LOGICAL REASONING AND THE YUCATEC MAYA LANGUAGE

by

Klaus Galda

TECHNICAL REPORT NO. 266

December 5, 1975

PSYCHOLOGY AND EDUCATION SERIES

INSTITUTE FOR MATHEMATICAL STUDIES IN THE SOCIAL SCIENCES

STANFORD UNIVERSITY

STANFORD, CALIFORNIA

LOGICAL REASONING AND THE YUCATEC MAYA LANGUAGE

A DISSERTATION

SUBMITTED TO THE DEPARTMENT OF PHILOSOPHY

AND THE COMMITTEE ON GRADUATE STUDIES

OF STANFORD UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

By

Klaus Galda

December 1975

Table of Contents

Acknowledgments

I wish to acknowledge my debt to the following people and organizations for assisting me in the work for this dissertation. Prof. Patrick Suppes of the Stanford Philosophy Department and the Institute for Mathematical Studies in the Social Sciences (IMSSS) was my thesis advisor. He has been most helpful to me for a number of years and made many interesting suggestions for research as well as comments on the dissertation. I would like also to thank the other members of my dissertation committees for their suggestions and questions. A number of improvements are due to the discussion in the oral examination, as well as other suggestions from the reading committee. The reading committee consisted of Prof. Ian Hacking, Prof. David Nivison, and Prof. Suppes, all of the Stanford Philosophy Department. In addition, Profs. Leonard Monk and Eileen Serene of philosophy also contributed to the oral examination.

Mr. James Fox of the Stanford Anthropology Department has also made a number of useful suggestions during the past year. He was largely responsable for my opportunity to go to Yucatan. In Yucatan I also benefitted from the field advice of Prof. Stephen Straight of SUNY Binghamton. A special debt of gratitude must be acknowledged to my experiment assistant Mr. Eduardo Couoh and the many people in Cansahcab and Santa Maria, Yucatan for their kindness and patience in participating in the experiment.

For travel and experiment funds I would like to thank the Stanford Latin American Studies Center and IMSSS. The production of the thesis has also benefitted greatly from the facilities at IMSSS. This dissertation will be published as IMSSS Technical Report 266. Dr. Barbara Searle of IMSSS did an excellent job of editing the dissertation.

Chapter I

Introduction

I.1 Statement of the problem

The relationship between logic and natural language is a subject that has created quite a bit of discussion. More specifically, it seems to be an open problem as to whether natural languages with different grammatical structures and vocabularies will generate different sets of logical truths and different patterns of logical inference. I believe that most logicians would assert that the laws of logic do not depend on the structure of the particular language in which they are expressed. The following statement by Quine (p.82) probably represents this point of view fairly well:

> Take the less fanciful case of trying to construe some unknown language on the strength of observable behavior. If a native is prepared to assent to some compound sentence but not to a constituent, this is a reason not to construe the construction as conjunction. If a native is prepared to assent to a constituent but not to the compound, this is a reason not to construe the construction as alternation. We impute our orthodox logic to him, or impose it on him, by translating his language to suit. We build the logic into our manual of translation. Nor is there cause here for apology. We have to base translation on some kind of evidence, and what better? ...It behooves us, in construing a strange language, to make the obvious sentences go over into English sentences that are true and, preferably, also obvious; this is the point we have been noting.

Quine uses the completeness theorems for quantification and identity logics to argue that "strange languages" will not have any new logical truths. However, he concedes that not all of our logical truths necessarily "carry over into truths of the foreign language; some of them might resist translation altogether." (p.83) Most of the present work will be concerned with logical inferences rather than truths, as the latter are extremely rare except in philosophy texts. I expect this is the case in Maya as well.

Relatively little work has been done on this whole problem at the empirical level. This is probably because most anthropological linguists are either ignorant of or not particularly interested in logic, whereas most logicians have little interest in or sometimes no aptitude for learning exotic languages. The present study is intended to be a beginning along these lines, at least for one language--Maya. Our problem is to give answers to at least some of the following questions:

1. Are the concepts "logical truth" and "logical inference" meaningful in Maya?

2. Is it possible to formulate all logical truths and inferences of English in Maya?

3. Can the native Maya speaker be convinced that all logical truths and inferences thus formulated are really valid?

4. Would a Maya have a concept of logical truth or inference that would include some sentences not conceded by us to be logically true or arguments not valid for us?

5. Would he be able to convince us that such a concept of logical truth is reasonable?

6. Is our symbolic notation adequate for dealing with problems of logic in Maya?

7. What sort of notation might a Maya logician have invented?

8. What types of logical argument have actually been used in Maya?

9. What types of logical argument seem acceptable to a Maya speaker?

I.2 The Whorf Hypothesis

The present work was first motivated by some of the literature connected with what is commonly known as the Whorf Hypothesis. This has also been sometimes called the Sapir-Whorf Hypothesis and the Linguistic Relativity Hypothesis. L. von Bertalanffy says (p.244),

> It would be important to apply the methods of mathematical logic to such languages. Can statements in languages like Nootka or Hopi be rendered by the usual logistic notation, or is the latter itself a formalization of the structure of Indo-European language? It appears that this important subject has not been investigated.

I have not been able to find any work on this subject relative to languages like those of the American Indians or African tribes. The only really extensive study of logics in non-Indo-European languages seems to have been done for the Chinese language. The extent to which

Chinese studies are relevant to the present investigation will be discussed briefly in the conclusion.

At another place in the same article von Bertalanffy makes a fairly sweeping statement about the limitations of traditional logic (p.261),

> It may well be that quite different forms of science, of mathematics in the sense of hypothetico-deductive systems, are possible for beings who don't carry our biological and linguistic constraints; mathematical "physics" that are much more fit than ours to deal with such aspects of reality. The same seems to be true of mathematical logic. So far, it seems to cover only a relatively small segment of what can easily be expressed in vernacular or mathematical language. The Aristotelian logic, for millenia considered as giving the general and supreme laws of reasoning, actually covers only the extremely small field of subject-predicate relations.

Although it seems hopeless to prove or disprove a thesis as broad as this, I think that detailed work in a non-Indo-European language should throw some light on how limited (or unlimited) our logic really is. I wish to make it clear that this investigation is not intended to prove or disprove (or confirm or disconfirm) the Whorf Hypothesis. Even if the Whorf Hypothesis is meaningless (as several people have tried to show), it is still significant to investigate the relationship between a specific natural language and the logic of the native speakers of that language. It does seem that since logic is a field that has been made fairly precise, and because there is an intimate relationship between logic and language, it may turn out that

the study of logic in different languages might be one of the most fruitful fields for gathering evidence relevant to the Whorf Hypothesis.

The idea of linguistic relativity did not originate with Whorf, but he probably made the most forceful and clear statement of this philosophy. Because of the tremendous amount of work done during the early part of the 20th century in anthropology, and especially in anthropological linguistics, it was possible for the first time to state these ideas and support them with extensive empirical data. The theory of the dominance of thought by the structure of language goes back at least as far as the 19th century German philosopher Wilhelm von Humboldt. More specifically in the area of logic we have the following amusing statement by C. S. Peirce. He is presumably expressing a negative opinion on the subject (p.37).

> When Sayce (Introduction to the Science of Language (1880), vol. 2, p. 329) says that 'had Aristotle been a Mexican, his system of logic would have assumed a wholly different form,' I am willing to admit that there is a great deal of truth in that. It is lucky that Aristotle's only language was one that led him into as few errors as did the Greek. But so far am I from finding in this remark any encouragement to trust to the indications of language as evidence of logical necessity that it seems to me to go quite the other way.

The present work could be seen as an endeavor to find out what the form of Aristotle's logic might have been, if he had been a (presumably pre-Columbian) Mexican.

Russell in his 1924 article "Logical Atomism" (reprinted in Logic and Knowledge,) also made a statement of which the above quotation from von Bertalanffy is reminiscent. (p.330)

> The influence of language on philosophy has, I believe, been profound and almost unrecognized. If we are not to be misled by this influence, it is necessary to become conscious of it, and to ask ourselves deliberately how far it is legitimate. The subject-predicate logic, with the substance-attribute metaphysic, are a case in point. It is doubtful whether either would have been invented by people speaking a non-Aryan language; certainly they do not seem to have arisen in China, except in connection with Buddhism, which brought Indian philosophy with it.

At this point it might be instructive to take a somewhat closer look at the Whorf Hypothesis. There have been many different formulations of this hypothesis (including several by Whorf himself) which are clearly not all equivalent. I am not at all certain that there exists in fact a single precise statement which we could call the Whorf Hypothesis. Rather it is a general outlook on the relations between the forms of language and the forms of thought. To begin with let us look at two different statements of Whorf's position as he states it in his article "Science and Linguistics". First, a fairly general statement (obviously a cultural-linguistic adaptation of Einstein's work) (p.214):

> We are thus introduced to a new principle of relativity, which holds that all observers are not led by the same physical evidence to the same picture of the universe, unless their linguistic backgrounds are similar, or can in some way be calibrated.

The next statement is more directly relevant to the problems discussed in the present study (p.212):

> It was found that the background linguistic system (in other words, the grammar) of each language is not merely a reproducing instrument for voicing ideas, but rather is itself the shaper of ideas, the program and guide for the individual's mental activity, for his analysis of impressions, for his synthesis of his mental stock in trade. Formulation of ideas is not an independent process, strictly rational in the old sense, but is part of a particular grammar and differs, from slightly to greatly, between grammars.

Whorf's work lends itself very well to quoting, so that we could go on ad infinitum in this vein. However, I believe it is more to the point to look at a somewhat more systematic exposition of linguistic relativity than is found in Whorf's writings.

There have been several attempts to give a more precise and elaborate form to the principle of linguistic relativity. A good, recent bibliography of this subject may be found in Gipper's book, Gibt es ein sprachliches Relativitaetsprinzip?. This book also has a good general exposition of the subject, especially the historical treatment of the von Humboldt school. The author makes an attempt to go further into the Hopi language in order to test some of Whorf's conclusions about Hopi physics and metaphysics.

The presentation given in the present work is based on Fishman's article. I don't believe that Fishman's work covers all aspects of the subject, and it is obviously aimed at a psychological

interpretation. Nevertheless, it seems adequate (since we are not concerned primarily with the Whorf Hypothesis) for present purposes. Fishman divides the Whorf Hypothesis into four different levels which he calls:

Level 1 -- Linguistic codifiability and cultural reflections;

Level 2 -- Linguistic codifiability and behavioral concomitants;

Level 3 -- Linguistic structure and its cultural concomitants;

Level 4 -- Linguistic structure and its behavioral concomitants.

Level 1 says that languages differ in the same ways as the general cultures or surrounding environments of their speakers differ. This is probably the weakest and least controversial level of the Whorf Hypothesis. It is also the least novel. Most of the examples illustrating this level concern vocabulary and are of the form: Language X has a single term for a certain phenomenon whereas Language Y either has no terms for it or else has several terms. Some of the well-known examples of this level are:

1. Hopi has only one term for the English terms "pilot", "airplane", "housefly".

2. Eskimo has many different words for different forms of what we would call "snow". Aztec, on the other hand, has only one word for all that we mean by "ice", "cold", and "snow".

These sorts of examples make wonderful bedtime reading, and

though they may be important for the practical linguist they are not of much interest for logic. However, there is a relevance to logic at this level. Generally, examples at this level are concerned with words (or phrases) which have what has been called a semantic meaning. In other words they refer to something, for example an action or object, outside the language. If we consider the words which may be conveniently classified as having a purely syntactic meaning (also called lexical particles), for example prepositions and conjunctions, then this level of the Whorf Hypothesis becomes relevant to the study of logic. Thus a system of logic in a language which has no word for "all" or "if" might be very different.

The second level is also primarily concerned with vocabulary. The difference between it and the first level is that here we are interested in whether vocabulary discrepancies between different languages are associated with corresponding behavioral discrepancies. The most common example has dealt with relative ability to discriminate between colors. In other words, if Language X has several terms for colors in a given range of light wave lengths and Language Y has only one term then the Whorf Hypothesis would predict that speakers of Language X should be able to discriminate better between different shades of color in that range of wave lengths. Is there anything interesting for a logician at this level? The answer to this question should be affirmative, but it is difficult to see how the appropriate experiments ought to be set up. Intuitively such experiments should

test whether the presence or absence of certain "logically crucial terms" would affect the ability of the speakers of that language to do certain types of logical reasoning. The difficulties of this type of experiment are immense, and I prefer to take the cowardly alternative of merely leaving it at the level of a vague suggestion. It is a fascinating possibility however, which, to the best of my knowledge, has not been explored in any depth.

Levels 3 and 4 are generally analogous to levels 1 and 2 respectively, except that they concern the grammatical structures of languages. This is probably the most original and important part of Whorf's work, as well as being the most difficult to test. In view of the traditionally intimate relationship between grammar and logic, there should be a number of interesting problems here for logicians. For example, in the first quotation by von Bertalanffy it is suggested that perhaps the symbolic languages used in logic are only formalizations of our Indo-European grammar. It is clear that this point should, in theory, be capable of proof or disproof. It would require the construction of symbolic languages based on given non-Indo-European languages. Then notions of isomorphism between different symbolic languages and between different systems of logic must be given. The "Catch-22" of the situation is, of course, that perhaps the idea and methods of proof involved are themselves somehow dependent upon our family of natural languages. I hope eventually to be able to discuss these problems in more detail. In particular, I want to work

on the problem of constructing symbolic languages associated with certain aspects of Maya, but this is admittedly in the (probably distant) future.

A natural question arises at this point with respect to exactly what the present work could hope to prove with respect to the Whorf Hypothesis. First, it is necessary to distinguish between two different formulations of a linguistic relativity hypothesis. Formulation (A) corresponds to what I would call "directional linguistic relativity" and formulation (B) to "non-directional linguistic relativity". These formulations are to be thought of only as inaccurate shorthand for rather lengthy formulations of two possible positions concerning linguistic relativity.

(A) The form (including vocabulary and grammatical structure) of a language essentially determines the form of all the mental activities of the native speakers of that language.

(B) There is a close connection between the form of a language and the form of all the mental activities of the native speakers of that language.

The concept of direction enters in the sense that (A) assigns a causal direction from language to thought, whereas (B) is essentially neutral as to which is the cause and which is the effect. (B) is clearly a weaker statement than (A). Whorf generally seemed to hold a position which might be summarized by (A). At times he appears to back off a little and support something closer to (B) however. His version

of the weaker view could be paraphrased by saying that language and thought influence each other to a very great degree, with language being the dominant factor.

Nothing in the present work could lead to any results concerning formulation (A). At best we might be able to reach some conclusions about (B), if we actually obtain some definitive results about logic as it is used by the Mayas. It seems to me that there are, broadly speaking, four different possible outcomes for this sort of investigation:

1. Mayan logic is sufficiently similar to our logic.
2. Mayan logic is quite different from our logic.
3. The Mayas have no logic.
4. The Mayas apparently have a logic, but we are not able to obtain significant results about it.

I would like to clarify an important issue at this point. The problem of what we would call "our logic" is not really settled yet. I am purposely not defining what I mean by "logic" in order not to introduce an unnecessary bias into the investigation. Otherwise we might arrive too easily at conclusion 3.

There are great difficulties involved in establishing relations between logic and a natural language, even for a language (like English) in which the grammatical structure has been more satisfactorily explained. Consequently I do not want to make it appear that I can define these relations for Maya.

Conclusion 1 would be a fairly serious blow to formulation (B) of the Whorf Hypothesis, assuming of course that it is reached by valid methods and that relevant parts of the languages are sufficiently different. Needless to say, it would also disconfirm formatulation (A). Since the structures of Maya and Indo-European are sufficiently different, conclusion 1 should be precluded by the Whorf Hypothesis. Conclusions 2 and 3 would tend to confirm formulation (B). This statement is made with tongue in cheek, as it might be plausibly argued that differences are due to non-linguistic considerations. Obviously a hypothesis as general as Whorf's is not going to receive very strong (if any) confirmation from a single study like this. Logics of several groups of people would have to be constructed, some of whom differ linguistically and others speaking languages of the same family but differing in other ways. Conclusion 4 merely suggests that the problem has not been investigated thoroughly.

Since discussion of the Whorf Hypothesis is not the primary purpose of this paper, let us go on to some other problems in philosophy to which the present type of study seems relevant.

I.3 Other relevant problems in logic

Another problem for which approaches like the present one might provide some empirical evidence is that of logical conventionalism. Logical conventionalism maintains, roughly speaking, that the laws of logic are merely linguistic rules governing the use of certain terms.

For example, the statement "If p and (if p then q) then q" is true and the corresponding rule of modus ponens is valid only because of certain linguistic conventions concerning the use of such terms as "and" and "if...then...". The following quotation from Pap gives a brief statement of the position of logical conventionalism and puts it in an historical context (p.98):

> We have seen that the claim of logical positivism, which derives from Wittgenstein, that systems of logic are systems of tautologies, must be taken with at least one grain of salt. But let us assume for the sake of argument, that all the laws of logic, including those of the so-called theory of quantification, are in some way reducible to tautologies, as was believed by Wittgenstein. Why did this seem to have great philosophical significance to the logical positivists, as well as some of their critics? Because it was believed that a tautology owes its <u>necessity</u> to the force of linguistic conventions, and that therefore such a reduction would <u>explain</u> logical necessity without any metaphysical assumptions. Consider again the prototype of tautology, "p or not-p," which corresponds to the law of the excluded middle: For any proposition p, either p or the negation of p is true. That any statement of this form must be true follows from the definition of "or" and "not", given in the form of disjunctions and negations. Similarly, the principle of deductive inference, that whatever proposition is implied by true propositions is itself true, would seem to owe its validity to the very rule governing the use of "implies": to say that p implies q though p is true and q is false, is just as self-contradictory as to say that X is a bachelor and married at the same time. If so, it looks as though the compulsion we feel to assent to these laws of logic is simply the ingrained habit of abiding by the linguistic conventions we were educated to conform to when we were taught the language. But linguistic conventions, after all, <u>may</u> be changed. Therefore, say the logical conventionalists systems of logic may be changed; there is no absolute logical

> necessity; the logical necessity of a proposition is entirely relative to linguistic conventions, which it is possible to change.

In a sense, the position of logical conventionalism is not terribly different from a philosophical position implied by the Whorf Hypothesis. An obvious difference seems to be one of emphasis. Whereas logical conventionalism seems to be mainly concerned with a particular language and its relation to logic, Whorf is more concerned with the differences between various languages and the effect of these differences upon thinking, or the structure of thinking. A more profound difference is that the logical conventionalist stresses the arbitrariness of the effect of language upon logic. Even given a fixed language with its associated structure there would be, according to logical conventionalism, many non-equivalent ways of building logic. I believe that Whorf is committed to the position that a given language probably implies a fixed logic. Thus the conventionalist position is even more extreme (although limited to the area of logic) than the Whorf Hypothesis. In general the conventionalist would predict that people speaking languages that have not had any connection with our Indo-European tradition will have constructed a different logic. If he does not predict this, i.e. if he says that logical truths and valid arguments are such because of linguistic convention but all languages will have approximately the same conventions, then his theory does not seem very interesting. In that case the interesting theory would examine why these conventions are the same for all languages.

Another difference between these hypotheses is that if non-related languages are sufficiently similar in matters relative to logic then this would tend to refute conventionalism but not affect the Whorf hypothesis. This is because the Whorf hypothesis should predict differences in reasoning only if the languages differ sufficiently; conventionalism presumably should predict differences in logical structures regardless, unless it is argued that the logics are accidentally similar in the case of two languages.

I believe that empirical studies of the uses of logic in different languages could provide relevant arguments for or against the philosophy of logical conventionalism. The strengths of these arguments would be generally the same as was outlined in the last part of the above discussion of the Whorf Hypothesis.

It seems to me that the general question of whether our laws of logic are in some sense universally valid for human reasoning has not been definitively answered. In fact, it is probably not even clear as to what we would regard as a satisfactory answer to this question. I think that empirical approaches of the type proposed in the present work could begin to solve general problems of this type. This approach is not necessarily limited to problems of the relationship between logic and language, but should generally consider the relations between logic and culture as well. Initial studies would probably deal with the description of logics used by other groups of people. Eventually it might be possible to have inter-cultural experimental studies of

normative logic. In these, different (at least superficially) logics could be tested to see whether a group could be convinced of the "correctness" of the logic used by another group.

