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Language and the latent structure of cognitive development (1)

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A cross-cultural method was used to explore theoretical implications of the reported association between mastery of the comparative forms in language and development of competency in dealing with difference and equality relations (such as those of Piaget's conservation problems). Since Turkish allows comparisons to be made without the use of a morphologically distinct form (equivalent to: John is to Mary tall), it was selected for contrastive study along with English and Greek which share a similar system for comparisons. One hundred and ten English, Turkish-Cypriot and Greek-Cypriot children (age 4-11) attending school in London were tested on a variety of language, conservation, and multiple classification problems. The results of this testing indicated that language competency does play a significant role during the course of cognitive development, and that variations in language structure can engender parallel variations in the structure of development. Statistical analyses suggested the following specific conclusions: (1) the concrete operations stage is not functionally unified; (2) the structure of development during this stage is multidimensional; and (3) constancy across cultures in the ordering of development during this stage arises, in part, from similarities between their languages in the representation of attribute and difference relations.

Piaget (1966) inaugurated this journal with a treatise on the necessity and significance of comparative research in which he drew attention to the potential cultural and linguistic relativity of his own findings:

> En un mot la psychologie que nous élaborons en nos milieux, caractérisés par une certaine culture, une certaine langue, etc. demeure essentiellement conjecturale tant qu'on n'a pas fourni le matériel comparatif nécessaire à titre de contrôle (p. 12).

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Such concern for cross-cultural comparisons is appropriate to all branches of psychology, and it is *crucial* for any theory which aspires to elaborate "l'épistémologie génétique". The present research was undertaken to provide such comparative material by exploiting an unusual opportunity for a quasi-experimental study of the influence of linguistic factors upon the structure of cognitive development in comparable groups of Turkish, Greek, and English speaking children.

Empirical evidence in this area is relatively meager. Although past cross-cultural research (reviewed by Dasen, 1972) has considered the possibility that children in other cultures may differ from the youth of Geneva in the structure or rate of their cognitive development, few studies have identified any factors which could account for the differences which have been found. As Dasen concluded in his summary of this research, the data provided by almost all of these studies is *descriptive*; a great deal of further research is needed to link variations in development to specific cultural factors. Furthermore, although theories of the functional interrelation of language and thought have a long history (*e. g.*, Whorf, Sapir, Vygtotsky, Luria), cross-cultural researchers have paid little attention to the manner in which structural differences in languages might account for variations in the development of cognitive skills.

An exception to the general case is the work of Sinclair de Zwart (1967) who has presented evidence that children who conserve use different linguistic forms than children who do not conserve. Adapting the notions of "scalar" and "vector" words from the linguist Bull (1963), Sinclair de Zwart observed that most French and English children designated as "conservers" made use of vectors, (*e. g.*, *more* and *less*), while "non-conservers" relied on ordinary scalars (*e. g.*, *much* and *little*) which could be coordinated to express comparisons, for example,

> This is bigger. (*using a vector*).
> This is big and that is small. (*using coordinated scalars*).

These findings, which have been replicated in a longitudinal study by Versey (1974), have interesting implications for the study of cognitive development in cultures whose languages do not have linguistic structures parallel to the English and French comparative forms.

Piaget (1966) in noting the significance of such research, has drawn attention to the need to extend these studies outside of the European language families,

> On voit alors d'emblée le très grand intérêt qu'il y aurait à multiplier des expériences de cette sorte en fonction de langues diverses. Sinclair a trouvé les mêmes résultats en français et en anglais. Mais il reste à recourir à des langues bien différentes. *En turc, par exemple, il n'existe qu'un seul vecteur*, qui correspond à notre terme « encore »; pour dire « plus » on dira « encore beaucoup » et pour dire « moins », « encore peu ». (p. 12, italics added)

In noting this divergence in linguistic structure between Turkish and French modes of comparison, Piaget suggests the unique importance of work with Turkish populations. Dasen's (1972) bibliography of cross-cultural Piagetian research includes no study carried out with a population speaking a Turkic language.

Since we will be reporting the first such study ([2]), it is important that we commence with a more precise statement of the relevant aspects of Turkish grammar.

Vectors and scalars in Turkish grammar—a restatement

Although Piaget was quite correct in his observation that the structure of the comparative in Turkish is very different from the French comparative, his explanation was somewhat incomplete and imprecise. First, although the translation of "daha" as "encore" is consistent with some, particularly Ottoman sources (*e. g.*, Barbier de Meynard, 1881), it does leave much to be desired. Its translation might better and more simply be rendered as the vector sign ("plus" = "more") which is the first listed translation given in Delibasi's (1944) and Hony's (1967) dictionaries of contemporary Turkish.

Secondly, in contrasting the formation of vectors in Turkish and French ([3]), Piaget oversimplifies the Turkish case, and thereby fails to convey just how different the two structures are. Specifically, while the simple comparison expressed in English by,

English: This is more.

is correctly and uniquely rendered by use of the vector sign "daha" *together with* the adjective "çok" (much, many), *i. e.*,

Turkish: Bu daha çok.
Literal: This (is) more much.

the "daha" is not required when the object of the comparison is stated. In this case the *scalar* (*adjective*) *may stand alone*, for example,

English: This is more than that.
Turkish: Bu ondan çok. *OR* Bu ondan daha çok.
Literal: This (is) much than that. *OR* This (is) more much than that.

Thus, in the case of two explicitly stated objects, a Turkish-speaker may communicate their comparison by using a scalar adjective alone. The use of "daha" in such cases is optional ([4]) (*cf.*, Nemeth, 1916, no. 53; Godel, 1945,

([2]) The only studies of which we are aware are the unpublished investigation of seriation by Professor Semin in Istanbul (cited in Piaget, 1952), the unpublished research of Professor Collier (personal communication), and the work of Professor Slobin (personal communication) and his colleagues on language acquisition.

