Children's Reasoning about Social, Physical, and Logical Regularities: A Look at Two Worlds

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KOMATSU, LLOYD K., and GALOTTI, KATHLEEN M. *Children's Reasoning about Social, Physical, and Logical Regularities: A Look at Two Worlds.* CHILD DEVELOPMENT, 1986, 57, 413–420. In 2 studies, 6-, 8-, and 10-year-old children were interviewed about 3 different types of regularities or rules: social conventions, physical laws, and logical necessities. In the first study, children were asked if regularities could be changed (by consensus) and/or be different in another world. In the second study, children were asked if regularities could be different in another country (on Earth) or on a different planet. Results showed that social regularities were distinguished from the other types, but physical and logical regularities were treated similarly. While the evidence for age differences was equivocal, it was clear that even first graders did not judge physical items as alterable on Earth. This fails to replicate a previously reported finding that children pass through a stage where all items are seen as alterable. Finally, a sex difference emerged, with boys more willing to judge physical and logical regularities to be alterable in another world.

Many events and circumstances occur with great regularity. In the game of tag, the first player touched by "it" becomes "it"; objects released from grasp fall; objects cannot be simultaneously blue and not blue. The bases for these regularities differ, however. Rules of a game reflect social conventions; falling objects are governed by gravity, a physical law; and contradictions follow necessarily from the meaning of the terms.

Children's understanding of regularities is both a basis for, and a reflection of, the complex inductions they make. Although they may be taught explicitly about particular regularities, they are not taught about different *types* of regularities. The delineation of regularity types is itself an induction, one that implies knowledge of the bases for regularities and the conditions under which regularities can be altered.

How can the distinctions among the three types of regularities illustrated above be characterized? Nucci and Turiel (1978) note that social conventions are arbitrary, subject to change if all (or most) people in the relevant community are willing. Physical (or natural) laws are not alterable, even by unanimous consent; they are not culturally relative or community specific (Carter & Patterson, 1982). Yet another kind of relativity is true of physical regularities—they are contingent on the empirical facts true of a particular environment and thus can differ from world to world. But not even this kind of relativity applies to logical necessities: A tautology on Earth must be a tautology on every possible world (see Moshman & Timmons, 1982).

Previous studies examined children's ability to distinguish among different types of regularities (most often, social conventions and moral prohibitions: see, e.g., Davidson, Turiel, & Black, 1983; Much & Shweder, 1978; Nucci, 1981; Smetana, 1981; Turiel & Smetana, 1984; Turiel, 1983; Weston & Turiel, 1980). Many of these studies were done to address the issue of whether children show differentiated understandings of rules within the domains of moral knowledge and social conventional knowledge (Davidson et al., 1983; Turiel & Smetana, 1984). Davidson et al. (1983) argue that one criterion children

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use in distinguishing domains is that of rule alterability. If children judge rules or regularities in one domain to be alterable under some circumstances but rules and regularities from another domain not to be subject to alteration under these conditions, then they are said to recognize the existence of distinct domains.

Lockhart, Abrahams, and Osherson (1977) investigated the development of distinctions among social conventions, moral rules, and physical laws. They asked first-, third-, and fifth-grade children about four social conventions (object labels, a rule of a game, a law of state, and a rule of etiquette), one moral rule (taking another's property), and one physical law (gravity). They concluded that the ability to make distinctions among these three types increases with age and that many children pass through a stage in which they believe that all regularities are subject to change. The fact that so few items were used, and that only one physical law was presented, suggests that further investigation of children's distinctions between the social and physical domains is warranted.

Other studies have described children's knowledge of logical necessity. Osherson and Markman (1975, Experiment 1) found that second graders treat tautologies (e.g., "Either the chip in my hand is yellow or it is not yellow") in the same way they treat empirically contingent statements (e.g., "Either the chip in my hand is red or it is blue"). Markman (1978) found that, up until sixth grade, children were unlikely to recognize the logical necessity of the superordinate class being more numerous than a proper subordinate class (although younger children could appreciate the logical status of the problem if collection terms were used). These studies suggest that awareness of logical necessity as a regularity type distinct from physical laws may be later developing than awareness of the distinction between conventional and physical regularity. However, previous work has not specifically compared children's relative judgments of the conditions of alterability of items from these two domains.

