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Satisfaction, Violation and Avoidance values of prescriptions in Western and Indian Trends: A Brief Review

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Abstract: *Imperative sentences refer to actions to be carried out. They lack truth value. In logic arguments are made of declarative sentences which are either true or false. But imperative sentences may be combined with logical connectives and imperative arguments may be formed. This paper attempts to make a critical survey of imperative logic from western and Indian perspectives.*

Keywords: *Speech Acts, Imperatives, prescriptions, logical connectives, Mīmāṁsā School.*

1. INTRODUCTION :

This paper attempts to undertake a critical estimation of the logic of imperatives from the view point of western and Indian philosophy. In the introductory section the nature of imperative sentence and its kinds, imperative argument and its kinds and the distinction between declarative and imperative sentences have been dealt with. The second section is concerned with the motivation behind the development of imperative logic from the linguistic and logical formalism. The next section discusses the system of Peter B.M. Vranas(2009) and the system developed by Bama Srinivasan and Ranjani Parthasarathi (2021) which offers a full fledged logical system for imperative sentences with its own syntax, semantics, completeness and soundness. It includes the discussion of the basic tenets of Mīmāṁsā philosophy on which it is based. The discussion ends with the comparative study of both the systems and some observations on them.

II

Logic of imperatives has become a topic of interest for logicians since last few decades. It is a logical system for imperative sentences. An imperative sentence is that which expresses a command or request. For example, “Close the door!” [! being the imperative operator]

2.1 Nature of imperative sentences:

1) An imperative sentence is neither true nor false.

2) It has a performative dimension.

3) It occurs in a context.

2.2 Kinds of imperative sentences:

An imperative sentence is mainly of two kinds, namely, unconditional and conditional.

Unconditional imperative: Love your neighbour as yourself!

Conditional imperative: If you love yourself, love your neighbour like yourself!

2.3. Distinction between a declarative sentence and an imperative sentence:

A declarative sentence is concerned with an assertion. For example, All roses are fragrant. It makes an assertion. All assertive sentences are either true or false. Classical two-valued logic deals with assertive sentences only. But unlike assertive sentences imperative ones are neither true nor false. They lack truth value.

2.4. Imperative arguments and its types

In our everyday life we often make useful imperative inferences. Imperative arguments have imperative sentence either as their premises or their conclusions or as both. An imperative argument is pure or mixed. A pure imperative argument is that in which premise/premises and its conclusion are all imperative sentences.

For example,

Respect your father and mother.

Respect your father.

A mixed imperative argument is that in which consists of both imperatives and declaratives. But its conclusion has to be an imperative sentence.

For example,

If you love him, respect him.

You love him.

Respect him.

III

Motivation behind the development of imperative logic

Actions are represented through imperatives and instructions. from the philosophical and linguistic viewpoint. Strong motivation may be found for developing imperative logic in the linguistic theory of speech act and its illucutionary force. Imperative logic dates from Aristotle in its subtle form. This section deals with the linguistic and logical foundation for articulating imperative logic.

3.1. Linguistic background:

In linguistics, imperatives are a part of directives from the perspective of the speaker and hearer. A speech act is the primary unit of language. It expresses the attitude during communication. J. L. Austin, in his Speech act theory, holds that any kind of utterance is a speech act. He draws a distinction between constative and performative utterances. The performative utterances are neither true nor false. Constative utterances are informative and either true or false. But performative utterances do not describe anything neither true nor false. It is a part of the doing of an action. Every utterance has a performative dimension and corresponds to an action. "… the issuing of the utterance is the performing of the action"… it is not normally thought of as just saying something.

Austin distinguishes between three kinds of performative utterances, namely, locutionary, illocutionary and perlocutionary. Locutionary utterance is just some noise like phone. To quote from *How to do things with Words*: "…… to say anything is… always to perform the act of uttering certain noise and the utterance is a phone." This particular kind of utterance shoes its constative nature of a statement. It denotes the actual meaning of the utterance.