I.4 General methodology

Before beginning discussion of the specific problem of this paper, which is the study of logic as used by the Mayan people, let us first take a brief look at the general methodology of trying to isolate what is relevant to logic in an unfamiliar language. The ideal starting point would be to find the Aristotle of the language and see what he wrote on the subject of logic. Unfortunately we have been unable to locate the Mayan Aristotle. At the time of the Spanish conquest of Yucatan in the 16th century a very great number of Maya hieroglyphic texts was burned by the Spanish priests in their zeal to stamp out the pagan influences. So far we have only been able to find three texts that escaped the general book-burning ceremony. It is possible that eventually others may be found. It is not inconceivable that some of these texts may have dealt with problems relevant to logic. However, our present state of knowledge about the ancient Mayas indicates that they did not seem to be particularly interested in the problems of their language or in the nature of reasoning. Most of the existing hieroglyphic texts are concerned with problems of time and astronomy, and corresponding problems in religion and astrology. Of course, our sample is limited to only these few books and inscriptions

carved into various stone stelae and tablets. The situation is analogous to a hypothetical burning of all Western books in 1500, with only the works of Ptolemy surviving. This obviously would not provide a reasonable basis for discussing the intellectual interests of ancient Mediterranean civilizations.

Given the situation that we are not in possession of a discussion of logic by a native speaker, we must obviously look elsewhere. I believe that the best place to begin is with a good grammar of the language, noting carefully which words (or morphemes) and aspects of the structure of the language seem to be relevant to the way inferences could be constructed in the language. As I said earlier and repeat here for emphasis, the greatest possible care must be taken to avoid the natural prejudices which we have acquired through our knowledge of logic. Keeping this in mind, it seems reasonable to begin with a search for equivalents of our usual "logical constants". In other words, a good place to begin (but not also end) the investigation is to find out whether the language has terms meaning "if", "all", "some", "not", "therefore", etc. Then, if the language possesses some of these terms, it is necessary to see whether they are used in analogous ways.

A next step, for languages which have written texts, is to examine some of these texts. In general, it seems to me that written texts are more likely to contain examples of explicit inferences, or at least more thinly disguised implicit inferences, than oral statements.

Written text is usually more carefully organized. This makes it easier to see instances of implicit reasoning. It is during the examination of written material that it becomes important to check how terms that seem to have the same meaning as our logical constants are used in the language. More difficult, but equally important, is to try to see whether there are examples of inferences which do not contain any of these terms (explicitly or implicitly). For a language without written texts it might be possible to substitute phonetic transcriptions from tape recordings of native speakers telling about legends, customs, etc.. There is a possible advantage of using oral texts, in that if there are substantial differences in the logics, then these may be more apparent in the oral language. Oral languages probably reflect more accurately than written languages how people really think. Of course it is much more difficult to work with oral texts, especially if one is not completely fluent in the language involved.

Fortunately for our work, there are large numbers of written works in Maya (in the Latin alphabet) dating from the 16th century until the present day. These works will be discussed later in this paper. Having covered a fairly representative set of native texts in the language, one should be able to start formulating some hypotheses about the structure of logical reasoning (if any) that speakers of the language seem to use. These will undoubtedly be preliminary and heavily influenced by the logic of the investigator. Some of the bias can be subsequently removed by actual experiments with native speakers.

It might also be possible to eventually collaborate with bilingual university students or other educated speakers of the language in question. The above sketch of method is admittedly somewhat vague. But then it is rather difficult to see the value of different types of approaches until the end of the investigation.

I.5 The Mayan languages

At this time I feel it is appropriate to discuss why the Maya language was chosen for this study. At the outset I knew absolutely nothing about the structure of this language, and thus did not choose it to confirm a specific theory or because it was particularly suited for transparency in logical reasoning. I did not have any reason, except possibly the generally high level of culture attained by the Mayas, for supposing that there was either more or less logic expressed by the speakers of this language than by those of any other language. As far as availability of material is concerned, it would probably have been easier to work with Chinese or Japanese. However, some work on logic has been done in these languages and for my purposes I wanted to be as free as possible from the biases of previous investigators. Consequently it seemed better to study a lesser known language. Considering the eventual possibility of field experiments made it more practical to limit the choices to North America. In order to have a wider selection of native written material it was imperative to choose a language with a long tradition of literacy. These considerations

together with my interest in different aspects of Maya culture over the past ten years led to the present choice of language. In addition, the different Maya languages are spoken by groups of people who are among the most culturally conservative native groups on the North American continent.

The Mayas of the Yucatan peninsula, partly for political reasons and partly because of their long cultural heritage, have fairly successfully resisted domination by Spanish or Mexican culture for the past 450 years. Consequently the Maya language, especially the grammatical structure, has not been too heavily influenced by Spanish. This is not to say that there has been no change whatsoever. Any language will change over this period of time, and in addition a large number of foreign objects and ideas have been absorbed by the Mayas. This brought about a fairly large number of Spanish loan words (and local corruptions thereof) into the Maya language. However, I believe that these will affect the present subject only minimally.

The word "Maya" when referring to languages is ambiguous. In the first sense it refers to the Mayan family of languages of southern Mexico and Central America (principally Guatemala, Belize, Honduras, and El Salvador). These languages, of which there are more than 20, are at present spoken by more than two million native speakers (Voegelin, p.6). The languages of the Mayan family are generally closely related to each other. They are grouped under the Penutian phylum of North American languages, but do not seem to be too similar

to other North American languages. There have been efforts to link Mayan languages with the Chipaya language of Bolivia.

Another sense of the word "Maya" is in connection with the language(s) spoken by the people of the classical pre-Columbian Maya civilization. This is presumably the language of the hiero-glyphic books. Although we are not completely certain about many of the details of this language, there seems to be sufficient evidence that it is not greatly different from modern Mayan languages especially as spoken in Yucatan.

The third sense of the word "Maya" refers to the particular language spoken today on the Yucatan peninsula. This is often called Yucatec, but I believe there will be no confusion if we continue to use the word "Maya" here (which will generally mean Yucatec in this paper). Yucatec Maya is spoken by about 300,000 people on the Yucatan peninsula of Mexico (Voegelin, p.10). Because of a greater availability of materials (especially early documents) our attention will be restricted to Yucatec.

Chapter II

A Brief Sketch of Some Salient Points of Maya Grammar

Since this paper is not primarily written for people who would be expected to have a knowledge of or indeed an interest in the Maya language it will not attempt to give a detailed presentation of Maya grammar. However, one generally finds a close relationship between logic and grammar. It is precisely this relationship that is being investigated here. Therefore there seems to be at least some inescapable minimum of necessary discussion of the grammar. Hopefully it will be self-contained to someone who has no previous knowledge of the language. I will attempt to confine discussion to only those points of grammar that I feel are in some way relevant to the structure of the logic. If we arrive at the conclusion that there are aspects of Maya logic that have no traditional counterparts, then the grammatical discussion may eventually have to be expanded. Eventually I also hope to study grammatical structure in greater depth in order to see how a transformational grammar might be constructed along the lines of current linguistic theories, although some work is already being done in this area.

II.1 Existing grammars

Many different Maya grammars have been written since about the

middle of the 16th century. Until about 1850 most of this work was done by Spanish Catholic priests. These early grammars were generally done very well, considering the lack of linguistic knowledge at that time and the fact that these were some of the first efforts at describing non-European languages. Unfortunately there was a great effort to put everything into the traditional categories of Latin grammar. Needless to say, this did not always meet with complete success, although the work is much better than what one might expect. There is an excellent discussion of these grammars in the Tozzer work listed in the bibliography.

Most of the following grammatical discussion, as well as some of the remarks which will be made later, is based on the following three sources (for complete references see bibliography):

1. Tozzer, A.M.-- "A Maya Grammar" (1921)
2. Andrade, Manuel--"A Grammar of Modern Yucatec" (microfilm dated 1957, but work was done about 1940)
3. McQuown, Norman--"Classical Yucatec (Maya)" (1967)

All of the above works have detailed presentations of Maya phonetics, which will not be discussed here. A brief comment must be made on the system of Maya writing to be used here. Whenever typographically feasible we will use the alphabet, basically designed for Maya in the 16th century by Spanish priests, in which most written Maya texts are found. The following table will give this alphabet on the left and a phonetic equivalent of each letter on the right.

a	a
b	b

c	k
ch	tsh
chh	tsh′
dz	ts′
tz	ts
e	e
h	h
i	i
y	j
k	k′
l	l
m	m
n	n
o	o
p	p
pp	p′
s	s
z	s
t	t
th	t′
u	u
x	sh

Some features of this version of the Maya alphabet that need special comment are:

1. The sound of s is sometimes written like the French c cedille.

2. The combination dz is generally written as a backward c.

3. The combination chh is often written as ch (with dash through the h).

4. In the phonetic version the apostrophe following the letter indicates that the sound is glottalized or fortis.

5. The letter u is pronounced as w when followed by a vowel.

In general, old (colonial) Maya orthography will be used in this paper. The examples of Maya expressions, however, are sometimes from old Maya and sometimes from modern Maya. Generally speaking, I am

more interested in using old Maya texts, as they show less Spanish influence. Unfortunately, I am often uncertain of the differences between the two, which will undoubtedly cause some confusion and justifiably evoke criticism from the Maya specialist. I hope that these shortcomings will not seriously affect the presentation. A brief historical note is in order here so that the reader will avoid a common misconception. The alphabet given here is merely the result of efforts by Spanish priests to capture Maya sounds with the Spanish alphabet. This was done in order to enable educated Mayas to write in their own language easily. It has absolutely no relation with classic Maya writing (still largely undeciphered) as found on ancient monuments and in hieroglyphic texts. There is often confusion on this point, caused partly by Landa's famous "alphabet" of the hieroglyphic writing. Landa's "alphabet" was based on the apparently erroneous idea that ancient Maya writing was simply phonetic and alphabetic in principle. With the help of native informants he produced a Maya hieroglyphic "equivalent" for each letter of the Spanish alphabet.

II.2 Types of syntactic units

In order to discuss the syntactic structure of a language, it seems helpful to decide first what the basic syntactic units are. In European languages the following terms seem to describe some meaningful basic units:

1. utterance
2. sentence

3. clause

4. phrase

5. word

6. morpheme

This list is not intended to be exhaustive, but merely to serve to enumerate some categories that I think are important in the present discussion. I will assume that they are reasonbly well understood with respect to English. The situation becomes more delicate when we try to analyze other languages using the same categories.

Utterances usually present no problem; they can generally be specified in any given context. It is not always clear what constitutes a Maya sentence. Unfortunately most of the texts written by literate natives are rather irregularly punctuated, so that punctuation cannot be used as a criterion. Translators in presenting a critical edition of the original usually provide punctuation according to the rules of their own language. The traditional definition of a sentence as a group of words expressing a complete thought is not really much help due to the difficulty of ascertaining when a speaker has expressed a complete thought. In general, Maya texts can usually be divided into sentences, which for practical purposes correspond roughly to the English sentences of a good translation. This procedure, though not entirely acceptable, seems to do only minimal injustice to the original meaning. We will adopt it here without definite ontological commitment. The terms "clause" and "phrase" will be treated in an analogous way.

The term "word" does not seem to be very useful in discussing the structure of Maya. In written texts, the division into words often appears to be fairly arbitrary. Although there is now a reasonably standard division of Maya text into words, I believe this has been imposed on the written form largely through Spanish influence. Many problems do exist in written Maya, as it is often not adequately transcribed from spoken text. There is a whole book by Martinez Paredez dedicated to exactly this point. Nevertheless, in this paper at least, we will blithely rely on written text. Linguists generally classify Maya as an agglutinative or polysynthetic language. The following statement by Tozzer (p.28) serves as a good introduction to the manner in which Maya expressions are built up:

> An idea is expressed in Maya either by a single stem, usually monosyllabic, to which one or more particles are affixed or by the juxtaposition of two stems modified and restricted by one or more prefixes, suffixes, or both. In the latter case each stem remains phonetically a unit and each is separated from the other by an hiatus. Grammatically, however, there is a unity existing between the two.

It is important to note that "idea" in the above quotation does not necessarily mean "sentence", as many sentences contain more than two stems. Tozzer generally marks the relation between a stem and its particles with a hyphen. Hyphens are also used to separate particles belonging to the same stem, and also stem-independent particles that belong together. Essentially the process seems to involve the

combining of various stems and particles. These two classes can be grouped under the generic name of "morpheme".

In order to get a better conception of what is involved here, let us analyze a fairly simple, typical Maya expression.

tan-in cam-be-s-ic

which means "I am teaching someone" or more literally "I am causing to make learn someone." The individual morphemes have the following meanings:

1. tan -- particle which according to Tozzer indicates present time. According to Andrade it stipulates that the occurrent is contemporary with the time index indicated by the context. It can be considered a progressive aspect marker.
2. in -- first person singular personal pronoun (either nominal or possessive).
3. cam -- learn
4. be -- do, make
5. s -- suffix which according to Tozzer indicates causality. Andrade says it is a suffix which transforms intransitive verbal stems into transitive verbs.
6. ic -- particle referring to an undetermined object of the action.

II.3 Schematic form of Maya expressions

Let us look briefly at the general form of simple Maya expressions. The term "expression" is used here to stand for any sequence (including unit and empty sequences) of morphemes. There are three types of expressions which are to be distinguished -- sentential expressions, stem expressions, and independent particle expressions. As was mentioned above, sentential expressions will not be precisely defined, but correspond to what is usually considered a sentence in English. A stem expression is of the form,

P1...PnRS1...Sm (with m,n non-negative integers),

where R is either a verbal root or a nominal root, Pi is a prefix particle, and Sj is a suffix particle. When both n,m = 0 the stem expression is merely a verbal or nominal root. An independent particle is a particle which can meaningfully stand alone, like certain adverbial, pronominal, prepositional, etc., particles. An independent particle expression is a sequence of particles, at least one of which is independent.

A sentential expression (except for trivial cases such as interjections) must contain at least one stem expression. Many elementary sentences contain only one stem expression. Some examples of these are:

1. Nak-en! (Climb!) verbal stem expression
2. Uinic-ech. (You are a man.) nominal stem expression
3. Max il-ech? (Who saw you?) verbal stem expression

An example of a longer sentence, showing the different types of expressions is,

Ua tin caxtah hunpele cin tasic ti tech.

PE PE SE PE PE SE PE PE

(If I find one I will bring it to you.)

ua -- single independent particle meaning "if"

tin -- contraction of tan-in (see above)

caxtah -- verbal root cax, transformational suffix t which marks transitive verbs, and tense marker ah

hunppele -- number "one" with numeral classifier ppel, indeterminate particle e

cin -- apparently contraction of ci in. Tozzer lists ci as a particle marking present tense. Another interpretation will be discussed in the section on conditionals.

tasic -- verbal root tas, transformational suffix ic marking transitive verbs

ti -- prepositional particle

tech -- second person singular pronoun

A complete transformational grammar for Maya has not been written yet. The thesis by Blair (reference in bibliography) contains a schematic presentation of Maya grammar, which could serve as a basis for a transformational grammar of at least the more elementary expressions of Maya.

II.4 Parts of speech

Let us assume that morphemes can be divided into stems and particles. A natural problem then arises with regard to classifying the morphemic expressions according to their functions. In other words we would like to see what the parts of speech (nouns, verbs, adjectives, etc.) are. Essentially the stems seem to be of two types--verbal and nominal. In Maya there are very close relations between verbs and nouns, and the same stem can often be used to form expressions which would be called nouns as well as those which we would call verbs. While this is also true in English, e.g. the word "fish" could be used as either, it happens much more frequently in Maya. For example,

cimi -- death

Tin cimil. -- I am dying.

Tin cimsic. -- I am killing something.

McQuown (p. 230) says,

> Verbs are distinguished from nouns by the fact that there is a special set of verbal derivational suffixes followed by special verbal inflexional suffixes. The derivational suffixes mark the status, the inflectional suffixes mark the voice, aspect, and mood. Nouns take neither of these sets of suffixes. Particles take no suffixes or prefixes for person and number, whereas both verbs and nouns take both. Those of the verb mark its subject or object. Those of the noun mark its possessor.

The problem of distinguishing nouns from verbs is very important in

setting up a logistic notation and will be discussed in greater detail in Chapter 4.

Usually the verb has been considered the most fundamental part of speech in Maya, and generally presents the greatest problems. Tozzer heretically maintains that nouns are more basic because he says that there are many more verbs made from nominal stems than there are nouns made from verbal stems. However, it is not always clear what criteria are used to decide the original character of the stem. Tozzer also claims that Maya is basically a nominal language because "the nominal pronoun used with predicative verbal expressions is fundamentally a nominal expression showing possessive relationship." (p.35) This is an interesting point that will also be discussed more extensively in chapter 4.

II.4.1 Verbs

Most verbal stems are monosyllabic, with suffixes indicating voice, mood, tense and aspect. Verbs can be generally classified as intransitive or transitive. Most intransitive verbs can be made into transitive verbs by using a variety of transformational suffixes. In our example above, the intransitive verbal stem cim, which means "to die", can be converted into the transitive verb cimsic meaning "to kill". A few transitive verbs become "almost intransitive" by incorporating the object into the verb, thus creating a compound intransitive verb. This is generally the case where the verb is almost invariably followed by the same object. An example in English might be

an expression like "spend money" which we could imagine eventually becoming the intransitive verb "spendmoney" (or perhaps "spemony"). A Maya example of this is xot che meaning "to cut wood", which becomes xoche. (Tozzer, p.29) Some interesting differences between intransitive and transitive verbs will be given after the section on pronouns.

The problems of tense and aspect are fairly complicated and will not be discussed in this paper, except possibly with regard to a few special verbs that are particularly relevant to logic. In general, the division of tenses does not correspond exactly to English tenses, but it appears that English expressions involving tense can all be expressed in Maya. Andrade has a very good discussion of this point. The treatment of aspect varies greatly among the different writers. I believe that the subject is not sufficiently relevant to the present work to warrant the necessarily long digression.

It is generally agreed that an active-passive voice dichotomy exists in Maya for transitive verbs. As usual it is identified by certain suffix endings that mark the passive voice. Andrade (pp. 103-108) has an interesting treatment of the passive voice, in which he points out that it does not seem to correspond completely to the passive voice in European languages. For example, a characteristic usually taken to describe the passive voice in English is that the logical object be expressed by the grammatical subject. Consider the pair of English sentences,

1. My wife saw me.
2. I was seen by my wife.

The Maya translations of these two sentences are respectively,

1′. Tu yilahen in uatan. (She saw me my wife)

2′. Ilaben tumen in uatan. (Seen I by my wife)

In both 1′ and 2′ the person who is the object of the seeing is referred to by the class B pronoun en. However, if I understand Andrade's point correctly, it is not clear exactly what, if anything, is the grammatical subject of 2′.

Another difference in the Maya passive voice is shown by the following example. In English the passive expression, "My hat was stolen" can be naturally transformed into the active "Someone stole my hat". According to Andrade, the passive in Maya is oclab in ppoc, but there is no corresponding active expression with an undetermined subject like "someone". My informant seemed to have no difficulty on this point and gave the active form as yan max oclin ppoc, literally "there is who stole my hat".

According to McQuown (p.236) there are two moods in Maya--imperative and optative. The imperative mood is generally similar to the English imperative. An interesting feature is that transitive imperative suffixes are generally different from intransitive imperative suffixes. For example, we have

1. Sut-en! (Jump!)

2. Puch-e! (Hit it!)

Various types of optative constructions will be explained in some detail in the following chapters, especially in connection with conditionals and modalities.

II.4.2 Nouns

It appears that most of the complexity of the Maya language is absorbed by the verb, making a reasonably simple treatment of the noun possible. Even Tozzer, who calls Maya basically a nominal language, devotes 43 pages to the verb and only 5 pages to the noun. A great many nouns are merely simple nominal stems, e.g. kak (fire), che (tree). Other nouns are merely compound expressions formed by combining simple stems. An example of this is

pop (mat) + che (tree) = popte (bridge).

Maya also has several suffixes, which when added to stems (or some other expressions) generate abstract and collective nouns. One of the most common suffixes for abstract nouns is il, e.g. kohan (sick) + il = kohanil (disease, illness). By prefixing the third person singular pronoun u we obtain the collective noun u kohanil (the sick).

With the exception of a few nouns pertaining to people and animals, there is generally no gender expressed in Maya nouns. Case seems also to be lacking in nouns, but is very important in pronouns. Plurals are generally expressed by certain suffix endings, the most common of which is variously written as ob or oob. Thus,

uinic (man) + oob = uinicoob (men).

Tozzer (p.48) makes the following interesting point about the use of nouns as subjects of sentences:

> The subject of the verb is always expressed by the pronoun even when there is a noun for the subject. This subject, the nominal pronoun, is really a possessive: winik u puch-ik Pedro, or u

puch-ik winik Pedro, the man is hitting Peter, literally, the man, his hitting something, Peter.