([3]) Some differences do exist between English and French. Sinclair de Zwart draws attention to the two structures used to express the comparative in English: (1) the "-er" suffix, and (2) the adverb "more"; as well as the multiple uses of "plus" in French. Nonetheless, in a comparative study of English and French, she found similar patterns of development.

In this regard it is interesting to note that the Turkish parallel to the "-er" suffix of English ("-rak", "-rek") disappeared from common usage during the Ottoman period, although it survives today in a number of Anatolian usages (*e. g.*, "yegrek" = "daha iyi": better); and in many other Turkic languages. See Menges (1968) and Nemeth (1916).

([4]) Lest the reader be misled, two points deserve clarification, (1) the simple comparative outlined above, is a grammatically acceptable form which is frequently employed. There is some tendency (which we cannot quantify at this point) for educated speakers to consider the simpler form (Bu ondan çok) incorrect or "peasant-like"; (2) the form "Bu daha cok" should *not* be understood as the English "This is much more" which would be expressed as "Bu çok daha çok."

p. 66; Lewis, 1967, pp. 54-55; Gencan, 1971, no. 382). This pattern is consistent for all adjectives; thus for "expensive" (pahali) we have:

SIMPLE: English: This is more expensive.
Turkish: Bu daha pahali.
Literal: This (is) more expensive.

COORDINATED: English: This is more expensive than that.
Turkish: Bu ondan pahali. *OR* Bu ondan daha pahali.
Literal: This (is) expensive than that. *OR* This (is) more expensive than that.

Table 1 summarises the structure of the comparative in Turkish and contrasts it to English. Readers will note that in English a morphologically distinct vector (more) is both the comparative for quantity (scalar = "much"), and it, or its analog (-er), *invariably* must appear in all comparisons of quality. However, in Turkish the scalar alone can suffice for comparisons, and *it* must appear even in the comparison of quantities. Thus, the linguistic divergences involved in the comparative study of Turkish and non-Turkish speaking populations are even greater than those set out by Piaget.

Overview of the research

The present study exploits a unique opportunity for the controlled investigation of the effect of linguistic factors upon cognitive development. This opportunity arises from the presence in London of a group of Cypriot immigrant children who come from equivalent social backgrounds ([5]), but differ in their native languages: Greek or Turkish. Since Greek structures the comparative in a manner similar to English, these samples provide the possibility of a quasi-experimental study in which language structure could be considered an independent variable (*i. e.*, a treatment condition) and in which a monolingual English group is available for further comparative analysis. The present study of these populations was designed to facilitate:

1) an analysis of the latent structure of the skills tapped by conservation, seriation, and multiple classification tasks, in order to test the assumption that the structure of operational development is invariant across languages;

2) and secondly, an extension of Sinclair de Zwart's analysis to the Greek and Turkish cases.

METHOD

Subjects

A sample of children ($N = 110$; 47 percent male) was drawn from among the four to eleven year old pupils in two junior and two infants schools in North London. These schools contained approximately equal numbers of Turkish and Greek Cypriot children (10 to 15 percent of population), a larger number of working class English children, and smaller numbers of Indian, Pakistani, Italian, and African students.

([5]) Greek-speaking Cypriots in London have a social status which is roughly equivalent to the Turkish Cypriots; both groups are migrants who have been resident in Britain for equal periods of time and who share the same neighborhoods and schools.

TABLE 1

COMPARISON OF LINGUISTIC STRUCTURE OF COMPARISONS IN ENGLISH AND TURKISH

	Type of comparison	*Structure in English*	*English example*	*Structure in Turkish*	*Turkish example*
QUANTITY	Description —no comparison	Scalar adjective alone	This is much	Scalar adjective alone	Bu çok.
	Simple comparison (object absent)	Vector sign alone	This is more	Vector sign and scalar adjective	Bu daha çok.
	Coordinated comparison (object present)	Vector sign alone	This is more than that	Scalar adjective alone *OR*[a] Vector sign and scalar adjective	Bu ondan çok. *OR*[a] Bu ondan daha çok.
QUALITY	Description —no comparison	Scalar adjective alone	This is beautiful	Scalar adjective alone	Bu güzel.
	Simple Comparison (object absent)	Vector sign and scalar adjective	This is more beautiful	Vector sign and scalar adjective	Bu daha güzel.
	Coordinated comparison (object present)	Vector sign and scalar adjective	This is more beautiful than that	Scalar adjective alone *OR*[a] Vector sign and scalar adjective	Bu ondan güzel. *OR*[a] Bu ondan daha güzel.

Note : For simplicity, we omit from the table the class of English vector-adjectives (bigger, etc.). This aspect of the English comparative is not paralleled in the Romance languages, although a similar duality does occur in Greek. This divergence has been the subject of a study by Sinclair de Zwart, who concentrated her attention on the three uses of the vector sign "plus" in French (*i. e.*, as vector sign for qualities, as comparative of "beaucoup", and lastly to express time as in "je n'en ai plus").

[a] forms are interchangeable, and equally correct.

Samples of Greek ($N=40$) and Turkish ($N=37$) children were randomly drawn from the population of four to eleven year olds. Only children speaking fluent Greek(G) or Turkish(T) and who reported this to be the normal language in their homes were included in these samples. The English(E) sample was restricted to children aged six to eleven due to widespread absences in the infants schools at the end of the term. All children in the English sample came from monolingual homes.

To test the social similarity of these samples, the children were asked how many brothers and sisters they had, and what type of work their fathers did. Children in all language groups reported a median of two siblings, and their fathers' were mainly employed in skilled manual and lower grade non-manual occupations. The English fathers, however, did tend to work in slightly more skilled occupations. Coding these data into the seven-point Hall-Jones (1950) classification of occupations, we found a 0.7 unit difference between Cypriot and English fathers [mean level = 5.5(T), 5.2(G), 4.6(E)]. Standardised reading test scores were available for 64 children in the sample. These scores showed *both* the Turkish and Greek Cypriot samples to be lagging 13 months behind the national reading norms for Britain. This result is not unusual for bilingual children from working class homes. Scores for the English sample were, as expected, significantly higher than those of the immigrant sample, however these scores also were somewhat lower than the national average.

