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ABSTRACT

This study was conducted to attempt to verify findings from an earlier study by I. M. Lawrence, W. E. Curley, and F. J. McHale (1988) in which differential item functioning (DIF) was examined for females on Reading subscore items from four forms of the Scholastic Aptitude Test-Verbal (SAT-V). The specific focus of this research was on verifying the technical science hypothesis as a contributing factor to DIF for females on science reading comprehension questions and the true-science classification as a contributing factor to DIF for females on sentence completion items. The total male sample for 3 SAT forms was 311,517 and the total female sample was 357,941. Confirmatory evidence for the factors identified in the earlier study is not clear-cut in this study. For reading comprehension items, the presence of technical science material in a reading passage tends to make the corresponding items more difficult for females. However, some items associated with highly technical passages do not function differently for males and females. With respect to sentence completion items, there was partial support for the hypothesis that true-science items are more difficult for females. However, the limited number of items studied does not warrant statements about the differential functioning of sentence completion items. An appendix contains some sample technical science reading comprehension items. (Contains six figures, seven tables, and two references.) (Author/SLD)

RESEARCH REPORT

DIFFERENTIAL ITEM FUNCTIONING FOR MALES AND FEMALES ON SAT-VERBAL READING SUBSCORE ITEMS: FOLLOW-UP STUDY

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Princeton, New Jersey
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DIFFERENTIAL ITEM FUNCTIONING FOR MALES AND FEMALES ON SAT-VERBAL READING SUBSCORE ITEMS: FOLLOW-UP STUDY[1,2]

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March 1989

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Abstract

This study was conducted to attempt to verify findings from an earlier study by Lawrence, Curley, and McHale (1988) in which DIF was examined for females on Reading subscore items in four forms of SAT-Verbal. Specifically, the focus of this research was on verifying the technical science hypothesis as a contributing factor to DIF for females on science reading comprehension questions, and the true-science classification as a contributing factor to DIF for females on sentence completion items. Confirmatory evidence for the factors identified in the earlier study is not clear-cut in this study. For reading comprehension items, the presence of technical science material in a reading passage tends to make the corresponding items more difficult for females. However, some items associated with highly technical passages do not function differently for males and females. With respect to sentence completion items, there was partial support for the hypothesis that true-science items are more difficult for females. However, the limited number of items studied does not warrant statements about the differential functioning of sentence completion items.

DIFFERENTIAL ITEM FUNCTIONING FOR MALES AND FEMALES ON SAT-VERBAL READING SUBSCORE ITEMS: FOLLOW-UP STUDY

In a previous study (Lawrence, Curley, and McHale, 1988), the verbal sections of four forms of the SAT were examined for differential item functioning (DIF) between male and female test takers. Minimal DIF was observed for the Reading Comprehension and Sentence Completion items. However, among the few items exhibiting DIF, two findings related to science content were noted:

(1) For reading comprehension items, there appeared to be a relationship between the size and direction of the DIF index and whether or not the reading passage contained technical science material. Items (particularly those requiring inference or application) associated with passages containing technical science material (as opposed to historical or philosophical science material) tended to be more difficult for females.

(2) Sentence completion items that contained "true" science references tended to be more difficult for females than were sentence completion items containing "surface" science or no science references. Science items whose context could easily be shifted to that of a non-science discipline were classified "surface science."

The aforementioned conclusions drawn in the Lawrence et al. research were considered tentative because they were based on limited occurrences of items with sizable DIF values in the four forms studied. Consequently, the present study was undertaken in an attempt to substantiate the conclusions from the earlier study by following up on the above two findings with respect to three additional SAT final forms.

Method

Data Source

The operational verbal sections of the SAT forms administered in November 1986 (Form A), April 1987 (Form B), and May 1987 (Form C) were examined for instances of DIF between male and female test takers. The data for the study were the item responses of male and female examinees on the reading comprehension and sentence completion items that appeared in these three forms. The analysis samples were restricted to juniors and seniors who had indicated on the Student Descriptive Questionnaire that English was at least one of their first spoken languages. Sample sizes and summary statistics for the analysis samples are reported in Table 1.

Differential Item Functioning Analyses

As in the prior study, the standardization method developed by Dorans and Kulick (1986) was used to assess DIF[1]. The standardization method identifies differences in item functioning between a focal group and a reference group after controlling for differences in ability. For these analyses, the focal group was defined as the female group and the matching criterion was total formula score on SAT-Verbal. Candidates who did not reach an item were excluded from calculation of that item's DIF statistic. Note that this adjustment for speededness was not used in the calculation of DIF statistics for the preceding study because distractor analyses indicated that the reading comprehension and sentence completion items studied were not affected significantly by differential speededness between males and females.

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[1] Although operational DIF analyses of the SAT also involve the use of the Mantel-Haenszel approach, DIF indices based on that approach were not available from the prior study. In the interest of consistency between this follow-up study and the original study, analyses were restricted to the standardization method.

Table 1

Summary of sample sizes and descriptive statistics (scaled scores)

Form	Group	N	Mean SAT-V	SD
Form A	Males	87,371	450	105
	Females	107,159	441	102
Form B	Males	85,842	433	108
	Females	95,019	427	105
Form C	Males	138,304	442	103
	Females	155,763	431	100

Note. Samples were restricted to juniors and seniors for whom English is the best language.

Thus, correcting the DIF statistics for the effect of speededness in the present study does not preclude valid comparisons of results between the two studies.

Selection of Test Forms

Because the intent of the study was to verify the hypothesis that technical science passages are differentially more difficult for females than for males, test forms with as many technical science passages as possible were selected for study. A total of six technical science passages were identified in the three forms studied. Note that non-technical science passages (i.e., science passages dealing with non-technical areas such as history or philosophy of science), which were in the prior study, did not appear in these three forms. However, in the prior study, reading questions associated with non-technical science passages were found to behave similarly to the reading questions associated with non-science passages. Consequently, it was assumed in this study that non-technical science passages and non-science passages could be grouped together without differentiating between them, and a decision was made to focus this research on DIF for technical science passages only, compared to non-science passages.

Classification of Items

Prior to analyzing the DIF data, items were classified by a test developer according to two features that were found to be salient factors explaining DIF in the original Lawrence et al. study. These factors were as follows:

1. the presence of "technical" science material in reading passages.
2. references to "true" science versus "surface" science in sentence completion items.

Reading passages were classified as technical if they discussed in some detail a biological, chemical, or physical process or phenomenon. Within the sentence completion item type, the test developer looked at items classified as Science (see the following section on traditional SAT content classifications) and categorized them based on the degree of scientific content in the sentence. All Science sentence completion items were classified as either "true science" or "surface science." Such distinctions were not related to the difficulty of the item. Sentences about heavy snowfall, features of planets, or the behavior of insects were classified "true science". Items concerning the rancor of rival researchers, an industrious laboratory technician, or the qualities of a particular scientific paper, i.e., items whose context could easily be shifted to that of politics or art or economics, were classified "surface science." Across the three forms, eight sentence completion items were identified as surface science, and four as true science.

The above classifications formed the item groups for confirming findings from the prior study. In addition, for the purposes of aiding explanation, items were grouped according to the traditional SAT content classifications:

Reading Comprehension Item Type

A. Category of passage

1. Biological Science
2. Physical Science
3. Social Studies
4. Humanities
5. Narrative
6. Argumentative

B. Type of reading question:

1. Main idea
2. Explicit Statement
3. Inference
4. Application
5. Author's logic
6. Style or tone

Sentence Completion Item Type

1. Aesthetics/Philosophy
2. World of Practical Affairs
3. Science
4. Human Relationships

Each reading question was also carefully examined and categorized with respect to its use, usually inadvertent, of "outside knowledge" in the field or subject covered by the passage. Such questions, which could reward familiarity with the subject covered, occurred infrequently in the three forms that were part of this follow-up study.

Results

Results are reported separately for the two item types and for the three forms studied. Note that positive DIF values indicate the item is easier for females, and negative DIF values indicate the item is more difficult for females.

Reading Comprehension Items.

Table 2 presents distributions of DIF values (referred to in the tables and figures as STPDIF) for males and females on the reading comprehension items in the three forms studied. The distributions pertain to DIF for items classified according to science content (technical science and non-science).

Table 2

Distribution of standardized P-differences between males and females on reading comprehension items, by science content and form

Form A (Administered in November 1986)

	Technical Science	Non-Science	Total
STPDIF ≥ .10	0	1	1
.05 ≤ STPDIF < .10	0	0	0
-.05 < STPDIF < .05	8	15	23
-.05 ≥ STPDIF >-.10	1	0	1
STPDIF ≤-.10	0	0	0
Total	9	16	25

Form B (Administered in April 1987)

	Technical Science	Non-Science	Total
STPDIF ≥ .10	0	0	0
.05 ≤ STPDIF < .10	0	2	2
-.05 < STPDIF < 05	8	14	22
-.05 ≥ STPDIF >- 10	1	0	1
STPDIF ≤-.10	0	0	0
Total	9	16	25

Form C (Administered in May 1987)

	Technical Science	Non-Science	Total
STPDIF ≥ .10	0	1	1
.05 ≤ STPDIF < .10	0	3	3
-.05 < STPDIF < .05	4	13	17
-.05 ≥ STPDIF >-.10	3	0	3
STPDIF ≤-.10	1	0	1
Total	8	17	25

Note. Negative DIF values refer to items that are more difficult for females.