I have been unable to confirm or refute this argument, but wish to return to it in the discussion on logistic notation. There is an analogous construction--often used in ordinary English, but generally considered ungrammatical. People often use such expressions as, "The man he went to town."

II.4.3 Pronouns

Pronouns play an important part in the Maya language. There are some differences in pronoun classification. The following classification is essentially due to Andrade.

PERSON	CLASS A	CLASS B	CLASS C
first, sing.	in	en	ten
second, sing.	a	ech	tech
third, sing.	u	i	le ti
first, plural	c, c -- ex	on, onex	ton, tonex
second, plural	a -- ex	ex	tex
third, plural	u -- ob	ob	le -- tiob

The existence of the third person singular class B pronoun i seems to be questionable as it is not always present, so most writers represent it by a null suffix.

The personal pronouns of class A have two general uses. They are used as possessive pronouns and as the subjects of most verbs. When used as subjects they generally precede the verb (except for the

part after the dash, which is suffixed onto the verb). As possessive pronouns they precede the noun. Class B pronouns are most commonly used as direct objects of verbs. The class B pronoun en is also used as a suffix for intransitive verbs in the imperative mood, as we saw above. Another use for class B pronouns is that they apparently serve as the subject of intransitive verbs in certain tenses. They always follow the verb, even when used as the subject. Class C pronouns are used chiefly as indirect objects. They are also used as devices for emphasis in many cases. The above classification appears to be fairly satisfactory, but is certainly not definitive.

In addition to personal pronouns there are also full sets of interrogative, demonstrative, reflexive, and reciprocal pronouns. The most common interrogative pronouns (usually appearing at the beginning of an interrogative sentence) are:

bix -- how

max -- who, whom

baax -- what

tuux -- where

baaxten, baaxtumen -- why

bahux -- how much

Demonstrative pronouns are usually found in two sections, consisting of a prefix le or leti and then a suffix a, e, or o. For example,

le uinic a -- this man

le uinic o -- that man (pointing)

le uinic e -- that man way over there

These demonstrative pronouns often have a function similar to the definite article in English. Reflexive pronouns are formed by using personal pronouns of class A followed by a special reflexive suffix ba. For example,

Tan in puch-ic-in-ba (generally contracted to tin puchcimba) which means "I am hitting myself".

Reciprocal pronouns are formed similarly to reflexive pronouns, using the particle tan-ba.

Tun puch-ic-u-tan-ba-ob. They are hitting one another.

Other pronouns that have a direct relevance to quantifier logic will be discussed in the appropriate place.

II.4.4 Modifiers and particles

The status of adjectives (or attributives) is not entirely clear. According to Tozzer (p.95),

> There is no real adjective in Maya. Words which have usually been considered as adjectives are really intransitive verbs. The term adjective has however been retained in describing these forms.

He then gives the example,

ceel uinic -- which can be rendered as either "the man is cold" or "the cold man".

Tozzer says that in Maya there is no distinction between the

attributive relationship and the predicate relationship. We will return to this point in the discussion of copulae. Adjectives generally do not express number, but there are a few exceptions when they are pluralized along with the accompanying noun. They most often precede the noun, but may sometimes follow it.

The ancient Mayas had an extensive and well-developed system of numbers. The system was vigesimal and used place notation. They could, and often did, easily express very large numbers, especially in calculations involving time. Along with the numbers there was a complicated system of numeral classifiers. The principal of these were tul, used for most animate objects, and ppel used for those inanimate objects not covered by any other of the plethora of classifiers. Numbers were generally not used alone, but had to be followed by a classifier. At the present time the Mayas generally use the old terms,

hun	one
ca	two
ox	three
can	four

but any quantity above four is more often expressed using the Spanish name for the number (without a classifier).

Definite and indefinite articles are not used as much as in English. Something like an indefinite article can be expressed by using the word for 1 (hun), e.g. "a man" might be translated as huntul uinic. There is no word which functions solely as a definite article. English definite article constructions can be expressed in Maya by using either demonstratives or the third person singular class A

pronoun u. For example, the expression "the man" might be translated as either u uinic or le uinice. There are many adverbial particles and other compounds used as adverbs in Maya. Not too much can be said about them without going into a mass of detail. Those which are interesting from the point of view of logic will be discussed in the appropriate place. This also applies to prepositions and especially to conjunctions which will dominate large parts of the subsequent treatment. For most of these particles the emphasis will not be so much concerned with general classifications as with the various uses of the individual ones.

As can be seen from some of the remarks above, our use of grammatical categories in Maya will be largely heuristic. It is certainly not definitive, nor is it even intended to imply that these categories (in the sense in which they are used in European languages) are appropriate to Maya grammar. I believe that the problem of grammatical categories in Maya is not completely solved. Some of the difficulties are directly relevant to problems of constructing a logic, and these will be analyzed further in the sequel.

II.5 Other grammatical problems

Problems of word order, as well as other syntactic and semantic problems, have not been mentioned in this very brief discussion of Maya grammar. Unfortunately, I have nothing very enlightening to say on these subjects, except by going into long discussions of particular

types of examples. (Such an approach might not be considered enlightening either.) Many examples will be used in the subsequent treatment of logic. Hopefully, this will shed some light on the problems neglected in this chapter. The aim here has been largely to give a general feeling for grammatical structure in Maya, while at the same time isolating a few problems that are relevant to our topic.

Chapter III

Logical Terminology in Maya

III.1 Truth and Falsity

Let us begin this chapter with a short discussion of concepts of truth and falsity in Maya. The basic root involved in most senses of truth is

hah -- defined by the Motul Dictionary as meaning "the truth, a thing true and certain in itself, without doubt".

Many of the uses of hah leave little doubt that there is often a sense of necessary truth involved. In fact, one of the secondary meanings of hah seems to be "necessary". Hah is often used merely to mean that someone is telling the truth, even when this truth may be a contingent one. This basic root hah combines with various suffixes, e.g.

hahal -- fact, true thing;

hahcunah -- affirm, ratify, prove with witnesses;

hahtal -- becoming true.

The case for falsity is not as clear. The basic root involved seems to be tuz. However, it generally appears to be used in the sense of lying, pretending, or deceiving. For example,

U tuzahen Juan. -- Juan lied to me. (he lied me Juan)

U tuzah u cimil. -- He pretended to be sick.

(N.B. In many of the Maya examples where the order of the elements is somewhat different from the given English translation a more literal translation will be provided in parentheses.)

There are other roots that serve similar purposes --

ye -- pretend, threaten;

cate -- doubt, pretend.

The nearest equivalent to "false" in Maya seems to be ma hahi, i.e. "not true".

It looks as if all terms having to do with falsity are more concerned with the action or motive of a person involved, rather than with pure falsity or contradiction. Although I have found examples of sentences dealing with abstract truth, I have not found any dealing with abstract falsity or contradiction. There are examples in native texts of negative statements that are intended to be abstract truths. The "abstract truths" which I have found in Maya texts are generally of a metaphysical or theological kind. I have discovered no examples of logical truths in the sense of sentences that are intended to be true solely by virtue of their structure. In general, this is the usual situation in English as well. This is why I will be devoting more attention to logical inference than to logical truths, tautologies, etc..

It is clear that Maya has the necessary vocabulary to deal with questions of truth and falsity. It would be an interesting experiment to formulate some (to us) logical truths and contradictions in Maya,

and then ask a native speaker whether they are always true (or false) and why this is the case.

In a field study of ethnosemantics in Yucatan, Stefflre (p.39) gives the following classification of utterances in Maya. According to Stefflre this seems to be the way that native speakers classify their (and probably most often foreigners') utterances. The four types correspond roughly to what we would call "ungrammatical, nonsense, true, false" respectively.

hadzutz u than -- sweet the talk

tzimin u than -- horse the talk

hah u than -- true the talk

ma hah u than -- false the talk

III.2 Negation

The principal particle of negation is ma, meaning "no, not", as well as other English negative particles, depending on the translation involved.

Ma tin bin. -- I am not going. (not am I going)

Ma binech. -- You did not go. (not went you)

Baxten ma ta betic? -- Why don't you do it? (why not you do it)

A special form of ma occurs when it is used together with the existential quantifier yan. Instead of the expected ma yan we have minan, which means "there is not, have not".

Minan toon tacin. -- We have no money. (not there is to us money)

Minan u cahob. -- There are no towns. (not there is its towns)

There are many special negative compounds, some of which will be mentioned again in the discussion of other logical constants. Some of the more common of these are:

mixma, mixun, mixbaal -- nothing

Ma tin naatah mixbaali. -- I didn't understand anything. (not I understood nothing)

ma tech -- absolutely not, definitely not

Ma tech u cimil. -- He is definitely not dead. (definitely not his death)

mix -- nor, not even (In colonial Maya this seems to be written maix or sometimes mayx.)

Mix toon ma tuyahi. -- We didn't hear it either. (nor we not heard it)

Ma u toholtic ti mix hunpel centavo. -- It does not cost him even one cent. (not its cost to him not even one cent)

mixmac -- no one, nobody

Mixmac cin bisic. -- I took no one away. (no one I take away)

Mixmac tu yilahen. -- Nobody saw me. (nobody he saw me)

mixbicin -- never

Mixbicin bin c xulex. -- Never are we to cease.

Ma tan a uilicen mixbicin. -- You will never see me again. (not are you seeing me never)

Negative imperative sentences often use a special negative particle bic.

Bic a tab le in cuch suuco. -- Be careful not to set fire to my load of straw. (don't you set fire that my load straw)

As can be seen from the examples above, the position of the negative particle is usually at (or at least very near) the beginning of the expression in which it appears. As a general rule, in very simple declarative sentences involving negation, the negative particle is the first element in the sentence. It seems to be the case that the negative particle negates the entire sentence that follows. For example, consider the simple Ma tin bin (I am not going)". Let p stand for the positive sentence Tin bin. In English the negative particle "not" apparently negates only the predicate rather than the entire positive sentence "I am going". It is necessary to apply a transformation to obtain the artificial negative sentence "Not I am going" which corresponds to the negation -p. In Maya the negation is represented very naturally by the symbolic -p. This is also true for many sentences involving negation and quantification. For example, we have

1. Yan u cahob. (There are towns.) (Ex)T(x)

2. Minan u cahob. (There are no towns.) -(Ex)T(x)

In Maya the transformation from 1 to 2 is made, just as in the symbolic case, by merely prefixing the negation. As we have seen in some of the examples above, Maya -- like Spanish and many other languages -- has a pseudo multiple negation. For example,

Ma tan a uilicen mixbicin. -- You will never see me again. (not you are seeing me never)

As in Spanish (and ungrammatical English) the meaning of the sentence is a simple negation with the extra negative particle added for emphasis.

I have been unable to find genuine double negation sentences in Maya. That is not very surprising, as they seem to be rare in most languages (logicians' speech excepted). However, in English there is an extensive use of something close to double negation as a rhetorical device. An example of this is, "The book is not without merit." I have not found devices like this in Maya. There are certain expressions in Maya that apparently involve a double negation. Thus, from the original root,

lob -- meaning "bad, to be bad", we get the word

malob -- literally "not bad", meaning "well, good".

The expression ma malob (not well or not good) is frequently used. Presumably this is equivalent to the original lob, although there is probably a subtle difference between the two.

An interesting feature of negation in Maya is that the mere presence of the negative particle often induces other grammatical changes. Consider the following examples from Blair and Vermont (p.65):

1. Cin naatic. -- I understand it.

2. Ma tin naatic. -- I don't understand it. (not I understand it)

3. Tin uuyah. -- I heard it.

4. Ma tin uuyahi. -- I didn't hear it. (not I heard it)

The change from 1 to 2 seems to involve a change of aspect. I am not clear about the change from 3 to 4. English also has grammatical changes induced by the presence of negative particles, as is clear from 1 and 2 above, in which an auxiliary verb enters into the negation. While it is apparently not ungrammatical to say "I understand it not", usage of the phrase seems to be limited to poetry and rhetoric. My informant tells me that it is incorrect to say Ma cin natic. The progressive and incompletive aspects also seem to undergo changes in the presence of negation, e.g. Blair and Vermont (p.105),

5. Tan in lubul. -- I am falling. (am I falling)

6. Ma tan in lubuli. -- I am not falling. (not am I falling)

7. Ca lubul. -- You fall.

8. Ma tech a lubul. -- You don't fall. (Apparently the insertion of the emphatic tech is customary in the incompletive.)

III.3 Logical conjunction

There are two principal particles of conjunction in Maya. The first is yetel, which can mean either "and" or "with". The tendency seems to be to use yetel (in the sense of "and") mostly as a conjunction between nominal constructions. However, it is sometimes used as a true sentential conjunction. Apparently it derives from a verbal root et meaning "to be with, to accompany".

Minan caan yetel luum. -- There is no heaven and earth. (not there is heaven and earth)

The following longer passage illustrates both conjunctive uses of yetel (Roys, Chumayel, p.292).

> Ton coon Batab yetel Justicias yetel Regidoresob yetel escribano yetel tulacal u nucil cahob uay ti cah Ebtun t talon kilae yetel ix cac hebe u kax cah.

> We, the governor, and the magistrates, and the regidors, and the clerk, and all the principal men of the town here at the town of Ebtun, have come to inspect and divide off the forests of the town.

The first four instances of yetel occur between nominal constructions, and the fifth occurs between verbal constructions. Sometimes yetel occurs as a sentential conjunction at the beginning of the first sentence of an utterance.

Yetel bin katic pakal cii.

And he shall demand the planted wine.

More often used as a sentential conjunction is the particle ca which generally means "and, and then". This particle is used very often at the beginning of a sentence to indicate a sort of continuity of speech, or perhaps as a rhetorical device. It can also be used as a subordinate conjunction "that". This usage can be identified because of the changes in verb endings in the clause that follows.

Ca tu chuchahob. -- And they kissed him.

Yan ix yolcab multunilob ca kuchuc yokol noh.

There are line mounds and it comes to a large mound.

Other particles also occur sometimes in Maya which may sometimes be used as logical conjunction. Among these are:

xan -- also

laili -- still, even so

heuac, hemac -- but (Modern Maya generally uses the Spanish pero.)

Ua tumen presotabone malob, ua tumen xan mae laili malobe.

If we are arrested it will be all right, and if we are not arrested it will be all right too. (if perchance arrested we, all right, if perchance also not, still all right)

U thanah yetel u thanob, heuac manan u nucul tulacal.

They told of it with their own words, but its meaning is not completely clear. (they told it with their words, but not there is its clarity all)

There is also a special postfixed particle of conjunction that has no real counterpart in English. This is the particle ix, which generally combines with other particles. I believe that it seems to be disappearing in modern usage.

caix -- and

maix -- but not, and not

yetel ix -- and

With perhaps the exception of the postfixed ix, conjunction in Maya appears to offer no features that are greatly different from English. The only point that might be noteworthy is the unusually

large number of occurrences of the apparently conjunctive particle ca both at the beginning of utterances and between the sentences of utterances. Andrade (p.372) attempts to give some rules for the uses of this particle. The only definite rule seems to be that it never occurs before negative sentences. He gives the following example from a recorded story:

> Ca tu yubah le tatatzilo, ca tu dzah tacin ti tup, ca tu machah le tacin tupo, ca bini, ca cuch ti hun pel nohoch cah, ca heeli.
>
> (And) the father heard it, and he gave some money to the youngest son. (And) the youngest son took the money and he went away. (And) he arrived at a city, and he tarried.

It is not clear whether this is really a series of simple sentences or one long compound sentence. In a logical argument this technique offers a rather convenient way of stating the premises. However, it is doubtful whether ca has any serious significance in these cases. It may merely serve as a rhetorical device emphasizing continuity. I think that this is probably generally true of the use of conjunction in ordinary language. One has the feeling that the conjunction does not really add anything. For this reason one generally has problems finding logical arguments that explicitly use rules of conjunction. This has been my experience in reading Maya texts. However, there seems to be no reason to doubt that there is a close correspondence between conjunction in Maya and conjunction in English.

III.4 Disjunction

Disjunctions occur rather infrequently in Maya. Many sentences which are translated into English as disjunctions seem to be somewhat problematic, as we will see in some of the examples. The principal affirmative particle seems to be ua -- "if, whether, or". It is used much more frequently as a conditional particle than as a disjunctive particle.

ua a iho ua a uatan -- whether your son or your wife.

ua utz ua lob yani -- whether it is good or bad. (whether good or bad there is)

Ua atial le naha ua utial leti? -- Is this house yours or his? (or yours this house or his it)

Strictly affirmative instances of disjunction appear to be somewhat rare, at least in colonial texts. Most disjunctions seem to involve some sort of negation. The particle ua also occurs in some negative disjunctions.

ti ua ix ti ma ix kui -- whether or not gods.

Matan yalic ua utial matan u pisic multun.

He did not say whether it was his property, nor did he survey the stone mounds. (not he say it whether his, not he survey stone mounds)

The most common particles of negative disjunctions are maix (colonial) and mix (modern). These are literally used as joint denial, which is really transparent in the colonial expression. They are

generally translated as "nor" or "neither ... nor ...". For example, the sentence type ma p maix q is really literally -p & -q, which is equivalent to "neither p nor q", This is the usual translation of both this type of sentence and also of the type mix p mix q.

Dzetzec ocan ti yol maix ocan ti yol xanie.

Little do they believe, nor do they really believe even that.

(little believed by spirit, nor believed by spirit really)

Manan in patan maix uchac in botic patan maix in mehenob maix in u ix mehenob bin u bote patan. I have no tribute nor do I pay tribute, nor will my sons nor my daughters pay tribute. (not my tribute, nor possible I pay tribute, nor my sons nor my the female sons go it pay tribute)

I have found several cases (even in fairly literal translations) in which translators produce a disjunction in English where there seems to be no particle of disjunction in the original. For example, we have the following passage from Roys' translation of the Book of Chilam Balam of Chumayel (p.36): Minan caan yetel luum. Roys translates this as "There was neither heaven nor earth." A literal translation would be "There was not heaven and earth."

Another example from the same book is (p.32):

Ma zazil cab, ti hun minan kin, ti hun minan akab, ti hun minan u.

Roys translates this as, "The world was not lighted; there was neither day nor night nor noon." Literally the passage reads, "not

light the world, there was no day, there was no night, there was no moon".

For the first example, let us use the notation,

p -- yan caan (there is heaven)

q -- yan luum (there is earth)

Then p & q is yan caan yetel yan luum, which presumably means the same as yan caan yetel luum. -(p&q) is minan caan yetel luum, which means, "There is not heaven and earth". Roys assumes a de Morgan law in making the more readable translation. The second example is similar. There are some similar cases to be found in Brinton as well. The point of all this is to show that Maya speakers appear to shy away from disjunctions in cases where disjunction seems very natural in English.

III.5 Conditionals

The most commonly used conditional particle is ua meaning "if, whether", which is apparently the same particle as the disjunctive ua. As a conditional particle it occurs very frequently in both written and oral texts. It generally occurs at the beginning of a pair of clauses, as in English, but there is usually no particle corresponding to the English "then" beginning the second clause. Here are some examples involving the conditional particle ua:

Ua cu pacale, ma tan u bin ti cah.

If he was planting, (then) he is not going to town.

(if was he planting, not is he going to town)

Ua ca betic tu ca tene, cin patcech hun puli.

If you do it to me again, I will leave you forever.

(if you do it, it two to me, I leave you one throw)

It is very common but apparently not obligatory to add e to the end of the antecedent. At times ua occurs together with ca in a manner somewhat reminiscent of the English "if...then...". We recall that at the beginning of a sentence ca means "and then" or merely "then" in the sense of temporal order. It is possible that the only real difference between Maya and English on this point is that ca gets dropped much more frequently than the English "then". In informal spoken English conditionals "then" is also commonly omitted. I don't believe that it is completely clear what the function of ca is in these sentences. For example,

Ua cin bin in uile, ca bin u bet ten hebix tu betah ten u sucune.

If I go to see him, then he will do to me as his elder brother did to me. (if I go I see, then go he do to me how ever he did to me his brother)

In addition to ua many other particle expressions are used as conditionals at times. One common expression is ua tumen, which Andrade translates as "if perchance" (tumen usually means "because, by").

Ua tumen lubceche ca cinsicaba.

If you happen to fall, you will kill yourself.

(if perchance fall you, you kill yourself)

Other conditional expressions are hali (provided), esac tumen (in case that), chen bale (only if), and cex (although). Some examples using these are

He in dzaic teche hali ca a uolte ca dzokol in bel ta uetele.

I will give it to you, provided that you be willing to marry me.

esac tumen toh cole ...