But 'illocutionary utterance' has a performative force. It impels us to perform something with the utterance of someone else. For example, the utterance of 'I promise' invokes in us a conventional force to do something or it brings force to do something or it brings force to do something or it brings about certain consequences as it has a performative force to do something. It demonstrates the function of the utterance.

The perlocutionary utterance also has a force to do something but the force here is not a conventional one. This category specifies the effect or result produced from the utterance.

The shop will be closed within another ten minutes.

1. The shopkeeper utters a group of meaningful words and gives the information to all present there that the shop is about to close within ten minutes from the time of his utterance. Thus he performs a locutionary act.

2. He is reminding others that they should collect their necessary articles which they need to buy. It is an illocutionary utterance.

3. The shopkeeper performs the perlocutionary utterance by making the buyers believe that the shop is going to be closed within ten minutes.

The locutionary utterance is an act of saying something. Illocutionary utterance is an act which one does in saying it and the perlocutionary utterance is an act which one does by saying it.

Austin develops his theory of Speech act by taking illocutionary utterance into opinion that illocutionary utterances of four kinds, namely, constatives, directives, commissives and acknowledgements.

List of constantive utterance: affirming, alleging, announcing, answering, attributes, claimimg, classifying, confirming etc.

List of directives: advising, admonishing, urging, asking, begging, suggesting, warning etc.

List of commissives: agreeing, guaranteeing, inviting, offering

List of acknowledgements: apolozing, condoling, congratulations.

Directives comprise of imperatives which address different illocutionary forces such as command, advise, threads and warnings.

Order: Take the pen./ Close the door.

Advise: Be cheerful./Be happy.

Treat: Touch the live and you will get burnt.

Warning: Touch the fire and you will get burnt. They may be treated as the stepping stone for the development of imperative logic.

3.2. Logical background:

The formal logic formulated by Aristotle is considered as the foundation in the field of logical studies in general. The common doctrine of Aristotelian logic, namely, classical two-valued logic, is that every proposition is true or false. But the primary trace of possibility of statements not confined to have the truth-values has been found in Aristotle's writings. In chapter 9 of his *On Interpretation* (De Interpretation) Aristotle himself has mentioned that truth or falsity may not be assigned to statements in some cases. Future contingent statement is one of these varieties. "There will be a sea- battle tomorrow". This statement is neither true nor false. It cannot be said that the statement is true because the sea-battle might happen or not. Nor can it be considered as false that there will not be a sea-battle tomorrow because it is to admit that there will not be a sea- battle tomorrow. It is not possible to predetermine the occurrence of a sea- battle one day prior.

A future contingent statement is neither actually true nor actually false, but has a third indeterminate truth value. Aristotle does not reject intermediate possibilities between being certainly true and being certainly false or between being known to be true and being known to be false. But he did not speak of any definite third value.

The primary notion of imperative logic is also found in Aristotle's distinction between a practical and theoretical syllogism in his Nicomachean ethics where the conclusion of a practical syllogism is an action.

There is a tendency among the logicians to translate imperative sentences into declarative sentences- in order to include them within the scope of classical two valued logic. This reductionist approach does not allow imperative logic as a separate system of logic. But the uniqueness and novelty of imperative sentences, a system of logic for imperative sentences may be envisaged which is not isomorphic to the classical two-valued logic.

In this context the contribution of Alf Ross (1941) is worth mentioning. In his "*Imperative and Logic*" he raises a question. Can imperative be a constituent part of a logical inference. He formulates the disjunctive paradox.

Post the letter.

Post the letter or burn it.

The rule of disjunction of two-valued logic is applicable here as the conclusion is counter intuitive in nature.

Imperative logic may be considered as a variety of extended logic. It refers to the extension of the classical two-valued logic introducing the imperative operator and other required syntax and semantic value keeping the entire vocabulary of C_2.