Table 3

Diagram of distributions of standardized P-differences between males and females on reading comprehension items, by science content and form

TECHNICAL SCIENCE				NON-SCIENCE		
Form A	Form B	Form C	STPDIF	Form A	Form B	Form C
			.20			
			.19			
			.18			
			.17			
			.16			
			.15			
			.14			
			.13			
			.12			
			.11			R5
			.10	R3		
			.09			R5
			.08			R5
			.07		R1	
			.06		R1	
			.05			R5
			.04	R2		R2 R6
			.03		R4	R6
	R6	R4	.02	R2 R2 R2 R3 R6 R6 R6	R1	R2 R6 R6
R1		R1	.01	R3 R6	R1 R1 R4 R5	R2 R3
R5	R6		.00	R2 R6	R5 R5 R5	R2 R6
R1 R5 R5	R6	R4	-.01	R4	R3	R3
R1 R5	R6	R4	-.02		R3 R3 R4	R3
R1	R2 R2 R2		-.03		R5	
	R2		-.04	R4 R4		R2
R1			-.05			
			-.06			
	R2	R1	-.07			
		R1	-.08			
		R1	-.09			
			-.10			
			-.11			
			-.12			
			-.13			
			-.14			
			-.15			
			-.16			
		R1	-.17			
			-.18			
			-.19			
			-.20			

Note. R followed by a number refers to reading passage number (Verbal 1 contains passages R1 and R2; Verbal 2 contains passages R3 through R6).

	TECHNICAL	NON-SCIENCE
Number of Items	26	49
Mean STPDIF	-.0341	.0173
SD STPDIF	.0419	.0364

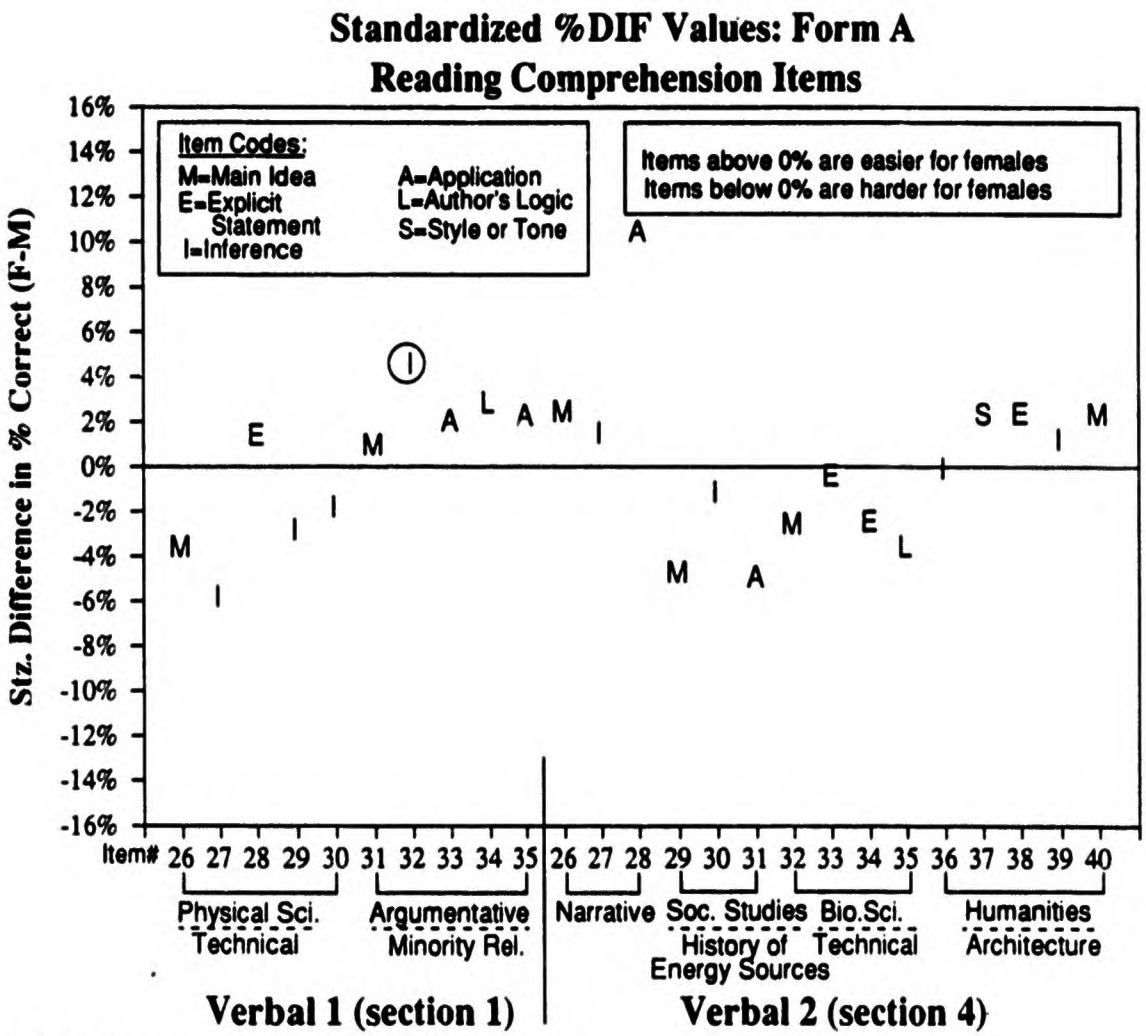
$t(73) = -4.65$, $p < .001$, one-tailed

As found in the original study, there were only a few items in each test form that exhibited extreme negative or positive DIF (i.e., standardized differences between males and females less than -.10 or greater than +.10). For form A, 23 out of 25 reading comprehension questions function similarly for males and females (i.e., DIF values range between -.05 and +.05). For Form B, 22 out of 25 items function similarly for males and females. The largest number of discrepant reading items appear in Form C, with 8 of 25 functioning differently for males and females.

Of the 6 reading items in the three forms found to be substantially more difficult for females than for males, all are associated with technical science reading material, apparently lending support to the conclusions drawn in the earlier study. However, it is also true that 20 of the 26 reading questions associated with technical science reading passages evidenced negligible DIF, suggesting that other factors besides technical science are operating. Of the items associated with technical science reading passages in the three forms, the most positive value of the DIF index is .02. DIF values across the three forms are presented in Table 3. The mean DIF value for reading questions associated with technical science passages (M = -.0341) is significantly lower than the mean DIF value for reading questions associated with non-science passages (M = .0173), $t(73) = -4.65$, $p < .001$.

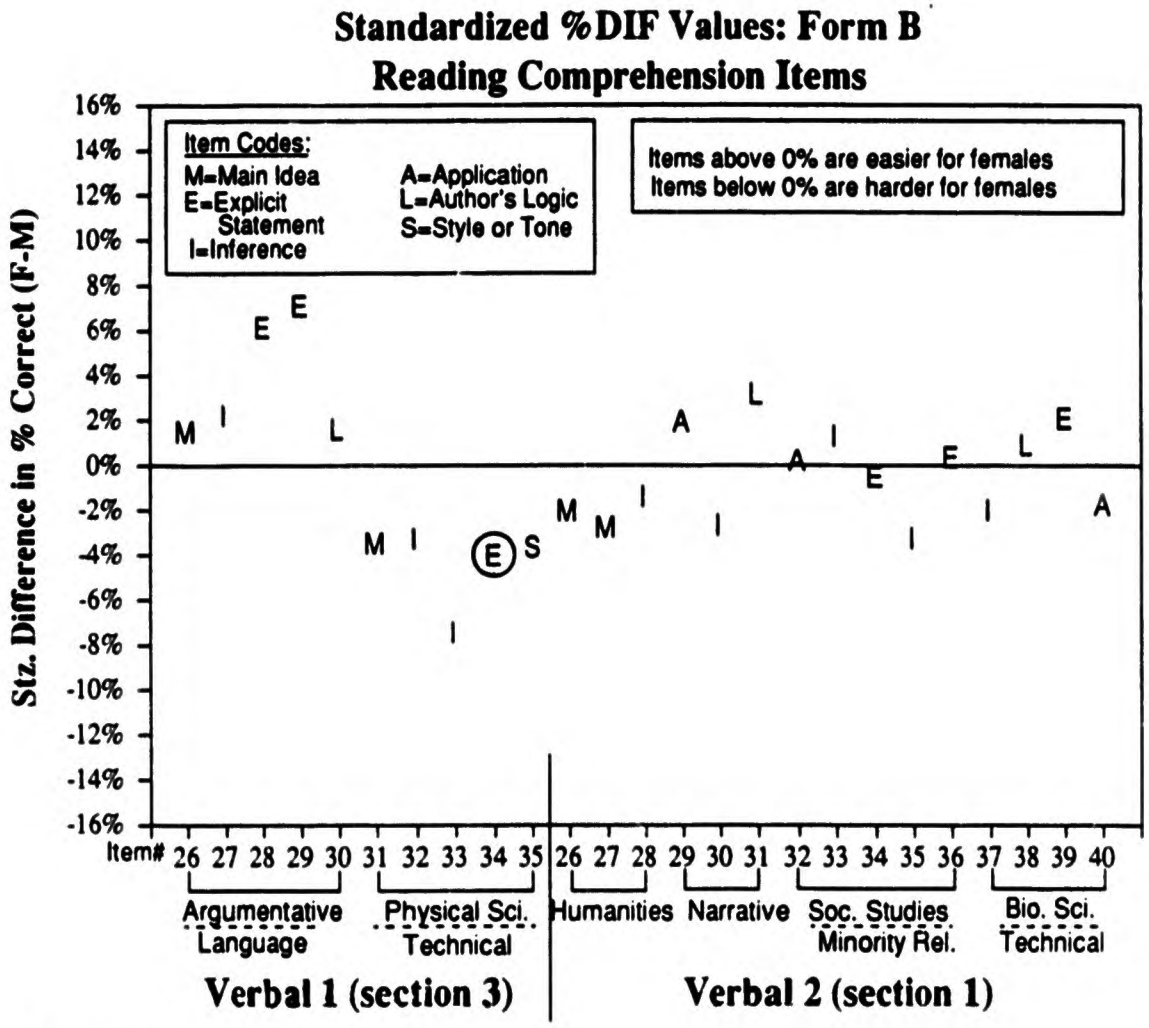
Figures 1 through 3 show the actual DIF values for each of the reading comprehension questions studied in each form. DIF values are indicated on the vertical axis, and item locations are indicated on the horizontal axis. Information about the content of each passage is labelled beneath the brackets along the horizontal axis. The data points (letters) correspond to the item codes used by test developers to classify items in terms of content.