In case we happen to be in good health...

Cex tali binen. -- Although he came, I went. (although came he went I)

In relating formal logic to natural language statements in European languages, perhaps some of the greatest controversies have been generated by the interpretation of conditional sentences. Many philosophers, and other people as well, have argued that normal symbolic logic (with its truth-functional interpretation of conditional sentences) does not give an adequate treatment of the various types of natural language implication. Without wishing to enter into this controversy, I would like briefly to point out some analogous problems in Maya. The following classification of conditionals is rather tentative and surely incomplete. It is based partly on some remarks from Andrade, except for the various types of counterfactuals.

III.5.1 Classification of conditionals

1. Contingency concerning a particular occurrence (if x then do y)

Ua cimene ca chaic ta uicnal. -- If I die then take him to your home.

2. Promissory conditionals (if x then I will do y)

He in dzaic teche hali ca a uolte ca dzokol in bel ta uetele. -- I will give it to you provided you be willing to marry me.

3. Inference from a past event (if x was the case then y was, is, or will be the case)

Ua cu pacale, ma tan u bin ti cah. -- If he was planting, then he is not going to town.

4. Inference from a present event (if x is the case then y must have been, is, or will be the case)

Ua tin caxtah hun pele cintasic ti tech. -- If I find one I will bring it to you.

5. Inference from a future event (if x will be the case then y must have been, must be, or will be the case)

Ua cin bin Saci samale cin tasic tech chamal. -- If I go to Saci tomorrow I will bring you cigarettes.

6. Inference from the absence of a past event (if x had been the case then y would be or would have been the case)

Ua ca cinsace, ma tan yuchul le bax cu yuchuul toona. -- If he had been killed, what is happening to us would not have happened. (if he killed had been, not it happening this thing it happening to us)

7. Inference from the absence of a present event (if x were the case then y would be the case)

Hi xicen Campech ca yanac in tzimin. -- I would go to Campeche if I had a horse. (would go I Campeche, that there were my horse)

8. Inference from the absence of a future event (if x were to be the case then y would be the case)

9. Generalized conditionals concerning customs, habits, etc. (whenever x is the case then y is the case)

Ua tumen tu yilah suce, cu heelel u chucte. -- If he sees that it has the habit, he lies in ambush waiting for it. (hunting procedure)

III.5.2 Other remarks on conditionals

There are clearly many examples of counterfactual statements in Maya. However, there is no general agreement as to how (if at all) they are marked grammatically. In fact, I am somewhat unclear about the sorts of grammatical changes induced by the presence of a conditional clause in general. I have not found a systematic discussion of the subject. The colonial grammarians translate a great number of Maya conditionals by various Spanish subjunctive constructions, but apparently their rules for determining how these are marked in the original are somewhat dubious. Tozzer (p.80) says that there is no real subjunctive in Maya, but defines instead a potential mode (indicating a future possibility) that includes these cases.

In the texts that I have examined there have not been any examples in Maya of conditionals in which the speaker knows that the consequent is unrelated to the antecedent. Presumably sentences like, "If I read a book each day then the president of Mexico will live for

100 more years" would, upon translation into Maya, be rightly judged as nonsense. Probably implication in Maya is intended as some sort of strict implication, as it usually is in ordinary English. Of course, there are cases in astrology and other occult fields where one might plausibly examine cases of conditionals with unrelated antecedents and consequents.

III.6 Biconditionals

I have found no instances of logical equivalence or biconditional statements in Maya. This is hardly surprising, since these statements have usually been artificial and a relatively recent development in European languages. It would be interesting to "construct" some of these and see what sort of formulation might make sense to a native speaker.

III.7 Universal quantifiers

The most common universal quantifier in Maya is tulacal, meaning "all, every, everything". Another generally used quantifier is la (also written lah) which may be a short form of tulacal. According to Andrade (p.306) the "word" tulacal is actually a sentence tu lacal containing the third person singular pronoun u, aspect marker t, and an apparently obsolete verb lah meaning "to be all, or complete". Andrade says that an earlier meaning of tulacal is "every one of them", basing this on the analogy with

t laclon -- every one of us;

t laclex -- every one of you.

Here are some examples using these quantifiers:

Ua tumen he a betic tulacal baax ca ualic, tene malob.

If you will do each thing that you tell me, it will be all right with me. (if perchance will you do each thing that you tell me, all right) Here tulacal functions as an adjective with baax (thing).

Yanhi u lucsic tulacal u noc u dzatic.

He had to take off all his clothes to give them to him. (tulacal u noc -- all his clothes) (must he, he removes all his clothes, he gives them)

Lah binob tulacal.

They all went. (Literally "All went they, everyone". This use of two universal quantifiers, apparently for emphasis, is fairly common.)

Lay zihez yokolcab tulacal.

Thus he created everything on earth. (Here tulacal is used as a pronoun in the sense of "everything".) (thus created he on earth everything)

With regard to word order, as a modifier tulacal is placed as in English; as the subject it generally follows the verb (like pronouns of class B when used as a subject). Here are some examples using lah:

Tin lah ukic. -- I am drinking all of it.

Tin lah hantic uah. -- I am eating all of the tortillas.

Tun la kaiob. -- They are all singing.

Lah cohantacob. -- All of them are sick.

The particle lah also plays an important part in the number system. For example la hun (ten) apparently has the literal meaning (Tozzer, p.98) "all of one count". Maya numbers from 10 to 20 contain lah:

12 la ca

13 ox la hun

14 can la hun, etc.

It is interesting to observe that while numbers must always be followed by a numeral classifier, the quantifiers are used without any kind of quantifier classifier. There are, however, some special quantifiers, that can only be used with certain types of words. This is especially true in quantifying temporal terms. For example,

u xocan akab -- every night

u xocan haab -- every year

u xocan yuil -- every month

u xocan kin -- every day.

This last term can also be expressed by the term sansamal (samal means "tomorrow", the prefix functions as a reduplicating particle). Thus,

Sansamal yan u cimsic huntul xkax.

Every day she has to kill a hen.

(every day must she kill it one hen)

There is also a term suc, which is generally translated into English as "always".

Suc cohanilen. -- I am always cold. (always cold I)

Maya also possesses another set of quantifiers which are formed from interrogative pronouns and used similarly to their English counterparts. These are:

hemax -- whoever, whomever

hebax -- whatever

hebix -- however (in every possible manner)

hetux -- wherever

III.8 Existential quantifiers

The only real (affirmative) existential quantifier that I have found in Maya is the particle yan (occurring with several suffixes or by itself), which has several different meanings, depending on the context:

A. there is, there exists

B. to have

C. to be in a place

D. to have to do something (necessity or obligation)

At this point only meanings A and B are relevant. (An intuitionist logician might find it interesting that the same word is used for both meanings A and B.) Some examples of meaning A are:

Ua yan mac tu yoltah cahtal tu hunalei...

If there is anyone who wishes to occupy it by himself...

(if there is man he wants occupying he alone)

Lae yan yadzilic ca katic tech.

There is a favor which we seek of you.

Yan tin botah holhiac.

I bought some yesterday. (some I bought yesterday.)

Meanings A and B seem to be closely related as we see in the following examples:

Yan tech dzimin.

You have a horse (There exists to you horse)

Yan ten takin.

I have some money (There exists to me money)

Yan is usually found at or very near the beginning of a clause. As we saw in the section on negation it often appears in the negative form minan (sometimes written manaan), which derives from ma yan. Other negative quantifiers, like "nothing", "nobody", were also discussed in the section on negation. Terms like "some, someone, something" can generally be formed with yan, as in the example above where we had the compound yan mac, which we translated as "anyone, someone". Mac means "person, man". It seems to be common in Maya that where we would use "someone, something", they would use the constructions yan huntul uinic, yan hunppel bal (literally: there exists one man, there exists one thing). I am not sure about how to translate "some" in the sense of an adjective indicating an indefinite number. Yan may be used to indicate an indefinite quantity. Andrade (p.369) gives the following example:

Tin botah holhiac. -- I bought it yesterday.

Yan tin botah holhiac. -- I bought some yesterday.

I assume that "some" in its adjective form can be used in the following way:

Yan uah tin botah holhiac. -- I bought some tortillas yesterday.

Another expression for "something" is formed from the particle ua and bal (thing). This is sometimes written as uabal and sometimes as uabax.

Le xipalo tun dzolic uabax ti le xchupalo.

The boy explains something to the girl.

(the boy he explains it something to the girl)

III.9 Equality

There are many different terms denoting some sort of equality in Maya. Perhaps the most general of these terms contain the root et (meaning "to accompany", apparently the same root that occurred in yetel, which means "and, with"). Thus we have cet meaning "equal, to be equal to", as well as many compounds containing cet. Some of these are cetcunah (to be equal to), cetil (equality), lah cet (a thing equal to another), ma lah cet (a thing unequal to another). The following examples use cet:

Cet in chheh yetel in kam. -- My expenses are equal to my income. (equal my expense and my income)

Cet cimci Pedro yetel u mehen.

Pedro died at the same time as his son.

(same died he Pedro and his son)

Very often something which might be thought of as identity may be expressed by merely juxtaposing the two equal terms. For example,

Batab-en. -- I am the chief. (chief I)

There are numerous other terms that indicate equality, or equivalence, usually restricted to a particular equivalence relation. There are also many terms for different types of inequality. Two general roots denoting inequality are kep and coy, which are used analogously to the cet constructions above.

Chapter IV

Logistic Notation

IV.1 Propositional symbols

In this section, as in the whole treatment of notation, we must be careful to separate at least two problems:

1. What sort of symbolism can we reasonably impose on the language?

2. What sort of notation might a Maya have used?

The primary concern will be with the first problem, as any attempt to answer the second would be purely speculative, unless hieroglyphic texts give us further information about mathematical notation. There are sections of the codices that have been interpreted as indicating that some rudimentary algebraic symbolism may have been used, but nothing definite has been established. Since our traditional symbolic notation depends heavily on the alphabet, it is not immediately obvious what the Mayas might have used instead of an alphabet. However, their mathematical and astronomical notation is very ingenious. One suspects that if they dealt with more abstract problems they would also come up with a satisfactory notation for general mathematical and logical purposes.

Basically the problem of whether the use of letters denoting

propositions or sentences is justified reduces to the problem of whether there is a distinguished class of expressions in Maya that we could consider to be the class of sentences. Obviously not all meaningful Maya utterances, or independent segments of utterances, are examples of sentences or sets of sentences. But then the same can be said for English. The only significant problem that could arise is if one wants to insist on using a subject predicate criterion for deciding whether an expression is a declarative sentence. I believe that most linguists would agree that the subject predicate criterion is not a very good one for defining sentences. I will try to show in this chapter that there is a class of Maya utterances corresponding to English declarative sentences. These do have at least two components, but the labels "subject, predicate" are not necessarily the most appropriate in describing these components. If the hypothesis that there is a class of Maya sentences is accepted then we may use the letters p, q, r,... to stand for those sentences. Given that we have a well-defined set of logical connectives, there is no problem in isolating the atomic sentences.

IV.2 Propositional connectives

The last chapter had a sufficient number of examples, so that the problem of a notation for connectives needs to be discussed only briefly. We saw that Maya, like English and other European languages had several words corresponding to most types of propositional

connection. Let us assume that all of these can be reduced (by finding sentences with the same meaning as a given sentence) to the following paradigms. (Presumably it is possible to check this reduction by asking native speakers whether certain sentences do have the same meaning.)

"ma p" for the negation of p

"p ca q" for the conjuntion of p and q

"ua p ua q" for the disjunction of p and q

"ua p q" for the conditional "if p then q"

"ma p maix q" for the joint denial of p and q

Negation and conjunction seem to already correspond naturally to the usual symbolic notation. Joint denial can also be obviously symbolized -p & -q, especially with the colonial Maya terminology. There seems to be some problem involved in the fact that both disjunction and implication use the same particle <u>ua</u>. However, it is easy to see that because of the positions of these particles (since "ua q" can not be an atomic sentence), there is no real ambiguity. As we will see in Chapter 6, there is some confusion in practice however. We will use the following notation: (for well-formed formulae p, q)

-p for "ma p"

p & q for "p ca q"

p v q for "ua p ua q"

p -> q for "ua p q"

p / q for "ma p maix q"

At this point there has been no justification that these Maya sentences really correspond to either the English or symbolic sentences, apart from the fact that they have always been translated that way. If there can be any other evidence for these translations it will have to come from their uses in Maya texts. In the next chapter I will try to present some apparently logical arguments from native texts, which use these particles. In these it will be seen to what extent they actually correspond to our logical connectives. Presumably if we can find logical arguments in Maya which are completely parallel to ours and generally valid by our standards, this will provide at least some prima facie evidence that they do in fact correspond. There is an appearance of circularity here that will be discussed in the conclusion. Another approach is to extract truth-functional definitions of these particles from a native speaker. This latter approach should also help to clarify problems such as whether we are dealing with inclusive or exclusive disjunction and the nature of implication.

IV.3 Analyzing atomic sentences

In this section the primary concern is to take extremely simple Maya atomic sentences and see how these might be represented symbolically. In European languages this has generally been done by dividing the atomic declarative sentences into a subject s and a predicate P, and then representing the sentence by P(s) or simply Ps.

For example, the sentence "John walks" is divided into the subject "John" which could be represented by j and the predicate "walks" by W to give us W(j). The sentence "the little girl walks slowly" is divided into the subject, "the little girl" written as g and the predicate "walks slowly" which we write as S, to give us S(g).

In order to see to what extent this procedure seems reasonable for Maya, let us first attempt to classify the simple sentences of Maya. Our classification will be a greatly simplified version of Blair's. He first divides Maya sentences into major and minor sentences. Minor sentences are those which have no noun or verb phrase (e.g. interjections, answers to questions, etc.), and these will not concern us here. The major sentences are subdivided into nominal sentences and verbal sentences. These are described as follows in Blair (p.101).

> Nominal sentences are those with a single predicated noun phrase (NP) or with two noun phrases as immediate constituents, one predicated (i.e. independent) and serving as the <u>topic</u> or <u>item to be described</u>. A predicated noun phrase must include a bound subject (a member of set 610).

> Verbal sentences are those with a single verb phrase (VP). A verb phrase, if it does not have 422 (Imperative) as one of its constituents, must include a bound <u>subject</u> morpheme (a member of pronominal set 610) or a bound <u>actor</u> morpheme (a member of pronominal set 610 or 210) or a bound <u>goal</u> morpheme (a member of set 610 or 210); it may include both a bound actor morpheme and a bound goal morpheme (210 and 610 respectively), one or more construct suffixes, as well as modifiers, appositives and the like.

N.B. Blair's pronominal set 610 is our pronoun B; his pronominal set 210 is our pronoun A.

In the following section, "mode" will refer to a large class of prefixes or particles referring to time, manner, and modes of doing things. Some of these may also be interpreted as aspect markers. TAV stands for "tense, aspect, voice marker", but may also include some other suffixes (like transitive transformational suffixes). The scheme is greatly oversimplified, as I wish to consider only the general logical form of the sentence without becoming involved in a large amount of detail, much of which is irrelevant to our present purposes. For a more complete treatment the reader is referred to Blair's thesis.

The only type of nominal sentence given by Blair is called "nominal stative". This is represented schematically by,

theme	subject	
NP	pro B	
uinic	ech	You are a man.
hach nohoch	le che a	This tree is very big.

In the second example the "real" subject is a null form third person pronoun immediately preceding the "appositive" subject <u>le che a</u> (this tree). There seems to be a natural symbolism P(s) for these sentences, where P is the theme and s is the subject. I think that there may be a question of whether P is "really" a predicate and s is "really" a subject, but this seems to me to be, however interesting for metaphysics, irrelevant for logic. To be on the safe side, it might be

best to avoid the term "predicate logic", but I believe that a similar symbolism can be used without making any ontological commitment as to what the letters stand for. In fact, in this particular type of case our usual predicate symbolism more faithfully reflects the structure of the Mayan sentence than the English translation.

Blair has several types of verbal sentences. These are divided into intransitive, transitive active, and transitive passive. First he gives a type of sentence which he calls "verbal intransitive stative". A simplified schematic representation of this type of sentence is,

mode	intrans. verb	TAV	pro B	
	ximbal	nah	ech	You walked.

It seems reasonable to let P stand for the whole sentence minus the pronoun B which we denote by s. Here again we represent the sentence naturally by P(s), although it is not completely obvious that grammatically speaking s is the subject. Blair calls it the subject, although it might be argued that it is in the "objective case". Perhaps this type of sentence originally had another subject, which in time became a dummy, and then disappeared altogether. There is generally some sort of past tense involved in this type of sentence.

Another type of sentence is called "intransitive active processive". The main difference between this and the last type is that this one takes a pronoun of class A as the subject, which precedes the verbal root. A schematic representation of this is,

mode	pro A	intrans. verb	TAV	
yan	a	uem	el	You must sleep.
c	u	dzib		He writes.
t	in	lub	ul	I am falling.

There are two problems in this type of sentence. The division between subject and predicate is not as clear, since part of the verb (the mode marker) seems to be attached to the subject. In the usual orthography we write cu dzib and tin lubul. In addition, this is the type of sentence which Tozzer seems to believe has no real subject and predicate. His interpretation is that this sentence basically describes an event using some sort of gerundial construction. He believes that this pronoun really is in the possessive case, rather than in the nominal (subjective) case, and that the particle which we call the "mode marker" really does belong with the pronoun. I think that both of these points are of great interest, but do not necessarily have any bearing on the logical symbolism. There is no reason why the notation P(s) is not just as adequate for the "event" construction (present time my falling) as it is for the usual predicate type of construction (I am falling). It might be argued that the "event" construction does not correspond to a complete sentence, and thus can not be suitable for this sort of logical symbolism. However, I think that this feeling of incompleteness is imposed on us by the inadequacy of the translation. In this sense, "I am falling" is a better

translation of the Maya version of the event, even if it does not convey the grammar of the original. I don't believe that the problem of the mode marker is serious, although I am not sure what the best solution is. A better diachronic knowledge of the language would probably help to settle the point, since there is some evidence that these are defective verbs. In general, the word order of this type of sentence using pronoun A does not correspond as nicely to our notation as the previous types, but it is no worse than English, for which the notation is equally artificial.

In our simplified classification scheme there are four types of simple transitive sentences. Two of these are in the active voice and two in the passive. The two types of transitive active differ mainly in that the first has the pronouns of class A as subject, while the second takes a noun phrase as the subject. The first type is of the form,

mode	pro A	trans. verb	TAV	pro B (refl. pro.)	
cen	u	lox		ech	He will hit you.
t	u	cim	sah	baob	They killed themselves.

Some comments are necessary here. First of all we notice that this type of sentence sometimes has special suffixes which mark the transitive sentences. In the second example both the suffixes <u>s</u> and <u>ah</u> are peculiar to transitive sentences. Other verbs, like <u>lox</u> seem to be inherently transitive and need no special suffixes. The second comment concerns the "goal" or "object" of the action. This can be either a

pronoun of class A or the reflexive pronoun ba (sometimes used with the plural suffix ob). Both of these sentences can be conveniently represented by a relation of the form aRb, which becomes aRa in the reflexive case.

The second type of transitive active is represented by the schema,

NP	trans. verb	TAV	pro B	
Juan	han	te	(null)	John ate it.

There seems to be some conflict here, as this sentence has no pronoun subject contrary to what was said in Chapter 2. Recall that Tozzer claims that the pronoun subject must always be present. Apparently the above type of sentence in which the subject is a proper name offers an exception. Tozzer's example, which is similar to our sentence is,

Uinic u puchic Pedro. -- The man hits Peter. (man he hits it Peter)

In this sentence the noun uinic appears as an appositive to the subject u (in Tozzer's interpretation) and the noun Pedro as an appositive to the object ic. Tozzer's literal translation of the sentence is, "man, his hitting something, Peter". I believe that the symbolic representation of the sentence does depend on the interpretation and grammatical status of the constituents. The example could be represented either by mHp or m=h & (Ey)(hHy & y=p). where,

m is "the man"

H is "x hits y"

h is "he"

p is "Peter"

In the first representation we assume that the sentence merely asserts a relation between the subject, expressed in two different ways as uinic u, and the object Pedro. The suffix ic is taken to be strictly a part of the verb, serving as a present tense transitive marker. The second representation corresponds more closely to Tozzer's interpretation. I am not sure which (if either) is correct.

The transitive passive processive type of sentence is represented by the schema,

mode	goal (pro A)	trans. verb	TAV	
t	u	han	tal	It is being eaten.

