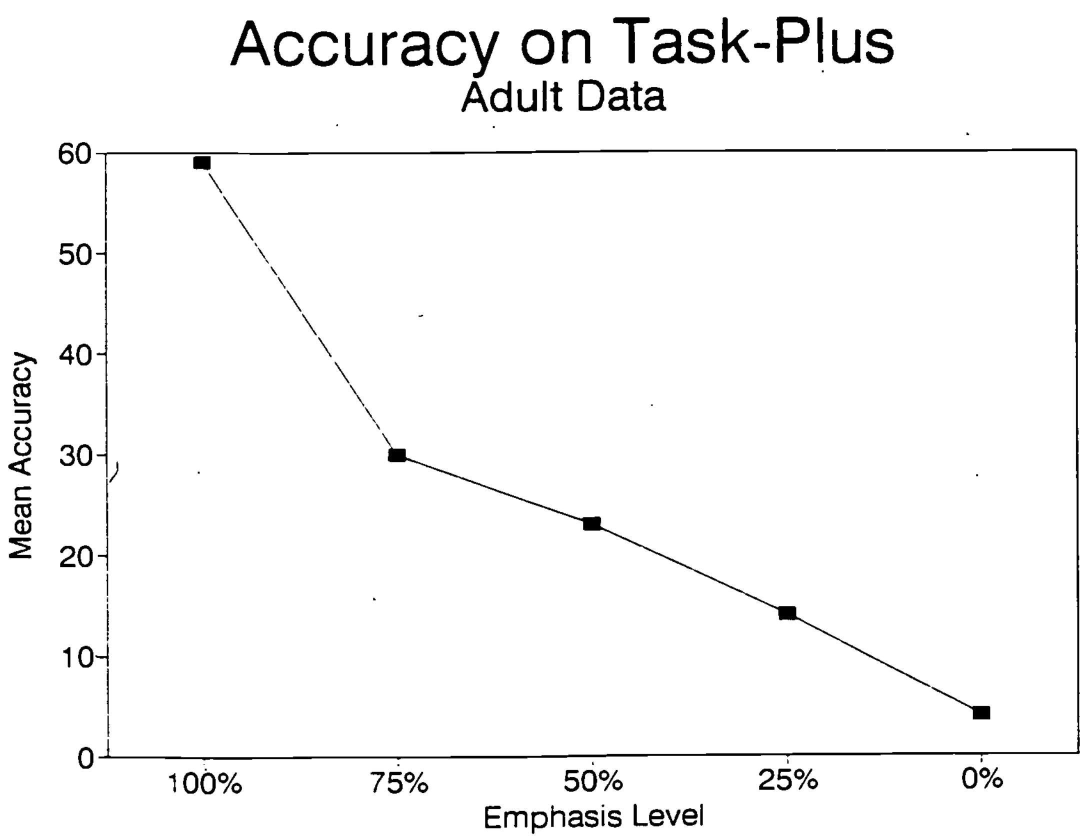

Accuracy on Task-Plus
Adult Data
60
50
40
30
20
10
0
Mean Accuracy
100%
75%
50%
25%
0%
Emphasis Level