Figure 1



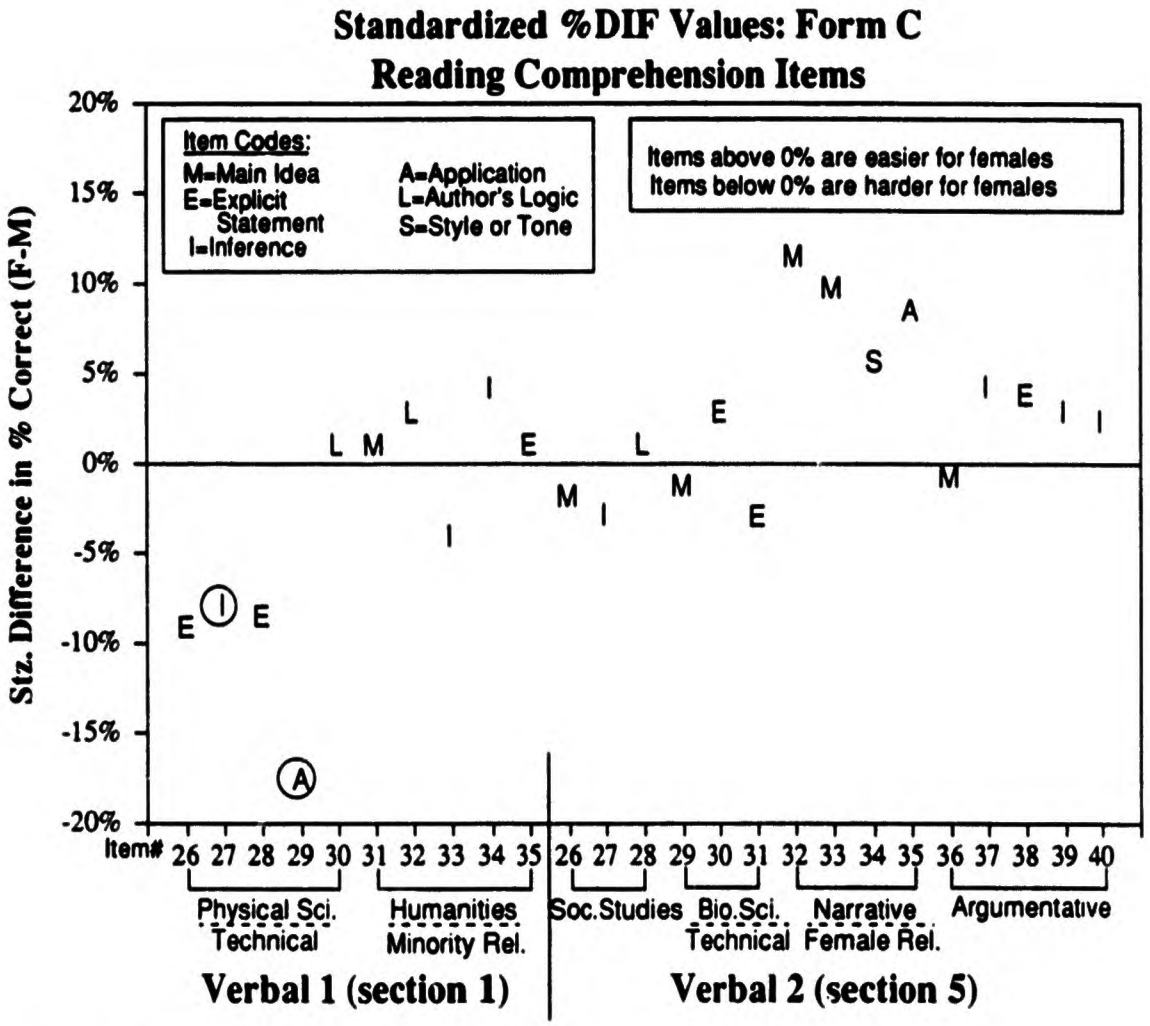
Note: Circles designate items identified as perhaps rewarding examinees having outside knowledge.

Figure 2



Note: Circles designate items identified as perhaps rewarding examinees having outside knowledge.

Figure 3



Note: Circles designate items identified as perhaps rewarding examinees having outside knowledge.

Circled data points indicate items identified as possibly rewarding examinees with outside knowledge in the subject covered by the passage.

The plot for Form A shows that most of the items associated with the two technical science passages are more difficult for females than for males, although none of the DIF values is extreme. Among the science items, one (#27 in Verbal 1) is more extreme than the others (-.06), and this item requires the examinee to make an inference about the material in the passage (a factor identified in the prior study). It should be noted, however, that the other inference items associated with this technical science passage are only minimally more difficult for females. The most discrepant reading comprehension item in the test (#28 in Verbal 2) is easier for females; this item is connected with a narrative passage that presents a character study. The Social Studies passage in Verbal 2 of Form A is associated with items that are differentially more difficult for females. Although not classified as a science passage, this passage is somewhat technical in nature, as it deals with the history and characteristics of various sources of energy.

Form B (Figure 2) contains two passages with technical science content. One inference item associated with the physical science passage (#33 in Verbal 1) is clearly more difficult for females than males, and may be rewarding examinees with outside knowledge in the field. The other four items with this passage are marginally more difficult for females. Clearcut support for the technical science factor is not apparent, however, as evidenced by DIF values close to zero for the items associated with the technical biological science passage in Verbal 2. It should be noted that this Biological Science passage is quite a bit more technical than most that appear in the SAT, and it is positioned last in the Verbal 2 section; one or

both of these factors may contribute to the fact that the passage does not seem to advantage or disadvantage males or females.

Figure 3 shows that four of the five items associated with the physical science passage in Form C (Verbal 1) exhibit extreme negative DIF for females (i.e., are more difficult for females than for males). Similarly to the previous forms, however, items associated with the technical science passage in Verbal 2 do not function significantly differently for males and females. It is of interest to note in passing that items associated with the female relevant passage in Verbal 2 are generally easier for females.

Despite a statistically significant difference between mean DIF values for items associated with technical science passages versus non-science passages, the findings for the reading comprehension items in this follow-up study provide only partial support for the hypothesis that items associated with passages containing technical science material are more difficult for females than males. Several items associated with technical science passages have been found to exhibit negligible DIF for males and females. It is worth noting, however, that technical science passages tend to include a majority of items with at least minimal DIF in the negative direction (i.e., indicating some degree of differential difficulty for females), and that very few items in technical science sets are significantly easier for females. It is also true in these three forms that the few items exhibiting extreme negative DIF are associated with technical physical science passages, rather than technical biological science passages. This effect was not observed as consistently in the prior study. Also, extreme negative DIF in this study is restricted to items associated with technical science passages that appear in Verbal 1, identical to the tendency observed in the earlier study. Since the Verbal 1 section sometimes appears before and sometimes after Verbal 2 --

sometimes in section 1 or 3 or 6 -- it is difficult to determine why such a pattern should be observed. It may be that "long" science passages (400-450 words) inherently pose more of a challenge than do less extended and less detailed excerpts.

Because the focus of this research was on verifying the technical science hypothesis as a contributing factor to DIF, standardized distractor analyses for the six technical item sets are presented in Table 4. Copies of the passages and items are presented in the Appendix to this report. The second to last column in Table 4 indicates the overall difficulty of each item. Note that within each item set there is a range of difficulty, indicating that items associated with technical science material are not always difficult for the testing group. Note also that, of those items exhibiting extreme DIF, some are difficult items (e.g., Form B #33), some are middle difficulty (Form C #29), and some are easy (Form C #26).