The last type of basic sentence is called "verbal transitive stative" by Blair. It can be represented as,

mode	trans. verb	TAV	pro B	
	han	tab	i	It was eaten.
	dzon	aan	en	I have been shot.

With both of these types of passives there is a problem of logical representation. In these passive sentences, no "logical subject" is mentioned. When it is known then, as in English, it may be introduced with a prepositional phrase (generally following the above schema). Some difficulties with the passive voice in Maya were mentioned in Chapter 2. Consider the following sentences again:

1. My hat was stolen.
2. My hat was stolen by John.

1′. Oclab in ppoc. (stolen my hat)

2′. Oclab in ppoc tumen John. (stolen my hat by John)

Let aSb stand for the sentence "a stole b". Then 1 and 2 are perhaps best represented by (Ex)xSh and jSh respectively (where j = John and h = my hat). 2′ seems to have the same meaning as John tu oclah in poc, which can be handled as one of the transitive active types mentioned above. However 1′ seems to have no equivalent active sentence. This makes the (Ex)xSh representation seem somewhat forced. Another alternative is to simply have a one-place predicate S = oclab (to be stolen), in which case 1′ is represented as S(h). This has the disadvantage of not capturing the sort of inherent transitivity in this type of sentence. This difficulty arises only if we accept Andrade's claim that 1′ has no active equivalent. As I mentioned in Chapter 2, my informant seems to disagree.

This essentially concludes the discussion of atomic sentences. I have assumed that all atomic sentences have one of the above types as the "heart" of the sentence with many types of embellishments possible. I have also assumed that these embellishments do not affect the logical form of the sentence. In general, although we have seen a few problems in representing atomic Maya sentences with our usual logical symbolism, none of these problems seems to be particularly serious. I believe that we can tentatively conclude that the usual symbolism of predicate and relation logic can be applied to these sentences, even though there may be some ontological objections as to the nature of the entities

represented by the letters. In fact, there seems to be nothing inherent in the structure of the spoken language that would block the development of this type of symbolic approach.

IV.4 Sentences with quantification

Up to this point, I have only considered "constant" atomic sentences of the type P(a) and aRb where a,b,P,R are all constants. In order to do any serious quantifier logic (in the usual way) we will have to investigate the problems of Maya sentences involving variables. What are the simplest types of sentence in English that are normally translated using variables?

A. atomic sentences with explicit variables like, "x is eating", "x is an even number", "x loves Mary", etc.

B. pseudo-atomic sentences like, "Someone is eating", "All natural numbers are prime", "Everyone loves someone", etc.

There is probably a reasonable amount of doubt that sentences of type A are legitimate English sentences. At any rate, this type of sentence has probably come into existence in European languages only with the symbolization of mathematics and logic, as well as sciences that use similar notation. One would not expect sentences of this type to occur in "normal" Maya utterances, just as one does not find them in "normal"

English utterances. Let us then examine some sentences of type B. Suppose we have the following universal sentence:

Ox Ben u mentci tulacal bal.

On (the day) 3 Ben he made all things. ("he" being the divinity previously referred to, and "all things" referring to physical objects on earth)

What is the usual logical analysis of the English sentence? Let M(a,b,c) be the ternary relation "at time a, b makes c"; let T(d) be the predicate "d is a thing"; and let c and a be the constants "he" and "the day 3 Ben" respectively. Then the sentence may be satisfactorily expressed by the formula (x)(T(x) -> M(a,x,c)). Is there any part of this analysis that could not be carried through for Maya? Apparently not, for in this sentence every one of the parts of the English translation corresponds exactly to a part in Maya, seemingly in exactly the same way. There are, however, at least three questions that might be raised about the translation into symbols.

1. How is the implication introduced into the symbolic representation?

2. Does the symbolic sentence have a meaningful literal natural language translation?

3. If it has this literal translation in both languages do they have exactly the same meaning?

I am not certain if there is a completely satisfactory answer to the first question. Presumably the implication is introduced

because it seems to work; in other words it gives a nice logical formula that intuitively captures the intended meaning of the original sentence. The problem for us is whether there is something peculiar to European languages that suggests this conditional formulation. Light might be shed upon this issue by seeing whether a Maya, upon understanding the issue involved would come up with a similar formulation. This brings us rather naturally to the second question. Let us first see what the literal English translation of this formula might be. To avoid some problems involving the word "thing" let us assume that T(d) is "d is a tree". A common literal reading of the formula would be, "For every object, if the object is a tree then on 3 Ben he made the object." Style purists would probably prefer other readings, but some of these do not accurately reflect the spirit of the symbolism. A native Maya speaker would have to decide whether some reasonably literal translation of this rather clumsy English sentence makes sense and has the same meaning as the original Maya sentence (with <u>che</u> substituted for <u>bal</u>). Another interesting question here involves the introduction of the variable x. This presumably stands for an arbitrary object in the larger domain under consideration. I assume that the introduction of the variable is not dependent on the particular language involved.

The above example of a universally quantified sentence was chosen because of the almost exact correspondence between the Maya original and the English translation. This made it easier to see the

similarities in the uses of the universal quantifiers in the two languages. The following example has some differences in word order between English and Maya.

Tin lah hantic uah.

I am eating all of the tortillas.

An analysis of this sentence is:

mode marker: t

subject pronoun: in

universal quantifier: lah

verb root: han

transitive suffix: t

aspect suffix: ic

direct object: uah

The position of the quantifier lah in the Maya sentence suggests that its range might be the entire predicate hantic uah, rather than merely the direct object uah. A characteristic of lah seems to be that it is very often found in this position, immediately preceding the verbal root. If this is really the case, then it is not clear exactly how to interpret the sentence. An alternative is that the sentence might be transformed into Tin hantic lah uah or perhaps Tin hantic tulacal uah without changing the meaning. If this is so, then it can apparently be treated the same as the English. According to my informant the version Tin hantic tulacal uah means the same as Tin lah hantic uah. The second suggested transformation is not

correct. This example also brings out another interesting aspect of quantification. In English we can distinguish between the sentences (the latter of which is empirically absurd):

I am eating all of the tortillas.

I am eating all tortillas.

It would be interesting to find out how a Maya speaker would distinguish between these sentences. My informant was not clear on this point.

Let us now look at some sentences with existential quantifiers.

<u>Lae</u> <u>yan</u> <u>yadzilic</u> <u>ca</u> <u>katic</u> <u>tech</u>.

There is a favor we ask of you.

The English translation can be symbolized as follows:

F(x) -- x is a favor

A(x,y,z) -- x asks y of z

a -- we

b -- you

(Ex)(F(x) & A(a,x,b))

The Maya sentence contains the following components;

<u>lae</u> -- rhetorical device (like French voila?)

<u>yan</u> -- there is (exists)

<u>yadzilic</u> -- favor

<u>ca</u> -- that we

<u>kat</u> -- ask, desire

<u>ic</u> -- transitive aspect suffix

<u>tech</u> -- second person indirect object (pro C)

This sentence also seems to correspond closely to the English translation; apparently there is nothing explicit in the English that suggests the conjunction in the logical construction. Once again, the problem is to see whether a sentence which consists of a literal reading of the symbolic version makes sense to a Maya, and if so whether it has the same meaning as the original sentence. As was pointed out before, negative existential sentences in Maya seem to suggest the usual symbolic representation. For example,

Minan u than in palob yoklal solar.

My children have nothing to say about the lot. (A more literal reading is "not there exists the word my children about lot".) The Maya version seems to fit the symbolic $-(Ex)(W(X) \& A(c,x,l))$. In general, Maya existential sentences seem to suggest the usual symbolic representation at least as well as their English translations, and sometimes better, as in the following examples.

Yan tin botah holhiac.

I bought some yesterday.

Ua yan mac tu voltah cahtal tu hunalei ca u ualkes lahcapis peso ti ca cilich nabil yglesia.

Roys (Ebtun, p.247) translates this as, "If there is anyone who wishes to occupy it (the property) by himself, let him return the twelve pesos to our Blessed Mother Church." This seems to be a readable and accurate translation. A reasonable symbolic version of the antecedent of the English translation seems to be, $(Ex)(P(x) \& O(x) \&$

H(x)). A literal version of the Maya antecedent is: there is person he wants occupy it by he alone. This antecedent appears to contain three simple sentences,

<u>yan</u> <u>mac</u>,

<u>tu</u> <u>yoltah</u> <u>cahtal</u>, and

<u>tu</u> <u>hunalei</u>, which are simply conjoined by juxtaposition. Presumably this juxtaposition can be interpreted as conjunction, thus reflecting somewhat more closely the symbolic version than a usual English way of expressing the same fact.

As an interesting exercise let us examine a slightly more conplicated sentence involving more than one quantifier.

<u>Yane</u> <u>cu</u> <u>dzaic</u> <u>takin</u> <u>utial</u> <u>u</u> <u>manal</u> <u>uabax</u> <u>dzabal</u> <u>ti</u> <u>le</u> <u>cohano</u>.

Some give money to buy whatever is given to the sick person. (There is someone, he gives money for the buying whatever is given to the sick person). If we set

xGy -- x gives y

xG´y -- x is given to y

xBy -- x buys y, then we obtain the symbolic

(Ex)(xGm & (y)(yG´s -> mBy)).

This generally follows fairly closely the structure of the Maya sentence.

IV.5 <u>Equality</u>

Not too much will be said about equality here. The most basic

form of a simple sentence in Maya involving equality seems to be =ab. This is illustrated in the example from the last chapter,

Cet in chheh yetel in kam

Equal are my expense and my income.

This type of example seems to suggest that a prefix notation is more natural for Maya than the usual infix notation. However, other examples with verbs of equality can also suggest an infix notation. Inequality can be expressed by simply prefixing the negative particle ma, or by replacing the equality expression by one of the many inequality particles. Therefore, it seems that either the usual "unequal" sign or a special prefix relation symbol would be appropriate for representing inequality in Maya.

IV.6 Classes and sets

This is one area in which the Mayan language seems to be lacking an essential ingredient. It appears that there is no natural way to express a membership or subset relation. The "copula" yan is not used in any way that would indicate membership. Sentences that in English naturally suggest a set theoretic representation are usually translated into Maya as a sort of juxtaposition. For example,

I am a man -- Uinic en.

Sentences involving a subclass interpretation are also expressed by mere juxtapositon. Thus,

Yax kuobe hauay kuobe. -- The first gods were perishable gods. (first gods perishable gods)

Ma kui chacob. -- The chacs were not gods. (not gods chacs)

All of this is not to say that class terms cannot be expressed in Maya. As we have seen in Chapter 2, one way of forming class terms is to take a property, e.g. cohan (sick), add the suffix il to form an abstract noun, and then prefix the third person singular pronoun to make the class term u cohanil (the sick). However, these class terms do not seem to occur very frequently in Maya texts. So it appears to be only the membership and subclass relations that are missing and not the classes themselves. There is a Maya word molay, which appears to be used much like the English word "set". It comes from the verbal stem mol meaning "to gather something, to congregate".

Chapter V

Some Logical Arguments from Native Texts

In this chapter an attempt will be made to take a few selected passages from native texts and organize them into the form of logical arguments. Even in English this is a hazardous enterprise at best. The limited selection of texts presently at my disposal is a great handicap. For example, the various Chilam Balam books, which although written in Maya during colonial times give us much of our information about the pre-conquest Maya, are filled with religious and ritual passages. These passages usually defy logical analysis. Many other texts available are also of a poetic, mystical or ritual nature. Even native works which generally deal with history usually stray into religious and mythological speculation. For the Maya there seemed to be no sharp divisions of subject material. It would almost be correct to say that every text touches upon every subject known to them, and often in such a fashion that adjoining sentences seem to us to have no possible connection. I think that a deeper study than the present one is necessary to determine whether there are implications for logical reasoning in all of this. At this point I have only selected a few examples that contain analogues of our own "logical constants", and that appear to give something close to what we have generally called a logical argument. Although the choice of passages is obviously limited to those conforming to a very restricted view of the nature of logic,

and in certain ways seems to beg the whole problem that this paper is intended to elucidate, I believe it is of some interest to see how far the analogy to our own classical logic can be pushed.

During the course of this study three texts have been selected from which material for this chapter is taken. All of these are from colonial times. Except for a few scattered legends, I have not had any good modern native texts available. The few that I have found have not contained anything of interest to the present work. Other colonial texts are not included, either because they are poetic or mystical or because there are no good editions which have both a good critical original text and an accurate translation. Consequently, only the following texts were used -- the first two translated by Roys and the last translated by Brinton.

1. The Book of Chilam Balam of Chumayel
2. The Titles of Ebtun
3. The Chronicles of Chicxulub

The first of these books was apparently compiled in the 18th century, although most of the text was apparently passed along through various generations of Maya priests. There is good evidence that much of the text actually existed well befor the Spanish conquest, and that some of it may have been copied from hieroglyphic texts. There are various books of Chilam Balam (which means "jaguar priest"). The last part of the titles of these refer to the towns in which the manuscripts were found. The Chumayel is apparently one of the best preserved and

contains fewer obvious errors than most of the others. The contents of these books are generally quite similar to each other. The subjects most thoroughly covered are native history, mythology, some astronomy and astrology, as well as native prophecies. The Titles of Ebtun is a compilation by Roys of the complete set of legal documents of the town of Ebtun in Yucatan. These date from about 1600 to around 1830, dealing mostly with land transactions and disputes. A few phrases seem obvious native adaptations of Spanish legal language, but most of the texts seem free of other corruption. The third text mentioned above is a native Maya version of the history of the Spanish conquest, written about 1560.

None of the selected passages are in a form that corresponds exactly to a symbolic argument, although some are fairly close. Consequently, I generally take some liberties with what I take to be the meaning of the text and with what I assume to be hidden premises as well as what seem to me to be unstated but implied conclusions. In some of the passages these liberties are so minimal as to be virtually non-existent. However, most passages would probably generate controversy as to whether the liberties are justified or not. The method of presentation used here is to first give the original text (from a critical edition), then the given translation, and finally my discussion as to how the passage could be seen as a logical argument. At this point I am not able to give my version of the arguments in Maya, but hope to do so in the future and attempt to check it with a native speaker.

The first argument very closely resembles what we would call an instance of the rule of modus ponens. The conclusion is not restated exactly as in the consequent of the conditional, but is obviously intended to be drawn as such. This argument has an interesting feature (found in many Maya arguments) of consisting of a mixture of declarative and imperative sentences. Presumably the imperatives could in principle always be replaced by declarative sentences. Another interesting aspect of this argument is that the conclusion is inserted between the premises.

> "Mehenexe, ua tex halach uinic uay ti luum lae," ci uil yalababob lae, "xenex chha xiknal balam, ca tac ex a dzab ex in hante. Cicii dza ex yuob, cicii dza ex u pputob, ca tac ex a dza ex in hante, yetel xen ex tac tuzebal hach hele yetel tac a tal exe. Mehen exe, hach yan in uol in hante. Cex mehen exe, cex halach uinic exe." (Chumayel, p.30)

> "Sons, if you are head-chiefs here in the land," they shall be told, "go and get the winged jaguar, and then come and give it to me to eat. Put his bead collar on him properly, put on his crest properly, and come and give him to me to eat. Go immediately today, and come soon. Sons, I greatly desire to eat him. You are my sons, you are head-chiefs." (Chumayel, p.97)

> ("Sons if you head chief (literally: real man) here in land this," which shall be told they this, "go get winged jaguar and then come you give I eat. Properly put you his bead collars, properly put you his crests, and then you come, you give I eat, and go you quickly immediately right today and soon you come. Sons, greatly there is my desire I eat it. You sons you, you head chiefs you.")

The form of this argument seems to be:

If you are x then do y.

You are x.

Therefore, do y.

I have found many instances of modus tollens type arguments in Maya texts. These are generally quite explicitly of the form: p->q, -q, therefore -p. Often the premise -q is not stated separately, but q is obviously a very undesirable event to be avoided. A typical example of this sort of argument is,

> Manezex u cuch katun lic u talele. Uamatan a manezexe ti u motzhal ta uoc exe, texi bin u helinte. Ua ma a manzic exe, texi bin kuxic u chun che yetel xiu. Ua ma a manzic exe, bay cimic cehil bin uchebal u hokol ta cahal ex. (Chumayel, p.41)

> Submit to the unhappy destiny of the katun (20 year period) which is to come. If you do not submit, you shall be moved from where your feet are rooted. If you do not submit, you shall gnaw the trunks of trees and herbs. If you do not submit, it shall be as when the deer die, so that they go forth from your settlement. (Chumayel, p.122)

> (Submit you its load katun will be its coming. If not you submit, from its rooting of your feet, to you it will remove. If not you submit, you will gnaw the tree trunks and herb. If not you submit, as die deer it will happen it leaves from your town.)

The argument is of the form,

If you do not submit then p.

If you do not submit then q.

If you do not submit then r.

You do not want p, q, r. (hidden premise)

Therefore, submit.

This is strictly speaking not a tight logical argument, but regardless of the way that a complete version might be formalized, the idea of modus tollens is at the heart of the argument. There appears to be a double negation involved, if the rule that the author uses is formalized in the way that we usually state modus tollens. It is also very common in Mayan passages of this sort to include more premises than are really necessary, probably in the hopes that the listener will find among them one to which he can readily subscribe. Promises in Maya are commonly given in an analogous form. As an example of this we have the following passage, which is in essentially the same form as the last argument except that it involves a promise from the speaker that he will keep his word, rather than imperatives. Note that in this argument only one premise is stated and no conclusion is explicitly given, but I believe the intention is sufficiently clear.

> lae hex ua bin hoppol yn bax tin than lae ca chacanpahcen tu tanil yn yum Sr. Gobernador tiho ca tzectabac yn pach hokal hadz tin Pach yetel ca luksabac in pena hoppel peso (Ebtun, p.262)

> If I should ever begin to make light of my statement, let me appear before my lord Governor at Tihoo (Merida), and let my back be chastised with one hundred blows. Also let me be fined five pesos. (Ebtun, p.263)

(Thus if go begin I play I am speaking, then should appear I in his presence my lord Sr. Gobernador at Merida, and punished my back hundred blows to my back, and also fined my shame five pesos.)

The following text seems to presuppose some sort of exhaustive classification of a two-valued type: If x then y, if not x then z.

Bay xan ua yan mac tu yoltah cahtal tu hunalei ca u ualkes lahcapis peso ti ca cilich nabil yglesis hetun ua mac bin xetlantabac ti ma minan u soralob utial u cahlahbalob (Ebtun, p.246)

Likewise, if there is anyone who wishes to occupy it by himself, let him return the twelve pesos to our Blessed Mother Church. On the contrary, it is to be divided among those who do not have ground plots on which to settle. (Ebtun, p.247)

(Likewise if there is person he wishes live he alone, that he return twelve pesos to our blessed mother church. Otherwise some one will divide to (those who) have not their lots for their living.)

The key phrases here are <u>ua yan mac</u> (if someone, if there exists person) and <u>hetun ua mac</u>. <u>Ua mac</u> in this context means "anyone"; <u>hetun</u> is usually translated as "but". I agree with Roys here that a good rendering of the intention of the utterance involves translating <u>hetun</u> as "on the contrary", especially since there are only two conditions given which are obviously intended to mutually exclude each other as well as exhaust the possibilities.

The Maya calendar also gives a case in which there was a two-valued division of omens for each calendrical division. Each division of the calendar (sometimes day, sometimes longer periods) had an associated omen. These omens were then divided into two mutually exclusive and jointly exhaustive classes -- good and bad. The following passage illustrates this division.

> Uay cu hokzabal tu lumil Nitundzala, Chactemal, Tahuaymil, Holtun Itza, Chichinila, ca utzac yoheltabal u cuch u ximbal katun, hunhundzit katune, ua utz ua lob yani. (Chumayel, p.53)

> Here it is published in the land of Nitundzala, Chactemal, Tahuaymil, Holtun Itza, Chichinila, in order that the charge of the course of the katun (20 year period) may be known, of each katun, whether it is good or bad. (Chumayel, p.146)

> (Here it is published in the land Nitundzala, Chactemal, Tahuaymil, Holtun Itza, Chichinila, that may be known the charge the passing katun, each katun, whether good or bad there is.)

It would be presumptious to attempt to argue from the limited evidence that Maya reasoning is in accordance with a two-valued logic. However, there are several other indications in this direction (e.g. the four-fold division utterances given in chapter 3), and I have not found any contrary evidence.

Let us now look at some arguments that involve quantifiers. The following is a passage taken from the Chumayel. After giving an

account of some native gods (chacob) the author argues for the Christian god. Admittedly this type of example might be influenced by statements that the author has heard from Spanish priests.

