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ABSTRACT

A study investigating developmental differences in the ability to reason with conditional propositions used five variations of Wason's selection task to assess conditional reasoning in 132 eighth, tenth, and twelfth grade adolescents. In addition to examining developmental differences, the study had as an objective to examine the role of semantic content as a moderator of logical competence. An experimental group and a control group were used, with the experimental group performing all five Wason tasks, including meaningful content problems and abstract content problems, and the control group receiving only the two abstract content problems. The results demonstrate developmental differences in the conditional relationship of deductive reasoning. The semantic relevance of materials moderated performance such that the twelfth graders' logical competence was assessed when the original abstract content of materials was replaced with familiar semantic content. The problems and statistical data on answer frequencies for all grades are appended. (MSE)

Conditional Reasoning and Content Effects: A Developmental Analysis of Wason's Selection Task

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A major contemporary area of investigation in the field of cognitive development concerns the development of deductive reasoning. In deductive reasoning a particularly important focus of interest has been the conditional relationship, i.e., if p then q. This interest is warranted for the conditional is central to logic it self. As Braine (1978) and others have noted, the conditional is the sole logical connective that is parallel to the metalogical concept of inference and is the "heart of logic." The developmental interest in the conditional relationship of deductive reasoning has focused upon the questions of when the skill is acquired and how the skill is influenced by various task and situational factors.

In the language of logic the if p then q or conditional relationship consists of two components. The component between the "if" and the "then" is called the antecedent proposition or p alternative. The component following the "then" is called the consequent proposition or q alternative. For example in the implication rule, "if you mow the lawn, then you may go to the movies" the phrase "you mow the lawn" is the antecedent and the phrase "you may go to the movies" is the consequent. What distinguishes the conditional from other logical operators is that its antecedent implies its consequent. It does not assert that its antecedent is true, but only that if its antecedent is true then its consequent is true also. It also does not assert that its consequent is true, but only that its consequent is true if its antecedent is true. The proper strategy to employ with respect to conditional propositions or what is also known as material implication is a falsification strategy. That is, in order to reason conditionally, it is necessary and sufficient to understand that the p and $\bar{q}$ instances falsify the implication. Therefore, a test of an hypothesis is its falsification with a counterexample. All other cases will prove material implication true.

Piaget's developmental theory as well as recent empirical work such as that conducted by O'Brien and Overton suggest that the competence to reason with conditional propositions is first evidenced in adolescence. Piaget argues that to reason successfully requires the development of the formal operational thought structures of the INRC group. The theory maintains that it is only with the coordinated transformations of formal operational thought that the ability to reason systematically with logical relationships within a complete propositional system should be expected. It is the formal operational structure that enables someone presented with the conditional, if p then q, to recognize both the inverse, p and $\bar{q}$, and the reciprocal, if q then p, to the conditional. Indeed, the hallmark of formal operational thought is a systematical understanding of the conditions with which the conditional can be tested for its truth or falsity.

Despite the evidence that conditional reasoning competence is acquired during adolescence, a number of studies have shown that poor test performance often extends well into adult years. Overton has presented a general competence - moderator - performance model which looks at the interplay between the underlying competence and various moderator variables that mediate ultimate performance. These moderators refer to factors which either enhance utilization or are determinants of errors. The poor performance that extends into adult years has most frequently been found in what has been called the Wason selection task. Wason and Johnson-Laird themselves suggest that this is a task designed to tap not specifically the underlying competence but rather moderators of performance. As they say "...we were interested in their determinants, the factors which governed performance and made it fail to reflect logical competence."

The Wason selection task presented a conditional reasoning task

consisting of symbolic materials and affirming antecedents and consequents to test performance on an implication rule. Subjects were shown four cards displaying on their facing sides, a D, an F, a 3, and a 7. Given the conditional rule, "If there is a D on one side of a card, then there is a 3 on the other," subjects were to test the truth or falsity of the rule. Performance on this selection task resulted in a dismal 10% correct selection rate among intelligent adults. Two errors were common. Although most subjects selected the p alternative, they failed to select the $\bar{q}$ alternative and frequently selected the q alternative instead.

An important issue then is a question of the determinants of poor performance on this problem despite the fact that they demonstrate conditional reasoning on other tasks. Although a number of alternatives have offered potential solutions to the problem, a current, important, and active area of research focuses on the semantic content of the conditional problem.

The specific aims of the present study are twofold. First, currently there is no available data with respect to developmental differences on the selection task. This study is designed to obtain such developmental data. Second, the study examined the role of semantic content as a moderator of logical competence.

Griggs and Cox, among others, have demonstrated that age relevant semantic content cues relevant experiences from memory. This familiar content facilitates adult performance on Wason's selection task. The meaningful semantic material chosen for this project was age-appropriate for the population studied.