Table 4 shows that several items (#27, 28, and 29) associated with the physical science passage in Form C have distractors that are differentially more attractive to females. With respect to item 27, females tend either to omit the item or to choose option B. For items 28 and 29, females are primarily drawn to option E rather than to the correct option.

As noted earlier, despite the complexity of one of the two technical science passages in Form B, the associated items (37-40 in Verbal 2) do not function differently for males and females. Distractor analyses indicate that no particular options were chosen differentially, and that differential speededness (as evidenced by the "not reached" statistic) is also not a factor. It is worth noting, however, that a large proportion of the examinees not reaching these items have scaled scores below 500 -- for item 37, 20% to 40% of examinees with scaled scores below 500 do not respond to

Table 4

Standardized difference in percentage of males and females choosing each option: Items associated with technical science reading passages

Form A Physical Science Passage (Verbal 1)

Item	A	B	C	D	E	OMIT	NR	% Correct	% Reaching
26	2	- 4*	0	0	0	1	0	80	100
27	1	4	0	1	- 6*	0	0	26	100
28	0	1*	- 1	0	0	0	0	66	100
29	2	3	- 3*	- 1	- 2	1	0	35	99
30	- 2*	0	1	0	0	1	0	67	99

Form A Biological Science Passage (Verbal 2)

Item	A	B	C	D	E	OMIT	NR	% Correct	% Reaching
32	0	- 1	2	1	- 2*	0	0	53	98
33	0	1	0	0*	0	0	- 1	76	98
34	- 2*	0	0	2	0	1	- 1	69	97
35	0	1	- 3*	1	0	1	- 1	43	95

Form B Physical Science Passage (Verbal 1)

Item	A	B	C	D	E	OMIT	NR	% Correct	% Reaching
31	1	- 1	2	- 3*	1	1	0	56	99
32	3	3	- 3	- 2	- 3*	2	0	25	99
33	0	1	1	1	- 7*	5	0	24	98
34	3	- 4*	2	0	- 1	0	0	69	98
35	- 4*	0	0	0	2	2	0	54	98

Form B Biological Science Passage (Verbal 2)

Item	A	B	C	D	E	OMIT	NR	% Correct	% Reaching
37	- 1	0	3	0	- 2*	1	- 1	35	80
38	1*	0	0	0	1	0	- 1	28	73
39	- 1	0	- 1	1*	1	0	- 1	44	67
40	1	0	0	1	- 1*	0	0	31	60

Form C Physical Science Passage (Verbal 1)

Item	A	B	C	D	E	OMIT	NR	% Correct	% Reaching
26	1	1	- 9*	2	4	1	0	72	100
27	- 2	6	- 8*	0	0	4	0	41	100
28	- 9*	0	0	3	5	1	0	56	100
29	-18*	2	2	3	7	4	0	56	100
30	1	- 1	- 2	0	1*	1	0	71	100

Form C Biological Science Passage (Verbal 2)

Item	A	B	C	D	E	OMIT	NR	% Correct	% Reaching
29	- 1	1	0	1	- 1*	1	0	63	99
30	0	0	3*	0	- 3	0	0	41	99
31	0	2	0	- 3*	1	1	- 1	41	98

Note. Correct answer is denoted by "*". % Correct is based on DIF analysis sample; % Reaching the item is based on item analysis sample.

the item, and for item 40, the last item in the section, this proportion increases to 30% to 50% at the various scaled score levels below 500. In the prior study, the distractor analyses of items associated with technical science passages indicated that differential item functioning tends to be most pronounced among low ability examinees and negligible among examinees scoring above 650. The scarcity of low ability examinees responding to this last item set in Form B (Verbal 2) may have made it difficult to observe DIF, if it exists. One way to study the possible effect of passage position would be to readminister this passage, but not as the last reading passage in Verbal 2.

Sentence Completion Items

Table 5 presents distributions of DIF for males and females on sentence completion items in the three forms studied. Distributions are for items classified according to science content (true science, surface science, and non-science). As was observed in the preceding study, minimal DIF between males and females is observed for this item type. Of the fifteen sentence completion items in Form A, one is easier, and two are more difficult for females. In Form B, one item is easier for females and fourteen function similarly for the two groups; none of these is more difficult for females. In Form C, one item is more difficult for females and two items are easier for females.

DIF values for sentence completion items, classified by science content, are presented in Table 6. The mean DIF value for sentence completion items with true science references is -.0590, considerably lower than the mean DIF values for sentence completion items with surface science references and non-science references, which are .0099 and .0090, respectively. An analysis of

Table 5

Distribution of standardized P-differences between males and females on sentence completion items, by science content and form

Form A (Administered in November 1986)

	True	Surface	Non-Science	Total
STPDIF ≥ .10	0	0	0	0
.05 ≤ STPDIF < .10	0	0	1	1
-.05 < STPDIF < .05	0	2	10	12
-.05 ≥ STPDIF >-.10	1	0	0	1
STPDIF ≤-.10	1	0	0	1
Total	2	2	11	15

Form B (Administered in April 1987)

	True	Surface	Non-Science	Total
STPDIF ≥ .10	0	0	0	0
.05 ≤ STPDIF < .10	0	0	1	1
-.05 < STPDIF < .05	0	4	10	14
-.05 ≥ STPDIF >- 10	0	0	0	0
STPDIF ≤-.10	0	0	0	0
Total	0	4	11	15

Form C (Administered in May 1987)

	True	Surface	Non-Science	Total
STPDIF ≥ .10	0	0	0	0
.05 ≤ STPDIF < .10	0	0	2	2
-.05 < STPDIF < .05	2	2	8	12
-.05 ≥ STPDIF >-.10	0	0	1	1
STPDIF ≤-.10	0	0	0	0
Total	2	2	11	15

Note. Negative DIF values refer to items that are more difficult for females.

Table 6

Diagram of distributions of standardized P-differences between males and females on sentence completion items, by science content and form

TRUE SCIENCE				SURFACE SCIENCE				NON-SCIENCE			
Form A	Form B	Form C		Form A	Form B	Form C		Form A	Form B	Form C	
			STPDIF				STPDIF				
			.15				.15				
			.14				.14				
			.13				.13				
			.12				.12				
			.11				.11				
			.10				.10				
			.09				.09				
			.08				.08		V1	V2	
			.07				.07				
			.06				.06	V2			
			.05				.05			V1	
			.04			V1	.04		V1	V1	V1
			.03				.03	V1	V2		
			.02	V1	V2		.02	V1	V1	V2 V2	V2
			.01	V2	V1		.01	V1 V1			
		V2	.00			V1	.00	V1 V1 V1	V1	V1	V1 V2
		V2	-.01		V2		-.01	V2	V1	V1	
			-.02		V1		-.02	V1		V1	
			-.03				-.03	V2	V1 V1		
	-- NONE --		-.04				-.04				
			-.05				-.05		V1		
V1			-.06				-.06				
			-.07				-.07			V1	
			-.08				-.08				
			-.09				-.09				
			-.10				-.10				
			-.11				-.11				
			-.12				-.12				
			-.13				-.13				
			-.14				-.14				
V2			-.15				-.15				

Note. V1 and V2 refer to the 45-item Verbal 1 section (sentence completion items are located in positions 16-25) and the 40-item Verbal 2 section (sentence completion items are located in positions 11-15).

	TRUE SCIENCE	SURFACE SCIENCE	NON-SCIENCE
Number of Items	4	8	33
Mean STPDIF	-.0590	.0099	.0090
SD STPDIF	.0613	.0202	.0377

$F(2,42) = 5.48$, $p < .01$

variance indicates a significant effect for science content, $F(2,42) = 5.48$, $p < .01$.

Figures 4 through 6 display DIF values (indicated on the vertical axis) for each sentence completion item in the three forms. Locations for the sentence completion items are marked along the horizontal axis. The data points in the plots refer to the item codes used by test developers for meeting content specifications. The labels beneath the item numbers for the science items indicate whether the item was classified "true" science or "surface" science.

Form A (Figure 4) contains two items classified surface science and two classified true science. One of the true science items (#15 in Verbal 2 exhibits extreme negative DIF for females, and the other true science item (#16 in Verbal 1) is somewhat more difficult for females. The two surface science items (#20 in Verbal 1 and #12 in Verbal 2), on the other hand, are comparable to the non-science items in terms of DIF for females. The texts for both of the true science items are presented in the Appendix.

Form B contains four sentence completion items with science content. As shown in Figure 5, all four items have surface references to science material, and none of them functions differently for males and females.

The third form studied, Form C (Figure 6), contains four items with science content, of which two are classified true science (#11 and #14 in Verbal 2). None of these four science items, however, functions differently for males and females.