Measures of linguistic and cognitive development

Tests used in the present research included:

1. Language pretests.
2. Conservation of number, weight, continuous and discontinuous substance, and three tests of conservation of (liquid) quantity.
3. Seriation.
4. Multiple classification.

The *language pre-tests*, derived from Sinclair de Zwart (1967), were used to explore the children's use and understanding of scalar and vector concepts. These tests included the marble-doll, and sticks tests which elicit childrens description of inequalities, as well as the multiple groups and pencil tests for the provoked understanding of vector concepts. The *multiple classification tasks* employed the nine matrices described by Inhelder and Piaget (1964) which were administered in the manner of Almy (1970) with the modification that children were shown a display of alternatives and required to select one element to complete the matrix.

Seriation and conservation tasks were administered using the procedures of Versey (1974). The *seriation* task required the ordering of a set of sticks into a staircase as first described by Piaget (1952). The conservation of *substance* and *weight* tasks employed plasticene which was deformed into a "sausage" in the manner of Piaget and Inhelder (1941). *Number conservation* was assessed by having the child and tester construct "towers" with counters; each time the tester put down a counter the child did likewise. Subsequently, one tower was re-arranged into a cross and the child was asked if the two configurations had the same number of counters. Four tasks involving transformations of quantities were used in this research. Briefly, they were (1) *continuous quantity-liquid 1:* liquids in two identical jars are adjusted until the child judges them to be equal, and then one jar is emptied into a tall narrow jar and the child is asked if the quantities are still equal; (2) *discontinuous quantity:* same as "liquid 1" except that beads are substituted for water; (3) *continuous quantity-liquid 2:* child is required to indicate when water poured into a wide beaker is equal in amount to the water in a much narrower beaker; a child passes this task if he stops the pouring before the water-level in the wide jar reaches that of the narrow jar; (4) *sum and division of continuous quantity:* the amount of liquid in two identical jars is adjusted until the child indicates they are equal and then one jar is poured into four smaller jars. The child is then asked if the amount in the large beakers is the same as the total amount in the four little jars.

All conservation and classification tasks were scored for their initial judgement, explanation, and judgemental stability. Answers were classified as operational only if the correct judgement was given, if an operational explanation was made, and if the initial judgement was stable. Operational explanations included: identity, reversibility, reciprocity, state of operations, addition-subtraction, or equality for conservation tasks (see Versey, 1974); mention of one or more correct criteria (and no incorrect ones) for two-dimensional matrices: and mention of two or more correct criteria for three-dimensional matrices.

Testing procedure

All testing was done in the children's native language by the first author who speaks native Greek and Turkish, and fluent English. To familiarise herself with any idiosyncrasies in the Cypriot dialects spoken by the Turkish and Greek children, the author resided for three months in the residential district from which the sample was drawn. The major peculiarities which she noted were distinctive accents in both languages and the occasional interjection of English phrases into conversations that were otherwise exclusively Greek (or Turkish).

Testing was done individually at the children's schools, and was divided into two sessions of approximately 40 minutes each. All conservation and seriation tasks were given in a single session and the order of tasks within this session was randomized across subjects. Multiple classification tasks were given in a fixed order at a separate session. The order of presentation of the two testing sessions was balanced across the study.

Test reliabilities

Since appropriate multi-lingual testers were not available in London for test-retest reliability analyses, all testing sessions were tape recorded. Subsequently one third of the recordings were rescored by raters who were unaware of the purpose of the study. Raters' agreement with the authors' classification of explanations averaged 88 percent.

RESULTS

Performance on the conservation and multiple classification tasks

The most striking result revealed by an analysis of the groups' performance on the various tasks was the delineation of two relatively *independent* areas of operational development: conservation and multiple classification. This result was evident even in a rather crude comparison. Summing results across the seven conservation problems, we found that the English children gave operational solutions to significantly more ($t=2.07$, $df=68$, $p<.05$) of these problems than the Turkish children. The performance of the Greek children was midway between that of the Turkish and English groups. This result, in itself, should startle no one, although it is unique in that all of the children were of similar socioeconomic status and were tested in their native languages. The surprising result was obtained when we performed a similar analysis of the children's performance on the eight multiple classification matrices. Here we found an exact reversal of the previous pattern: the Turkish children solved significantly more classification problems than the English children ($t=2.05$, $df=68$, $p<.05$), and again the Greek children fell midway between the two extremes. Identical results were obtained when analyses of covariance were employed across the three groups, with the effects of age being held constant.

This *reversal* of performances is representative of the findings on each individual task. Table 2 presents a breakdown by age and language group of the children's performance, and the results of covariance analyses for each task (controlling for age). An examination of Table 2 confirms the results of the gross analysis. With only one exception, we find that all significant differences on conservation tasks show the Turkish children to perform most poorly, and on the multiple classification matrices, for them to perform most competently. We also note that the poor performance of the Turkish children on the conservation tasks cannot be attributed to a deficiency in their ability to seriate since all the Turkish children aged six or above demonstrated competency in this area.

These results are disquieting since they preclude any simplistic notion of a general deficit in operational development, and thus they bring into question the unity of the concrete operations stage itself. While the present study was being completed, Heron and Dowel (1974) encountered a similar phenomenon in their work with Serbo-Croatian immigrants in Australia. A series of analyses which parallel those of Heron and Dowel have been performed on the present data, and the results substantially support their conclusions. In particular, classifying as "operational" any child who succeeded at five of the problems in either set, it was found that *all* the Turkish children who were "operational" on the conservation tasks were also "operational" in the multiple classification tasks, whereas seven of the seventeen English children who were "conservers" did not succeed at the multiple classification tasks ($p < .05$ by Fisher exact test). Conversely, of the 24 Turkish children who were operational in the classification tasks, only 33 percent exhibited the appropriate range of conservation skills, while the comparable figure for the English was 72 percent ($p < .05$ by the Fisher exact test). Here again the Greek children fell midway between the extremes delimited by the Turkish and English cases; 52 percent of the Greek children who were "operational" on the classification tasks also evidenced operational thought on 5 or more conservation problems.