Our work was designed to further assess children's alterability judgments of items from the social, physical, and logical domains. We not only asked children about alterability through consensus, but also whether regularities could be different in another, presumably dissimilar, world. This manipulation was necessary to probe children's understanding of the distinction between physical and logically necessary items.

Study 1

Method

Subjects.—Children from two elementary schools in New Haven, Connecticut, who received parental consent participated. There were 14 first graders, 19 third graders, and 20 fifth graders. One additional third grader and one additional first grader did not complete the task. Data from four other third graders and six fifth graders were randomly excluded to create a balanced design, leaving 14 children in each of the three grades (mean ages were 6.41, 8.50, and 10.50 years, respectively). There were 6 first-grade boys, 7 third-grade boys, and 11 fifth-grade boys.

Materials.—Pictures of Grover (a character in the popular TV series "Sesame Street") and E.T. (an alien from a well-known movie of the same name) were displayed throughout. Stimuli consisted of 18 colored pictures, 6 inches square, mounted on cardboard and covered with plastic. The 18 stimuli were evenly divided among the three domains of social conventions, physical laws, and logical necessities. Included among our stimuli were items of the kind investigated by Lockhart et al. (1977) and Markman (1978). A full listing of the stimuli is given in Table 1.

Procedure.—Children were questioned individually by one of the authors. It was first explained that we were interested in children's opinions about certain issues. Displaying the pictures of Grover and E.T., the experimenter asked the child to imagine that (1) Grover had been elected mayor of New Haven by unanimous vote and wanted to change some things, and (2) E.T. had told us about the way certain things were on his home planet. The first picture was then presented, and the regularity depicted was called to the child's attention. The child was asked two questions: (1) "Grover wants to change things so that [indicated change]. Can he do this, if he gets everyone in New Haven to agree?" and (2) "E.T. says on his planet [indicated change] is the way things really are. *Could* he be telling the truth or does he have to be fibbing?" The order of questions (E.T. vs. Grover question) was counterbalanced across children.

After the child's acceptance or rejection of the indicated change was noted, and all spontaneous justifications were recorded, the next stimulus card was presented. The order of stimuli was random and counterbalanced across children. If a child seemed not to understand a regularity, that item was skipped. Because children have previously

TABLE 1

STIMULUS ITEMS USED BY DOMAIN: STUDY 1

Regularity	Proposed Change
Social domain:	
In hide and seek, the first person found is "it."	The second person found is "it."
In tag, the first person tagged is "it."	The second person tagged it "it."
Dogs are called "dogs."	Dogs are called "wugs."
Jumping is called "jumping."	Jumping is called "gidging."
The school year begins in September.	The school year begins in January.
Cars stop at red traffic lights.	Cars stop at purple traffic lights.
Physical domain:	
Pencils fall when dropped.	Pencils float in the air.
Rocks sink in water.	Rocks float in water.
Winter is cold and snowy.	Winter is warm and not snowy.
Flowers bloom in spring.	Flowers do not bloom in spring.
Pepper makes people sneeze.	Pepper does not make people sneeze.
Mittens warm hands.	Mittens do not warm hands.
Logical domain:	
An object cannot be both blue and not blue at the same time.	An object can be both blue and not blue at the same time.
An object must either be green or not green.	An object does not have to be either green or not green.
A mother must have (at some time) a child.	A mother need not ever have a child.
A triangle must have exactly three sides.	A triangle can have four sides.
There cannot be more daisies than flowers.	There can be more daisies than flowers.
There cannot be more apples than fruit.	There can be more apples than fruit.

been shown to have difficulty with logical items (Osherson & Markman, 1975), we required that they first demonstrate understanding of logical items (e.g., by solving the class inclusion problem). If a child failed to do this, the item was skipped.

Results

We first consider the number of items skipped as a function of age and domain. First graders missed 3.6% of the social items and 50% of the logical items. Third graders skipped 33% of the logical items and fifth graders skipped 23% of the logical items. Hence, the results from this study regarding logical items must be cautiously interpreted. We note, however, that every child did answer at least two of the six logical items.

We determined the proportion of items within a domain correctly answered by each child. Table 2 reports the average percentage of correct responses by grade, world, and domain. (Correct responses were: accepting alterations of social conventions, rejecting alterations of logical necessities, and accepting alterations of physical laws in E.T.'s world only.)