The findings for the sentence completion items do not consistently substantiate the hypothesis that items with true science references are more difficult for females than males. Four of the nine true science sentence completions in the earlier study had DIF for females less than -.05; two of

Figure 4

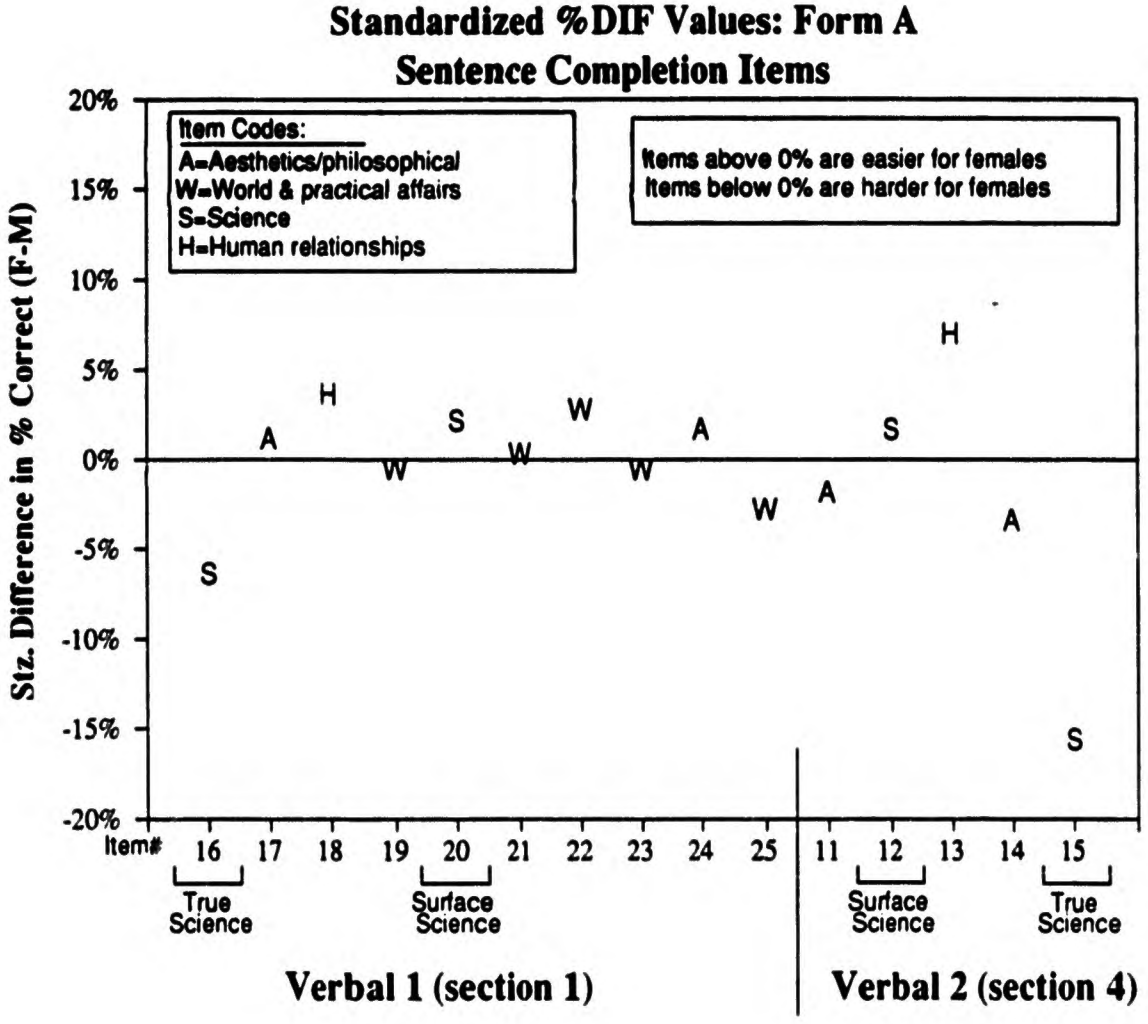

Standardized %DIF Values: Form A
Sentence Completion Items
Item Codes:
A=Aesthetics/philosophical
W=World & practical affairs
S=Science
H=Human relationships
Items above 0% are easier for females
Items below 0% are harder for females
Stz. Difference in % Correct (F-M)
20%
15%
10%
5%
0%
-5%
-10%
-15%
-20%
Item#
16 17 18 19 20 21 22 23 24 25 11 12 13 14 15
True Science
Surface Science
Surface Science
True Science
Verbal 1 (section 1)
Verbal 2 (section 4)

Figure 5

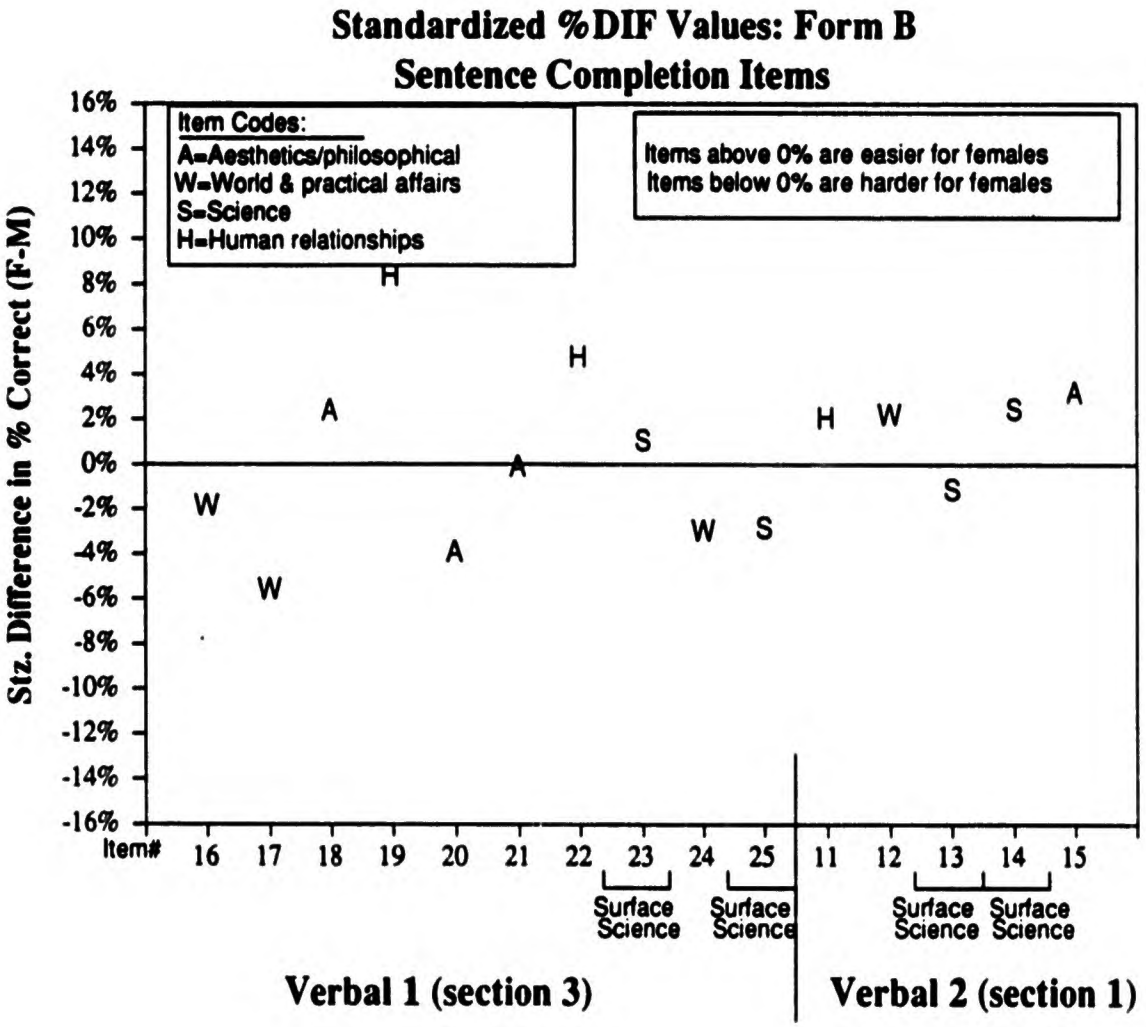
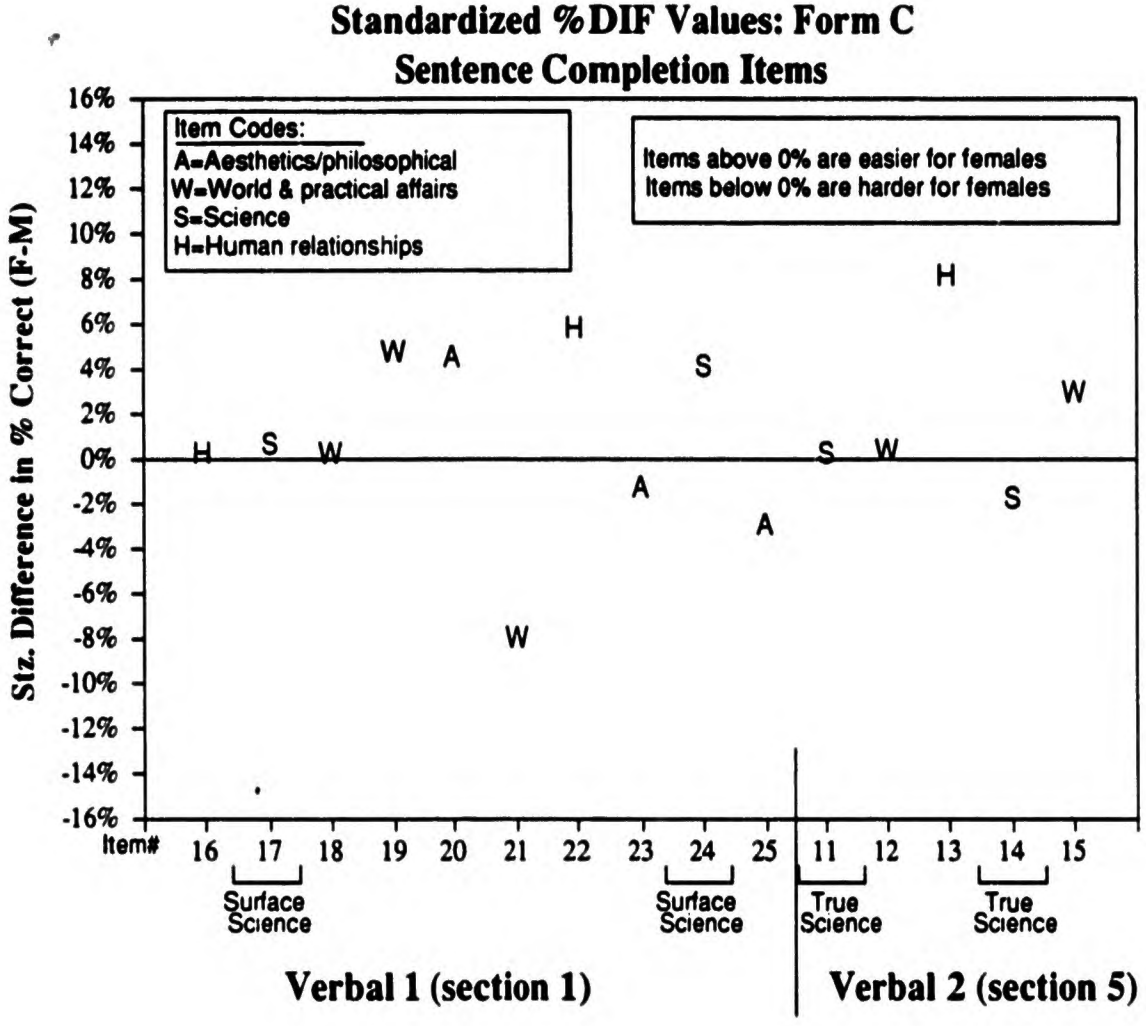