> Ma kui chacob. Halili hahal ku ca yumil ti Diose; u kulob tu than tu yidzatil Mayapan. (Chumayel, p.16)

> The Chacs were not gods. The only true God is our Lord Dios; they worshipped him according to the word and the wisdom of Mayapan. (Chumayel, p.68)

> (Not god chacs. Only true god our lord of God; they worship by its word its wisdom Mayapan.)

The argument seems to be of the form:

Premise: (E!x)(Gx) & Gd

Hidden premise: (y)(Cy->-(y=d))

Conclusion: (y)(Cy->-Gy), where Gx is "x is a god", Cy is "y is a chac", and d is the constant "Dios".

The following two passages might be said to suggest an implicit definition of the universal quantifier tulacal. The first passage could be interpreted as being of the form,

(x)Px, therefore, Pa & Pb & Pc

The second passage is the converse part of the definition: Pa & Pb & Pc & Pd & Pe, therefore, (x)Px.

> Ox Ben u mentci tulacal bal, hibahun bal u bal caanob yetel u bal kaknab yetel u bal luum. (Chumayel, p.39)

On 3 Ben he made all things, as many as there are, the things of the heavens, the things of the the sea and the things of the earth. (Chumayel, p.117)

(3 Ben he made every thing, how many there are, the thing heavens, and the thing sea, and the thing earth.)

Lay zihci uinal yetel uchci yahal cab, tzolci caan yetel luum yetel cheob yetel tunich, zihci tulacal tumen ca yumil ti Dios lae (Chumayel, p.40)

The uinal was created, the earth was created; sky, earth, trees and rocks were set in order; all things were created by our Lord God, the Father. (Chumayel, p.119)

(Thus created he uinal (month), and made happen he earth, arranged he sky and earth and trees and rock, created he everything by our lord of God here)

Another example of the same type of argument involving universal quantifiers follows. This passage suggests more strongly that given (x)Tx there are no exceptions. The author appears to be arguing for the strength of (x)Tx by insinuating that (Ex)-Tx->-Tav-Tb but Ta&Tb.

lai tun tu yala Ahau ca u bote patanob tulacal, yal u mehenob tulacal, heix ton Ah Pechob yaxchhibal uai ti lum yetel yaxchhibal tal ti Cupul (Brinton, p.202)

> then the ruler said that all should pay tribute and all their sons, even we the Pechs of the first lineage in this land, and the first lineage of the Cupuls (Brinton, p.226)

> (then he said the ruler that they pay tribute all, and the sons all, even we honorable Pechs first lineage here in land and first lineage of Cupuls)

The following passage seems to imply another modus tollens argument, as well as showing a relationship between maixmac (nobody) and heixmac (anybody). Once again it is not really in the form of an argument, and to make it so would take a lot of hidden modal premises, but I believe that the basic point is clear. The first sentence merely serves to identify the "it" of the second sentence. Roys' translation is not really faithful to the original since there is no "if" in the original of the last sentence. If we let Txtc stand for "x takes the tank from Cupul" and Pxm stand for "x is punished by the magistrate", then the underlying predicate argument seems to be (modal considerations aside):

(x)(Txtc->Pxm)

(x)-Pxm

Therefore, -(Ex)Txtc

> Lae heix xmahaycab lae haltun. Maixmac bin luksic Cupul. Heixmac u uinicil bin luksic tie ca dzabac u tzecul tumen justicia. (Ebtun, p.122)

> This Xmahaycab is a rock tank. No one shall

take it from Cupul. If any man take it from him, let him be punished by the magistrate. (Ebtun, p.123)

(This here xmahaycab this rock tank. No one shall take it Cupul. Whoever the man shall take it from him that given his punishment by magistrate.)

If the following passage is seen as a logical argument then it is an invalid one of the form: p->q, therefore -p->-q. However, it is not clear whether the author believes that the second sentence would follow from the first or whether he is merely stating two separate facts. The fallacious inference of -p->-q from p->q is fairly common in ordinary English. This example illustrates the difficulties of determining when we are faced with an invalid argument; since passages are rarely in a logically organized form, it can generally be argued that the intention is not really to present an argument, hence nothing invalid is involved.

Heuac concierto yanil yan u xul, ca yanac hun olal ton yetel dzulob. Uamae bin yanac toon noh katun. (Chumayel, p.22)

However there is at last an agreement so that there may be peace between us and the foreigners. Otherwise there will be a great war. (Chumayel, p.84)

(However agreement exists there is its end (i.e. at last), that there be one peace to us with foreigner. If not, going to be to us great war.)

Chapter VI

Experimental Results

VI.1 Description of experiments

In the summer of 1975 I spent about two months in Yucatan with two purposes. One was to obtain some experimental results about native ability to use logical arguments. The other was to ask specific questions about Mayan sentences that have been used in past chapters of this study. The informant's answers to these questions have been incorporated at the appropriate places in those chapters. The experiments will be described below.

Most of the experimental work was concerned with the ability of Maya speakers to draw conclusions to what we would call logical arguments. Since the word "ability" presupposes some sort of correctness of our conclusions to the argument, it would be better to say that the work was concerned with the extent to which an average Maya speaker's conclusion would agree with the conclusion of traditional logic. Also in the sequel whenever I speak of "correctness" I really mean "agreement with that conclusion which we would call correct". In the experiment a number of ordinary language arguments, simple in content but illustrating different types of logical arguments, was needed. Many of these were taken from the work

of Hill, who used them in testing logical abilities of American school children in the first three grades of elementary school.

A complete description of Hill's experiment is given in her thesis, listed in the bibliography. I will confine myself to a brief summary relevant to the experiment as done in Yucatan. Of the original 100 problems in Hill, 28 were used in this experiment. These were translated into Maya with no changes in logical form, and only minor changes in content where the content of the original was not appropriate to local life style. These problems consisted of two or three sentences (premises) which, as was explained to the subjects, could be thought of as a small story. Then a yes-no type question was asked containing the conclusion of the argument. For example,

In the movie Mike will be either an Indian or a soldier.

Mike will not be a soldier.

Will he be an Indian?

Hill allowed only two answers -- yes and no. I allowed for a third possibility, that one could not know the answer because of a lack of information. In the Hill experiment most of the subjects were given the problem orally and asked to write the answers down. We changed the procedure slightly and did the whole test and answers orally, with all of it being taped. We did this because some of the subjects were illiterate, and those who could read and write were only able to do so in Spanish, being afraid to try it in Maya. Only the assistant and one of the subjects had any idea as to how Maya might be written. The

questions were read by the assistant, a native Maya speaker, who also did the translations from Spanish into Maya. Unfortunately with the oral procedure it was only possible to test one subject at a time. Consequently, the total number of subjects was limited to 20.

In O'Brien & Shapiro there are several objections to the Hill experiment. One of these, with which I agree, is that all of the arguments in the test are valid, requiring only a yes-no answer depending on whether the conclusion is a positive or negative statement. In the Yucatan experiment six problems were added that involved invalid arguments of common logical fallacy types. These were usually identical to given valid arguments except that one of the premises was changed, so that neither the putative conclusion nor its negation necessarily follow from the premises. For example, in addition to the arguments of type modus ponens -- p, p->q, ?q? -- the invalid argument -- q, p->q, ?p? -- was also given as a problem. For this type of problem the "one can't know" option is appropriate. A complete list of all of the problems in both Maya and the English translations will be found in the appendix. They are listed in the same order as given to the subjects.

VI.2 Description of subjects

As mentioned before, the total number of subjects was 20. Of these, 3 were from the small town of Cansahcab and the remaining 17 from the nearby village of Santa Maria. These places are located about

40 miles northeast of Merida. Of the 20 subjects, 12 were male and 8 were female. Their ages ranged from 14 to 75 with a median of about 38. The education level was fairly low, from complete illiteracy to about a 6th grade education. I believe that all of the subjects spoke Maya as a first language. Some were monolingual with only a very rudimentary knowledge of Spanish, while perhaps 4 or 5 of them were about as fluent in Spanish as in Maya. In each case I inquired as to how much Spanish they knew, but the answers were not very reliable as it often turned out that they understood more Spanish than was originally admitted. In general, the male subjects spoke more Spanish than the female ones. I believe that about 6 of the subjects were essentially monolingual. The assistant was a man from Cansahcab, in his 40's, who was completely bilingual, although a few years of living in Merida seemed to have the effect of making it slightly easier for him to converse in Spanish than in Maya.

After the initial subjects had completed the tests, 4 of these were asked to repeat. In this second round I also gave the test to the assistant, who had been given none of the answers. These 4 were chosen because of high scores, a keen interest in what was going on, and a greater degree of articulateness than most of the other subjects. At this point these subjects received more explanation as to the purpose of the questions. Due to the previous extreme reluctance of all subjects to use the "can't know" option, an example was given at this point of a problem (of exactly the same form as one on the test) in

which the premises were inadequate for obtaining the conclusion. The reason for this phenomenon was also explained to them in some detail. In addition to simply answering the question as before, they were also asked this time to supply, whenever possible, some sort of reason for answering as they had done. One set of these responses is also included in the appendix along with the problems. These responses were given by a 20 year old woman whose score was relatively high, and who was perhaps the most articulate of all the subjects.

VI.3 Results of Hill-type experiment

First the results of the 28 Hill problems will be given. According to Hill, the mean score among 150 first, second, and third graders was 78.77% correct for the whole set of 100 problems. Since she gives the results for each problem it was possible to calculate the mean score among her subjects for the subset of 28 problems used in the Yucatan experiment. This comes out to be 81.50%, or slightly higher than the score as a whole. This is probably due to the fact that we placed more emphasis on problems using only a single rule of inference, although others requiring several rules of inference were also included. For the 50 first graders in Hill's experiment the results were 71.18% for the 100 problems and 73.79% for the 28 problem subset. Our scores were somewhat lower than Hill's for the same 28 problems. The mean score for the 20 subjects was 17.65 correct answers out of 28, or 63.04%. The second round of four subjects plus the assistant

produced a mean score of 22.80 out of 28, or 81.43%. This is comparable to the Hill mean score, but of course this group of 5 was specially selected.

Sex differences were only slight with females scoring slightly higher. The 12 males averaged 61.90% and the 8 females averaged 64.73%. The range of scores was much greater among male subjects, from a low of 11 correct answers to a high of 24, whereas the female subjects ranged between 16 and 21. Age differences were also not significant. The 9 subjects over 40 averaged 62.70%, while the 11 subjects under 40 averaged 63.31%.

For this study, it is of great interest to see what the results are for the different types of arguments. The following table tabulates the results for each of the 34 problems. The first column gives the problem number. The next column gives the symbolic form of the argument involved; the actual arguments are found in the appendix. The two question marks around the conclusion indicate that this part was given in question form. The next column gives the "correct" answer (i.e. according to our logic). The next three columns give the respective numbers of yes, no, and other answers. The "other" answers are generally of the "I don't know" or "who knows" type. In problem 10 the total number of answers is only 19 because this problem was inadvertently omitted in the case of one of the subjects. The next column gives the percentage of agreement between the subjects' answers and the correct answers. Note that for a few of the disjunction

problems, the correct answer depends on whether one uses inclusive or exclusive disjunction. In these cases, the exclusive disjunction results are given in parentheses below the results for inclusive disjunction. For comparison purposes the percentage of correct answers for Hill's subjects is given in the last column. This percentage is only approximate because she does not list the results for each problem, but only gives an average for all of the problems of exactly the same logical form.

	Form	Correct	Yes	No	Other	Corr	Hill
1	-p->-q, -p ?q?	no	0	20	0	100	90
2	p->-q, p ?q?	no	2	18	0	90	66
3	p->q, p ?q?	yes	12	6	2	60	94
4	pvq, -q ?p?	yes	10	10	0	50	94
5	p->q, q ?p?	c.k.	14	6	0	0	--
6	pvq, -p ?q?	yes	6	14	0	30	98
7	pvq, q ?p?	c.k. (no)	9	11	0	0 (55)	--
8	pv-q, -p ?q?	no	6	14	0	70	62
9	-pv-q, p ?q?	no	7	13	0	65	89
10	-pv-q, -p ?q?	c.k. (yes)	8	11	0	0 (42)	--
11	-pv-q, q ?p?	no	8	12	0	60	89
12	pvq->r, -r ?q?	no	7	13	0	65	90
13	-p->q, -q ?p?	yes	9	11	0	45	45
14	-p->-q, q ?p?	yes	13	7	0	65	80
15	p->q, -q ?p?	no	8	12	0	60	88
16	p->q, -p ?q?	c.k.	7	13	0	0	--
17	p->-q, -q->-r, p ?r?	no	3	17	0	85	88
18	-p->-q, -q->r, -p ?r?	yes	7	13	0	35	58
19	-p->-q, -q->-r, r ?p?	yes	10	10	0	50	74
20	p->q, q->r, -r ?p?	no	8	12	0	60	84
21	pvq, p->r, -r ?q?	yes	14	5	1	70	85
22	p->q, r->-q, r ?p?	no	11	9	0	45	83

	Form	Correct	Yes	No	Other	Corr	Hill
23	(x)(Px->Qx), Qa ?Pa?	c.k.	12	8	0	0	--
24	(x)(Px->Qx), Pa ?Qa?	yes	14	6	0	70	86
25	-(Ex)(Px&Qx), Pa ?Qa?	no	4	16	0	80	72
26	-(Ex)(Px&Qx), -Qa ?Pa?	c.k.	9	11	0	0	--
27	(x)(Px->Qx), -Qa ?Pa?	no	7	13	0	65	91
28	(Ex)(Px&-Qx) (x)(Px->Rx) ?(x)(Rx->Qx)?	no	8	12	0	60	76
29	(x)(y)(Px&Rxy->Qy) (y)(Sy->-Qy) ?(Ex)(Ey)(Px&Sy&Rxy)?	no	7	12	1	60	75
30	(x)(Px->Qxa), Pj ?Qja?	yes	11	8	1	55	91
31	(x)(Px->-Qx) (X)(Rxa->Qx) ?(Ex)(Px&Rxa)?	no	11	8	1	40	69
32	(x)(Px->Qx) (Ey)(Ry&(x)(Qx->-Lyx)) ?(Ey)(Ry&(x)(Px->-Lyx))?	yes	16	3	1	80	82
33	(x)(Fx->Lxa)&(Ey)(Fy&-Lyb) (x)(-Lxb->Lxc) ?(Ex)(Fx&Lxa&Lxc)?	yes	16	4	0	80	81
34	-(Ex)(Fx&-Lxa), Fb ?Lba?	yes	14	6	0	70	79

Let us now attempt to draw a few conclusions from these data. These will be quite tentative due to the small number of subjects and the large number of factors that could bring about the variations. Obviously the nature of the language involved is only one of many differences between the two groups of subjects involved.

First, we recall that the mean percentage of correct responses for the 28 Hill problems was 81.50% for Hill's group and 63.04% for the Yucatan group. This is a difference of over 18%, which is certainly

significant. There are a number of possible explanations for this difference. Some of these will be listed here, although no attempt will be made to decide on the correct explanation. Presumably it is a combination of several factors.

1. The difference in mean score may be largely due to linguistic differences involved. This hypothesis could be tested by using a control group from the same area. The control group should be similar in educational level, with the only difference being that they should be Spanish speaking and the test given under the same conditions only in Spanish. It might be difficult to find a good control group as there are generally socio-economic differences inherent in the class structure between Maya and Spanish speakers.

2. The difference may be due to the differences in administering the test. Basically there were two differences. One is that the Yucatan group was given three options (including the "can't know" option) for answering, whereas the Hill group had only two. At first glance this difference appears to be sgnificant as the expected percentage of right answers by pure guesswork drops from 50% to 33%. However, the third option was actually used in only 6 responses out of a total of 560. Even if all of these 6 had been correct the percentage would only have increased to 64.11%, still leaving a difference of 17%. The other difference in administration was that in Yucatan each subject was tested individually with at least two individuals, the assistant and myself, looking on. Although the subjects did not generally appear

to be noticeably nervous, the difference between this mode of administering the test and the relative anonymity of writing down the answers in a classroom may be quite significant.

3. There may have been a difficulty in understanding the directions. Our group received the same type of explanation as the Hill group. It seems that upon being told that each problem was to be treated as a story, they generally got the idea. However, there was still some confusion, as can be seen in problem 3. Unfortunately this problem deals with the weather, and it was difficult to persuade the subjects that it was a hypothetical situation and had nothing to do with their weather situation. Typical initial responses to this problem were, "I don't understand anything about the weather" and "The rain comes with the east wind" (which it generally does in Yucatan).

4. The difference may be due to different educational levels. As was mentioned earlier this group ranged in school education from none at all to the sixth grade level. The "average" level was probably not too different, i.e. about second grade, from Hill's group. However, it is not clear how to compare two years of education in a rural Yucatan school with two years in an urban California school? I assume the formal education advantage would be on the side of the Hill group.

5. There is also a difference due to the fact that Hill's subjects were currently in school. Of the Yucatan subjects only one was currently in school. Presumably a person doing the types of tasks

given in school ought to perform better on tests like this, even though the school curriculum is not directly concerned with formal logical reasoning.

6. There was a considerable age difference between the two groups of subjects. The Hill group were all between six and eight years old, while the Yucatan group were between 14 and 75. According to the Hill study scores increased with age (at least between six and eight years). This might seem to predict higher scores for the Yucatan group. However, the Hill study was only within a very narrow age group, and with subjects who also had increased schooling along with their increase in age. Within our group, between the over 40 and under 40 groups there was not much difference, scoring 62.70% and 63.31% respectively. However, as the cutoff age decreases, the gap widens. The 7 subjects under 30 averaged 67.86%; the 13 subject over 30 averaged 60.44%. If the cutoff is taken as 25 years old, then the 4 subjects under 25 averaged 73.21% whereas the 16 who were 25 and older averaged only 60.49% The age groups with the lowest scores were the thirties and fifties. Obviously the numbers of subjects are too small to come to any general conclusions.

7. The difference in scores is probably partly due to a large number of other socio-economic differences between the two groups of subjects.

VI.4 Results for different types of arguments

It is of considerable interest to this study to attempt to determine the relative success of using different types of logical rules. In order to do this we must examine the results for each problem, or at least each group of problems that use the same rules. One convenient way to divide up the 28 Hill problems is into the following groups:

A. Modus ponens -- problems 1-3, 17, 18

B. Disjunction -- problems 4, 6, 8, 9, 11

C. Modus tollens -- problems 13-15, 19, 20

D. Mixed propositional -- problems 12, 21, 22

E. Classical syllogism -- problems 24, 25, 27, 28

F. Other quantifier -- Problems 29-34

The following table shows the results for each group of problems and also the Hill results for each group. These latter are given so that we might have some idea as to how "inherently difficult" each type of problem seems to be.

Problem group	Yucatan mean score	Hill mean score
A	74	79
B	55	86
C	56	74
D	60	86
E	69	81
F	64	80

The Yucatan group did quite well on Group A. This seems to

agree with the fact that modus ponens arguments occur in the Mayan literature, as was seen in the preceding chapter. They did very poorly both in an absolute sense and compared with the Hill group on the problems of Group B. This is also in agreement with previous remarks in this paper about the relative paucity of disjunctions in Mayan writings. Even some of the better subjects seemed to have some difficulty understanding the disjunctive premises. In particular, the subject with the highest score tended to interpret the disjunctions as conditionals.

In the preceding chapter we saw examples of modus tollens arguments, which abound in the written literature. The results for Group C were somewhat mixed, however. On the one hand the group did rather poorly, but on the other hand this was also the type of problems with the lowest results for the Hill group. The results for Group D were rather poor compared to the Hill group. These problems require mixed applications of propositional rules. In general, the quantifier problems seemed to offer no particular difficulties. The differences here in Groups E and F between the two groups of subjects were consistent with the overall differences. Maya speakers seemed to have no problem understanding sentences with quantifiers. For example, in problem 34 the premise, "There is no one in our family who does not love John" appears. On the part of two of the subjects there was an immediate response of the type, "Oh, you mean everyone in our family loves John."

Let us turn our attention briefly to the six problems of the logical fallacy type. As we saw above, the 20 subjects made almost no use of the "can't know" option in answering the questions (only 6 such responses out of 680, 5 of the 6 being from the same subject). None of these 6 responses hit the mark. This is the same tendency, but to a greater extreme, that was reported in the O'Brien & Shapiro article. They report an extreme reluctance to use what they call a "not enough clues" option. Their subjects, also children of the same age group as in the Hill study, fell far short of the 33% score on those problems that they would have attained by random guessing. Consequently on our second round of testing (the assistant and four of the original 20 subjects), more emphasis was placed on this option, and an example explained to them in some detail. The frequency of this type of response, although still low, went up to 14 out of a total of 170 responses. The table below gives the six problems for which the "can't know" option is appropriate and the percentage of correct responses among the 5 subject. The results are still fairly low (23% average on these problems), but there seemed to be some recognition on the part of some of the subjcts of the fallacies involved. A perversely interesting fact is that the example explained to them (which apparently everyone understood) was of exactly the same form as problem 23. No one answered problem 23 correctly.