We find it more convenient to use an equivalent measure—the proportion of alterations accepted by a child. Figure 1 shows these data by grade, world, and domain. Figure 1 also presents comparison data from adult college students who judged whether each item could be altered. (The task given to college students is described in Study 2.)

TABLE 2

MEAN PERCENTAGE CORRECT BY GRADE, DOMAIN, AND WORLD: STUDY 1

	Domain					
	Social		Physical		Logical	
Grade	Grover	E.T.	Grover	E.T.	Grover	E.T.
1	22.0	36.3	91.7	23.8	88.1	74.4
2	71.4	72.6	96.4	51.2	74.4	72.0
3	88.1	94.0	94.0	76.2	77.5	67.0

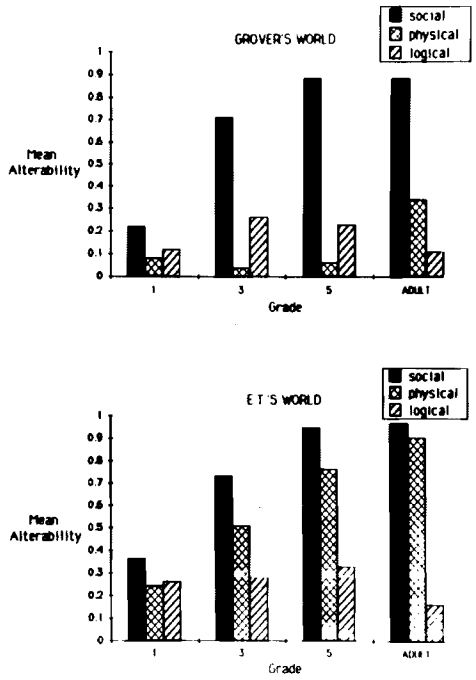

FIG. 1.—Mean alterability scores by age, domain, and world: Study 1.

Figure 1 shows that, for all ages, logical items are regarded as unalterable in both worlds. With increasing age, social conventions are seen as alterable in both worlds. The proportion of physical law differences accepted for E.T. shows the same dramatic increase with age found for social conventions, but the proportion of physical changes accepted for Grover remains low for all groups.

A 2 (sex) × 3 (grade) × 3 (domain) × 2 (world) ANOVA, adjusted for unequal cell sizes, with repeated measures on the last two factors confirms the reliability of the grade × domain × world interaction: $F(4,78) = 7.25$, $p < .001$. Specific comparison tests revealed that for first graders no means differ; for third graders, social, physical, and logical means differ within each world, and means for physical items differ between worlds; fifth graders show the same pattern as third graders, except that within Grover's world, physical and logical items are not distinguished. Significant main effects were: grade, $F(2,36) = 20.24$, $p < .001$; domain, $F(2,72) = 54.03$, $p < .001$; and world, $F(1,36) = 24.90$, $p < .001$. Significant two-way interactions were those for grade × domain, $F(4,72) = 7.53$, $p < .001$, and domain × world, $F(2,72) = 7.01$, $p < .001$.

Only one effect with sex as a factor emerged: a marginally significant sex × world interaction, $F(1,36) = 4.01$, $p < .06$. Males were significantly more likely to allow changes in E.T.'s world. Because so few females were included in the fifth-grade group, interpretation of this effect is difficult, and we defer consideration to the general discussion.

The issue of coherence of responses to different stimuli within a domain is a question widely recognized in psycholinguistic research: To what extent will findings generalize simultaneously to a new group of subjects and a new sample of items? The generally accepted solution is to use the *min F'* statistic (see Clark, 1973, for details of when and how this is computed). *Min F'* is a lower bound of the appropriate quasi-*F* ratio. When we calculated *min F'*s, the only effect we found reasonably certain to generalize with new subjects and new stimuli was the main effect for domain, *min* $F'(2,87) = 3.31$, $p < .05$. As Clark (1973) points out, and our own data illustrate, effects that appear very reliable when only a single random effect (subjects) is taken into account may weaken considerably when both random effects are properly analyzed. Note that no previous studies in the literature have reported *min F'*s, and so it is unclear to what extent previous findings depend on the particular items used.

Discussion

The finding that older children make distinctions that younger children do not suggests that younger children do not recognize distinct domains. However, the *min F'* results suggest that this finding might not be obtained with new items. Hence, the age differences found might be specific to the particular items we chose.