IV

4.1. Peter B.M.Vranas (2009)

The most recent developed system of logic for imperative logic is the system developed by Peter B. M. Vranas. A system of three-valued logic may be formulated for imperative sentences in parallel to two-valued logic of assertive sentences of subject-predicate form. Any form of command or imperative sentence, according to Vranas is expressed in terms of 'prescription' which is the basic unit of imperative logic. It is necessary to determine the logical status of prescriptions as they are the constituent parts of an imperative argument. A prescription is satisfied and violated. The prescription "Love him" is satisfied if you love him and violated if you do not love him. The proposition "You help him" is the satisfaction proposition and the proposition "You do not help him" is the violation proposition of the prescription "Help him". A prescription is an ordered pair of satisfaction proposition and violation proposition. These two propositions are logically incompatible propositions as both cannot be fulfilled at the same time. It is impossible for a prescription to be both satisfied and violated. The prescription 'I' may be defined as an ordered pair of sets S and V. Vranas defines a prescription as follows:

"A prescription is any ordered pair of logically incompatible propositions".
The letter S stands for the satisfaction proposition and V stands for the violation proposition which may be symbolized in the following manner.
I= < S, V >
Prescriptions may be defined with examples in the following way:
i) Unconditional prescription:
Help him = < you help him, you do not help him >.
ii) conditional prescription:
If you love him, help him= < you love him and help him, you love him but do not help him >.

It may be argued that the imperative logic would then be isomorphic to classical logic, as the key concept of imperative logic which is a prescription has two values, namely satisfaction and violation. For this reason it is argued that imperative logic is nothing new but isomorphic to the classical logic in which a proposition is of two values- truth and falsity. In that case, imperative logic would be of no use and become very uninteresting. But the uniqueness and novelty of the imperative logic has been retained by the distinction between unconditional and conditional prescriptions. A conditional prescription is different from an unconditional prescription as the conditional prescription is conditional if it is prefixed or suffixed with a condition. It has been already mentioned that a prescription is defined in terms of two incompatible propositions which cannot be true at the same time, it may be neither satisfied nor violated, i.e., to be avoided. Vranas attributes this third value of avoidance to a conditional prescription. For this reason, he claims that though an unconditional prescription has two values of satisfaction and violation but three values, namely, satisfaction, violation and avoidance. For example,
If you love him, trust him.
This prescription is

a) satisfied if you love him and help him
b) violated if you love him but do not help him
c) avoided if you do not love him, no matter you help him or not.

Vranas justifies the reason for admitting the third value of avoidance for a conditional prescription. According to him, a material conditional in traditional logic, "If he proposes, you will marry him" is true, even if the antecedent does not hold, or if he does not propose because a false antecedent can entail a true proposition. But in the conditional prescription, "If he proposes, marry him", it cannot be considered as either satisfied or violated, if the antecedent does

not hold or he does not propose. Hence, a third criterion is required to tackle this situation. If the antecedent does not hold, i.e. he does not propose, then the conditional prescription is neither satisfied nor violated, but avoided.
According to Vranas prescriptions have logical connectives like negation, conjunction, disjunction, conditional and bi-conditional. They can be defined in terms of satisfaction criterion and may be represented in tabular forms in the following way:

i) Negation:

The definition of negation is defined as follows:

Definition 1. The negation of the prescription with the satisfaction set S and violation set V is the prescription with the satisfaction set V and violation set S.

It may be symbolically represented as

$I = \langle S, V \rangle$

$\sim \langle S, V \rangle = \langle V, S \rangle$

The pair of 'S, V' is an ordered pair with first member S and second member V in the prescription.

The negation of an unconditional prescription

"Help him" is "Do not help him".

Now the negation of this prescription is satisfied if the negated prescription is violated. Again, the negation is violated if the negated prescription is satisfied.

Prescription= Help him.

Negation= Do not help him.

Satisfied = you help him.

Violated = you do not help him.

This logical connective of negation may be explained with the help of a conditional prescription as well.

If you trust him, help him.

or

Help him, if you trust him.

The negation of the prescription would be

Do not help him, if you trust him,

or

If you trust him, do not help him.

The above prescription is satisfied if the negated prescription is violated i.e. "If you trust him, but you do not help him." It is violated if the negated prescription is satisfied and i.e. "If you trust him and help him".

The satisfaction and violation criterion of a conditional prescription are identical to that of an unconditional prescription. But it is different from an unconditional prescription as the former possesses a third value of avoidance.