Since this evidence is congenial to the hypothesis that language structure may exert a determining influence upon the course of cognitive development, we have undertaken a closer analysis of the underlying structure of development.

Searching for developmental structure: a unidimensional approach

A basic aim for the present study was the elaboration of the latent structure of cognitive development during the concrete operations stage, so as to permit an examination of the influence of language. One approach to this question is to begin by assuming that the 16 Piagetian tasks may show an invariant ordering of "difficulty" which reflects a developmental sequence such as that in which all children learn to walk by first crawling. The Guttman scaling procedure (*cf.* Torgerson, 1958) provides a method for such analyses. By using this technique to obtain *independent* orderings of task difficulty for the Greek, Turkish, and English samples, we can test the hypothesis that the order of difficulty for the 16 tasks is constant across languages.

Performing this analysis we found substantial inconsistency across groups in the ordering of task difficulty, with the least consistency existing between the

TABLE 2

TASK PERFORMANCE (% PASSING) BY AGE AND LANGUAGE GROUP

Task	Age	LANGUAGE				COVARIANCE ANALYSIS[a]	
		Turkish (N=37)	Greek (N=40)	English (N=33)	Total (N=110)	sig. level	order
Conservation of quantity (discontinuous)	4- 5	0 (5)	0 (3)	----	0 (8)	n.s.	----
	6- 7	75 (8)	27 (11)	30 (10)	41 (29)		
	8- 9	53 (13)	92 (13)	50 (14)	65 (40)		
	10-11	91 (11)	70 (13)	78 (9)	78 (33)		
Conservation of number	4- 5	20	0	----	13	p<.02	G/E/T
	6- 7	13	27	60	35		
	8- 9	23	54	36	38		
	10-11	36	85	67	.64		
Conservation of substance (plasticene)	4- 5	0	0	----	0	p<.001	E/G/T
	6- 7	13	0	60	24		
	8- 9	23	7	71	35		
	10-11	55	77	67	67		
Conservation of weight (plasticene)	4- 5	0	0	----	0	n.s.	----
	6- 7	13	0	30	14		
	8- 9	23	31	36	30		
	10-11	55	39	67	52		
Conservation of quantity (continuous/liquid 1)	4- 5	20	0	----	13	p<.01	G/E/T
	6- 7	13	46	50	38		
	8- 9	31	77	57	55		
	10-11	64	92	89	82		
Conservation of quantity (continuous/liquid 2)	4- 5	0	0	----	0	n.s.	----
	6- 7	13	9	20	14		
	8- 9	15	39	36	30		
	10-11	18	31	33	27		
Sum & division of continuous quantity	4- 5	40	0	----	25	n.s.	----
	6- 7	38	9	30	24		
	8- 9	69	85	36	63		
	10-11	100	100	67	91		
Seriation	4- 5	0	0	----	0	n.s.	----
	6- 7	100	55	80	76		
	8- 9	100	93	79	90		
	10-11	100	100	90	97		
Matrix 2	4- 5	60	100	----	75	p<.005	G/T/E
	6- 7	100	100	80	75		
	8- 9	92	100	71	88		
	10-11	100	100	89	97		
Matrix 3	4- 5	40	67	----	50	p<.05	T/G/E
	6- 7	38	46	30	38		
	8- 9	92	77	50	73		
	10-11	100	77	78	85		
Matrix 4	4- 5	40	0	----	25	n.s.	----
	6- 7	50	64	40	52		
	8- 9	85	62	50	65		
	10-11	91	77	89	85		
Matrix 5	4- 5	0	67	----	25	n.s.	----
	6- 7	13	18	20	17		
	8- 9	54	54	57	55		
	10-11	73	62	78	70		
Matrix 6	4- 5	20	33	----	25	p<.05	T/G/E
	6- 7	25	0	10	10		
	8- 9	46	39	21	35		
	10-11	73	54	33	55		
Matrix 7	4- 5	20	67	----	38	n.s.	----
	6- 7	38	27	20	28		
	8- 9	69	46	43	53		
	10-11	82	77	67	76		
Matrix 8	4- 5	0	67	----	25	p<.15	T/G/E
	6- 7	50	36	30	38		
	8- 9	46	31	29	35		
	10-11	91	85	56	79		
Matrix 9	4- 5	20	0	----	13	p<.05	T/G/E
	6- 7	50	46	20	38		
	8- 9	54	62	29	48		
	10-11	91	51	50	73		

Note: Sample sizes for the table are given in parentheses with the entries for the first task; because of extremely small sample sizes, results for the 4-5 year olds should be interpreted with extreme caution.

[a] Covariance analysis tests the significance of differences between the three language groups, after first adjusting for the effects of age on performance. For all tests, the degrees of freedom were 2/106.

rankings for the Turkish and English groups ($tau = +0.3$, *ns*). Since the Turkish and English groups differ in *both* their (1) immigrant status and attendant bilingualism, and (2) the manner in which their native languages structure comparisons, this result may be interpreted as evidence of the influence of *either*, or both, factors. This problem may be resolved by reference to the orderings obtained for the Greek and English groups, who differ in migrant status but share a common structure in their native languages for the expression of comparisons. Since the similarity ($tau = +0.6$, $p < .001$) between task rankings for these two groups (who differ on only one dimension) is almost double that between the Turkish and English samples (who differ on both dimensions) we have a basis for concluding that additional variation in language structure diminishes consistency in the sequencing of cognitive development ([6]).