The amount of missing data for logical items was unacceptably high. We also wanted to probe the reasoning behind an alterability judgment (specifically, if children judged an item not to be alterable, were they merely reacting to the specific proposed change?). We also wanted to compare children's alterability judgments to those of adults. These objectives guided the design of Study 2.

Study 2

Method

Subjects.—Children from two elementary schools in New Haven and one elementary school in Northfield, Minnesota, who received parental consent participated. There were 14 first graders, 15 third graders, and 14 fifth graders. Five of the first graders were

TABLE 4

MEAN PERCENTAGE CORRECT BY GRADE, DOMAIN, AND WORLD: STUDY 2

	Domain					
	Social		Physical		Logical	
Grade	Sashi	E.T.	Sashi	E.T.	Sashi	E.T.
1	57.1	60.7	83.9	35.7	81.5	61.9
2	86.7	86.7	92.8	48.3	82.2	68.3
3	87.5	96.4	89.3	53.0	75.0	62.5

as it was for the children, data from college students are included only for comparative purposes.

Results

First graders did not skip any social or physical items, and skipped 5% of the logical items. Third graders did not skip any social items but skipped 1% of the physical items and 8% of the logical items. Fifth graders skipped less than 1% of the social and physical items and 2% of the logical items. These figures are a significant improvement over those for Study 1.

As before, the proportion of items within a domain and world correctly answered by each child was calculated. Table 4 reports these proportions for each age group. Also as before, these figures are represented along with adults' corresponding judgments as mean alterability scores in Figure 2. Figure 2 shows that children of all ages regard social items as alterable in both worlds and physical items as more alterable in E.T.'s world. Children seem to treat logical items in a similar fashion to the way they treat physical items.

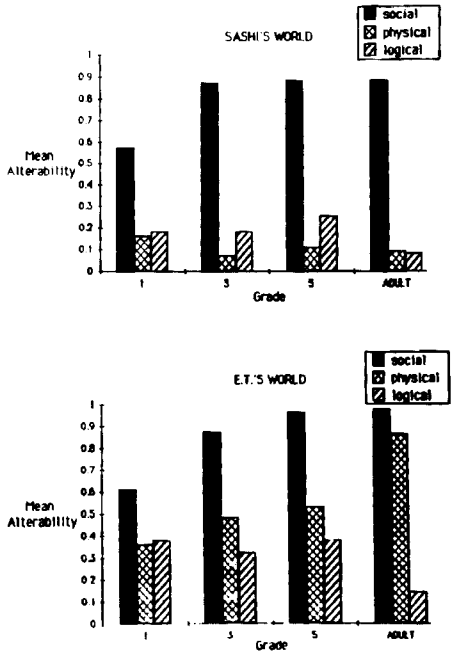

FIG. 2.—Mean alterability scores by age, domain, and world: Study 2.

A 2 (sex) × 3 (grade) × 2 (world) × 3 (domain) ANOVA, adjusted for unequal cell sizes, with repeated measures on the last two factors was run on mean alterability scores. It yielded significant main effects for grade, $F(2,32) = 3.98$, $p < .05$; domain, $F(2,64) = 94.28$, $p < .001$; and world, $F(1,32) = 28.84$, $p < .001$. Significant two-way interactions emerged for grade × domain, $F(4,64) = 5.59$, $p < .01$, and domain × world, $F(2,64) = 21.12$, $p < .001$.

A three-way interaction with sex, domain, and world was also significant, $F(2,64) = 5.96$, $p < .01$. Table 5 presents the means for this interaction. Post hoc tests showed that boys and girls differ in their judgments only for E.T.'s world with logical and physical items.

Significant *min F'* statistics were obtained only for the following effects: domain, *min* $F'(1,20) = 33.33$, $p < .01$; world, *min*

TABLE 5

MEAN ALTERABILITY PROPORTIONS BY SEX, DOMAIN, AND WORLD: STUDY 2

	Domain		
World	Social	Physical	Logical
Sashi:			
Girls	.81	.11	.22
Boys	.76	.12	.18
E.T.:			
Girls	.78	.38	.43
Boys	.85	.54	.28