The conditional prescription is avoided, if "if you do not trust him".

This kind of negation has been considered as the total negation by Vranas.

However, the law of double negation holds good for both unconditional and conditional prescription in this total negation. The rule of double negation of a prescription is that the negation of a prescription of a given prescription is the given prescription.

$\sim (\sim \langle S, V \rangle)$

$= \sim \langle V, S \rangle$

$= \langle S, V \rangle$

Beside total negation, there are two other kinds of negation, namely, satisfaction negation and violation negation.

The satisfaction negation and violation negation of a conditional prescription is explained in the following way:

Do not do B, if you do A.

or

If you do A, do not do B.

It is equivalent to

Do not do the following: do B if you do A.

which is equivalent to

Do not satisfy the following prescription.

Violate the following prescription.

Given a prescription I with satisfaction set S and violation set V the satisfaction negation of an unconditional prescription may be expressed as

"Let I not be satisfied". [With the violation set S]

And its violation negation may be expressed as

"Let I be violated". [With the satisfaction set V]

It may be schematically represented as

$I = \langle V, S \rangle$ [negation of the prescription with S as the first member and V as the second member]

Its satisfaction negation ($\sim_S I$) is as follows:

$\sim S \langle V, S \rangle$

$= \langle S^c, S \rangle$

Its violation negation ($\sim_v I$)is as follows:

$\sim V \langle S, V \rangle$

$= \langle V, V^c \rangle$ [where c denotes complementary class]

The satisfaction negation and violation negation are not free from defects.

Firstly, the law of double negation does not hold here. The application of double negation of satisfaction negation and violation negation of a conditional prescription makes it an unconditional prescription which is different from the original conditional prescription. Secondly, different prescriptions may have same satisfaction negation.

For example,

If you do A, do B.

If you do B, do A.

The satisfaction negation of both the prescriptions

"Do not do both A and B", is firstly an unconditional prescription. Moreover, this unconditional prescription is the same satisfaction negation of the above two conditional prescriptions.

Apart from total negation, satisfaction negation and violation negation, Vranas mentions three other kinds of negation. They are permissive negation, illocutionary negation, and bindingness negation. The prescription

"Help me"

may be negated as

i) You may refrain from helping me. (permissive negation).

ii) I am not asking you to help me. (illocutionary negation)

iii) You have no reason to help me. (bindingness negation)

The table for negation is as follows:

P	~p
S	V
V	S

Conjunction

Conjunction has been defined in the following way:

> **Definition 2.** The conjunction of two prescriptions (the conjuncts) is the prescription in which the context is the union of the contexts of the conjuncts and in which the violation is the union of the violation sets of the conjuncts.

Let us explain the definition of conjunction in terms of unconditional and conditional prescriptions.

The conjunction of two unconditional prescriptions "Trust me" and "Help me" is

"Trust me and help me".

Now being an unconditional prescription, it is either satisfied or violated. The conjunction is satisfied if both the conjuncts are satisfied. It is violated if at least one conjunct is violated. In the example, the conjunction,

"Trust me and help me" is satisfied if you both trust me and help me. The same conjunction is violated if you do not trust me and you do not help me.

Two conditional prescriptions may also be conjoined in the following way:

Prescription I: "If you love me, trust me".

Prescription II: "If you love me, help me".

The conjunction of these two conditional prescriptions would be

"If you love me, trust me and if you love me, help me". It is also equivalent to

"If you love me, trust and help me".

This conjunction, being a conditional prescription would have three values, namely, satisfaction, violation and avoidance. The prescription is satisfied if both the conjuncts are satisfied. In the above example, the conjunction is satisfied, if you love, trust and help me. The conjunction is violated, if at least one conjunct is violated. The above conditional prescription is violated if you love but do not trust me or help me. But according to Vranas, a conditional prescription is avoided if both conjuncts are avoided. The conjunction, stated in the example, is avoided if you do not love me.

Vranas next proceeds to define violation, avoidance and satisfaction conditions of a conjunctive prescription.