Problem	Correct
5	20
7	40
10	40
16	20
23	0
26	20

VI.5 Truth tables

Apart from the above experiments in logical arguments, I also attempted with a few of the subjects to construct truth tables for Mayan connectives. Starting out with simple atomic sentences expressing indisputable elementary anatomical facts, like numbers of hands and fingers, I tried to obtain truth conditions for compound sentences. In the case of negation they agreed on the usual interpretation, namely that if p is true then -p is false and if p is false then -p is true. In the case of binary connectives, however, the results were negative. The binary connectives -- conjunction, disjunction, and implication -- all received the same tables as we generally reserve for conjunctions. That is, if one component of a compound sentence is false then the whole sentence is false. The connecting words didn't appear to influence the outcome. When presented with statements of the form p&-p, pv-p there was a consensus that the first was false and the second true.

VI.6 Other logical inferences

A few other types of logical arguments, corresponding to commonly used rules of inference, were also tried with the 20 subjects. These were of the same type as the Hill problems except that some had only one premise, and then the question was asked. Some of these also represented indirect ways of obtaining truth functional definitions of connectives -- e.g. given the premise -p is it true that if p then q. The following table gives the forms of these problems and the results with the 20 subjects. The actual problems in English and Maya can be found in the appendix.

Problem	Form	Correct	yes	no	other	Percent
101	-p ?p->q?	yes	8	11	1	40
102	p&q ?p?	yes	13	7	0	65
103	pvq ?p?	c.k.	14	6	0	0
104	q ?p->q?	yes	14	5	1	70
105	p ?p&q?	c.k.	14	6	0	0
106	(x)(Px->Qx) ?(Ex)(Px&Qx)?	yes	15	5	0	75
107	(Ex)(Px&Qx) ?(x)(Px->Qx)?	c.k.	18	1	1	5
108	-(x)(Px->Qx) ?(Ex)(Px&-Qx)?	yes	16	4	0	80

Note: In problems 106 and 108 it is assumed that (Ex)Px.

In the case of problems 101 and 104 I doubt that the subjects really understood the problems. For problems 102 and 103 it is interesting that a slightly higher percentage inferred p from pvq than inferred p from p&q. In problems 106 and 107 the paradoxical result

that more people inferred "all" from "some" than the opposite direction is probably better explained by sociology than by logic. In problem 106 the premise is "All of John's friends are rich", while in problem 107 the premise is "Some of Joe's friends are poor". In general the subjects seemed to have difficulties understanding what was expected of them in this last group of problems.

VI.7 General conclusions from the experiment

It seems that the results of the experiment are not sufficiently definite to provide strong evidence for any general conclusions. On the one hand, the average score was considerably lower than that of the children used in the Hill experiment. This might be interpreted as providing very weak evidence for a logical relativity hypothesis. However, there are many other factors apart from linguistic differences that could have influenced these average scores. Some of these were already discussed above.

Another way of interpreting the results would be to decide that the average scores are really irrelevant for the issues at hand. Perhaps what should really interest us is not the average score, but the best scores. Ideally one might argue that if some of the subjects scored very highly, then this would indicate that the same arguments which are valid in European languages are also valid in Maya. The fact that the "average" Maya speaker cannot understand the arguments is no reason to suppose them not valid in that language. This is certainly

true in European tradition. Logical systems have not usually been constructed by asking the man in the street whether certain arguments are valid.

Looking at the problem from this point of view, let us examine the higher scores on the 28 Hill problems. Two of the subjects scored 25 out of 28 and one scored 24 out of 28. One of those scoring 25 was the assistant, who had gone through the test 20 times before taking it. Although he was not given the answers before taking the test he probably guessed some of them from watching my reactions with previous subjects, so it is not really fair to include his score. Of the other two top scorers one was apparently completely bilingual and the other was reasonably fluent in Spanish (although not nearly as much as in Maya). It might be argued that knowledge of Spanish was an influence in their ability to answer. The two subjects scoring 22 and 21 had a fair knowledge of Spanish but spoke it somewhat hesitantly. Some monolinguals scored 19 and 20.

For the case of problems expressing valid arguments these results show considerable agreement with what we take to be the correct conclusions. Many of the comments of the higher scoring subjects also indicated that they basically understood the problems and made their inferences in the same way as European language speakers would. Some exceptions to this have already been pointed out. In general, the very highest scores were obtained by people who also had a fairly good knowledge of Spanish. This might be because of a Spanish influence in

their interpretations of the problems, which would tend to invalidate our conclusions here. On the other Hand, it might also be because there is probably a tendency in Yucatan for the more intelligent Maya speakers to learn Spanish.

Chapter VII

Conclusions

VII.1 Partial answers to initial questions

This chapter will list a few conclusions that have been reached during the course of this study. A good place to start is with the questions that were posed at the beginning. These are found on pages 2-3 of the present work. Let us see to what extent these have been answered. The first question can be interpreted in two ways. If we want to know whether Maya has terms meaning "logical", "truth", and "inference", then the question has not been answered. As we saw in Chapter 3, there are definitely terms for "truth" which include abstract truths. I have not really seen any terms that could be naturally translated as "logical" or "inference", but since Spanish priests were able to formulate most of the Christian metaphysics in Maya we could probably come up with some phrases that would express the idea. If, on the other hand, we merely want to know whether what we would call "logical truths" and "logical inferences" exist in Maya, then the answer is affirmative. Inferences are easily found and seem to be recognizable as such by native speakers. Logical truths are generally more artificial. The only one that was understood and assented to was pv-p. This seems to be a general feature of logical truths, however, and not peculiar to speakers of this language.

The second question is primarily one of whether adequate terminology exists in Maya. Chapter 3 shows that this terminology does exist for most of the usual first-order logic with equality -- with two possible exceptions. No terminology naturally corresponds to biconditionals, and sentential disjunctions are not often found. The latter, i.e. sentential disjunctions, seem to cause some confusions with conditionals. Theoretically in standard logic both of these can be eliminated, i.e. all logical truths and valid inferences can be derived without using these connectives. This answer is not completely satisfactory since both of these play significant intuitive roles in the development of logic. In the case of biconditionals the absence is not significant, as we can easily formulate p<->q as (p->q) & (q->p) in Maya. The problem with disjunctions seems to be not that they cannot be formulated, but that the formulations cause some confusion in practice. If we extend our basic problem to include modal and other logics built upon first-order logic, then the answer still seems to be affirmative. These logics have not been discussed in this work, but the necessary terminology seems to be adequate in Maya. For example, if we consider basic modal and epistemic logic then we have the following terms in Maya:

necessary -- <u>kabet</u>

possible -- <u>uchac</u>

know -- <u>ohel</u>

believe -- <u>ocan</u>

These terms seem to adequately express the ideas that their English counterparts express. They usually immediately precede the clause that they qualify. In summary, I believe that the answer to the second question is "yes".

Of course it is one thing to be able to express all logical truths and inferences and another to agree that they are really valid in some sense. I am not sure what the answer to the third question is (if we mean "really convince" rather than merely "elicit assent"). The results of Chapter 6, which deals with this problem to some extent, were somewhat mixed. In order to see whether a Maya speaker could be convinced, one would have to find a sufficiently intelligent monolingual who would not be convinced merely by authority. The difficult part of this process is to find one who is not convinced by authority. In this paper, there is only fairly weak evidence that in general, Maya speakers seem to recognize the validity of most of our logically valid inferences. Chapter 5 also provides some evidence that many of our inferences are implicitly used in native texts.

The fourth and fifth questions have not really been investigated. I have found at least one clear case of a use of what we would call an invalid inference in the native literature, but there is no particular reason to believe that it would be seriously proposed as valid reasoning in Maya. Experimental work also produced some unorthodox truth functional definitions, but there is good reason to believe that this was due to a misunderstanding of the problem posed.

These same sorts of problems occur frequently in English, but the parties concerned can usually be made to see the error of their ways. I am not at all sure how one would methodically look for serious inferences other than those that we usually take to be valid. This point will be brought up again later in this chapter.

I believe that the sixth question can be answered affirmatively. Chapter 4 shows that at least for the case of the usual predicate and sentential logics, our symbolic notation is at least as natural and plausible for Maya as it is for English. In some case it was shown to correpond more naturally to Maya. This statement can also be extended to modal logic. There is a sense in which both Russell (quoted on page 5) and von Bertalanffy (quoted on page 4) overstate their cases, although both formulate their hypotheses cautiously. The subject-predicate logic could very well have been invented by a Maya speaker, at least the formal part of it. It might be that the associated metaphysic is peculiar to speakers of Indo-European languages as Russell suggests; I have not seen a convincing argument as to whether subjects and predicates in Maya perform the same functions as they do in English, for example. Probably they do not fit all of our criteria (whatever those may be) for being called such. However, I believe that this is not really relevant to questions of constructing symbolic languages. As has already been mentioned in Chapter 4 one might not wish to call the relevant parts of a Maya sentence "subject" and "predicate", but formally speaking they can be construed as such.

At least in this sense, Indo-European languages are not as exceptional as Russell and von Bertalanffy (as well as many others) have thought them to be, nor are the symbolic languages that we have constructed as provincial as they have often been presented. The logic of relations also seems to have a natural formulation in Maya; the so-called transitivizing suffixes make good relation markers. In general the symbolic languages that have been constructed abstract away many of the idiosyncrasies of European languages. For this reason we have been able to fit them reasonably well to Maya. I am not claiming that this can be done with every natural language. But the fact that Maya, with a greatly different grammatical structure and an independent historical development corresponds fairly well to our usual symbolism makes this symbolism seem a great deal less regional.

In a sense this leads us into a possible answer to the seventh question. A Maya logician might very well have invented a system of symbolic notation much like ours. There would probably be some differences, e.g. instead of a sign for disjunction as is the case in our most commonly used symbolic languages there might be a sign for joint denial. Of course the development of the alphabet has greatly influenced the development of our symbolic languages. This would mean that the Maya logician's symbols would be completely different, but in a formal sense the systems might be isomorphic or at least homomorphic. There seems to be nothing in the Maya language that would make this possibility implausible. The big problem here is the following: If a

Maya speaker were to characterize a set of logical truths or inferences, subject to the same conditions as our logic (truth preserving conditions), would the usual features of logic (i.e. our set of logical constants, predicates, variables, etc.) seem relevant to him? I think that there is no real linguistic restriction that would prevent this possibility, but it is not really clear as to whether he would be naturally compelled to come up with the same relevant concepts. For this seventh question I believe that I have shown that it would not be unreasonable for a Maya logician to have built up similar systems of symbolic logic; I have not given any reasons why he should do so.

The eighth and ninth questions were partially answered in Chapters 5 and 6. There has been no systematic attempt to list the types of inference as the analysis of arguments found in texts depend on our (shaky) assumptions as to what is involved in these arguments, and the results of the experiment were not sufficiently convincing. It appears that the common inferences involving negation, implication and quantifiers are generally considered valid in Maya.

VII.2 Comparisons with Chinese logic

At this point I would like to discuss a few connections between the present study and some of the work that has been done on Chinese logic. It is a popular belief that logic in ancient China was a seriously neglected field of study. A common explanation of this

phenomenon is that this is due largely to the structure of the Chinese language itself (especially ancient Chinese). I believe it is true that Chinese logical theory never developed even to anywhere near the level of Aristotle's writings on logic. However, there are numerous examples of complicated, logically correct arguments in Chinese philosophy and other writings. It appears that these have not always been recognized as such for at least two reasons. One reason is that many Sinologists have only had a minimum of training in classical logic and no training at all in modern symbolic logic. Consequently, if an argument does not fit the form of one of the classical syllogisms, it has often not been recognized as a logical argument. Apparently not very many Chinese arguments do fit into these forms. Chmielewski (I, p.15) says,

> Contrary to Kou Pao-koh and J. Needham, I do not know of any clear example of syllogistic reasoning in ancient Chinese texts. Moreover, Kung-sun Lung's theory of classes and the form of his reasonings as well are by no means typical of early Chinese philosophy; they appear to have been characteristic of the group of 'dialecticians' in which Kung-sun Lung was a prominent figure, if not characteristic of this particular thinker alone. As will be seen later on, much more common and typical methods of reasoning actually to be found in ancient Chinese texts are those which can be best interpreted in terms of the calculus of propositions and the calculus of functions.

Another reason is that epistemological mistakes are often confused with logical mistakes. The fact that a conclusion is either wrong or highly suspicious in a Chinese philosophical argument is often attributed to

the invalidity of the argument itself, whereas more generally the mistake is actually in supposing the premises to be true.

There are many interesting similarities between the conclusions that Chmielewski has reached about logical reasoning in Chinese and the conclusions to which I have come in this study about logical reasoning in Maya. This does not mean that reasoning in the Maya texts to which I have had access approached anywhere near the level of sophistication of the arguments in ancient Chinese texts. This is understandable, since in the Chinese literature there are many texts intended to be philosophical, whereas the few Maya texts that we have at present generally deal with other topics and only contain some philosophical passages as by-products.

An example of the similarity of Chmielewski's conclusions to my own is the above quotation. The part about absence of strict classical syllogisms and suitability of propositional and functional calculi is in general agreement whith what I have found in Maya. However, native Maya speakers did perform reasonably well on the classical syllogisms included in the experiment of Chapter 6. Another similarity between Chmielewski's conclusions and the ones of this work is apparent from the following quotation (II, p.103).

> As we have seen, early Chinese possessed a considerable number of linguistic means...to express and emphasize the conditional sequence largely corresponding to what is implication in logic and what, by the way, is the most fundamental logical operation. Thus, we are not surprised that it is precisely the implication -- together with a few simple and self-evident logical laws concerning

> it -- which is so largely exploited in Chinese propositional logic, namely in the form of the so-called chain-reasoning. On the other hand, the lack of a specific word for 'and' in Chinese could not be a serious obstacle to the extensive use of the operation now known as logical product (actually invoved in the chain-reasoning) since, first, the operation was regularly expressed by mere juxtaposition (which latter, consequently, was felt as a specific means to this purpose), second, the operation itself is so elementary that practically any form of reasoning (and of thinking in general) would be impossible without it. But not so with some less elementary and less self-evident logical operations for which Chinese had no common and adquate grammatical word (directly corresponding to the appropriate logical functor).
>
> Now, the student interested in the logical analysis of early Chinese texts is struck by the fact that the logical sum or alternative ("pvq", that is to say "p or q") plays so insignificant a role -- if any -- in Chinese reasoning; at any rate, it does not belong to the stock of operations constituting early Chinese propositional logic. Consequently, we can take it for granted that the very operation itself escaped the Chinese thinkers.

This agrees to a great extent with many of the statements made in this work about propositional connectives in Maya.

The general conclusions of Chapter 4 about the degree of correspondence between many aspects of the structure of Maya and the structure of the common symbolic languages are also in the same vein (although somewhat more cautious) as some of Chmielewski's remarks about Chinese. For example, (IV, p.103)

> Such characteristic features of early Chinese as monosyllabism of lexical units, lack of inflections and lack of clearly delimitated grammatical word-classes (especially the lack of a clear morphological distinction between nominal and

> verbal forms) could hardly have any negative bearing on Chinese implicit logic; in fact, they are beneficial rather than detrimental to this logic, since they make the Chinese language more similar to the symbolic language of modern logic than any tongue of the Indo-European type can claim to be. This latter point seems to be of special importance in connection with the (implicit) logic of functions, -- and it is precisely this topic which is to be dealt with presently.

Chmielewski then goes on in the next several pages to argue for these conclusions. I find his arguments plausible and provocative, but not totally convincing. As they are only partly relevant to Maya they will not be examined here. The aspects of Maya which I have found to correspond very closely to symbolic languages have been discussed in both Chapters 3 and 4 above.

VII.3 Conclusions about Whorf hypothesis

Keeping in mind the four levels of the Whorf hypothesis described on pages 7-10 above, let us now see what sorts of evidence the present study has provided relevant to this hypothesis. With respects to levels 1 and 2, which deal with vocabulary, perhaps the only noteworthy differences between English and Maya are that disjunctions occur only rarely and that the lack of a copula might make set theoretic types of statements very awkward to formulate. Juxtaposition seems to do the job, but perhaps it does not clearly distinguish between the membership and subset relations. There seems to be some confirmation for Level 2 in the fact that we saw in Chapter

6 that apparently Maya speakers do have difficulties in reaching "correct" conclusions in (to us) relatively simple arguments involving disjunctions. The effect of linguistic structure on actual reasoning has not been really tested here. What has been shown is that the relevant aspects of Maya grammatical structure are reasonably close to the symbolic forms of logical representations of sentences (and not that different from English). There seems to be no reason why the differences in Maya grammatical structure should affect logical reasoning. One point worth mentioning here however, is that syllogisms do not seem to occur in Maya texts (at least not in a transparent form). This may be due to the fact that the lack of a copula prevents these arguments from arising as naturally as they seem to in European languages.

Thus on certain points there seems to be a small amount of evidence in favor of the Whorf hypothesis. However, if the hypothesis is to be taken very literally such that every difference involving logical constants should correspond to some difference in logical reasoning, then the evidence is largely negative in this study. I would like to suggest however, that on the whole, there seems to be relatively little divergence on significant points between Maya and English in matters relevant to logic. Both of them have enough flexibility so that only some minor transformations are necessary to have corresponding sentences be in the same logical form. The really significant conclusion is that although there are generally many

differences between the languages, these differences are not ones that would seriously affect logic. The situation seems to be (at least for this language) not that the implications of the Whorf hypothesis for logic are true or false, but that this hypothesis has turned out to be not really relevant here.

VII.4 Conclusions about conventionalism

If we assume that the conclusions about logic in Maya that have been reached in this study are correct, then they would tend to refute the conventionalist view. If, as the conventialists believe, logical truths are only convincing because of the conventions of language, then presumably languages developing independently would generate different types of logical truths. However, the evidence here seems to indicate that there is no reason to think that our logical truths do not carry over into Maya. At least the similarity seems to be too great in general to be merely due to coincidence. Even though there may be a few logical differences between Maya and European languages, the important point is that Maya has an adequate set of connectives and quantifiers for expressing all logical truths. The examples of implicit logic we have seen together with the experimental evidence indicate that a (formally) complete system of logic incorporating only axioms and rules accepted by Maya speakers could probably be constructed in Maya. Admittedly the present study has not been systematic enough to actually prove this point, but I believe that it has been made extremely plausible.

VII.5 Criticisms and suggestions for further research

Probably one of the chief limitations of this study has been that the choice of terms to be examined was already predetermined by the traditions of European logic. Rather than build up a system of logic from "inside" the Maya language, I have already assumed that I knew which portions of the language would turn out to be relevant and then showed to what extent these portions could be handled like similar items in English. As I pointed out in Chapter 1, this sort of approach is not necessarily meant to be the end of research, but merely a beginning. It has often been pointed out by Tarski and others that in a sense our logic largely depends on the type of terms that are initially deemed to be relevant. Unfortunately this problem has not been dealt with, to my knowledge, in a very systematic way. However, much of the work of modern logic might be viewed as an attempt to expand our logically relevant vocabulary. It is conceivable that an "internal" construction of logic in a language like Maya could have interesting implications for logic in general. Perhaps nothing would be developed that couldn't have been developed in European languages, but certain things might be more naturally suggested. An example of the type of thing I have in mind is the following, which is not put forth for reasons of great logical importance, but merely as an illustration.

Consider the Maya particle ua, which has appeared often during the course of this study. I assume that it is no accident that the

same particle is used in the following ways (Martinez Hernandez, p.883).

1. At the beginning (or occasionally in the middle) of a sentence it is the conditional "if". (See Chapter 3.)

2. In the middle of a sentence (often appearing for the second time) it often means "or". (See Chapter 3.)

3. Prefixed to an interrogative particle it makes that particle indefinite.

Ma in uohel uamac chhai in nok.

I don't know who took my clothes.

4. Postfixed to the topic of the sentence it makes that sentence interrogative (usually of the type requiring a yes-no answer). Many examples of this usage are found in the appendix.

5. Postfixed to the topic of an answer to a question it expresses uncertainty.

Taba u benel Pedro? Taba ua.

Where is Pedro going? I don't know where.