The subjects were eighth, tenth, and twelfth graders, forty-four from each grade level. Five variations of Wason's selection task were used to assess conditional reasoning. (PLEASE REFER TO THE FIRST HANDOUT AS IT LISTS

THESE FIVE VARIATIONS.) Three of these problems employed meaningful content. These were called (1) the Drinking Age Problem, (2) the Motor Vehicle Problem, and (3) the School Problem. The remaining two problems were drawn directly from Wason and consisted of abstract content. These were the Vowel Problem and the Abstract Problem.

Each problem was presented on a separate page of a booklet. Using the Drinking Age Problem as an example, the format of each problem was as follows. At the top of each page were four response alternatives, Drinking Beer, the p alternative; 22 years of age, the q alternative; Drinking Coke, the not-p alternative; and 16 years of age, the not-q alternative; each depicted on cards. The subjects were instructed that each card has information relevant to a person sitting at a table. For this problem, the information on one side of a card is a person's age and on the other side of the card is what the person is drinking. Each problem has a conditional rule; here the rule stated: "IF A PERSON IS DRINKING BEER, THEN THE PERSON MUST BE OVER 21." The subject's task is to decide which card or cards necessarily must be turned over to decide whether or not the rule is being broken.

The correct solution to each problem involves selection of the p alternative and the $\bar{q}$ alternative because each of these alternatives and only these alternatives can potentially demonstrate the falsifying condition, p and not-q. In other words, turning the $\bar{q}$ card could potentially yield a p alternative and turning the p card could potentially yield a not-q alternative and only these two cards can establish deductive certainty with respect to the question is the rule being broken or not being broken.

Subjects were assigned to either an experimental or control group. The experimental group was administered all five selection tasks and the meaningful set always preceded the abstract set. The control group received

only the two abstract content problems.

An initial analysis of the five selection problems revealed a difference in performance among the meaningful content problems. Subjects performed more poorly on the School Problem than both the Drinking Age Problem and the Motor Vehicle Problem. Performance on the School Problem did not differ from that on either the Vowel Problem or the Abstract Problem. Due to the fact that the School Problem was so different from the other meaningful content problems and similar to the abstract problems, this task was not included in any developmental analyses.

An analysis of developmental differences on meaningful content resulted in a main effect for grade, with only the twelfth graders performing significantly better than the eighth graders.

There were no significant differences between the performance of the experimental group and the control group on the abstract content problems. This suggests that the effects of semantic content in performance on the meaningful problems did not generalize to the abstract problems. No eighth grader provided the correct response on either abstract content problem. In the experimental condition three tenth and three twelfth graders provided correct choices to the Vowel Problem while only two tenth graders and three twelfth graders provided correct choices to the Abstract Problem. In the control group only two correct selections from each the tenth and twelfth grades were given for each problem.

For each problem there were 16 possible selection combinations, that is, each alternative and all possible combinations of the alternatives. The correct response, the p and not-q selections, occurred more frequently than expected by chance for each of the meaningful content problems. This correct response combination was chosen significantly more often than other

combinations across grade levels for the Drinking Age Problem. The developmental difference for the proportion correct for this problem is between the eighth and twelfth grades. The correct selection combination for the Motor Vehicle Problem approached significance. The most frequent combination for the School Problem fell into the "other" category. Examination of the individual combinations composing this category revealed no pattern.

Among the abstract content tasks the most frequent combination selected was the matching combination, p and q. (TABLE 3). This high selection frequency of the matching combination on abstract content task is consistent with earlier work by Wason and Johnson-Laird. There were no differeces across grade levels for the matching selection within each condition. A comparison between conditions revealed that only the twelfth grade experimental group selected the matching combination significantly fewer times than the twelfth grade control group. The mediation of semantic content effects on the reasoning competence of the twelfth grade experimental group may have alerted them to a partial insight to the logically abstract problems.

This research demonstrates developmental differeces in the conditional relationship of deductive reasoning. The selection task, as designed, provides an assessment of possible moderators of ultimate performance. It was found that semantic relevance of materials moderated performance such that the twelfth graders, who have expressed logical competence on other tasks, successfully reasoned on problems consisting of meaningful content. That is, logical competence was assessed when the original abstract content materials of the selection task were replaced with familiar semantic content. This semantic content enhanced logical performance on meaningful problems as compared to logically abstract problems.

MEANINGFUL CONTENT PROBLEMS

Drinking Age Problem

"IF A PERSON IS DRINKING BEER, THEN THE PERSON MUST BE OVER 21."

Motor Vehicle Problem

"IF A PERSON IS DRIVING A MOTOR VEHICLE, THEN THE PERSON MUST BE OVER 16."