While these findings derive from "difficulty orderings" which are maximally faithful to the patterns extant in the data, it is appropriate to ask just how invariant these orders were. The coefficients of reproducibility for the three scales ranged from +0.85 to +0.89, and they indicate that the orderings admit to considerable exception. A conventional minimum value for acceptable scale reproductibility is +0.90 (Torgerson, 1958).

A consideration of the nature of the tasks used in this study provides a basis for interpreting this result. The analytic method we have used—Guttman scale analysis—assumes that each task taps the same underlying trait, and that performance varies only with the level of the trait which is required to succeed on a given task. This assumption of a single dimension of difficulty is untenable, as our results demonstrate. Each of the various Piagetian problems differs not only in the sophistication of the logical operations required for solution, but it also varies in cultural familiarity, openness to perceptual distortion, relative demands upon memory, etc. Thus, the representation of problem difficulty requires *at least* two dimensions: one summarising the complexity of the logical operations required for solution, and a second summarising the extraneous situational complexities of the problem ([7]).

Searching for developmental structure: a multidimensional approach

Since unidimensional analyses confound the operational difficulty of the Piagetian tasks with extraneous contextual factors, we have employed non-metric multidimensional scaling techniques (see Kruskal, 1964) to provide a more appropriate model of the developmental structure of the concrete operations stage. Using this technique we can position the 16 Piagetian tasks

([6]) The correlation between task orderings for the Turkish and Greek groups – who differ only in language structure – is also greater than that between the Turkish and English groups ($tau = +0.7$, $p < .001$), and thus we might conclude that migrant status (and its attendant bilingualism) have an influence which may be slightly more potent than language structure.

([7]) Multi-dimensionality in task difficulty is not a problem unique to the present inquiry. Such considerations inevitably arise when one attempts to conclude from a comparison of failure rates for two tasks, that one involves more complex cognitive processes. It always may be the case that a difference in the failure rates arises not from the complexity of the cognitive processes required, but rather from extraneous characteristics of the context of the problem. Examples of such difficulties can be found in the controversy between Bever *et al.* (1968) and Beilin (1968), and in the critical writings of Bryant (1974).

in (m-dimensional) space in such a way that the *distances* between the tasks correspond (monotonically) to their *dissimilarities*. Estimates of task-dissimilarity, in turn, can be derived from the empirically observed associations (Yule's Q) between performance on each pair of tasks; for dichotomous data such as these, Yule's Q is identical to the "monotonicity coefficient" recommended by Bentler (1971).

Applying these procedures, we computed solutions for up to four dimensions, and it was found that the concrete operations problems were best represented by two axes corresponding to the *operational* and *situational* complexity of the tasks. Thus, we found a substantial reduction in stress (*i. e.*, badness-of-fit) when we moved from a one- to a two-dimensional solution: $+0.36$ to $+0.13$, while the addition of further dimensions did not substantially reduce the stress value ($+0.10$ and $+0.07$ in 3- and 4-dimensions). These results using the total sample were replicated when the tasks were rescaled separately for each language group. For all groups, the two-dimensional solutions were statistically reliable ($p<.05$, using the standards of Klahr, 1969).

Figure 1 displays the structure of the solutions obtained for the total sample, and for each group taken separately. Examining the results for the complete sample (top left panel) we find the tasks to be spatially arranged in an intuitively reasonable pattern; along the *operational* complexity dimension (O) the tasks form two separate clusters, one consisting of the multiple classification problems and the other of the conservation and seriation problems (to aid interpretation each cluster has been delimited in the figure). Furthermore we see that the seriation and liquid summation problems are themselves somewhat isolated from the clusters of classification and conservation problems. Along the *situational* complexity dimension (S) the most extreme point represents the second liquid conservation problem in which the children were required to stop pouring water in time to produce equal quantities in two jars of different diameter. Since almost 50 percent of the children failed this task because they did not stop pouring in time – although they subsequently realised their error – the scale position of this task is interpretively meaningful. Similarly, the low "situational" complexity of the conservation of discontinuous quantity problem (DQ) reflects the greater availability of perceptual cues in this context; thus this representation accounts for the fact that young children who conserve quantity when the problem involves *discrete* units (*e. g.*, beads), often fail to conserve when the same problem is repeated with a *continuous* substance (*e. g.*, water) ([8]).

([8]) To test these interpretations we have used the "complexity dimension" scores for each of the 16 tasks to predict the passing rates shown in Table 2. Regressing the passing rates for the total sample upon the task complexity scores and the ages of the children, we were able to predict 59 percent of the variation in passing rates shown in this table. The standardised partial regression coefficients for the operational complexity ($b^* = +0.18$) and situational complexity ($b^* = +0.36$) dimensions indicated that the orientation of the dimensions was correct, *i. e.*, increasing complexity was reliably associated ($p < .05$) with decreasing rates of passing. Moreover, by referring to the coefficient for age ($b^* = +0.65$), we find that individually these dimensions of task difficulty were one-quarter to one-half as effective as the child's age in accounting for the variations in passing rates summarised in Table 2.