Figure 10

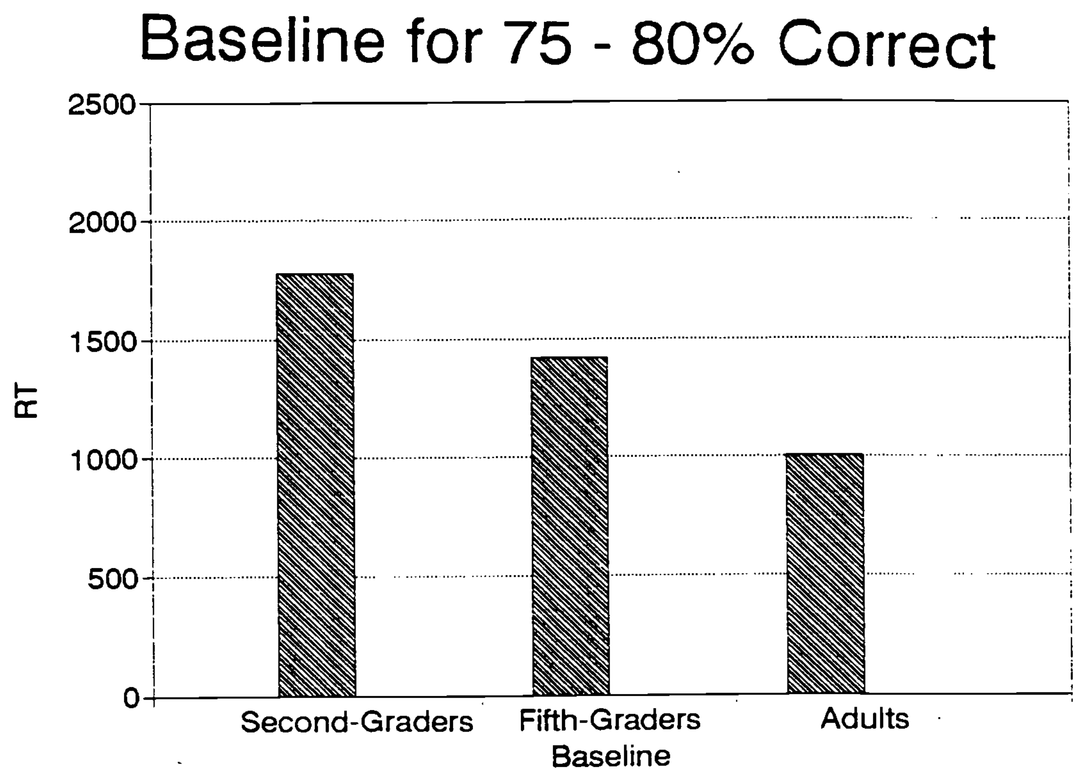
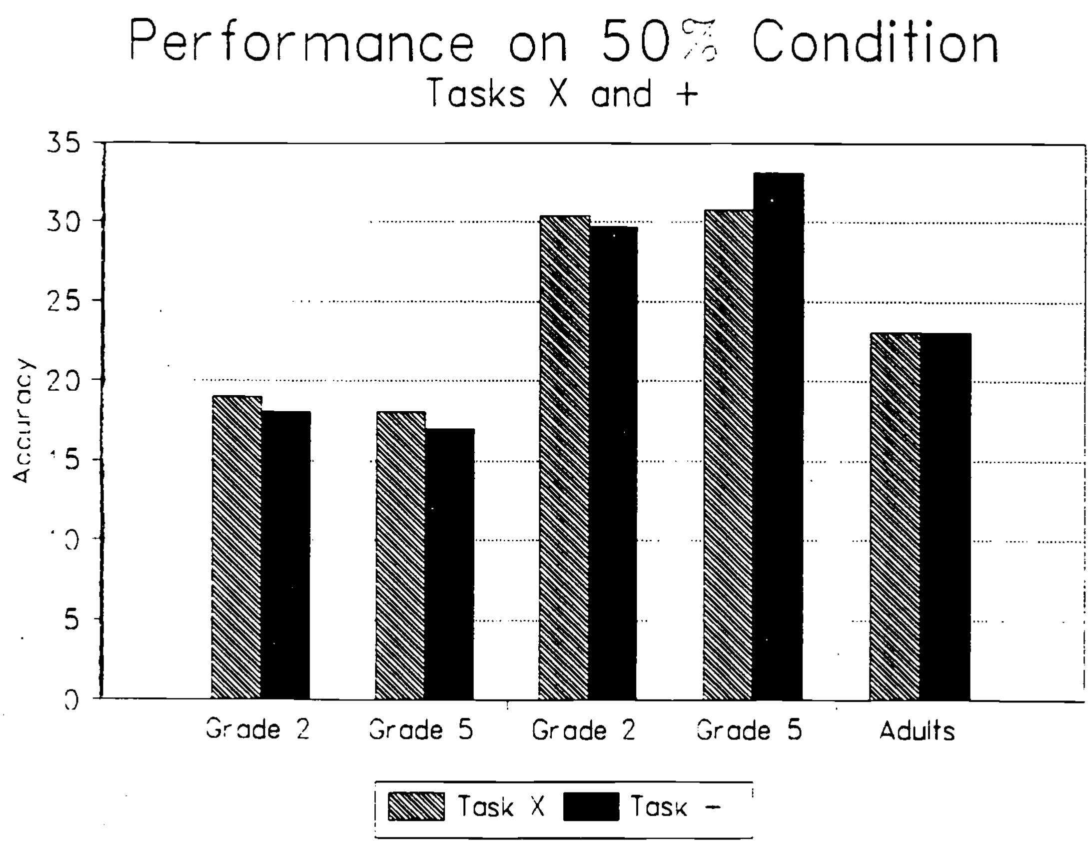
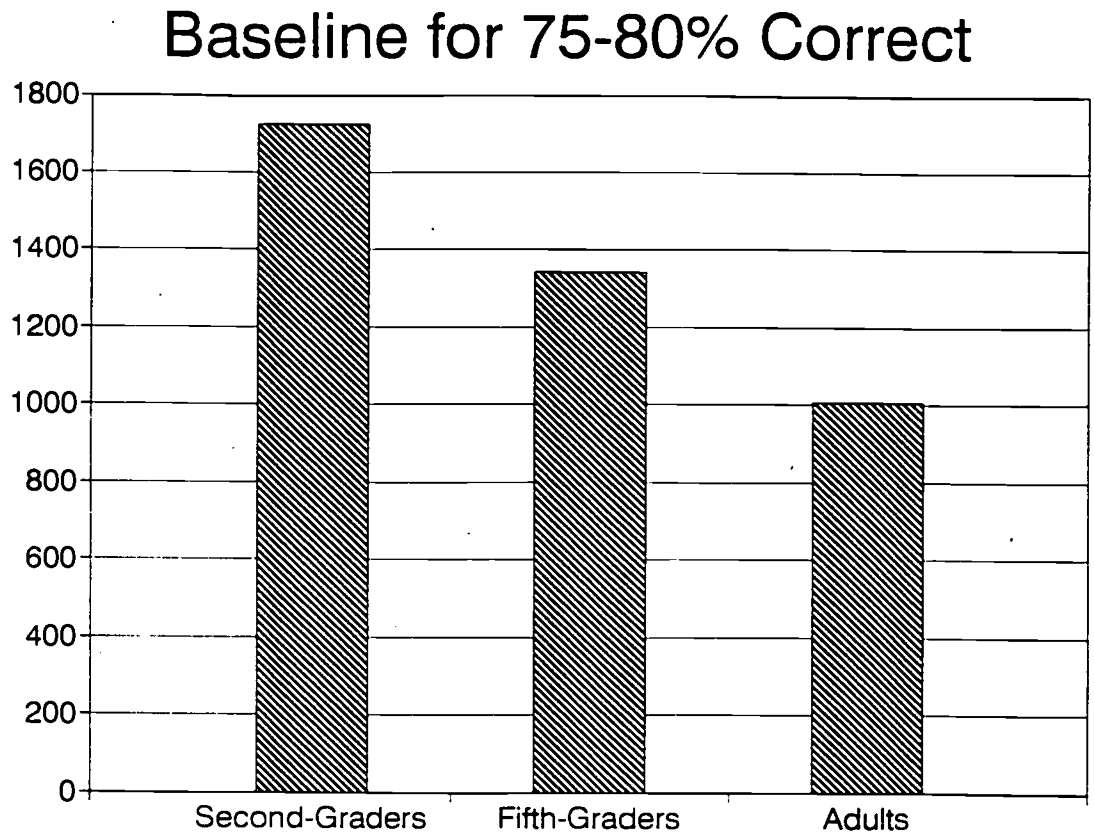