School Problem

"IF A STUDENT HAS MORE THAN 10 ABSENCES IN A SCHOOL YEAR, THEN THE STUDENT MUST REPEAT THE SCHOOL YEAR."

ABSTRACT CONTENT PROBLEMS

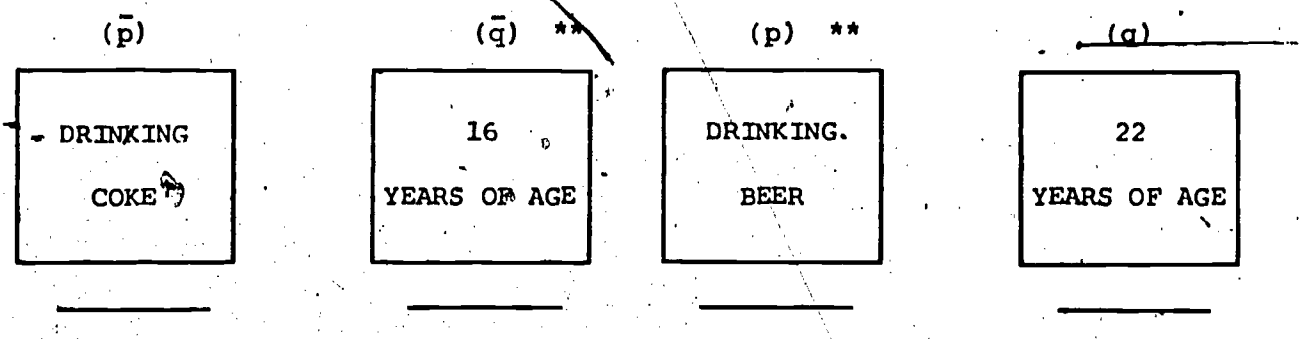
Vowel Problem

"IF A CARD HAS A VOWEL ON ONE SIDE, THEN IT HAS AN ODD NUMBER ON THE OTHER SIDE."

Abstract Problem

"IF A CARD HAS A D ON ONE SIDE, THEN IT HAS A 3 ON THE OTHER SIDE."

An Example of how each Problem was Presented



Instructions:

"Each of the above cards has information about a person sitting at a table. On one side of a card is a person's age and on the other side of the same card is what a person is drinking.

Here is a rule: IF A PERSON IS DRINKING BEER, THEN THE PERSON MUST BE OVER 21.

Pick the card or cards that you would definitely need to turn over to decide whether or not the rule is being broken."

Note: The labels above each card are for illustration and did not occur in test materials

** denotes the correct selections

Table 1.

Average Correct Selection on each Problem Type as a Function of Grade Level.

	EIGHTH	TENTH	TWELFTH
	Experimental Group (N = 66)		
Drinking Age	.63	.81	.95
Motor Vehicle	.59	.68	.86
School	.22	.36	.18
Vowel	.00	.14	.14
Abstract	.00	.09	.14
	Control Group (N = 66)		
Vowel	.00	.09	.09
Abstract	.00	.09	.09

Note: Maximum score = 1.

Table 2.

Frequencies for Thematic Problems Selection Combinations for the Experimental Group.

Problem	Selection Combination	Grade 8	Grade 10	Grade 12
Drinking Age	p	1	1	1
	p,q	--	1	--
	p,q,q̄	--	--	--
	p,q̄	13	18	21
	other	8	2	--
Motor Vehicle	p	2	2	2
	p,q	1	1	--
	p,q,q̄	1	--	--
	p,q̄	14	15	19
	other	4	4	1
School	p	3	--	2
	p,q	2	3	2
	p,q,q̄	--	1	1
	p,q̄	5	8	5
	other	12	10	12
Total	p	6	3	5
	p,q	3	5	2
	p,q,q̄	1	1	1
	p,q̄	32	41	45
	other	24	16	13

Table 3.

Frequencies for Abstract Problems Selection Combinations.

Problem	Selection Combination	Grade 0	10	12
		experimental		
Vowel	p	2	2	4
	p,q	9	5	5
	p,q,$\bar{q}$	1	--	1
	p,$\bar{q}$	--	3	3
	other	10	12	9
Abstract	p	1	3	4
	p,q	12	7	9
	p,q,$\bar{q}$	--	--	--
	p,$\bar{q}$	--	2	3
	other	9	10	6
		control		
Vowel	p	2	3	3
	p,q	9	9	14
	p,q,$\bar{q}$	--	--	--
	p,$\bar{q}$	--	2	2
	other	11	8	3
Abstract	p	1	4	2
	p,q	12	11	14
	p,q,$\bar{q}$	--	--	--
	p,$\bar{q}$	--	2	2
	other	9	5	4