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LOGICAL REASONING FOR FORECASTING IN MESOPOTAMIA

Abstract. In this paper, I show that a kind of perfect logical competence is observed in the Babylonian tablets used for forecasting. In these documents, we see an intuition of some algebraic structures that are used for inferring prognoses as logical conclusions. The paper is based mainly on the omen series reconstructed by N. De Zorzi. It is shown that in composing these divination lists there was implicitly used the Boolean algebra.

Keywords: symbolic logic, omens, divination, Judaic logic, Akkadian, modus ponens, modus tollens.

1. Introduction

Conventionally, there are considered only two “independent” logical traditions: (i) the Greek logic founded by Aristotle (384–322 B.C.) and Chrysippus (c. 279–c. 206 B.C.) and their successors (Orthodox-Byzantine, Catholic-Scholastic, Islamic, etc.); (ii) the Indian logic founded in Gandhāra in the 2nd century A.D. at the time, when the Greek language was official still for edicts, business and duties for about four hundred years in this region, and the successors of the ‘Gandhāran’ logic (*nyāya*, Buddhist logic, *navya-nyāya* and so on). Nevertheless, recently there are many works about symbolic logic (*middot*, מידות) in Judaism: [1]–[4], [22]–[26]. These works about ‘Talmudic symbolic logic’ mean that there is at least one new symbolic-logical tradition absolutely beyond (i) and (ii). In turn, it means that we really do not know the true history of logic and what its origin was. The point is that the good logical tradition of the Talmud would mean that the Greek and Talmudic logics were concurrent and may have a common root in the Akkadian culture.

This paper is devoted to a logical reconstruction of algebraic aspects of Babylonian divination in Akkadian. Whether this reconstruction is correct,

can be checked by the reader readily – I’ve cited all the fragments both in Akkadian and in the English translation to allow the reader to check. It is the only goal of this paper – to show a perfect logical competence of the authors of divination texts in Akkadian (mainly, the omen series reconstructed by N. De Zorzi [31], [32]). It is absolutely not trivial, because we do not face such a perfect competence in other cultures of Bronze Age. In Greece the good logical competence of some authors is well visible only after Aristotle (i.e. since the 4th century B.C.) and in India the good logical competence of some authors is well visible only after Nāgārjuna (according to some Chinese chronicles he was born in Kashmir, he was a contemporary of Kaṇiṣka the Great who ruled since 127 A.D. and he was invited by Kaṇiṣka to organize the Buddhist Council, i.e. the perfect logical competence of some Indian authors can be observed only after the 2nd century A.D.). Hence, it is a mystery why in Mesopotamia we observe the perfect logical competence much earlier than in Greece (the 4th century B.C.) and in India (the 2nd century A.D.).

In Babylonian divinations, each individual forecasting is presented strongly as the conditional: “if a sign (omen), then an event”. Nevertheless, omen series consisting of many conditionals and used for divinations are very different, according to their content and composition rules. So, their possible content can be as follows: astrology, physiognomy, interpretation of dreams, extispicy, oil interpretation, interpretation of aromatic smoke, and many others [17, p. 6]. There are the following three main types of composition rules for conditionals involved into forecasting:

(1) The earliest rule for composing omens is denoted now by scholars as ‘divinatory empiricism’ [17, p. 7]. It consists of recording events which really occurred one after another in the past: “if a sign (omen) [was], then an event [was]”. In the instances of it we detect a logical fallacy *post hoc ergo propter hoc* very often. This rule of composing omens is typical for ‘historical oracles’, where the apodosis of the conditional occurs rather in the past tense.

(2) The second rule of composing involves a “chain of association between elements of the protasis and elements of the apodosis” of conditionals [17, p. 7]. Here we deal either with a phonetic association between the signifiers or with a tropic association between the signifieds.

(3) The third rule of composing omens offers “codes which cover a finite series of completely identifiable cases” [17, p. 7]. This type of structure of omen series has appeared since the second quarter of the second millennium B.C. Here we find codes or systematic collections of very detailed divinatory signs presented in all possible combinations. For instance, let

us take the following four signs: ‘the threshold of the Door of the Palace’, ‘the middle of the Door of the Palace’, ‘on the right’, ‘on the left’ [17, p. 11]. So, we have the four signs (omens), where there are the two possible locations: ‘the threshold of the Door of the Palace’, ‘the middle of the Door of the Palace’, with the two possible additional details: ‘on the right’, ‘on the left’. As a consequence, we have 2^2 of their possible combinations: (i) ‘the threshold of the Door of the Palace’ & ‘on the right’; (ii) ‘the threshold of the Door of the Palace’ & ‘on the left’; (iii) ‘the middle of the Door of the Palace’ & ‘on the right’; (iv) ‘the middle of the Door of the Palace’ & ‘on the left’. Hence, the algorithm of composing omens of this type is as follows. Let us take $2k$ signs of the first order, $2l$ signs of the second order, $2m$ signs of the third order, etc., where $k, l, m \geq 1$. The point is that there are considered only binary oppositions so that each sign has an opposition within a couple. Then we have $2^{(k+l+m+\dots)}$ of all possible combinations of the protasis of conditionals¹. In the meanwhile, each possible combination is presented as an item in long lists of divinations containing all the combinations. As a result, we deal with a code of conditionals: (i) **if** ‘the threshold of the Door of the Palace’ & ‘on the right’, **then** ...; (ii) **if** ‘the threshold of the Door of the Palace’ & ‘on the left’, **then** ...; (iii) **if** ‘the middle of the Door of the Palace’ & ‘on the right’, **then** ...; (iv) **if** ‘the middle of the Door of the Palace’ & ‘on the left’, **then** ..., where for $2k$ signs of the first order, $2l$ signs of the second order, $2m$ signs of the third order, etc., where $k, l, m \geq 1$, we always have $2^{(k+l+m+\dots)}$ conditionals for foreseeing. In the meanwhile, in this foreseeing any logical inconsistency or contradiction is avoided. First, at the place of the protasis of conditionals, we have different $2^{(k+l+m+\dots)}$ combinations without any contradiction and it holds true by definition and construction – each opposite combination of signs (omens) is contained in another conditional. Second, at the place of the apodosis of conditionals for each combination from $2^{(k+l+m+\dots)}$ possibilities used in the protasis, we have one of the appropriate signs from the list of not more than $2^{(k'+l'+m'+\dots)}$ signs used in the apodosis, where each $k', l', m', \dots$ corresponds to $k, l, m, \dots$, respectively, so that each sign from the apodosis has an opposition within a couple, too, which is contained in another conditional. So, we deal with not more than $2^{(k'+l'+m'+\dots)}$ signs in the apodosis of conditionals and they are distributed in the way to avoid any logical inconsistency or contradiction, as well. Each opposite sign is contained in another apodosis of another conditional. Indeed, for different oppositions at the place of protasis we observe different oppositions at the place of apodosis. As a consequence, we obtain a rule-based expert system if to name it within the modern AI and symbolic logic. And in this system, any inconsis-

tency (contradiction) is excluded absolutely. Furthermore, this rule-based expert system assumes a binary logic of always opposite signs. Therefore, by applying logical inference rules we cannot draw a contradiction here. It is very nontrivial that we face such a logical system since the second quarter of the second millennium B.C. In any case, it is the first known example of rule-based expert system in its explicit form in the world history.