Standardized %DIF Values: Form B
Sentence Completion Items
Item Codes:
A=Aesthetics/philosophical
W=World & practical affairs
S=Science
H=Human relationships
Items above 0% are easier for females
Items below 0% are harder for females
Stz. Difference in % Correct (F-M)
16%
14%
12%
10%
8%
6%
4%
2%
0%
-2%
-4%
-6%
-8%
-10%
-12%
-14%
-16%
Item#
16 17 18 19 20 21 22 23 24 25 11 12 13 14 15
Surface Science
Surface Science
Surface Science
Surface Science
Verbal 1 (section 3)
Verbal 2 (section 1)

Figure 6


Standardized %DIF Values: Form C
Sentence Completion Items
Item Codes:
A=Aesthetics/philosophical
W=World & practical affairs
S=Science
H=Human relationships
Items above 0% are easier for females
Items below 0% are harder for females
Stz. Difference in % Correct (F-M)
16%
14%
12%
10%
8%
6%
4%
2%
0%
-2%
-4%
-6%
-8%
-10%
-12%
-14%
-16%
Item# 16 17 18 19 20 21 22 23 24 25 11 12 13 14 15
Surface Science
Surface Science
True Science
True Science
Verbal 1 (section 1)
Verbal 2 (section 5)

the four true science items across the three forms in this study exhibit similar levels of DIF. The highest positive value of DIF in favor of females in the 13 true science sentence completions across the seven forms studied is .01.

Standardized distractor analyses for the science sentence completion items in each of the three forms are presented in Table 7. The discrepant items classified true science in Form A (#16 in Verbal 1 and #15 in Verbal 2) range in difficulty from easy to slightly above middle difficulty. Females are drawn to option E in #16 and to option B and D in #15. In Form C, options A and B for item #14 in Verbal 2 attract females differentially, but option E draws fewer females than males (as does the correct answer, C). Note that the other item classified as true science in Form C (Verbal 2, #11) is an extremely easy item (95% correct) that functions identically for both males and females.

Summary and Conclusions

This study was conducted to attempt to verify findings from an earlier study by Lawrence, Curley, and McHale (1988) in which DIF was examined for females on Reading subscore items in four forms of SAT-Verbal. Confirmatory evidence for the factors identified in the earlier study is not clearcut in this study.

For reading comprehension items, the presence of technical science material in a reading passage tends to be more difficult for females. On the other hand, some items associated with highly technical passages do not function differently for males and females. For two of the technical science passages (one in Form A, Verbal 2, and the other in Form C, Verbal 2), this absence of DIF was not completely unexpected; none of the items

Table 7

Standardized difference in percentage of males and females choosing each option: Sentence completion items with science content

Form A

Item	Sec.	Type	A	B	C	D	E	OMIT	NR	% Correct
16	V1	T	0	- 6*	1	1	4	1	0	84
20	V1	S	1	- 3	1	2*	0	0	0	65
12	V2	S	0	0	- 1	2*	0	0	0	77
15	V2	T	- 15*	6	0	5	2	2	0	41

Form B

Item	Sec.	Type	A	B	C	D	E	OMIT	NR	% Correct
23	V1	S	- 1	2	1*	1	- 2	- 2	0	37
25	V1	S	0	4	0	- 3*	0	- 1	0	22
13	V2	S	1	0	0	- 1*	1	0	0	43
14	V2	S	- 2	3	- 1	2*	0	- 2	0	29

Form C

Item	Sec.	Type	A	B	C	D	E	OMIT	NR	% Correct
17	V1	S	0	0	0	1*	0	0	0	84
24	V1	S	- 1	- 1	- 1	4*	0	- 1	0	43
11	V2	T	0	0*	0	0	0	0	0	95
14	V2	T	3	3	- 2*	0	- 4	0	0	27

Note. Correct answer is denoted by "*". % Correct is based on DIF analysis sample. % Reaching the item is 100% for items in this table (based on item analysis sample).

T = True science reference; S = Surface science reference.

calls for inference or application, which are the types of cognitive demands normally found to be associated with larger values of DIF indices for females in the earlier study. However, another passage containing technical science material (Form B, Verbal 2) includes an inference item that does not function differently for males and females; among the 60% to 80% of the examinees reaching the items associated with this passage, all four items function similarly for the two groups.

While it appears that further understanding of the relationship between technical science material and DIF for females is still needed, there is certainly evidence that few items associated with technical science passages are ever differentially <u>easier</u> for females. It may be that females are either disadvantaged by technical science passages or unaffected by them, but never advantaged to any great extent. If, in the interest of validity, technical science passages are an essential component of the SAT, then there is a need to understand more clearly why certain technical science passages and items seem to disadvantage females while others appear to have little or no effect. It may be that the salient factors in technical science passages are: (1) the specific content of the passage (Physical versus Biological science), (2) the length of the passage (400-450 words versus 200-250 words), or (3) the nature of the specific questions asked. Passage position (particularly the last position in Verbal 2) is another possible factor. Examination of further forms of the SAT may be required to achieve suitable instances of passages unconfounded in these various ways.

With respect to the sentence completion items, only two of the four true science items across the three forms studied supported the hypothesis that such items may be differentially harder for females than for males. While it may be (again) that female examinees are either disadvantaged or unaffected

by true science content in sentence completion items -- but never advantaged by such content -- the limited number of items studied does not warrant statements about the differential functioning of sentence completion items.

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APPENDIX

TECHNICAL SCIENCE READING COMPREHENSION

PASSAGES AND ITEMS FOR FORMS A, B, AND C

SENTENCE COMPLETION ITEMS WITH TRUE SCIENCE REFERENCES

FORM A

Two kinds of electric force operate between atoms or molecules: an attractive force, which is effective over a limited range (a few times the atom's or molecule's diameter), and a highly repulsive force, which is effective over a much shorter range. In the solid state, the forces between atoms or molecules determine the structure. When two atoms or molecules are about one hundred-millionth of an inch apart, these two forces cancel each other out, establishing a point of equilibrium and causing atoms or molecules to vibrate slightly toward and away from each other, as if held by invisible springs.

A small bar of iron looks solid, but the component atoms of the iron are entirely separate, suspended in space. Each of the individual atoms is vibrating unceasingly toward and away from each one of its neighbors. As they hang in space, the atoms form the intersections of a regular latticework. In iron, the lattice is composed of tiny cubes with an atom at each corner and one in the middle. Other substances have lattices with sides forming a variety of geometrical shapes which give each element its peculiar internal structure. When an object is broken, it normally separates along the lines of the lattice.