6. Ua often expresses uncertainty in other types of sentences.

Ma uchac in ximbal, bal ua yan ten.

I can't walk, I don't know what thing I have.

7. Ua sometimes means "to lie".

Ua u cah Juan. -- Juan often lies.

Essentially all of the uses of ua have something in common, namely there is some sort of doubt or uncertainty expressed or implied

in all of them. In conditionals of the type "if p then q" we often imply that we don't know whether p is true, but if it is then q is true. In disjunctions we generally imply that we don't know which of the disjuncts is true. In the case of a lie, it is often dubious what the truth really is. For the cases 3-6 it is obvious how uncertainty is expressed by ua.

The point of the example is that Maya has a single particle that brings together all sorts of sentences in which uncertainty is expressed. This naturally seems to suggest a logic of dubitatives, which is not so naturally suggested in English. I am uncertain whether such a logic would be fruitful or not (ma in uohel ua...). Another example along the same lines could involve the existential particle yan, which also has a number of different but related uses (see Chapter 3).

A systematic study of examples of this type in different languages could eventually have implications of some interest for the study of logical reasoning. I believe that collaboration between logicians and anthropological linguists would probably turn out to bring up some interesting problems and perhaps offer a few solutions to present problems in the foundations of logic.

Appendix I

This appendix lists the actual problems given in the Yucatan experiment described in Chapter 6. In the first 34 problems the problem is stated first in Maya, followed by the response of Maria Paulina Tun. Then the English translations of the problem and the response are given. In problems 101-108 only the Maya and English versions of the problems are given.

1. Ua Jorge minan 7 habtie matun yet habil Juani. Jorge minan 7 habti. ?Yet habil uatun beyo?

Ans: Ma yet habili tumen ma u mismo kin ca anhi.

1. If Jorge is not 7 years old then he is not the same age as Juan. Jorge is not 7 years old. ?Are they the same age?

Ans: They are not the same age because they were not born at the same time.

2. Ua Jose cu bin te alcabo Juane ma tun ganar. Jose yan u bin te alcabo. ?Yan uatun u ganar Juan?

Ans: Ma, matun ganarnac tumen ma bin letiobi.

2. If Jose enters the race Juan will not win. Jose is going to enter the race. ?Will Juan win?

Ans: No, he will not win because they are not going.

3. Ua le ik cu hopsic chikino he u tale yun chaco. Le iko tun hopsic te chikino. ?Nu ca ua tal le chaco?

Ans: Uatun hu tale, uatun ma, ua cu sut yikale min hel u tale.

3. If the wind blows from the west it will rain. The wind blows from the west. ?Will the rain come?

Ans: It might come or it might not. If the wind blows very hard then I believe it will come.

4. Te chan cineo Minguele he u ua betic u nochil le indiobo ua u nochil le soldadobo. Minguele matun u bet u nochil le soldadobo. ?U nochil uatune indiobo?

Ans: Min yan u mentico un nochile de indiobo, tumen ma tu betah le soldadobo.

4. In the movie Miguel will be either an Indian chief or a soldier chief. Miguel will not be a soldier chief. ?Will he be an Indian chief?

Ans: I believe he is an Indian chief, because he was not a soldier.

5. Ua le ik cu hopsic chikino he u tale yun chaco. Nu ca tale chaco. ?Le iko chikin ua u tal?

Ans: Yan u tale chaco, pero ma coheli macalmac cun taci uatun te lakino uatun te chikino cun taco.

5. If the wind comes from the west then the rain will come. The rain comes. ?Does the wind come from the west?

Ans: The rain has to come, but no one knows whether the wind comes from the east or from the west.

6. U tata Pabloe tu dza diezti ua veinte. U tata Pabloe ma tu dza hunppel diezti. ?Tu dza ua hunppel veinte ti?

Ans: Ma tu dza diezti, tumen yan ca tu dza hunppel veinte ti.

6. Pablo´s father gives him either a dime or a quarter. Pablo´s father does not give him a dime. ?Does he give him a quarter?

Ans: He does not give him a dime because he must give him a quarter.

7. U tata Pabloe tu dza diezti ua veinte. U tata Pabloe tu dza veinte ti. ?Tu dza ua diez ti?

Ans: Ma, ma tu dza ti tumen mix diez mix veinte tu dza ti.

7. Pablo´s father gives him either a dime or a quarter. Pablo´s father gives him a quarter. ?Does he give him a dime?

Ans: No he does not give it to him, because he gives him neither a quarter nor a dime.

8. Ua Gabriel tian kiuice ua minan yetel Jaime. Gabriele minan kiuic. ?Tian uatun yetel Jaime?

Ans: Ma, minan tumen minan Jaime te kiuico.

8. Either Gabriel is in the park or he is not with Jaime. Gabriel is not in the park. ?Is he with Jaime?

Ans: No he is not, because Jaime is not in the park.

9. Ua minan huntul in cic ua minan huntul in zucuun. Yanten huntul in cic. ?Yan ua huntul in zucuun?

Ans: Ma, minan tumen si minan mixhuntul in lakob.

9. Either I don´t have a sister or I don´t have a brother. I have a sister. ?Do I have a brother?

Ans: No I have not, because there is not even one in my family.

10. Ua minan huntul in cic ua minan huntul in zucuun. Minan huntul in cic. ?Yan ua huntul in zucuun?

Ans: Ma, mixhuntul yani tumen minan in cic, minan in zucuun.

10. Either I don´t have a sister or I don´t have a brother. I don´t have a sister. ?Do I have a brother?

Ans: No, I have not even one, because I have no sister, I have no brother.

11. Ua Petra ma ustich u chac noko ua ma ustich u kankan noko. Petrae ustich le kankan noko. ?Ustich uatun le chac noko?

Ans: Ma, ma ustich u chac noko, mas ustich u kankan noko.

11. Either Petra doesn´t like red clothes or she doesn´t like yellow clothes. Petra likes yellow clothes. ?Does she like red clothes?

Ans: No, she doesn´t like red clothes, she likes yellow clothes more.

12. Uatun las ocho ua las dieze le campanao hu paye. Le campanao ma tu pay beora. ?Las diez ua beora?

Ans: Ma, ma las diezi. Ua las dieze he u paye.

12. If it is either 8:00 or 10:00 the bell will ring. The bell does not ring now. ?Is it 10:00 now?

Ans: No, it is not 10:00. If it were 10:00 the bell would ring.

13. Ua le exo ma yaxe in uex. Le exo ma intiali. ?Yax ua le exo?

Ans: Ma, ma yaxi tumen ma intiali.

13. If the pants are not green then they are my pants. The pants are not mine. ?Are the pants green?

Ans: No, they are not green because they are not mine.

14. Ua ma marzoe ma u kin u kaba Juanai. U kin u kaba Juana. ?Marzo uatun?

Ans: Ma, ma marzoi tumen ma leti u mes cu man u kin u kaba letio.

14. If it is not March then it is not Juana's birthday. It is Juana's birthday. ?Is it March?

Ans: No, it is not March because it is not the month in which Juana's birthday falls.

15. Ua in uala peke box. Le peko ma boxi. ?Lela in uala pek ua?

Ans: Ma, ma in uala peki, ua boxe si in uala pek, pero le hela como ma boxi bix tun cin in ualic ua in uala pek.

15. If that is my dog then it is black. That dog is not black. ?Is it my dog?

Ans: No, it is not my dog, if it were black then it would be my dog, but since it is not black how will I say whether it is my dog.

16. Ua in uala peke box. Lela ma in uala peki. ?Box uatune peko?

Ans: Ma, ma boxi tumen lela ma in uala peki.

16. If that is my dog then it is black. That is not my dog. ?Is the dog black?

Ans: No, it is not black because it is not my dog.

17. Ua David tu hunale matun man chumuce beo. Ua David matun

man chumuce beo matun u yil Juanai. Davide tu hunal. ?Davide cilic uatun Juana?

Ans: Ma, ma tun yil Juana tumen matun man te mismo beo.

17. If David is alone then he does not cross the road. If David does not cross the road then he does not see Juana. David is alone. ?Does David see Juana?

Ans: No, he does not see Juana because they do not pass on the same road.

18. Ua ma las cincoe Juane minan tu tana. Ua Juan minan tu tanae minan xan yala peki. Ma u dza las cincoi. ?Bin ua yala pek Juan?

Ans: Ma, minan leti hasta u tale Juane cu tal yala pek xan.

18. If it is not 5:00 Juan is not at home. If Juan is not at home then his dog is not there either. It is not 5:00. ?Is the dog gone?

Ans: No, he is not, until Juan comes his dog comes also.

19. Ua le xchupal minan u tzotzel u hol boxe ma in cici. Ua le xchupal ma in cico ma u cic xan Juani. Le xchupalo u cic Juan. ?Yan uatun u tzotzel u hol box?

Ans: Yan, tumen u cic Juan.

19. If the girl does not have black hair then she is not my sister. If the girl is not my sister then she is not Juan's sister either. The girl is Juan's sister. ?Does she have black hair?

Ans: Yes, because she is Juan's sister.

20. Ua lunese Margaritae bihan xoc. Ua Margarita bihan xoce Panchoe bihan xoc xan. Panchoe ma bihan xoci. ?Lunes ua behelae?

Ans: Ma, ma lunesi tumen ua lunese behelac bihan xoce.

20. If it is Monday then Margarita went to school. If Margarita went to school then Pancho also went to school. Pancho did not go to school. ?Is today Monday?

Ans: No, it is not Monday, because if it were Monday they would have gone to school.

21. Jose uatun u mas canlil ua Juan u mas canlil. Ua Jose u mas canlile mas canal ti Jaime. Jose ma mas canal ti Jaime. ?Juan uatun u mas canlil?

Ans: Leti, Juan mas canlil, tumen Jaime leti mas cablil.

21. Either Jose is the tallest or Juan is the tallest. If Jose is the tallest then he is taller than Jaime. Jose is not taller than Jaime. ?Is Juan the tallest?

Ans: Yes, Juan is the tallest, because Jaime is shorter than he.

22. Ua le miz zaco a uala miz. Ua le miz yab u tzotzelo ma a uala mizi. Le mizo hach yab u tzotzel. ?Letie ua miz zaco?

Ans: Ma, ma letie zaco, tumen ua letie zaco leti ma yab u tzotzeli, en cambio le hela hach yab u tzotzel.

22. If the cat is white it is your cat. If the cat is furry it is not your cat. The cat is very furry. ?Is the cat white?

Ans: No, it is not white, because if it were white then it would not be furry, however it is very furry.

23. Tulacle libroso xoco de historiao la tianob te mesao. Le chac libro tian te mesao. ?Letie ua chac libro de historiao?

Ans: Letie chac libro yan te mesa, porque ua ma letie chac libro minan te mesao.

23. All of the history books are on the table. The red book is on the table. ?Is the red book a history book?

Ans: Yes, the red book is on the table, because if it were not a red book then it would not be on the table.

24. Tulacle libroso xoco de historiao la tianob te mesao. Le chac libro de historiao. ?Tian ua chac libro te mesao?

Ans: Tiani tumen el libro es de historia, tian te mesa y tian xani chac libro de historiao.

24. All the history books are on the table. The red book is a history book. ?Is the red book on the table?

Ans: It is, because it is a history book, it is on the table and the red book is also a history book.

25. Mixhuntul u cicob Jose yanob uaye behelae. Mariae u cic Jose. ?Uay ua yan Mariae?

Ans: Ma, minan uaye pero u cic le hele.

25. None of Jose's sisters is here today. Maria is Jose's sister. ?Is Maria here?

Ans: No, she is not here but she is his sister.

26. Mixhuntul u cicob Jose yanob uaye behelae. Estelae minan uay behelae. ?Le Estelao u cic ua Jose?

Ans: Leti u cic pero chen bale minan leti uaye.

26. None of Jose´s sisters is here today. Estela is not here today. ?Is Estela Jose´s sister?

Ans: She is his sister, but only thing is she is not here.

27. Tulacle mehen palalob yanob tanao la yan 7 anos tiob. Anae minan 7 anos ti. ?Tian Ana ua tanae?

Ans: Ma, minan tumen ua tianic kabet u yantale 7 anos xan tiob.

27. All of the children in the house are 7 years old. Ana is not 7 years old. ?Is Ana in the house?

Ans: No, she is not because if she were she would have to be 7 years old too.

28. Yan hunhunppel le kaiob ohelon minan te discosobo. Tulacle kaiob ohelon la tian te cancioneroo. ?Tulacle kaiob yan te cancioneroo tianob ua te discosobo?

Ans: Ma, bix tun cun haber antal te discos si minani, bax yane te cancioneroo pero chen bale ma cohel tulacali.

28. Some of the songs we know are not on records. All of the songs we know are in the music book. ?Are all of the songs in the music book on records?

Ans: No, how then are they on records if there is not what there is in the book. But only thing is we don´t know them all.

29. Le palalob de cuarto ano chen cu baxlob futbol yetel u yetxocilob de quinto ano. Le palalob chac nokobo ma de quinto anobi. ?Cu baxa tun ua le palalob de cuarto ano yetel yetpalalilob u dzama u chac nokobo?

Ans: Ma, ma tu baxli tumen ma iguali chacile nokobi.

29. The fourth grade boys only play football with the fifth grade boys. The boys with the red clothes are not in the fifth grade. ?Do the fourth grade boys play with the boys wearing red clothes?

Ans: No, they don't play because they are not the same (age?) as the ones wearing red clothes.

30. Tomase cu thanic hemacal mace yan u chac nok tial u baxlobo. Julioe u dzama hunppel u chac nok. ?Tomase he ua u thanic Julioe?

Ans: Yan, yan u thanic tumen leti bey u kaio, leti yan u chac noko.

30. Tomas chooses anyone wearing red clothes for his team. Julio wears red clothes. ?Does Tomas choose Julio?

Ans: Yes, he has to choose him because, he wears red clothes.

31. Mixhuntul in lakob yan u tanao nadz ti escuela. Pabloe chen cu conic uah tie macob cahacbalob nadz tie escuelao. ?Pabloe cu conic uatun uah tin lakob?

Ans: Ma, ma tu conic ti, si mixhuntul in lak cahacbal tu banda le escuelao bixtun cun u conic uah ti.

31. None of my family has a house near the school. Pablo only sells bread to people living near the school. ?Does Pablo sell bread to my family?

Ans: No, he does not sell to them, if none of my family lives in the direction of the school how then could he sell bread to them.

32. Tulacle palalob escuelailobo cu baxicob bola. Yan

xchupalobe ma ustichob u baxa bola mixhuntul xipalobi. ?Yan uatun xchupal ma ustich mixhuntul xipal te escuelao?

Ans: Yan xchupale ustich huntul xipal, pero ma ustituthane baxnac xan yetelo bola.

32. All of the boys in the school play ball. Some girls do not like any boys who play ball. ?Is there a girl who does not like any boy in school?

Ans: Yes, there is a girl who likes a boy, but does not like to play ball with them.

33. Tulaclu lakob Juanae ustuthano buul pero yan u lakobe u ppecmao uah. Tulacle macob u ppecmao uah ustuthano cafe. ?Ichil u lako Juanae yan ua ustuthan buul yetel cafe xan.

Ans: Yan, yan ustuthan buuli, yan ustuthan uahi, yan ustuthan cafe, tumen ma igualobi u tuculobi.

33. All of Juana's family like beans but some of her family hate bread. All people who hate bread like coffee. ?Do some of Juna's family like beans and coffee too?

Ans: Yes, some like beans, some like bread, some like coffee, because they don't all think alike.

34. Minan ichil clakobe ma yacunto Juan. Robertoe clak. ?Robertoe u yacuma ua Juan?

Ans: Leti, Roberto u yacuma Juan tumen u lak.

34. There is no one in our family who does not love Juan. Roberto is in our family. ?Does Roberto love Juan?

Ans: Yes, Roberto loves Juan because he is in the family.

101. Juane minan u tana. ?Hah uatun: uatun Juan yan u tanae nohoch?

101. Juan does not have a house. ?Is it true that if Juan has a house then the house is big?

102. Juane yan u yala tzimin, Jose yan huntul u tzimin xan. ?Yan uae yala tzimin Jose?

102. John has a horse and Jose has a horse too. ?Does Jose have a horse?

103. Ua yan pek ti Juane ua yan pek ti Jose. ?Yan ua yala pek Juan?

103. Either Juan has a dog or Jose has a dog. ?Does Juan have a dog?

104. Jose yan u mascab. ?Hah uatun: uatun Juan yan u mascabe Jose yan u mascab?

104. Jose has a machete. ?Is it true that if Juan has a machete then Jose has a machete?

105. Juane yan hunppel u ppoc. ?Hah uatun: Juane yan u ppoc Jose yan xan u ppoc?

105. Juan has a hat. ?Is it true that Juan has a hat and Jose also has a hat?

106. Tulaclu yet meyahob Juane la alliklob. ?Ichil u yetmeyhulo Juane yan ua alliklobi?

106. All of Juan's colleagues are rich. ?Are some of Juan's colleagues rich?

107. Ichil u yetmeyhulo Jose yan otzil macobi. ?Tulaclu yet meyhulo Jose otzilob ua?

107. Some of Jose´s colleagues are poor. ?Are all of Jose´s colleagues poor?

108. Ma tulaclu yetmeyhulob Juan yan u tzimnobi. ?Yan ua ichil u yet meyhulob Juan minan u tzimno?

108. Not all of Juan´s colleagues have horses. ?Do some of Juan´s colleagues not have horses?

References

1. Andrade, M. -- "A grammar of modern Yucatec", University of Chicago Microfilm Collection of Manuscript Materials on Middle American Cultural Anthropology 41, 1956

2. von Bertalanffy, L. -- "An essay on the relativity of categories", Philosophy of Science, vol. 22, 1955, pp. 243-263

3. Blair, R. -- Yucatec Maya Noun and Verb Morpho-syntax, Ph.D. dissertation, Indiana University, 1964

4. Blair, R. & R. Vermont Salas -- "Spoken Yucatec Maya", University of Chicago Microfilm Collection of Manuscript Materials on Middle American Cultural Anthropology 65, 1965

5. Brinton, D. -- The Maya Chronicles, New York, 1969

6. Chmielewski, J. -- "Notes on early Chinese logic (I)", Rocznik Orientalistyczny, vol. 26, 1962, pp. 7-21

7. Chmielewski, J. -- "Notes on early Chinese logic (II)", Rocznik Orientalistyczny, vol. 26, 1963, pp. 91-105

8. Chmielewski, J. -- "Notes on early Chinese logic (IV)", Rocznik Orientalistyczny, vol. 28, 1965, pp. 87-111

9. Fishman, J. -- "A systematization of the Whorfian Hypothesis", Behavioral Science, vol. 5, 1960, pp. 323-339

10. Gipper, H. -- Gibt es ein sprachliches Relativitaetsprinzip, Frankfurt am Main, 1972

11. Hill, S. -- A Study of the Logical Abilities of Children, Ph.D. dissertation, Stanford University, 1960

12. Martinez Hernandez, J. -- Diccionario de Motul Maya-Espanol, Merida, Mexico, 1929

13. Martinez Paredes, D. -- El Idioma Maya Hablado y el Escrito, Mexico, D.F., 1967

14. McQuown, N. -- "Classical Yucatec (Maya)", Handbook of Middle American Indians, vol. 5, pp. 201-247, Austin, 1967

15. O'Brien, T. & B. Shapiro -- "The development of logical thinking in children", American Education Research Journal, vol. 5, 1968, pp. 531-542

16. Pap, A. -- An Introduction to the Philosophy of Science, London, 1963

17. Peirce, C. -- Collected Papers (ed. by C. Hartshorne & P. Weiss), Cambridge, Mass.,1932

18. Quine, W. -- Philosophy of Logic, Englewood Cliffs, 1970

19. Roys, R. -- The Book of Chilam Balam of Chumayel, Norman, 1967

20. Roys, R. -- The Titles of Ebtun, Washington, D.C., 1939

21. Russell, B. -- "Logical atomism" (reprinted in Logic and Knowledge, London, 1956)

22. Stefflre, M. -- Lexical and Syntactic Structures in Yucatec Maya, Ph.D. dissertation, Harvard University, 1972

23. Tarski, A. -- Logic, Semantics and Metamathematics, Oxford, 1956

24. Tozzer, A. -- "A Maya grammar", Papers of the Peabody Museum of American Archeology and Ethnology, vol. 9, 1921

25. Voegelin, C.F. & C.M. (eds.) -- "Languages of the world: native America fascicle two", Anthropological Linguistics, vol. 7, 1965

26. Whorf, B. -- Language, Thought and Reality, (ed. by J. Carroll), New York, 1956