In this paper, I focus on the omen series possessing the structure described in (3). My claim is that in these omen series we can reconstruct an implicit usage of Boolean algebra – a very advanced logical-algebraic technique.

Usually, in Assyriology, omen series are analyzed for reconstructing some cultural contexts of Babylonians, such as social [13] or even economic one (how astrologically they can have predicted market rates) [18]. But a reconstruction of Babylonian science on the basis of omen lists is of special interest – first of all, I mean a reconstruction of their exact astrology with advanced mathematical calculations [6], [7].

A good philosophical reflection on conditionals used in the omen series of type (3) is proposed in [19], [20], where F. Rochberg paid attention that we can treat conditionals of type (3) even truth-functionally. Then she noted that in the rule-based expert systems presented in the omen series of (3), we can detect some combinations at the place of protasis, which are physically impossible. From this fact, she concluded that in the implications “if P , then Q ” of divinations, the relation between the antecedent P and the consequent Q “need not be physical, causal, or even divinely produced for P to indicate Q ” [19, p. 11]. So, we can predict from the implications “if P , then Q ”, as she remarked, only being based on the antecedent P that is true now. But if P is physically impossible, then such a prediction is impossible, too. It is right. However, there are other combinations of signs which are always physically possible. Then in the list of $2^{(k+l+m+\dots)}$ combinations for binary signs (omens) $2k, 2l, 2m, \dots$, there are ever possible some predictions made by *modus ponens*, since all the possible combinations are given for us (some of them must be realized in reality at any moment).

Then F. Rochberg assumed that we can say that a kind of logic did not exist in Mesopotamia: “The question is not whether Mesopotamian omens reflect a conscious interest in the nature of conditionals or in the logic of conditional statements. They do not” [19, p. 8]. However, this assumption is quite contentious. Yes, some antecedents in divinations can be physically impossible, but they are ever possible logically and this property is a determining factor for our reconstruction of Mesopotamian logic. Furthermore,

she did not pay attention that in the omen series of (3), we deal with the rule-based expert systems which are always complete and inconsistent for binary signs (omens) $2k, 2l, 2m, \dots$. So, in contrast, we can draw there logical conclusions without contradictions for ever. It is a logic, surely.

Let us refer to Kolmogorov's probability theory. In this theory, we do not consider events whether they are physically possible or not, but we consider events, whether they are logically possible or not. For instance, events such as 'a self-assembling Boeing' or 'a flying crocodile' seem to be physically impossible for us at least now, but they are always logically possible, therefore they cannot be treated as a zero percent chance. Only a contradictory proposition such as 'in a coin toss we obtain a head and a tail' is probabilistically equal to a zero percent chance, because this proposition has a logical form of contradiction: 'a head and not a head' or 'a tail and not a tail' ($A \wedge \neg A$). In the list of $2^{(k+l+m+\dots)}$ combinations for binary signs (omens) $2k, 2l, 2m, \dots$, there are no contradictions at all by definition, therefore all combinations are logically possible. This fact tells us that each complete divination list (code) was composed rather as a logical system, which is reconstructed in my paper. Furthermore, the omen lists of type (3) are a knowledge base which can be treated probabilistically in the meaning of Kolmogorov's theory.

Methodologically, my approach to formalizing logical ideas of omen series (3) is close to the approach presented by L. Brack-Bernsen [7]. She noted that divinations were a sacral knowledge taught orally and we can reconstruct this knowledge by assuming that there is an inner structure in composing conditionals. For example, astrology presented by a list of conditionals was regarded as a secret doctrine in Mesopotamia (BM 42282+)²:

- 1 Tablet of the secret of heaven, the hidden thing of the great gods. He must not give it out of hand; let him teach (it) to his son whom he loves.
- 2 To teach (it) to a non-citizen of Babylon or a non-citizen of Borsippa or anyone who is not learned, is a taboo of Nabû and Nisaba [7, p. 278].

As a result, we find some lists of astrological conditionals fixing some strong relations among numerals without any instructions how it did work in fact. But the assumption that there is an inner mathematical structure allowed L. Brack-Bernsen to reconstruct a very advanced mathematical technique used in the analyzed conditionals implicitly for astrological predictions. To the same extent, I've assumed that in the omen series of (3), there exists an inner algebraic structure which can be formalized by logicians. As it turned out, it is true. The implicit usage of advanced astrological calculations [6], [7] is a good proof that the Babylonians knew this system

in a way. On the one hand, the thesis that theoretical knowledge follows from practical usage is a fallacy in general case. For example, beavers build dams according to some advanced building technology. However, they do not “know” how they do it. But, on the other hand, we are talking about a kind of human exact knowledge and not about unconscious practices of swarms (such as colonies of beavers). In the case of human knowledge, there is always a form of its self-reflection, and the question is how far this self-reflection is developed. From this point of view, it is impossible to know an advanced mathematics for astronomy/astrology without its knowledge with a form of its reflection which can be even not mathematical in the narrow sense of modern mathematics. To the same extent, it is excluded to use (even implicitly) the Boolean algebra (very advanced logical-algebraic technique) without a form of its reflection. There is no problem to point somebody who reasons according to all the rules of propositional logic without knowing them in the sense of modern logicians. But if he or she does it in all examples, then we can assume a form of logical reflection. Moreover, if there is a group of people who do it in their social practice, then we can assume that they follow a logical tradition in this practice. The matter is that, according to experimental data of cognitive science, logic (as well as mathematics) is not an innate ability and even scientists are cognitively biased and make logical fallacies [14], [30], although they especially learnt logic. In other words, logic is a knowledge that is possible only within a permanent reflection which consciously eliminates cognitive biases and logical fallacies. The divination lists of (3) are consciously composed in accordance with the rules which have some logical meanings. It does not mean that it is a logic, but it is a knowledge containing some logical algorithms which were understood by them in a way.

In composing the omen lists of type (3), the Babylonians put forward the following logical-philosophical presuppositions (they hold true anyway for these texts; therefore, they are readily reconstructed on the basis of appropriate cuneiform fragments):

- (O₁) For each event Q there is an appropriate combination P of signs (omens) such that the implication “if P , then Q ” holds true.
- (O₂) Each individual proposition A about an event (even in the future) is either true or false: $A \vee \neg A$.
- (O₃) Everything happens in accordance with omens.

We know that the first system of propositional logic was created by Chrysippus, the Stoic philosopher. His main logical-philosophical presuppositions are as follows:

- (S₁) For each event Q there is a reason P (this reason is not only a cause, but it can be a sign, too) such that the implication “if P , then Q ” holds true. In the Stoic terms: “Nothing happens without a cause”, *nihil enim fieri sine causa potest* (Cicero: *De Divinatione* 2, 61); “No motion is without a cause” *motum nullum esse sine causa* (Cicero: *De Fato* 23).
- (S₂) Each individual proposition ($\acute{\alpha}\xi\iota\omega\mu\alpha\tau\alpha$) A (even about future) is either true or false: $A \vee \neg A$.
- (S₃) Each individual proposition (even about future) A is necessarily true or it is necessarily false: $\Box A \vee \Box \neg A$.
- (S₄) Each (past, present, future) event A is actual and then necessary: $A \Rightarrow \Box A$.
- (S₅) Everything happens in accordance with fate ($\tau\acute{\alpha} \pi\acute{\alpha}\nu\tau\alpha \kappa\alpha\theta' \epsilon\iota\mu\alpha\rho\mu\acute{\epsilon}\nu\eta\nu \gamma\acute{\iota}\nu\epsilon\tau\alpha\iota$).