Given the statistical and theoretical meaningfulness of this two dimensional representation of the concrete operations stage, we are in a position to assess the consistency of this structure across language groups. The three remaining panels of Figure 1 provide the needed information. Here we note that the solutions obtained for the English and Greek samples are similar to each other

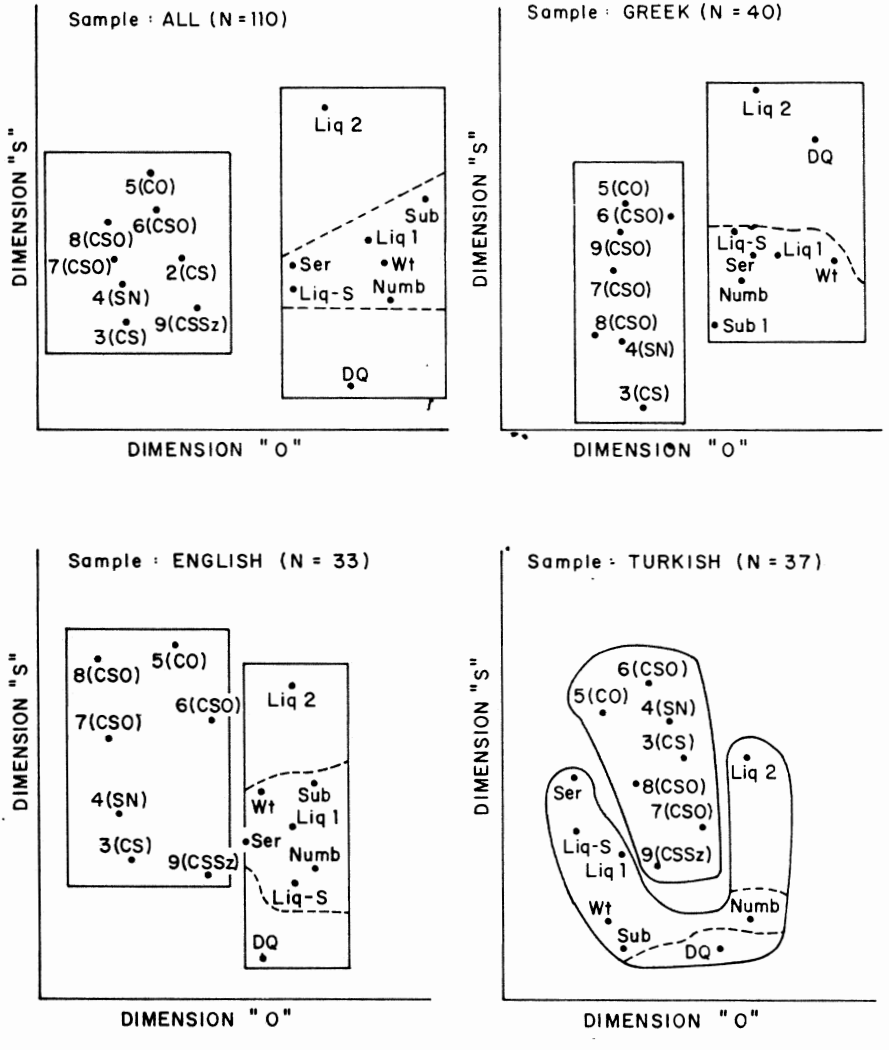

FIG. 1. – Two dimensional solutions from non-metric multidimensional scaling analysis. Points 2 through 9 represent the multiple classification tasks; classification criteria are given in parentheses (C = colour, S = shape, Sz = size, N = number, O = orientation). The other points represent the conservation and seriation problems (Liq = liquid, DQ = discontinuous quantity, Wt = weight, Sub = substance, Numb = number, Ser = seriation).

and replicate the overall pattern, although there is some variation particularly in the situational complexity dimension. Nonetheless, both structures show a characteristic and theoretically appropriate division of operational complexity into two non-intersecting sets – the classification and the conservation tasks. The structure obtained for the Turkish case, however, is quite different, and shows no evidence of an operational differentiation between the classification and conservation tasks.

The conclusions which our eyes would draw from a study of Figure 1 are faithful to fact. As corroboration, Table 3 presents correlation coefficients showing the consistency of task orderings on the two dimensions. It will be seen from these coefficients that while there is substantial consistency across language groups in the order of the tasks' situational complexity, and although there is a consistent ordering ($rho = +0.6$) of operational complexity for the Greek and English cases, the structure of operational complexity in the Turkish case is *unique*.

TABLE 3

RANK-ORDER CORRELATIONS BETWEEN DIMENSIONS OF THE CONCRETE OPERATIONS STAGE FOR THREE GROUPS OF CHILDREN

Operational Complexity				Situational Complexity			
	T	G	E		T	G	E
Turkish	---			Turkish	---		
Greek	.08	---		Greek	.49*	---	
English	.09	.62**	---	English	.63**	.43*	---

Note: Values are Spearmans rank-order correlation coefficient, *rho*.
* $p < .05$.
** $p < .01$.

These results are consistent with our analysis of the representation of attribute and difference relations in the three languages, but it remains to be seen whether there is an appropriate variation across languages in the relation between mastery of the comparative forms and the development of competency with classification and conservation tasks.

The use of language and the mastery of conservation and classification problems

Two language pre-tests provide suitable information upon the children's use of language. In the first pre-test the children were *provoked* to respond in difference terms by asking that they indicate which of two pencils was longer, thicker, etc., while in the second pre-test (*spontaneous* usage) the children were asked simply to describe the differences between two blocks of wood. In both cases, children's responses were coded for their use of scalar, vector, bi-partite

and quadripartite forms. Given the focus of our present interest, we will concentrate our analysis upon the use of vectors (*e. g.*, "more") in their speech.