An increase in temperature speeds up the average velocity of molecular vibration within solids just as it does in gases. Each swinging movement of a single molecule, under the influence of added heat, is wider and faster and increases the average molecular separation. In other words, a solid object generally expands as a whole when the temperature is increased. As the additional heat forces the vibrating movement of the tightly bound molecules to become wilder and wilder, a point is reached at which some of the molecules begin to burst away from the binding forces exerted by their neighbors—they slip out of the regular latticework. With further heat, more molecules escape their captivity. As the rigid order begins to diminish, whole clusters of molecules begin to slip past each other. Finally the substance is no longer a solid, and the resultant breakdown of order is a process called melting.

When internal fluidity is fully achieved, the molecules are said to be in the liquid state. In liquids, the molecules hurtle in and then out of each other's areas of influence. Thus the force of a single molecule on another can be exerted for only the briefest time. Neighbors appear and disappear in millionths of a second. In liquids, as in solids, the addition of heat increases the average space between molecular centers. The observation that both liquids and solids generally expand with the addition of heat is best explained by the kinetic theory.

26. The primary focus of the passage is on

(A) how liquid substances alter when changing to the solid state
(B) how forces among molecules determine the structure of matter
(C) the shapes disrupted by lattices of atoms
(D) the advantages of equilibrium in liquids
(E) the dominance of the repulsive force in the solid state

27. Which of the following best describes what happens to the latticework of iron when iron changes from a solid to a liquid state?

(A) It recombines into larger cubes
(B) Its sides shift to form other geometric shapes
(C) It vibrates.
(D) It shrinks.
(E) It disappears.

28. According to the passage, a substance is very near its melting point when which of the following occurs?

(A) A change in temperature speeds up the average velocity of molecular vibration
(B) Whole clusters of molecules begin to slip past one another.
(C) An object separates along the lines of the lattice.
(D) The attractive and repulsive forces cancel each other out.
(E) The component atoms are completely separated from one another

GO ON TO THE NEXT PAGE

FORM A (CONTINUED)

29. It can be inferred from the passage that internal fluidity has been fully achieved when which of the following conditions exists?

(A) More and more molecules escape their captivity.
(B) Heat increases the average space between molecular centers.
(C) Forces are effectively exerted by any particular molecule on another for only a very brief time.
(D) The vibrating movement of the tightly bound molecules becomes wilder and wilder.
(E) The lattice assumes a different geometric shape.

30. The passage indicates that which of the following statements is true of both a solid and a liquid?

(A) The addition of heat generally increases the average space between molecular centers
(B) The lattice is composed of tiny cubes with an atom at each corner and one in the middle
(C) The molecules hurtle in and then out of each other's areas of influence.
(D) Each swinging movement of a single molecule is wider and wider.
(E) The attractive force is always stronger than the repulsive force.

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FORM A

About 10,000 years ago, as glaciers retreated into Canada, North America lost most of its large animals. The casualty list included mammoths, many species of horses and camels, the giant beaver, and others, totaling over 100 species. The question of what caused this late Pleistocene extinction has provoked a storm of controversy.

One widely held hypothesis is that sudden climatic change was responsible for the abrupt extinctions. My own hypothesis is that prehistoric human hunters were responsible. This view is neither new nor widely held. To discount the hypothesis one need simply identify a major wave of extinctions anywhere in the world in the late Pleistocene age prior to the hunters' arrival. To date, such evidence has not been found. In fact, the chronological sequence of extinction closely follows human footsteps, occurring first in Africa and southern Asia, next in Australia, then through northern Eurasia and into North and South America, much later in the West Indies, and finally, during the last 1,000 years, in Madagascar and New Zealand. The pattern shows that late Pleistocene extinction did not occur in all locations at the same time, as it would have if there had been a sudden climatic change or perhaps a cataclysmic destruction of the Earth's atmosphere by lethal radiation from cosmic-ray bombardment, another common hypothesis. Since no synchronous destruction of plants or of plant communities is known, the long-held belief that climatic change caused the extinction lacks credibility.

32. The central argument of the passage is that

(A) all the evidence points to the arrival of humans in North America about 10,000 years ago
(B) large animals became extinct in North America 10,000 years ago
(C) sudden climatic change does not affect the survival of a species
(D) no species became extinct before the arrival of human hunters
(E) human hunters caused the extinction of large animals in the late Pleistocene age

33. According to the passage, which of the following is (are) true of the author's hypothesis?

I. The author is the first person to propose it.
II. No evidence has yet been found to disprove it conclusively.
III. Few scholars interested in the subject have endorsed it.

(A) I only (B) I and II only
(C) I and III only (D) II and III only
(E) I, II, and III

34. According to the passage, which of the following would invalidate the author's argument?

(A) The discovery of major Pleistocene extinctions that occurred before the arrival of humans
(B) Evidence that a bombardment of cosmic rays had occurred after humans had reached North America
(C) Proof that North America has experienced little climatic change
(D) Discovery of a species of large animal that survived the arrival of humans in North America
(E) Proof that humans had come to North America from Europe

35. All of the following are central to the author's argument EXCEPT:

(A) The number of species of large animals native to North America decreased.
(B) Cosmic-ray bombardment would have affected every place on Earth at the same time.
(C) Many animals became extinct before the late Pleistocene age.
(D) Prehistoric humans hunted large animals
(E) A dramatic and widespread climatic change would destroy both plant and animal species.

GO ON TO THE NEXT PAGE

FORM B

Originally, Mars was probably surrounded by a protoatmosphere of reducing gases, such as methane and ammonia, and must have exuded great quantities of water vapor and carbon dioxide. The planet had a force of gravity sufficient to keep all the gases except the light hydrogen from escaping into space, as all the gases of our Moon did. Because of Mars's greater distance from the Sun, the cooling and condensation of water vapor would have taken place more rapidly than on Earth. For a geologically brief time, oceans probably formed in the basins that are now filled with dust. There is no plausible reason why life could not have developed in these primeval oceans as it did in the oceans of Earth. However, the course of evolution on the two planets would have diverged early in their history. No matter how much oxygen was released, a biologically determined, oxygen-rich atmosphere comparable to that which results from the process of photosynthesis probably could never have formed on Mars. It is unlikely that the oxygen content of the Martian atmosphere, and the accompanying formation of ozone in sunlight would ever have risen to a level sufficient to protect organisms from ultraviolet light so that they could live on dry land.

One explanation stems from the size of the planet. The Earth had a force of gravity strong enough to form a dense iron core; Mars did not. On Mars, a larger proportion of iron in relation to the planet's mass lies closer to the surface. Water vapor molecules were split into oxygen and hydrogen by the ultraviolet portion of solar radiation. While the light hydrogen escaped into space, the highly reactive oxygen promptly combined with the iron on the surface to form iron oxides. These same processes probably took place during the early history of the Earth. But on Earth there was proportionately less iron on the surface, so that a certain amount of oxygen was left over to enrich the atmosphere. The conversion of some oxygen to ozone led to the blocking of ultraviolet radiation which prevented the further dissociation of water vapor and of liquid water, and also protected life forms. On Mars oxygen atoms released into the atmosphere were almost immediately consumed again. A self-regulating process that would have shielded the water from ultraviolet radiation probably could not get started. As the water vapor in the Martian atmosphere was dissociated, the iron crust of Mars was gradually oxidized. The iron oxides and iron hydroxides formed give Mars its characteristic reddish or "rusted" appearance.

31. Which of the following is the best title for the passage?

(A) The Formation of Iron Oxides
(B) Evaporation of the Martian Oceans
(C) Early Life of Earth and Mars
(D) Development of the Martian Atmosphere
(E) Atmospheric Ozone and Ultraviolet Radiation

32. The passage suggests that which of the following could have happened on both Mars and Earth?

I. Dissociation of water vapor
II. Oxidation of iron on the planet's surface
III. Development of marine organisms

(A) I only
(B) II only
(C) I and III only
(D) II and III only
(E) I, II, and III

33. The discussion in the passage is based on which of the following general assumptions about chemical interactions?

(A) Catalysis of chemical reactions is inhibited by low temperatures.
(B) Generation of water vapor requires high atmospheric pressure.
(C) Fusion of hydrogen and oxygen takes place constantly.
(D) Binding between iron and oxygen is accelerated in low gravity.
(E) Reactions among chemical elements are consistent from planet to planet.

34. According to the passage, the characteristic color of Mars is a result of

(A) absorption of ultraviolet light
(B) oxidation of a metallic element
(C) concentration of organic compounds
(D) consolidation of land masses
(E) accumulation of cloud cover

35. The author's discussion of the possibility of life on Mars is best described as

(A) speculation within the limits of scientific knowledge
(B) criticism of unwarranted assumptions
(C) analysis of past misconceptions
(D) extrapolation from recent discoveries
(E) explication of facts accepted by prominent scientists

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FORM B

Intercellular adhesions are important in a wide variety of organisms, from bacteria to humans. Organelles of adhesion are thought to provide certain bacteria with devices for securing nutrients and facilitating genetic exchange. In higher organisms, adhesive forces are presumed to be of prime importance during embryonic development and in maintaining distinct structural features of tissues in the adult. Intercellular adhesion also facilitates such diverse processes as ferulization, nutrient absorption, and excretion, and the presence of receptors on animal cell surfaces allows infection by viruses and bacteria to occur. Moreover, the normal adhesive properties of a cell may be lost or modified under abnormal conditions, such as when transformation to malignancy occurs.