We see that between presuppositions (O₁)–(O₃) and presuppositions (S₁)–(S₅), there is a strong similarity, and the Stoic presuppositions can be evaluated as a continuation and further elaboration of the Babylonian assumptions. Indeed, the Stoic propositional logic assumes that each individual proposition can be considered as a succedent of true implication – to the same extent as it was understood in the Mesopotamian logic from the beginning. Hence, the ideas of logical determinism were first expressed in an implicit way not by the Stoic philosophers, but by the Babylonian authors of divinations of type (3).

The influence of Babylonian logical ideas presented in the divinations of (3) on the Stoic logic is well traced. The point is that the Babylonian art of divination (called “the Chaldean art” at the time of Old Stoa) was regarded by the Stoics as an important “art” included by them into their doctrine. The Stoic philosophical teaching on divinations was founded by Zeno of Citium (ca. 334–262 B.C.) and Cleanthes (ca. 330–230 B.C), see *Cicero's De Divinatione* 1.6. In turn, Chrysippus “discussed the whole theory of divination in two books” (*Chrysippus, qui totam de divinatione duobus libris explicavit sententiam*), and “wrote one book on oracles and another on dreams” (*uno praeterea de oraculis, uno de somniis*), see *Cicero's De Divinatione* 1.6. Evidently, the Stoics were inspired by divinations in their modal-logical investigations.

The idea that implications from the divination lists of type (3) have a pure logical meaning is quite old [19], [20]. Some basic arguments for this claim are collected in Section 2. De Zorzi has shown [31], [32] that there is

an algebraic intuition in composing omen lists of type (3). I explicate this intuition formally in Section 3 and demonstrate that all reasoning of omen series reconstructed by De Zorzi are correct within the Boolean algebra so that each conditional divination is a tautology of propositional logic with the following two values: positive sign (+1) and negative sign (−1). We can take other omen series, such as [10], and check that the prophecy logic is the same. In Section 4, I show some Akkadian roots for the Talmudic terminology: *halakah*, [*tôrâ še*]-*be'al peh*, *middâ*, *barait'a*, which were first used in Akkadian commentaries to divination lists.

This paper is a continuation of research of [27], [28], [29].

2. Divination as Logical Inference

Since the Old Babylonian period (ca. 1800 B.C.) each forecasting was formulated in the form of implication: “if (*šumma*) P , [then] Q ” ($P \Rightarrow Q$). The same form of implication was engaged in formulating articles in the Mesopotamian law codes since the earliest ones (ca. 2300 B.C.) [21]: “if someone does thus and such, he shall be sentenced so”. Hence, we can suppose that the idea of using implication in formulating divinations might have been loaned from legal documents.

While in the Old Babylonian period omens usually started with the lexeme BE-*ma* with the obvious reading *šum₄-ma* “if”, in the Neo-Assyrian period (from 911 B.C. to 609 B.C.) another lexem DIŠ was used, just to designate “item” or “entry”, although this form “ $P : Q$ ” of divinations had the meaning of implication, too:

DIŠ MUL SAG.ME.GAR *ana* UL Á.MUŠEN *iteḥḫi*

If (or, ‘given,’ or, ‘on the condition that’) Jupiter approaches the Eagle Constellation (Aquila)

miqittim būlim išakkan muršānu ina mati ibašši zunnu arḫi 1.KAM *ul izannun*
there will be (meaning ‘there is as a result’) disease of the cattle herds, sickness
in the land (and) no rain for one month [20, p. 380].

Usually, it was assumed that each divination $P \Rightarrow Q$ was first based on an empirical foundation for the association of P and Q , see [10]. In other words, it was supposed that omens were an erroneous attempt to formulate empirical/physical laws. Nevertheless, there are many textual evidences that divinations do not concern physics at all, but logical descriptions of the world which should take into account all events $P_1, P_2, \dots, P_n$ from impossible

to necessary for inferring all conclusions $Q_1, Q_2, \dots, Q_n$ from the set of implications $P_1 \Rightarrow Q_1, P_2 \Rightarrow Q_2, \dots, P_n \Rightarrow Q_n$:

The relation between protasis and apodosis, or antecedent and consequent, is the working dynamic of Mesopotamian divination, and although to us that connection, at least semantically, is not readily understood, it is subject to certain relational (propositional logical) rules in the same way as are the casuistic statements of the cuneiform laws. I contend that the relation of antecedent and consequent in the omens can be understood as a matter of conditional logic, which applies independently of any semantic, causal, or empirical connection there may be (or not be) between the statements P and Q so related [20, p. 379].

The matter is that many divinations introduce the so-called “impossible” phenomena which cannot appear as such:

That is, the list of statements (P) constitute data, or knowledge, on the basis of which the diviner makes judgements and draws conclusions about what will happen. The use of the terms possible and impossible are, among other things, relative to one’s accepted knowledge of how and what things are [20, p. 389].

For example, in some divinations there are examined the eclipses that occur on days of the month when eclipses are not possible at all or there is regarded the sun appearing at midnight that is impossible, too. The point is that the main goal of divinations is to consider all the combinations of phenomena – from the phenomena, possible in the world, and up to the phenomena, which cannot occur at any time. For instance, there are only three watches and it is known that the sun appears only in the morning watch. But there are the following three combinations: (i) “the sun appears in the evening watch”; (ii) “the sun appears in the middle watch”; (iii) “the sun appears in the morning watch”. All these combinations are considered in the following Old Babylonian text:

^d*Utu ina bararti* IGI.DU₈ *šaḫluḫti maš nāši*

If the sun appears in the evening watch: destruction of the herds of the people.

^d*Utu ina qablīti* IGI.DU₈ *bartum ana šarri*

If the sun appears in the middle watch: revolt against the king.

^d*Utu ina šaturri* IGI.DU₈ *ina ali šuātu šarru šanumma ibašši*

If the sun appears in the morning watch: in that city there will be another king [20, p. 389].

Thus, the divinations $P \Rightarrow Q$ are to consider all the combinations of events P, Q for predicting their consequences Q on the basis of omens P .

Each divination as an implication “[if] P , Q ” tells us about *purussû* “[divine] decision” or “verdict” Q inferred by *modus ponens*:

Divination: $P \Rightarrow Q$;

Observer: P

Diviner: Q

more precisely by *transitivity of implication*:

Divination: $P \Rightarrow Q$;

Observer: an event E that is a particular case of P (i.e. $E \Rightarrow P$)

Diviner: $E \Rightarrow Q$

Thus, the role of diviner was similar to the role of judge – both of them should have applied logical inference rules in formulating appropriate divine decisions concerning our future in divinations or our presence in trial verdicts. While the diviner applied *modus ponens* to articles of omen series, the judge applied *modus ponens* to articles of law codes [28], [29]. For example, in the subscript to a late astrological text from Uruk we read: BE-*ma* EŠ.BAR 3,20 *ana* IGI-*ka*, “In order for you to see a divine decision concerning the king ...” (TU 11 rev. 37) [20, p. 416].