Defining satisfaction, violation and avoidance conditions of conjunction:

1) Violation condition of two prescriptions:

The conjunction of two prescriptions is violated, if at least one conjunct is violated, so the violation set of the conjunction is the union of the violation sets of the conjuncts.

$(V_I \ \& \ V_I') = (V_I \cup V_I')$

2) Avoidance condition of two prescriptions:

The conjunction of two premises is avoided if both conjuncts are avoided so the avoidance set of the conjunction is the intersection of the avoidance sets of the conjuncts.

$(AV_I \& AV_I' = AV_I \cap AV_I')$

The context of the conjunction is the union of the contexts of the conjunct.

3) Satisfaction condition of two prescriptions:

The conjunction of two prescriptions is satisfied exactly if at least one conjunct is satisfied and no conjunct is violated.
$S_I \& S_I' = (S \cup S_I') - (V \cup V_I')$

which is equivalent to if at least one conjunct is not avoided if and no conjunct is violated.

The conjunction has been defined in terms of its context and violation set, which can be symbolically expressed as

$\langle S, V \rangle \ \& \langle S', V' \rangle$

$= \langle (C \cup C') - (V \cup V'), V \cup V' \rangle$

$= \langle (S \cup S') - (V \cup V'), V \cup V' \rangle$

(where $C = S \cup V$ and $C' = S' \cup V'$)

The conjunction of the conditional prescriptions mentioned above, is the conjunction of two prescriptions having the same context. There are also prescriptions having three other kinds of contexts, namely, complementary, nested and overlapping contexts. These three kinds of conjunctions have been discussed in the following paragraph.

A. **Conjunctions with complementary contexts:**

Two conditional prescriptions

(i) “If you love me, trust me”,

(ii) “If you do not love me, trust me”,

have complementary context. The conjunction of (i) and (ii) is

“If you love me, trust me and if you do not love me, trust me”, which is equivalent to

“Trust me whether or not you love me”, which is again equivalent to

“Trust me”.

The difference between a conjunction of two prescriptions having the same context and a conjunction of two prescriptions having the complementary context is that ,in the former case, its avoidance set being the same of its context, if any of the prescription of the conjunction is avoided then the other conjunction is avoided. It cannot be the case that the one of the prescription of the conjunction is avoided, but the other is either satisfied or violated.

But in the conjunction of two prescriptions having the complementary contexts, if one of the prescriptions is avoided, the other one may be satisfied or violated. The example of this prescription is “Trust me whether you love me or not”. In the first prescription “If you love me, trust me” is avoided. But it is satisfied as the prescription is “If you do not love me, trust me”.

B. **Conjunctions with nested context:**

Two prescriptions ‘Help me’ and ‘If you love me, trust me’ have nested context as the first prescription is an unconditional prescription but the second prescription is a conditional prescription. The context of the second prescription is already contained in the context of the unconditional prescription. As a result, the conjunction becomes unconditional. The conjunction is violated exactly if the first conjunct is violated or the second. For example, either you do not help me or you love me but do not help me is equivalent to if you do not help me.

C. Prescriptions with overlapping context:

Prescriptions may have overlapping context. For example, ‘If he proposes, marry him’ and ‘if he loves you, marry him’ are two prescriptions with overlapping context. The conjunction of two prescriptions would be as follows.

“If he proposes, or he loves you, marry him”.

Furthermore, Vranas speaks of three other varieties of conjunctions, viz.

1) violation conjunction

2) satisfaction conjunction

3) fusion (following Rescher)

The above mentioned three kinds of conjunctions have not been discussed in details as that would deviate us from the focus of our discussion. The table for conjunction is as follows:

I / I′	I & I′ S A V
S	S S V
A	S A V
V	V V V

Disjunction

Disjunction, has been defined by Vranas as follows:

> **Definition 3.** The disjunction of two prescriptions (the disjuncts) is the prescription whose context is the union of the contexts of the disjuncts and whose satisfaction set is the union of the satisfaction sets of the disjuncts.

Two unconditional prescriptions may form a disjunction. Two disjuncts are 'Trust me' and 'Hate me'. So the disjunction is

Trust me or hate me.