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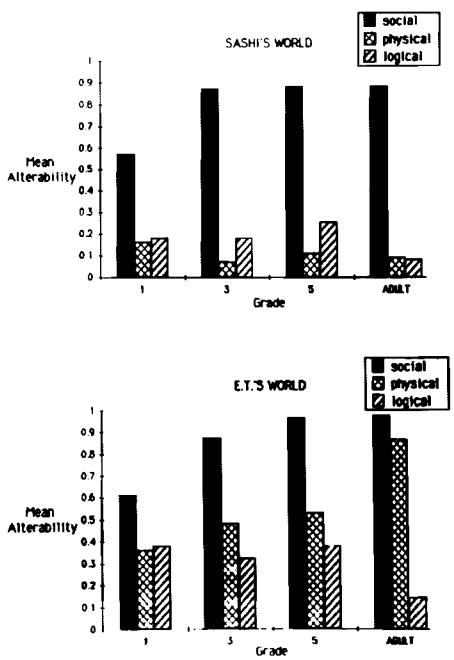

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Boys	.76	.12	.18
E.T.:			
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$F'(1,14) = 26.51$, $p < .01$; and domain × world, *min* $F'(2,18) = 6.21$, $p < .01$. The three-way interaction between sex, domain, and world was marginally significant, *min* $F'(2,33) = 3.08$, $p < .10$. Note that no effects with grade as a factor are significant in this analysis.

General Discussion

Both studies yielded similar results. First, consider the issue of distinctions between domains. Both studies suggest that older children make more distinctions between social and nonsocial items than do younger children. This implies that knowledge of different types of regularities increases with age since knowledge of a regularity would include, in particular, knowledge of the circumstances under which it applies and can be changed. However, *min F'* statistics were not significant for the age × domain interaction in either study, which implies that this finding may not generalize simultaneously to other subjects using different items.

In fact, a close comparison of the two studies reveals a considerable difference in the data for first graders in the social domain. This discrepancy may be due to differences between the two studies in procedures, subjects, or items. The principal procedural difference was in asking about conditions in Sri Lanka rather than changes in New Haven. Given that the results for E.T.'s planet differed in the two studies as well, we do not think that procedural differences are wholly responsible. But subject differences cannot be ruled out as a source for the discrepancy between the two studies since some of the first-grade subjects in Study 2 came from a community somewhat different from the one that provided the other subjects. However, given the strong effects when subjects are analyzed as the only random variable (see the results for Study 1), we favor item differences as an explanation.

What we have called the social domain may in fact consist of more than one subtype, with the subtypes differentially represented by the items of our two studies. The ages at which children recognize the alterability of these social subtypes may differ. This is an issue that warrants further investigation.

What about distinctions between physical and logical items? In Study 2 we found no evidence that children at the ages studied made any distinction between them. The lack of distinction between physical and logical items is consistent with the findings of Markman (1978) and Osherson and Markman (1975), described above. Our findings support the claim that understanding of logical necessity emerges later than understanding of other regularity types (see Moshman & Timmons, 1982, for a related argument). We did have success in introducing the world manipulation, nonetheless, and believe it will be a useful technique to investigate the physical/logical distinction in older subjects.

Neither of the present studies replicated the Lockhart et al. (1977) finding of a stage of development in which all regularities are seen as subject to change. Our subjects, even first graders, recognized that physical items were not subject to alteration in this world. Most subjects readily allowed for differences in physical laws, especially gravity, in E.T.'s world. (Although logical items were treated similarly, children lacked any ability to explain their judgments of logical items.) We suspect that Lockhart et al.'s results are due in large part to their stimulus set, which consisted of four social items, one moral item, and only one physical item.

The sex difference that emerged, which was especially apparent in Study 2, shows that boys are more likely to distinguish between worlds for physical items. One speculative account of the sex difference is the following: Boys have a stronger interest in science fiction, which results in greater familiarity with, and flexibility in, considering altered circumstances in other worlds. This finding is reminiscent of content effects commonly found in studies of adults' formal reasoning (Evans, 1982; Johnson-Laird, 1983). In a variety of studies, it has been shown that performance on a task varies as a function of what the task is nominally about. Typically (although not always), the more familiar the content, the better the performance. In the present context, we are suggesting that a similar mechanism (increased familiarity with the content) explains the improved performance for boys.

We have found that alterability is a basis along which children distinguish domains, and that children recognize that items that are not subject to consensual change might still be different in another world. Our findings leave open several issues, the most fundamental being: What defines a domain and how does the definition develop? Further work is needed to describe the structure of domains and how the structure evolves.

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