As we see, the divine decisions should be inferred by *modus ponens* or *transitivity of implication*. In the meanwhile, all the possible combinations are fixed in divinations to introduce a full enumeration of particulars $P_1, P_2, \dots, P_n$, appearing in the antecedent of the divinations and related to one general Q , appearing in the succedent, i.e. a full list of implications $P_1 \Rightarrow Q, P_2 \Rightarrow Q, \dots, P_n \Rightarrow Q$ with the same Q . Those $P_1, P_2, \dots, P_n$ should be exclusive – they should be connected by strong disjunctions “either ... or ...” (Akkadian: “*ūl ... ūl...*”, symbolically: “ $\dots \otimes \dots$ ”). In this case there is the following equivalence: $(P_1 \otimes P_2 \otimes \dots \otimes P_n) \Leftrightarrow Q$. From this we can draw the following conclusion:

$$\frac{P_1 \Rightarrow Q; P_2 \Rightarrow Q; \dots; P_n \Rightarrow Q; E \Rightarrow \neg P_1; E \Rightarrow \neg P_2; \dots; E \Rightarrow \neg P_n}{(P_1 \otimes P_2 \otimes \dots \otimes P_n) \Leftrightarrow Q; \quad E \Rightarrow \neg(P_1 \otimes P_2 \otimes \dots \otimes P_n)} \\ \hline E \Rightarrow \neg Q.$$

This property of divinations can be called a *completeness of forecasting information*. This completeness means that if we take any empirical event E , then for any general (“divine decision”) Q from the divination list, each diviner can announce either a “divine verdict” $E \Rightarrow Q$ or a “divine

verdict” $E \Rightarrow \neg Q$ inferred from the divination list just logically. The same completeness of information was assumed in collecting the Babylonian law code [28], [29].

3. Logical Reconstruction of Divination Lists

Let us reconstruct a logical intuition guessed in composing divination lists. In this reconstruction, we propose a semi-formal system with the following alphabet. Assume that small letters $a, b, c, \dots, x, y, z, \dots$ are signs to denote individuals. Meanwhile, the letters $a, b, c, \dots$ are constants, and $x, y, z, \dots$ are variables. First-order formulas are defined as follows: (i) each $a, b, c, \dots, x, y, z, \dots$ is a first-order formula; (ii) each Boolean combination of formulas defined in (i) is a first-order formula (Boolean connectives: $\neg$ negation, $\&$ conjunction, $\vee$ disjunction, $\Rightarrow$ implication, $\otimes$ strong disjunction).

Let an action “verb” in the antecedent or succedent of divinations be denoted by $[[\text{verb}]]$. Each action is an n -place relation among things. For example: $[[\text{twinkle-from-right-to-left}(x, y)]]$ means that x twinkles from the right of y to the left of y ; $[[\text{recover}(x)]]$ means that x is recovering; $[[\text{wail}(x)]]$ means that x wails; $[[\text{get-up}(x)]]$ means that x gets up, etc. Let an opposite action to the action “verb” be denoted by $[[\underline{\text{verb}}]]$. For example, $[[\text{twinkle-from-left-to-right}(x, y)]]$ is equal to $[[\underline{\text{twinkle-from-right-to-left}}(x, y)]]$ or $[[\text{lower-cheek-to-right}(x)]]$ is equal to $[[\underline{\text{lower-cheek-to-left}}(x, y)]]$. Second-order formulas are defined as follows: (i) each $[[\text{twinkle-from-right-to-left}(x, y)]]$, $[[\text{recover}(x)]]$, $[[\text{wail}(x)]]$, $[[\text{get-up}(x)]]$, $[[\underline{\text{twinkle-from-right-to-left}}(x, y)]]$, $[[\underline{\text{recover}}(x)]]$, $[[\underline{\text{wail}}(x)]]$, $[[\underline{\text{get-up}}(x)]]$, ... is a second-order formula; (ii) each Boolean combination of formulas defined in (i) is a second-order formula (Boolean connectives: $\neg$ negation, $\&$ conjunction, $\vee$ disjunction, $\Rightarrow$ implication, $\otimes$ strong disjunction).

Now, let us formulate divinations as statements of this semi-formal system. In [31], it was detected that there is an asymmetry in omens with opposite verbs:

1. *šumma-DIŠ amēlu-NA ana šibûtišû-Á.Áššû itebbîma ZI^{ma} kakkabu-MUL ištu-TA imitti-15 amēli-NA ana šumēl-GÛB amēli-NA iṣarriḫ-SUR damqu-SIG₅*
2. *šumma-DIŠ ištu-TA šumēli-150 ana imitti-15 iṣarriḫ-SUR aḫîtu-BAR*
3. *šumma-DIŠ kakkabu-MUL ina ku-tál amēli-NA ištu-TA imitti-15 ana šumēli-150 iṣarriḫ-SUR aḫîtu-BAR*

4. *šumma*-DIŠ *kakkabu*-MUL *ina ku-tál amēli*-NA *ištu*-TA *šumēli*-150 *ana imitti*-15 *išarriḫ*-SUR *damqu*-SIG₅

If a man leaves (in order to achieve) his purpose and a star twinkles **from the right** of the man **to the left** of the man – favourable.

If (it) twinkles **from the left to the right** – unfavourable.

If a star twinkles **on the back** of the man **from the right to the left** – unfavourable.

If a star twinkles **on the back** of the man **from the left to the right** – favourable [31, p. 97].

Symbolically:

- (i) $([[\text{leave}(y)]] \ \& \ [[\text{twinkle-in-front-from-right-to-left}(x, y)]]]) \Rightarrow [[\text{favourable}(y)]]$
- (ii) $([[\text{leave}(y)]] \ \& \ [[\text{twinkle-in-front-from-left-to-right}(x, y)]]]) \Rightarrow [[\underline{\text{favourable}}(y)]]$
- (iii) $([[\text{leave}(y)]] \ \& \ [[\text{twinkle-on-back-from-right-to-left}(x, y)]]]) \Rightarrow [[\underline{\text{favourable}}(y)]]$
- (iv) $([[\text{leave}(y)]] \ \& \ [[\text{twinkle-on-back-from-left-to-right}(x, y)]]]) \Rightarrow [[\text{favourable}(y)]]$

We have the four opposite combinations: (i) $[[\text{twinkle-in-front-from-right-to-left}(x, y)]]$ ‘ x twinkles from the right of y to the left of y in front of y ’; (ii) $[[\text{twinkle-in-front-from-left-to-right}(x, y)]]$ ‘ x twinkles from the left of y to the right of y in front of y ’; (iii) $[[\text{twinkle-on-back-from-right-to-left}(x, y)]]$ ‘ x twinkles from the right of y to the left of y on the back of y ’; (iv) $[[\text{twinkle-on-back-from-left-to-right}(x, y)]]$ ‘ x twinkles from the left of y to the right of y on the back of y ’.