An unconditional disjunctive prescription is satisfied if at least one disjunct is satisfied. It is violated if both disjuncts are violated. The above prescription

"Trust me or hate me",

is satisfied if you either trust me or you hate me. It is violated if you neither trust me nor hate me.

In case of two conditional prescriptions with complementary context, it is satisfied if one of the disjuncts is avoided but the other disjunct is satisfied. It is violated if one of the disjuncts is avoided but the other disjunct is violated. The prescription is avoided if one of the contexts is avoided.

It may be schematically represented as follows:

$\langle S, V \rangle \text{ v } \langle S', V' \rangle$

$= \langle S \cup S', (C \cup C') — (S \cup S') \rangle$

$= \langle S \cup S', (V \cup V') — (S \cup S') \rangle$

Vranas bases the disjunctive connective on De Morgan's law. It holds two conditions:

Firstly, the negation of the conjunction of two prescriptions is the disjunction of their negation and secondly, the negation of the disjunction of two prescriptions is the conjunction of their negation. This may be proved in the following way:

$\sim (\langle S, V \rangle \& \langle S', V' \rangle)$

$= \sim \langle (S \cup S') - (V \cup V'), V \cup V' \rangle$

$= \langle V \cup V', (S \cup S') - (V \cup V') \rangle$

$= \langle V, S \rangle \text{ v } \langle V', S' \rangle$

$= \sim \langle S, V \rangle \text{ v } \sim \langle S', V' \rangle$

The table for disjunction is as follows.

I / I′	I ∨ I′ S A V
S	S S S
A	S A V
V	S V V

Conditionals

The definition of conditional has been offered by Vranas as follows:

> **Definition 4.** The conditional whose antecedent is the proposition P and whose consequent is the prescription with satisfaction set S and violation set V is the prescription whose satisfaction set is intersection of P with S and whose violation set is the intersection of P with V.

Let us take an example in order to define conditionals. According to Vranas, a conditional is a combination of a proposition and prescription. In the example, 'If he loves you, help him', the antecedent 'he loves you', is a proposition, and "help him' is a prescription. Now the conditional is satisfied if the antecedent is true and its consequent is satisfied. The violation of the conditional depends on the fact that the antecedent is true and its consequent is violated. So, the conditional is violated if the antecedent 'he loves you' is true and its consequent 'help him' is violated. A conditional is avoided if the antecedent does not hold good or if he does not love you.

It may be symbolically stated as

$P \rightarrow \langle S, V \rangle = \langle P \cap S, P \cap V \rangle$

While defining the characteristics of conditionals, Vranas highlights three important aspects. Firstly, the context of a conditional is the intersection of the antecedent which is a proposition and the context of the prescription which is the consequent of the conditional. The context of P→I is the intersection of P and the context of I.

Secondly, negation of an imperative conditional is the negation of its prescription which is its consequent. For example, the negation of a conditional prescription 'If he loves you, trust him', is 'If he loves you, do not trust him'.

Thirdly, the definition of conditional is not identical to the definition of any implicative sentence in standard logic. For example,

$P \rightarrow I$ is not $P^c \vee I$

$= \sim (P \& \sim I)$

Lastly, the format of a conditional prescription offered by Vranas is that the antecedent is always a proposition and the consequent is a prescription.

It is also true that a conditional may have a prescription as its antecedent and a proposition as its consequent. For example, "Marry him only if he loves you". But according to Hecter Neri Castaneda and Gensler, the prescription, "Marry him only if he loves you" is same as "If he does not love you, do not marry him".

In that case, $I \rightarrow P$ may be defined as $P^c \rightarrow \sim I$. But there are many objections to this view, the discussion of which is restricted here for fear of digression.

p → I		S	A	V
T/F	S/A/V			
T		S	A	V
F		V	A	S

Biconditionals

The biconditional has been defined by Vranas as follows:

> **Definition 5.** The biconditional P↔I of the proposition P and the prescription I is the conjunction of the conditionals of P →I and $P^c \rightarrow \sim I$.

A biconditional prescription is the conjunction of two conditional prescriptions each having a proposition and a prescription.

For example, “Trust him if and only if you love him”.