Overall it was found that, regardless of the language spoken, older children were more likely to use the vector forms [covariate $F(1,106) = 10.7$ (provoked), and 16.4 (spontaneous), $ps < .005$]. The frequency with which vector forms

TABLE 4

RELATIONSHIP BETWEEN USE OF VECTOR FORMS ON LANGUAGE PRETESTS AND PERFORMANCE ON THE CONSERVATION AND MULTIPLE CLASSIFICATION TASKS

4a. Conservation								
	GREEK				TURKISH			
Test	Provoked Use		Spontaneous Use		Provoked Use		Spontaneous Use	
	S	*V*	*S*	*V*	*S*	*V*	*S*	*V*
Pre-Op	5	3	5	3	8	1	6	3
Int	8	11	7	12	13	7	10	10
Op	1	12	1	12	5	3	2	6
	$\chi^2 = 6.49$, $p < .05$		$\chi^2 = 6.45$, $p < .05$		$\chi^2 = 1.99$, ns		$\chi^2 = 2.97$, ns	
4b : Multiple Classification								
	GREEK				TURKISH			
Test	Provoked Use		Spontaneous Use		Provoked Use		Spontaneous Use	
	S	*V*	*S*	*V*	*S*	*V*	*S*	*V*
Pre-Op	5	2	4	3	6	0	6	0
Int	2	8	3	7	6	1	6	1
Op	7	16	6	17	14	10	6	18
	$\chi^2 = 5.31$, $p < .05$		$\chi^2 = 1.95$, ns		$\chi^2 = 4.97$, $p < .05$		$\chi^2 = 15.6$, $p < .001$	

Note: Children were classified as vector users (*V*) if they used this form one or more times during the pre-test. Operational performance for *both* sets of tasks was defined as: Pre-operational, 0 or 1 problem solved; Intermediate, 2 to 4 problems solved; Operational, 5 or more problems correctly solved.

As a rule, chi-square results for tables with small cell sizes should be treated cautiously. In the present case, collapsing categories of operational performance and applying the Fisher exact test produces a similar pattern of results although the overall significance levels decline slightly.

were employed also varied significantly across languages and this variation replicated the pattern of group differences in performance on the conservation tasks. While 91 percent of the English children spontaneously used vectors, only 67 percent of the Greeks and 51 percent of the Turkish children used such forms [controlling age, $F(2,106) = 8.68$, $p < .001$]. Furthermore, Turkish and

Greek children showed an overwhelming preference for encoding the vector sign as a separate word (πιο or daha) rather than using the Greek forms in which the vector sign is a suffix (−τερο) (9), or using the comparison by scalars (*e. g.*, bu ondan çok) available in Turkish. Use of the latter forms did not exceed 10 percent in either language.

The gross relationship between use of the vector forms in Greek and Turkish and performance on the conservation and classification tasks are shown in Table 4. From these tabulations we see that the use of the vector forms in Greek was reliably related to performance on the conservation tasks, but there was no reliable association in Turkish. For the multiple classification tasks the reverse holds true; use of the vector form was reliably related to classification performance in the Turkish sample.

TABLE 5

REGRESSION ANALYSIS OF "EFFECTS" ATTRIBUTABLE TO AGE AND MASTERY OF THE LINGUISTIC STRUCTURE OF THE COMPARATIVE UPON THE DEVELOPMENT OF CONSERVATION AND MULTIPLE CLASSIFICATION SKILLS

	REGRESSION COEFFICIENTS		
	Effect of age	"Effect" of language	Variance explained
CONSERVATION			
Turkish Sample	+.61	(+.04)	.39[a]
Greek & English Samples	+.61	+.18	.47[b]
MULTIPLE CLASSIFICATION			
Turkish Sample	+.52	+.40	.63[c]
Greek & English Samples	+.39	(+.08)	.18[d]

Note: "Effect coefficients" are standardized partial regression coefficients; analysis of the unstandardised coefficients produces similar results. Coefficients in parentheses are not reliably greater than zero (*i. e.*, $p < .05$, one-tail). Language mastery is a dichotomous variable coded "1" if the child used a vector form in either pretest (coded zero otherwise).

[a] $F(2,34) = 11.07$, $p < .0005$.

[b] $F(2,70) = 24.6$, $p < .0005$.

[c] $F(2,34) = 28.14$, $p < .0005$.

[d] $F(2,70) = 6.11$, $p < .005$.

(9) For commonly used adjectives, Greek comparatives may be formed by *either* preceding the adjective by πιο or appending the suffix "— τερο". The two forms are equally correct. The present finding suggests a possible explanation for Kelley *et al.*'s (1973) observation that many bilingual children in their study could conserve in English but *not* in their native Greek. Their testing procedures phrased all of the conservation questions in the less common "—τερο" suffix form.

Although Table 4 replicates the analysis of Sinclair de Zwart, it does not take into consideration the most important developmental variable—age. For this reason it may be argued that Table 4 overstates the relationship between language and cognitive development. Since a tabular analysis of these data, controlling for age, would produce many empty cells, we have employed a regression approach to further study this relationship. Multiple regression permits us to estimate the contribution of language mastery to performance while controlling for the spurious association arising from the effect of maturation on *both* language acquisition and operational development.

Table 5 presents the results of a regression analysis in which the dependent variable was the number of classification (or conservation) problems which were correctly solved. To simplify presentation we have combined the English and Greek samples since the nature of the comparative and the multidimensional structure of development for these groups were similar.

The coefficients shown in Table 5 exhibit a consistent and reliable developmental trend. For all language groups, the older children solved more conservation and more classification problems than younger children; the average rate of this development was approximately two additional solutions for each three years of age. Examining the coefficients for the independent "effect" arising from the use of the vector forms we find an identical trend to that shown previously. The mastery of the vector forms has a reliable independent "effect" upon performance on the conservation tasks for the Greek and English children but *not for the Turks*, while for the classification tasks the reverse again holds true. By comparison to the coefficients for age, we find that these two language "effects" were weaker than the effect of maturation.

DISCUSSION

These results suggest a number of important conclusions about the nature of cognitive development and the role of language during the concrete operations stage. Since our analyses have been undertaken in some detail and have yielded consistent results, the main conclusions require little embellishment. From the data it appears warranted to conclude that,

1) The concrete operations stage is *not functionally unified*, but rather it consists of two relatively independent sets of cognitive competencies whose order of development can vary across languages and cultures.

2) The latent structure of cognitive development during the concrete operations stage is *multi-dimensional*. Performance on any task reflects both the operational sophistication of the child and also the child's developing abilities to deal successfully with the other situational demands of the task (*e. g.*, requirements of memory, perception, motor coordination, etc.).