Baseline for 75 - 80% Correct
2500
2000
1500
1000
500
0
RT
Second-Graders
Fifth-Graders
Adults
Baseline

Figure 11



Performance on 50% Condition
Tasks X and +
Accuracy
35
30
25
20
15
10
5
0
Grade 2
Grade 5
Grade 2
Grade 5
Adults
Task X
Task +

Figure 12


Baseline for 75-80% Correct
1800
1600
1400
1200
1000
800
600
400
200
0
Second-Graders
Fifth-Graders
Adults

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
Educational Resources Information Center (ERIC)

ERIC®

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Attention Sharing in Middle Childhood: An analysis of Performance Operating Characteristics

Author(s): Holly M. Irwin Chase and Barbara M. Burns

Corporate Source: University of Louisville

Publication Date:

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic/optical media, and sold through the ERIC Document Reproduction Service (EDRS) or other ERIC vendors. Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following two options and sign at the bottom of the page.

[✓] Check here
For Level 1 Release:
Permitting reproduction in microfiche (4" x 6" film) or other ERIC archival media (e.g., electronic or optical) *and* paper copy.

The sample sticker shown below will be affixed to all **Level 1** documents

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY
Sample
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

Level 1

The sample sticker shown below will be affixed to all **Level 2** documents

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN OTHER THAN PAPER COPY HAS BEEN GRANTED BY
Sample
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

Level 2

[ ] Check here
For Level 2 Release:
Permitting reproduction in microfiche (4" x 6" film) or other ERIC archival media (e.g., electronic or optical), but *not* in paper copy.

Documents will be processed as indicated provided reproduction quality permits. If permission to reproduce is granted, but neither box is checked, documents will be processed at **Level 1**.

"I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic/optical media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries."

Sign here→ please

Signature: Holly M. Irwin-Chase

Printed Name/Position/Title: Holly M. Irwin-Chase

Organization/Address: Department of Psychology
University of Louisville
Louisville KY 40292

Telephone: (502) 852-6775

FAX:

E-Mail Address: hmirwi01@ulkyvm.louisville.edu

Date: 4-5-97

PS 025231

to: ERIC/EECE, Children's Research Center, 51 Gerty Drive (over)
Champaign IL 61820-7469