Despite the importance of intercellular adhesion, experimental data defining the phenomenon in molecular terms are largely lacking. This paucity of information has generated abundant hypotheses on the chemical nature of cellular adhesion. For example, one hypothesis originated with the observation that glycosyl transferases, enzymes that catalyze the transfer of sugars to appropriate acceptor glycoproteins or glycolipids, are associated with the surface membranes of certain animal cells. The suggestion was advanced that cell adhesion may result from the interactions between the glycosyl transferases associated with one cell and the surface glycosyl acceptors of another cell. Since each glycosyl transferase exhibits specificity for its acceptor molecule, highly specific cell interactions would be possible. Because this hypothesis can account for the high degree of specificity observed in cell recognition, it is an appealing one.

37. It can be inferred from the passage that adhesion is vital to both bacteria and higher organisms in which of the following functions?

(A) Organizing basic cellular structure
(B) Regulating cellular growth rate
(C) Stabilizing the genetic complement of each cell
(D) Providing a means of communication within each cell
(E) Securing suitable nutrients from an external source

38. The author addresses which of the following points directly in describing the glycosyl transferase hypothesis?

(A) The highly specific nature of the enzyme/acceptor interaction
(B) The chemical nature of the enzyme/cell membrane association
(C) The structure of cells that have glycosyl transferases
(D) The molecular nature of the sugars that are transferred
(E) The types of acceptor glycoproteins in the enzyme/acceptor interaction

39. The passage reports that which of the following hypotheses has been proposed about the role of gylcosyl transferases?

(A) They allow infections by viruses and bacteria to occur.
(B) They are the primary receptors of certain animal cells.
(C) They react with sugar molecules to effect the creation of proteins.
(D) They are involved in cell adhesion via interaction with acceptors.
(E) They actively seek out certain acceptor glycoproteins and glycolipids.

40. The information in the passage indicates that the glycosyl transferase hypothesis represents which of the following stages in the establishment of a theory?

(A) Purely speculative consideration of extreme possibilities
(B) Acceptance of a theory characterized by scientific validity
(C) Compilation of information from diverse sources
(D) Verification of an explanation by laboratory experiments
(E) Conjecture based on observed phenomena

FORM C

An observer watching the sky on any clear moonless night can easily observe streaks of light flashing across it every now and then. The ancients interpreted these flashes as "falling stars," and this name is still used by many people in referring to such phenomena. This colorful description gives an entirely wrong impression of the flashes. They are actually caused by meteors, often not much larger nor more massive than grains of sand, which enter the Earth's atmosphere at a speed of about 20 miles per second. Most meteors are disintegrated by the intense heat generated by friction with the air. The temperature of the meteor and of the air surrounding it increases to a few thousand degrees as the kinetic energy of the meteor is quickly transformed into heat; one then sees a sudden luminous streak across the sky whose length, duration, and brightness depend on the size, mass, and speed of the meteor. If it were not for the deceleration resulting from the Earth's atmosphere, many meteoric particles striking the Earth would have an impact greater than that of a .45-caliber bullet and would be very destructive. The number of meteors that enter the Earth's atmosphere in a single 24-hour period and are bright enough to be seen is extremely large. In fact, these meteors are the source of the several tons of meteoric or cosmic dust that are added to the Earth and its atmosphere every day.

Since the debris that separates from the head of a comet continues to move as a stream of matter in the orbit of the comet, a much larger number of meteors is observed when the Earth passes close to such an orbit. In fact, one then observes what is called a meteor shower, with all the meteors in the shower appearing to diverge from, or converge to, a single point in the sky. This phenomenon is illusory; the meteors are really traveling parallel to each other, but they seem to converge to or diverge from a point in the sky because parallel lines seem to intersect at infinity. During the Leonid shower—one whose apparent convergence point was in the constellation of Leo—that occurred on November 13, 1833, meteors were so abundant that many thousands were seen at some observing stations. Such rich showers, however, are rare. Twelve distinct meteor showers, almost one a month, occur every year, but most of them are not very impressive. Each of these is associated with the orbit of a comet.

26. According to the passage, the intensity of the streak caused by a meteor is influenced by which of the following?

    I. The dimensions of the meteor
    II. The origin of the meteor
    III. The velocity of the meteor

    (A) I only
    (B) I and II only
    (C) I and III only
    (D) II and III only
    (E) I, II, and III

27. Which of the following statements about the kinetic energy of a meteor traveling through the Earth's atmosphere can be accurately inferred from the passage?

    (A) It increases the closer the meteor gets to the Earth's surface.
    (B) It serves to neutralize the atmosphere's effect on the meteor.
    (C) It is partially converted into light.
    (D) It is not sufficient to make the meteor visible.
    (E) It cannot be precisely calculated.

28. According to the author, a meteor shower results when

    (A) the Earth passes near the path of a comet
    (B) a massive comet begins to disintegrate
    (C) meteor clusters collide and break up
    (D) the kinetic energy of a meteor is transformed into heat
    (E) meteors converge to a single point in the sky

29. With which of the following statements concerning meteors would the author be most likely to agree?

    (A) Meteors can alter the surface of a planet without an atmosphere.
    (B) Meteors diverge from a single point in the sky.
    (C) Meteors converge to a single point in the sky.
    (D) The speed of a meteor determines its mass.
    (E) The brightness of a meteor indicates its distance from Earth.

30. The author does all of the following in developing the passage EXCEPT

    (A) refute a mistaken notion
    (B) use an illustrative analogy
    (C) explain an optical illusion
    (D) refer to a historical event
    (E) present a personal anecdote

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FORM C

In any part of the world where there are pronounced seasonal changes in climate, organisms appear and disappear at particular times with uncanny precision. Biologists have long wondered how they do it, and the answer to this question is even now not entirely clear.

As the Earth spins through its seasonal cycle, several environmental parameters change on an annual basis. Temperatures fluctuate, periods of high and low precipitation alternate, and day length increases and decreases. Like temperature, the time and amount of precipitation in most parts of the world is highly unpredictable on a week-to-week basis, even though seasonal averages may not fluctuate significantly. Unlike temperature and precipitation, however, day length repeats itself with monotonous precision year in and year out; it is not particularly surprising, therefore, that many organisms respond to this parameter.

Response to day length, or photoperiodism, among most groups of higher organisms is well known. However, the most detailed studies have been done with flowering plants and insects—partially because they are readily handled in large numbers under laboratory conditions, and partially because many of them have sufficiently short life cycles that their response to photoperiod is quickly evident and hence accessible to experimentation. In insects the most carefully studied phenomenon is entry into diapause, a dormant state that occurs in different insects at very different developmental stages, from the egg through adulthood. In flowering plants the phenomenon subjected to closest analysis has been the transformation from vegetative to reproductive growth—the initiation and development of flowers—although it has been demonstrated that other phenomena, such as the onset of autumn coloration and entrance into winter dormancy, are also responses to day length.

29. The passage is best described as which of the following?

(A) A response to a controversial theory of ecological relationships
(B) An explanation of a newly discovered cycle of growth
(C) An account of climatic events in different parts of the world
(D) A list of observations made during the course of one year
(E) An inquiry into possible causes of certain biological phenomena

30. The author cites all of the following as responses to photoperiodism EXCEPT

(A) insect entry into diapause
(B) development of flowers
(C) short life cycles of plants and insects
(D) onset of winter dormancy in plants
(E) start of autumn coloration in leaves

31. According to the passage, the phenomenon of diapause is accurately characterized as which of the following?

I. A state of inactivity
II. A response to a change in the number of daylight hours
III. An effect produced primarily through artificial laboratory conditions

(A) I only
(B) II only
(C) III only
(D) I and II only
(E) I, II, and III

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Appendix

Sentence Completion Items with True Science References

Form	Item #	Section	Item
Form A	16	Verbal 1	The strong affinity of these wild sheep for mountains is not ----: mountain slopes represent ---- because they effectively limit the ability of less agile predators to pursue the sheep. A useful..peril *B accidental..security C instinctive..attainment D restrained..nourishment E surprising..inferiority
Form A	15	Verbal 2	The new instrument proved to be of little usefulness to the geologists; because it had no midrange sensitivity, it only registered disturbances that were either inconsequential or ----. *A cataclysmic B improbable C subjective D instantaneous E unintelligible
Form C	11	Verbal 2	Because of improvements made in the microscope, organisms that heretofore were ---- are now easily studied. A unavoidable *B indistinguishable C inactive D intolerable E inconsequential
Form C	14	Verbal 2	Rice has been referred to as a nearly perfect food, in that one can ---- with rice as the major part of one's diet without any ---- physical effects. A survive..salutary B languish..harmful *C subsist..deleterious D decline..deteriorating E thrive..benign

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