Each combination from (i) to (iv) gives either the positive sign $[[\text{favourable}(y)]]$ or negative sign $[[\underline{\text{favourable}}(y)]]$. We know that ‘to be in front’ is a positive sign in the omens and ‘to be on the back’ is a negative sign. At the same time, ‘to move from right to left’ is a positive sign and ‘to move from left to right’ is a negative sign. Let us denote a positive sign by +1 and a negative sign by -1. Then we have:

- (i) $(+1 \ \& \ +1) \Rightarrow +1$;
- (ii) $(+1 \ \& \ -1) \Rightarrow -1$;
- (iii) $(-1 \ \& \ +1) \Rightarrow -1$;
- (iv) $(-1 \ \& \ -1) \Rightarrow +1$.

Logically, we can reconstruct the following truth tables for $\neg$, $\&$, and $\Rightarrow$, respectively:

Truth table for $\neg$

$[[\text{verb}]]$	$[[\underline{\text{verb}}]]$	$\neg[[\text{verb}]]$	$\neg[[\underline{\text{verb}}]]$
+1	-1	-1	+1
-1	+1	+1	-1

Truth table for $\&$

$[[\text{verb}_1]]$	$[[\text{verb}_2]]$	$[[\text{verb}_1]] \& [[\text{verb}_2]]$
+1	+1	+1
+1	-1	-1
-1	+1	-1
-1	-1	-1

Truth table for $\Rightarrow$

$[[\text{verb}_1]]$	$[[\text{verb}_2]]$	$[[\text{verb}_1]] \Rightarrow [[\text{verb}_2]]$
+1	+1	+1
+1	-1	-1
-1	+1	+1
-1	-1	+1

Indeed, according to these truth tables, we have:

- (i) $((+1 \& +1) \Rightarrow +1) = (+1 \Rightarrow +1) = +1$;
- (ii) $((+1 \& -1) \Rightarrow -1) = (-1 \Rightarrow -1) = +1$;
- (iii) $((-1 \& +1) \Rightarrow -1) = (-1 \Rightarrow -1) = +1$;
- (iv) $((-1 \& -1) \Rightarrow +1) = (-1 \Rightarrow +1) = +1$.

To sum up, in the divination list of [31, p. 97] we see an intuition of Boolean algebra $\langle \{-1, +1\}, \neg, \&, \Rightarrow \rangle$. In the meanwhile, all the implications from the analyzed divination list are considered axioms, i.e. they have always the truth value +1.

Let us regard another example, whether its implications are axioms according to reconstructed truth tables:

122. *šum₄-ma alpu-GUD is-su-us-ma it-bi kašād-KUR^{ad} šibûti-ÁŠ*
 123. *šum₄-ma alpu-GUD is-su-us-ma ul-NU it-bi lā-NU kašād-KUR^{ad} šibûti-ÁŠ*
 124. *šum₄-ma alpu-GUD itbīma-ZI^{ma} lēssu-TE^{su} ana imittiššu-15^{šú} iddi-ŠUB lā-NU*
kašād-KUR^{ad} šibûti-ÁŠ
 125. *šum₄-ma alpu-GUD itbīma-ZI^{ma} lēssu-TE^{su} ana šumēlišu-150^{šú} iddi-ŠUB*
kašād-KUR^{ad} šibûti-ÁŠ

122. If an ox **wailed and (then) got up** – attaining of the desire.
 123. If an ox **wailed and (then) didn't get up** – not attaining of the desire.
 124. If an ox **got up and lowered his cheek to the right** – not attaining of the desire.
 125. If an ox **got up and lowered his cheek to the left** – attaining of the desire
 [31, p. 103–104].

Symbolically:

- (v) $([[\text{wail}(x)]] \ \& \ [[\text{get-up}(x)]]) \Rightarrow [[\text{favourable}(y)]]$
 (vi) $([[\text{wail}(x)]] \ \& \ [[\underline{\text{get-up}}(x)]]) \Rightarrow [[\underline{\text{favourable}}(y)]]$
 (vii) $([[\text{wail}(x)]] \ \& \ [[\text{get-up}(x)]] \ \& \ [[\text{lower-cheek-to-right}(x)]]) \Rightarrow$
 $[[\underline{\text{favourable}}(y)]]$
 (viii) $([[\text{wail}(x)]] \ \& \ [[\text{get-up}(x)]] \ \& \ [[\text{lower-cheek-to-left}(x)]]) \Rightarrow$
 $[[\text{favourable}(y)]]$

We see that $[[\text{wail}(x)]]$ and $[[\text{get-up}(x)]]$ and $[[\text{lower-cheek-to-left}(x)]]$ are positive signs, and $[[\underline{\text{get-up}}(x)]]$ and $[[\text{lower-cheek-to-right}(x)]]$ are negative signs. Therefore, we formalize these conditional statements in the following manner, according to the truth tables:

- (v) $((+1 \ \& \ +1) \Rightarrow +1) = +1;$
 (vi) $((+1 \ \& \ -1) \Rightarrow -1) = +1;$
 (vii) $((+1 \ \& \ +1 \ \& \ -1) \Rightarrow -1) = +1;$
 (viii) $((+1 \ \& \ +1 \ \& \ +1) \Rightarrow +1) = +1.$

Thus, all the conditional statements from (v) to (viii) are axioms, too. One more example:

63. *šumma-DIŠ kakkabu-MUL ištu-TA imitti-15 amēli-NA ana šumēl-150 amēli-*
NA iṣruḥ-SUR^{uh} damqu-SIG₁₅ ana marši-GIG imât-BA.ÚŠ
 64. *šumma-DIŠ kakkabu-MUL ištu-TA šumēl-150 amēli-NA ana imitti-15 amēli-*
NA iṣruḥ-SUR^{uh} aḫītu-BAR ana marši-GIG iballuṭ-AL.TI
 65. *šumma-DIŠ kakkabu-MUL ana pān-IGI amēli-NA iṣruḥ-SUR^{uh} kašād-KUR^{ad}*
šibûti-ÁŠ ana marši-GIG imât-BA.ÚŠ

66. *šumma*-DIŠ *mi-iḫ-ra ana pān*-IGI *amēli*-NA *iṣruḫma*-SUR^{ub-ma} *eli*-UGU? *ītiq*-DIB^{iq} *lā*-NU *kašād*-KUR^{ād} *šibūti*-AŠ *ana marši*-GIG *iballuṭ*-AL.TI

63. If a star twinkled from the right of the man to the left of the **man** – **favourable**; the **patient: he will die**.
64. If a star twinkled from the left of the man to the man right of the **man** – **unfavourable**; the **patient: he will recover**.
65. If a star twinkled in front of the man – **attaining of the desire**; the **patient: he will die**.
66. If (a star) twinkled directly in front of a man and passes by him? – **not attaining of the desire**; the **patient: he will recover** [31, p. 105].