3) The structure of development during the concrete operations stage is *not constant across languages*. Rather, constancy in the ordering of operational development seems to arise from a common order embedded in the linguistic

structure of the children's native languages. Languages (*e. g.*, English and Greek) that code attribute and difference relationships in separate linguistic forms (scalars and vectors) show a similar division of operational development into classification and conservation skills. In such languages, mastery of the vector form is predictive of performance on the conservation problems. However, in a language (*e. g.*, Turkish) which allows an identical form to be used in both classification and comparison, we find an overlapping in the development of conservation and classification skills, and no association between mastery of the vector form and performance on the conservation problems.

To these conclusions we add the following *caveats*. First, since the critical comparisons in this study have involved *bi*lingual children, it is possible that the phenomenon we have discovered arises from a still more complex interaction (*i. e.*, interference pattern) between the linguistic structures of the native and second languages. Secondly, it must be remembered that all of our evidence relates to development during the concrete operations stage, and thus we are not suggesting that there is variability in the ordering of Piaget's developmental stages. Furthermore, even within our Greek and English samples we do not find that mastery of vector structures in language is either necessary or sufficient for the attainment of conservation. Although most theorists would agree in our conclusion that language plays a *contributory* role in cognitive development, there is disagreement about its relative importance *vis à vis* maturation (contrast, for example. Bruner, 1964; Leontiev, 1963 and Piaget). We attempted by regression analysis to assess the relative contributions of language competence and maturation, and we found that while both factors have a *statistically* significant "effect" ([10]), the influence of maturation is by far the stronger. This, of course, is consistent with Sinclair de Zwart's (1967, ch. 2) finding that formal training in language produces a *slight* improvement in conservation performance. Since many theoretically relevant aspects of language remain to be studied, these findings cannot settle the matter; nonetheless they do give a tentative guide to the relative importance of each factor and illustrate the use of new methods for studying such questions.

Our results raise the broad question of "linguistic relativity" in cognitive development. We have seen that there is a parallel between the structure of language and that of cognitive development. Where languages encode classification and difference relations into strictly separate grammatical forms there is a parallel cleavage in operational development; mastery of the comparative (vector) forms in such languages is associated with operational competence in dealing with *difference and equality relations* (*e. g.*, the conservation problems). However where languages permit classification and difference relations to be encoded in the same (scalar) grammatical form, there is

([10]) We have used a vocabulary of "cause and effect" in discussing the regression analysis, although some might venture other explanations, *e. g.*, viewing language as a *dependent* variable (Anastasiow and Hanes, 1974). The results of the quasi-experimental comparisons provide a basis for our present interpretation.

no division in (concrete) operational development, and mastery of the comparative forms indicates only a higher level of *classification* ability.

These phenomena prompt us to recall the linguistic theories of Benjamin Whorf. In a treatise on the interrelationship of epistemology and language he wrote:

> The phenomena of language are background phenomena of which talkers are (generally) unaware... These involuntary automatic patterns of language are not the same for all men but are specific to each language...
> From this fact proceeds what I have called the "linguistic relativity principle", which means, in informal terms, that users of markedly different grammars are pointed by their grammars toward different types of observations and different evaluations of extremely similar acts, and hence are not equivalent as observers but must arrive at somewhat different views of the world. (1965, p. 221)

Stated as it is, in static terms, Worf's relativity principle is both challenging and difficult to test. However, if we view it in the framework of genetic epistemology, we can see the rich variety of contrastive developmental studies which such a principle suggests. From this perspective, we might reword Whorf's concluding sentence to read: *users of markedly different grammars are pointed by their grammars toward different types of observation with different cognitive consequences, and hence their intellectual development does not follow identical paths, but they deviate somewhat from each other in working through the basic patterns induced by maturation.*

The present research is a tentative step toward the study of linguistic relativity within the context of developmental psychology. As with all such research, many further questions are raised. Initially, we shall be anxious to see our findings replicated with even larger samples of children. Work in this direction is already under way (Sevinç, 1977), but other crucial questions remain to be considered. For example, the study of other Turkic languages (*e. g.*, The Central Asiatic and Aralo-Caspian languages; see Menges, 1968) which encode comparisons in a manner similar to English will provide important evidence in verifying that the structure of the comparative is the *critical* linguistic factor in producing the patterns we have obtained.

The potential field of study, however, is not limited to the narrow focus with which we have begun, but rather it is as rich and wide as the variety of human grammars. The coding of difference and attribute relations is but one of the myriad aspects of language. The developmental consequences of grammatical variations in the handling of spatial, temporal, and causal relations, to name three promising candidates, remain to be studied, and development beyond the concrete operations stage has yet to be considered.

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RÉSUMÉ

On a employé une méthode interculturelle pour sonder les implications théoriques de la corrélation connue entre la maîtrise des formes comparatives du langage et le développement de l'aptitude à utiliser les relations de différence et équivalence (telles que celles rencontrées dans les tâches piagétiennes de conservation). Comme la langue turque permet les comparaisons sans recourir à des formes morphologiquement distinctes (par exemple, Jean est à Marie grand), elle fut choisie pour cette étude, ainsi que l'anglais et le grec qui possèdent un système analogue pour exprimer la comparaison. Cent dix écoliers anglais, cypriotes turcs et cypriotes grecs furent soumis à diverses épreuves de langage, conservation et classification multiple. Les résultats indiquent que l'aptitude linguistique joue un rôle significatif dans le cours du développement cognitif et que les variations de la structure du langage peuvent produire des variations parallèles de la structure du développement. Des analyses statistiques suggèrent les conclusions spécifiques suivantes : (1) le stade des opérations concrètes n'est pas fonctionnellement unifié; (2) la structure du développement pendant ce stade est multidimensionnelle; et (3) la constance interculturelle de la séquence du développement pendant ce stade provient, en partie, des ressemblances linguistiques quant à la représentation des relations d'attribut et de différence.