Formally:

- (ix) $[[\underline{\text{ill}}(y)]] \ \& \ [[\text{twinkle-from-right-to-left}(x, y)]] \Rightarrow [[\text{favourable}(y)]]$
- (x) $[[\underline{\text{ill}}(y)]] \ \& \ [[\text{twinkle-from-right-to-left}(x, y)]] \Rightarrow [[\underline{\text{favourable}}(y)]]$
- (xi) $[[\underline{\text{ill}}(y)]] \ \& \ [[\text{twinkle-from-left-to-right}(x, y)]] \Rightarrow [[\underline{\text{favourable}}(y)]]$
- (xii) $[[\underline{\text{ill}}(y)]] \ \& \ [[\text{twinkle-from-left-to-right}(x, y)]] \Rightarrow [[\text{favourable}(y)]]$
- (xiii) $[[\underline{\text{ill}}(y)]] \ \& \ [[\text{twinkle-in-front}(x, y)]] \Rightarrow [[\text{favourable}(y)]]$
- (xiv) $[[\underline{\text{ill}}(y)]] \ \& \ [[\text{twinkle-in-front}(x, y)]] \Rightarrow [[\underline{\text{favourable}}(y)]]$
- (xv) $[[\underline{\text{ill}}(y)]] \ \& \ [[\text{twinkle-in-front-pass}(x, y)]] \Rightarrow [[\underline{\text{favourable}}(y)]]$
- (xvi) $[[\underline{\text{ill}}(y)]] \ \& \ [[\text{twinkle-in-front-pass}(x, y)]] \Rightarrow [[\text{favourable}(y)]]$

In these axioms there are two position of a man y : he is ill (i.e. $[[\underline{\text{ill}}(y)]]$) or not (i.e. $[[\text{ill}(y)]]$), that is, he has a positive or negative status – he is himself a positive or negative sign. Hence, there are the following positive signs in these omens: $[[\underline{\text{ill}}(y)]]$, $[[\text{twinkle-from-right-to-left}(x, y)]]$, $[[\text{twinkle-in-front}(x, y)]]$. The negative signs: $[[\text{ill}(y)]]$, $[[\text{twinkle-from-left-to-right}(x, y)]]$, $[[\text{twinkle-in-front-pass}(x, y)]]$. So, the same, according to the truth tables:

- (ix) $((+1 \ \& \ +1) \Rightarrow +1) = (+1 \Rightarrow +1) = +1;$
- (x) $((-1 \ \& \ +1) \Rightarrow -1) = (-1 \Rightarrow -1) = +1;$
- (xi) $((+1 \ \& \ -1) \Rightarrow -1) = (-1 \Rightarrow -1) = +1;$
- (xii) $((-1 \ \& \ -1) \Rightarrow +1) = (-1 \Rightarrow +1) = +1;$
- (xiii) $((+1 \ \& \ +1) \Rightarrow +1) = (+1 \Rightarrow +1) = +1;$
- (xiv) $((-1 \ \& \ +1) \Rightarrow -1) = (-1 \Rightarrow -1) = +1;$
- (xv) $((+1 \ \& \ -1) \Rightarrow -1) = (-1 \Rightarrow -1) = +1;$
- (xvi) $((-1 \ \& \ -1) \Rightarrow +1) = (-1 \Rightarrow +1) = +1.$

Hence, each atomic divination (conditional statement for forecasting) is an axiom (always true statement, according to the truth tables). The informal rules for composing the divination lists can be formulated as follows:

M1 *A succedent of conditional divination gives a positive sign if and only if all signs in the antecedent are positive or all signs in the antecedent are negative.*

M2 *A succedent of conditional divination gives a negative sign if and only if there are positive and negative signs in the antecedent simultaneously.*

Let F be an n -place function that maps from the set of signs $\{-1, +1\}^n$ in the antecedent to the set of signs $\{-1, +1\}$ in the succedent in the conditional divinations. Then, according to **M1** and **M2**, F is a logical biconditional $\Leftrightarrow$ with the following truth table:

Truth table for $\Leftrightarrow$

$[[\text{verb}_1]]$	$[[\text{verb}_2]]$	$[[\text{verb}_1]] \Leftrightarrow [[\text{verb}_2]]$
+1	+1	+1
+1	-1	-1
-1	+1	-1
-1	-1	+1

Each atomic divination has the following form:

Axiom

$([[\text{verb}_1]] \& [[\text{verb}_2]] \& \dots \& [[\text{verb}_n]]) \Rightarrow F([[\text{verb}_1]], [[\text{verb}_2]], \dots, [[\text{verb}_n]]),$

i.e.

$([[\text{verb}_1]] \& [[\text{verb}_2]] \& \dots \& [[\text{verb}_n]]) \Rightarrow ([[\text{verb}_1]] \Leftrightarrow [[\text{verb}_2]] \Leftrightarrow \dots \Leftrightarrow [[\text{verb}_n]]).$

In the Boolean algebra this statement is an axiom (it is true for any valuation). In the divination lists, this statement has only the value +1. As we see, each atomic divination is a tautology of two-valued propositional logic. It cannot be occasionally that the Babylonians formulated the divination lists with the perfect logical competence – they should have known a kind of symbolic logic.

Rules **M1** and **M2** are verified in some passages from the Bible, too:

And he showed me Joshua the high priest standing **before** the **angel of the Lord**, and **Satan** standing at his **right hand** to accuse him (*Zechariah* 3:1)

Let x be Joshua. ‘An angel’ ($[[\text{angel}(x)]]$) is a positive sign. ‘To be before a man’ ($[[\text{before}(x)]]$) is a positive sign. The combination of both positive signs ‘an angel is before a man’ gives a positive sign for this man. Nevertheless, ‘Satan’ ($[[\text{Satan}(x)]]$) is a negative sign. ‘To be at the right hand’ ($[[\text{at-the-right-hand}(x)]]$) is a positive sign. The combination of negative and positive signs ‘Satan is at his right hand’ is a negative sign. The resulting combination of all four signs ‘an angel is before a man and Satan is at his right hand’ gives a negative sign:

$$(xvii) \quad ([[\text{angel}(x)]] \& [[\text{before}(x)]] \& [[\text{at-the-right-hand}(x)]] \& [[\text{Satan}(x)]]) \\ \Rightarrow [[\text{favourable}(y)]]$$

According to **M1** and **M2**, we have the always true proposition:

$$(xvii) \quad ((+1 \& +1 \& +1 \& -1) \Rightarrow (+1 \Leftrightarrow +1 \Leftrightarrow +1 \Leftrightarrow -1)) = (-1 \Rightarrow -1) \\ = +1.$$

However, the Lord decided to help the man:

וַיֹּאמֶר יְהוָה אֶל־הַשָּׂטָן יָגֹעַר יְהוָה בְּךָ הַשָּׂטָן וַיִּגְעַר יְהוָה בְּךָ הַבֹּחֵר בִּירוּשָׁלַם הָלֹא זֶה אִישׁ
מֵצֵל מֵאֵשׁ:

And the Lord said unto Satan: ‘The Lord rebuke thee, O Satan, yea, the Lord that hath chosen Jerusalem rebuke thee; is not this man a brand plucked out of the fire? (*Zechariah* 3:2)

As a consequence, the Lord changed the omen:

וַיְהִי־שֶׁעַ הָיָה לְבָשׁ בְּגָדִים צוּאִים וַעֲמַד לִפְנֵי הַמַּלְאָךְ:

Now Joshua was **clothed with filthy garments**, and stood **before** the **angel** (*Zechariah* 3:3).

$$(xviii) \quad ([[\text{angel}(x)]] \& [[\text{before}(x)]] \& [[\text{clothed-with-filthy-garments}(x)]]) \Rightarrow \\ [[\text{favourable}(y)]]$$

In truth values:

$$(xviii) \quad ((+1 \& +1 \& +1) \Rightarrow (+1 \Leftrightarrow +1 \Leftrightarrow +1)) = (+1 \Rightarrow +1) = +1.$$

This proposition is a tautology, as well.

The fact that rules **M1** and **M2** might be verified in the Bible means that the Biblical prophets had some rudiments from the tradition of the Akkadian divinations. In this tradition, divinations as axioms of Babylonian prophecy logic are formulated due to **M1** and **M2**.

The axiomatic system of Babylonian prophecy logic contains some inference rules which can be reconstructed by us. Assume that A , $\neg B$, $A \Rightarrow B$ are axioms. Then the basic inference rules are as follows:

Modus ponens (**MP**):

$$\frac{A; \quad A \Rightarrow B}{B}$$

Modus tollens (**MT**):

$$\frac{\neg B; \quad A \Rightarrow B}{\neg A}$$

Some other inference rules:

Introducing conjunction (**I&**):

$$\frac{A; \quad B}{A \& B}$$

Deleting conjunction (**D&**):

$$\frac{A \& B}{A; \quad B}$$

Introducing disjunction (**I $\vee$**):

$$\frac{A; \quad B}{A \vee B}$$

Let $S[B]$ mean that B is a variable $a, b, c, \dots, x, y, z, \dots$ belonging to a formula S . Let A be a constant. An additional inference rule:

Substitution rule (**SR**):

$$\frac{S[B]; \quad A \Rightarrow B}{S[A]}$$

In other words, if $A \Rightarrow B$ holds, then we can substitute A for any occurrence of B in a formula S .

Inference rules **MP**, **MT**, **I&**, **D&**, **IVI**, **SR** are enough for inferring “divine decisions” from the divination lists and facts, but in order to reduce a length of deduction we can introduce some new inference rules of the form:

$$\frac{A; \quad B}{C}$$

if and only if the formula $(A \& B) \Rightarrow C$ is a tautology of propositional logic.

Let us show an example of drawing conclusions by Babylonian diviners.

If a woman gives birth and (the foetus) has two ears on the right and none on the left – the **gods (who were) angry will return to the land and the land will live in peace.**

If a woman gives birth and (the foetus) has two ears on the left and none on the right – **the advice of the land will be unheeded.**

If a malformed foetus has a second ear inside its right ear – **the prince will have advisers.**

If a malformed foetus has a second ear inside its left ear – **the advisers of the prince will advise him badly** [32, p. 53].

Assume that ‘the foetus has two ears on the left and none on the right’ is a true event now. We should infer a forecasting in our semi-formal system. The axiom for the forecasting is as follows:

- (1) $[[\text{foetus}(x_1)]] \& [[\text{two-ears-on-right}(x_1)]] \& [[\underline{\text{two-ears-on-left}}(x_1)]] \Rightarrow [[\text{peace}(y)]]$
- $[[\text{foetus}(x_2)]] \& [[\underline{\text{two-ears-on-right}}(x_2)]] \& [[\text{two-ears-on-left}(x_2)]] \Rightarrow [[\text{unheeded}(y)]]$
- $[[\text{foetus}(x_3)]] \& [[\text{second-ear-inside-right-ear}(x_3)]] \Rightarrow [[\text{advisers}(z)]]$
- $[[\text{foetus}(x_4)]] \& [[\text{second-ear-inside-left-ear}(x_4)]] \Rightarrow [[\underline{\text{advisers}}(z)]]$

The empirical facts:

- (2) $a \Rightarrow x_2$, where a = a concrete malformed foetus.
- (3) $b \Rightarrow y$, where b = a concrete land.
- (4) $[[\text{foetus}(a)]]$.
- (5) $[[\underline{\text{two-ears-on-right}}(a)]]$.
- (6) $[[\text{two-ears-on-left}(a)]]$.

From (1) we deduce by **D&**:

$$(7) \quad ([[foetus(x_2)])] \& [[\underline{two\text{-}ears\text{-}on\text{-}right}(x_2)]] \& [[two\text{-}ears\text{-}on\text{-}left(x_2)])] \Rightarrow [[unheeded(y)]].$$

Then by **SR** we obtain from (7) the following statement:

$$(8) \quad ([[foetus(a)]] \& [[\underline{two\text{-}ears\text{-}on\text{-}right}(a)]] \& [[two\text{-}ears\text{-}on\text{-}left(a)]]]) \Rightarrow [[unheeded(b)]].$$

From (4), (5), (6) we can infer by **I&**:

$$(9) \quad ([[foetus(a)]] \& [[\underline{two\text{-}ears\text{-}on\text{-}right}(a)]] \& [[two\text{-}ears\text{-}on\text{-}left(a)]]]$$

Now by modus ponens from (8) and (9):

$$(10) \quad [[unheeded(b)]].$$

Thus, just automatically the diviner concludes that $[[unheeded(b)]]$, i.e. ‘the advice of land b will be unheeded’.

Rules **M1** and **M2** allowed the Babylonians to formulate deterministic forecastings for all events with all possible combinations of positive and negative signs. It gives a main feature of their prophecy logic. It is totally deterministic: plausible events are impossible, all events are necessary.

4. Akkadian Roots of Some Talmudic Hermeneutic Terminology

As it is known from [1]–[4], [22]–[27], the Talmud introduces a specific logical hermeneutics consisting of the following two parts: (i) a *classical propositional logic* for inferring court decisions on the basis of Torah’s articles and wise men orders; (ii) some *non-classical logics* for deducing new laws of wise men from the text of the Torah (the so-called *middot* in Hebrew). At least first part has its roots in the Mesopotamian tradition [27]: (i) a kind of classical propositional logic was borrowed by Jewish wise men not from Greeks, but from Babylonians (Akkadians and then Arameans) to deduce trial decisions by *modus ponens*, *modus tollens*, substitution rule, etc. from the law codes whose articles are formulated in the casuistic form: “if/when (Akkadian: *šumma*) this or that occurs, this or that must be done” in the same way as it is formulated in the Bible, e.g. “If [w *’im*] he has not been redeemed in any of those ways, he and his children with him shall go free in the jubilee year” (*Leviticus* 25:54); (ii) a kind of classical propositional logic, such as prophecy logic with rules **M1** and **M2**, was implicitly used to induce new omen lists for forecasting; meanwhile

each divination was formulated in the same casuistic form: “if (*šumma*) *P*, [then] *Q*”, therefore each forecasting was inferred by *modus ponens* or *modus tollens*, as well [20].

A Mesopotamian origin of Talmudic logic is well visible due to the hermeneutic terminology which has Akkadian roots quite often [9]. Let us start with the following prayer in Akkadian:

13. *i-zi-za-nim-ma* DINGIR.MEŠ GAL.MEŠ *ši-ma-a da-ba-bi*

14. *dī-ni dī-na a-lak-ti lim-da*

13. Stand by me, O great gods, and give heed to my suit,

14. Judge my case and grant me an (oracular) decision! [15]

The term *dīnu* is *dīn* (דִּין) in Hebrew and the term *alaktu* is *halakah* (הִלָּךְ) in Hebrew, see also [5]. So, this short phrase may have the following expanded meaning:

[O great gods,] let [the human] trial against me be a trial [of righteous people], show me the [righteous] way by your omens.

In this paper, I have just shown that symbolic-logical tools were applied by Akkadians not only for (i) justice (*dīnu*), but also for (ii) composing omens (*alaktu*). In other words, there were detailed lists of signs (*ittātu* / GISKIM.MEŠ) of two types: (i) articles of the law code; (ii) omens for divination. Each article of the code and each divination has the same logical structure “If (Akkadian *šumma*) *S*, then *P*.” The code was used for legal proceedings (as a part of *dīnu*), while the omens (as a part of *alaktu*) were used for prognoses. In both cases *modus ponens* and *modus tollens* were actively engaged as inference rules. In Greece, Chrysippus (c. 279 – c. 206 B.C.) defined *modus ponens* and *modus tollens* for the first time correctly [8].

The Sumerian writing of the word GISKIM (Akkadian *ittu*) consists of the graphic element IGI “eye”. It means that *dīnu* and *alaktu* were two fundamental tools to see everything. The Hebrew word *’ot* came from the Akkadian *ittu*. So, Kabbalistic aspects in interpreting Hebrew “letters” (*’otiot*, אותיות) as starting points for everything have Akkadian philosophical roots in fact. According to the Akkadians, *ittu* is a basic element participating in all the combinations (lists of law articles or omens) creating the world. And these combinations are represented in both law codifications (*dīnu*) and omens (*alaktu*). Both systems are a revelation of the heaven. And our task is only to read the “word” (Akkadian *amatu*) as a message from gods:

^dSAG.ME.GAR *ina* EGIR 30 *i-ti-ti-zi an-ni-u pi-šir-š[ú]* / DIŠ MUL.SAG.ME.GAR *ina* [EGIR ^d30] GUB-iz MÍ.KÚR *ina* KUR [GÁL-šú] / LUGAL *be-lí[á]-[bu-tú] in-nu-ú[šú-i]*

Jupiter stood behind the moon; this is its interpretation: “If Jupiter stands [behind the Moon] – there will be hostility in the land.” Oh king, my lord, [this is] a **w[ord]** concerning us! [9, p. 283]

Later the Akkadian *alaktu* (in the meaning to follow omens) might have been transformed into the Hebrew *halak^hah* (in the meaning to follow commandments). The point is that some Akkadian omens had the following reading: “If you perform something bad in context *X*, then there will be evil for you in context *X*” and “If you perform something good in context *X*, then there will be good for you in context *X*”. And this reading is quite similar to the Jewish commandments. In the *Babylonian Talmud*, some Jewish commandments are presented as conditional divinations directly and even in the form of implications “If *S*, then *P*”, e.g.:

Women die in childbirth for three transgressions: **If** they are not careful with [the laws] of menstruation; and **if** they are not careful [to separate some] dough [when baking to give to the priest]; and **if** they are not careful with the lighting of the [Shabbat] lamp (*Mishnah Shabbat* 2:5).

Thus, quite probably, the commandments of the Torah were divinations at the beginning.

For the first time, the phenomenon of canonical corpus of texts appeared in Mesopotamia:

Almost all of the texts that have attracted commentaries belong to the canonical corpus of first-millennium B.C.E. Mesopotamian literature. I use the term “canonical” to refer to texts that meet four criteria: (1) they belong to a relatively closed group of texts that circulated in various localities and in different periods during the first millennium B.C.E.; (2) their manuscripts are standardized and display a minimum number of variants; (3) they have been grouped into corpora, often as segments of an individual composition or (especially in Nineveh) as a series of compositions arranged in a standard sequence; and (4) they are attributed to a figure of great authority, often a divinity. Although the notion of canonization is not universally accepted in studies of Mesopotamian literature, I prefer to treat texts that meet these four criteria as members of a canon, even if there are limits and exceptions – as is the case with any canonical corpus [9, p. 4].

This canonical corpus mainly consisted of legal codes and omens. In the meanwhile, there existed a tradition of “oral lore” – how to interpret

this corpus (i.e. the written Scripture) correctly. In Akkadian the oral lore is denoted as *ša pî* (“of the mouth”), *ša pî ummâni* (“according to a scholar”), and *šût pî* (“those of the mouth”). They are very similar to the Hebrew expression [*tôrâ še*]-*be‘al peh*, תורה שבעל פה (“[Scripture that is] upon the mouth”).

A logical rule for interpreting the written Scripture of omens was called in Akkadian *nindanu ša bārûti* (“measurement of the *bārûtu* lore”) at one commentary [9, p. 300]. The term *nindanu* is interesting because it has a meaning closer to the Hebrew *middâ*, מִדָּה (“measurement”, a logical rule to interpret the Torah) of the same root. The Akkadian term *bārûtu* means divination or lore of the diviner. There is a closer Hebrew term *barait’a* of the same root in the meaning “lore of the Torah”. It is worth noting that the Judaic logical rules (*middot*) were well-defined explicitly in the *Barait’a Derabbi Išm‘a‘el* (בריתא דרבי ישמעאל) for the first time. Also, the Judaic gematria as a way of hermeneutic interpretation has its origin in Assyria [16].

5. Conclusions

Logical rules (*middot*, מִידוֹת) of Judaism were formalized in several logical papers and books: [1]–[4], [22]–[27]. The main conclusion of all these works is that (i) the *middot* of Judaism were concurrent to the Ancient Greek logic, on the one hand, and (ii) the *middot* are a kind of symbolic logic, because they can be formalized logically as well as the Ancient Greek logic was formalized, on the other hand.

In this paper, I propose a logical reconstruction for *alaktu* (composing omens) which were implicitly used by Babylonians. It was a prophecy logic, where the Boolean algebra was used implicitly.

It is possible to show that both Greek logic and Talmudic logical hermeneutics have their common roots in the Sumerian-Akkadian culture [27], [28], [29]. Both traditions have developed concurrently, but both had had the same origin in Mesopotamia [27]. Hence, the Ancient Greek logic was not the first, obviously. We can assume that this logic was invented within the Semitic legal culture [8], [27], [28], [29]. In fact, we know only four logical systems of the Ancient Greeks: (i) the Aristotelian syllogistic (Aristotle’s *Prior Analytics* and *Posterior Analytics*); (ii) the Aristotelian modal logic (Aristotle’s *On Interpretation*); (iii) the Stoic propositional logic (Hans Von Arnim’s *Stoicorum Veterum Fragmenta*); (iv) the Stoic modal logic (Cicero’s *On the Nature of the Gods*, *On Divination*, *On Fate*). These logical systems

can be formalized within the modern symbolic logic. In Mesopotamia there are two logical systems: (i) the Babylonian prophecy logic (for composing divination lists in Akkadian of different periods, first of all the Assyrian ones, ca. the first millennium B.C.); (ii) the Babylonian propositional logic for legal proceedings [28], [29] (the trial records, first of all the trial records of Neo-Babylonian period – from 626 B.C. to 539 B.C. [11], [12]). It is a direct evidence for the fact that in Mesopotamia there was a good logical competence in composing the divination lists.

NOTES

¹ In composing the divination lists, the Babylonians used only finite sets $2^{(k+l+\dots+m)}$ of signs, but we can expand their approach to put infinite sets $2^{(k+l+m+\dots)}$ of signs to produce an infinite Boolean algebra.

² The astrology of Babylonians has many features of astronomy, including good predictions of planetary rotations, but in general it does not satisfy Galileo's paradigm, then it cannot be called astronomy in the narrow sense.

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