However, the biconditional “Trust him if and only if you love him” is the conjunction of the conditionals expressed by “Trust him if he loves you” and “Trust him only if he loves you”. It is the conjunction of two prescriptions namely, “If you love him, trust him” and “if you do not love him, do not trust him”.

Now, regarding the satisfaction, violation and avoidance condition, it may be stated that a biconditional is satisfied if P is true and I is satisfied or P is false and I is violated. It is violated if P is true and I is violated, or P is false and I is satisfied. In the example, the biconditional is satisfied if he loves you and you trust him or he does not love you and you do not trust him. The same biconditional is violated if he loves you and you do not trust him or he does not love you and you trust him.

It may be symbolically represented in the following way:

$P \leftrightarrow \langle S, V \rangle$

$= (P \rightarrow \langle S, V \rangle \& (P^c \rightarrow \langle V, S \rangle$

$= \langle (P \cap S) \cup (P^c \cap V) , (P \cap V) \cup (P^c \cap S) \rangle$

In biconditional, Vranas claims two further points. Firstly, the context of $P \leftrightarrow I$ is the context of the imperative sentence or prescriptions.

Secondly, the negation of an imperative biconditional “Trust him if and only if he loves you” is “Trust him if and only if he does not love you”.

The tabular form of the bi-conditional may be represented in the following way:

$P \leftrightarrow I$	S	A	V
T	S	A	V
F	A	A	A

4.2. Mīmāṁsā Inspired Representation of Actions (MIRA) by Bama Srinivasan and Rajani Parthasarathi (2021)

Purva Mīmāṁsā, one of the six orthodox systems of Indian philosophy, gives an exhaustive method of interpreting Vedas. With the help of the sentences, dealt by them, namely, vidhi and niṣedha, a logical formalism has been developed by Bama Srinivasan and Rajani Parthasarathi (2014).

Basic tenets of Mīmāṁsā system

The founder of Mīmāṁsā school is Jaimini. It is also called as karma Mīmāṁsā which deals with rituals, rites and sacrifices. The first verse of the text Jaimini Sutra is Athāto dharma jiĵnāsā. It is an enquiry into the nature of dharma. It impels one to know or to learn. Dharma is that which is indicated by Vedic injunctions. (Codonā lakśana artho dharma) The vedic injunctions are of two kinds: “Do’s” and “Don’ts”. The vedic injunctions are given in some kind of sacrifices. Do’s indicates dharma. Don’t indicates adharma. It is to eliminate adharma. For example, a person desirous of heaven should perform Agnihotra which indicates dharma. (Svargakāma yajeta) What is to be done or vidhi indicates dharma. An example of adharma is “Perform śyenana to kill enemies” (Śyenana abhicaran yateta).

Mīmāṁsāka speaks of different kinds of karmas in the form of sacrifices:

1) Nitya karma (obligatory sacrifice): Nitya karmas are those actions that a person performs every day. Doing these actions does not lead to accumulation of virtue but not doing them leads to the emergence of sin. For example, sandha bandana should be performed by an individual everyday throughout the life.

2) Naimittika karma (occasional sacrifice): It is an action done on special occasions. Actions done at the time of birth, death and marriage are examples of naimittika karmas.

3) kāmya karma: (Utilitarian sacrifice): Such actions which are done for the purpose of achieving certain fruits are called kāmya karma. It is done for the attainment of something. For example, sacrifice performed for the attainment of wealth, house-peace, sacrifice for rain etc.

Following Mīmāṁsā school, some important kinds of injunctive sentences are required to be mentioned.

a) Vidhi (Injunctive statement): It initiates a person to perform actions.

b) Niṣedha (Prohibitory statement): This prohibits a person from performing an action.
c) Arthavāda (Corroborative statements): These statements support injunctions and encourage the performance of injunctive statements (vidhi) and discourage the performance of prohibited actions (Nisedha). Example, Vāyu being a God of speed will help you achieve the results faster (Vāyur vai kshepista Devata)

2 Mīmāṁsā Inspired Representation of Action (MIRA)

Mīmāṁsā Inspired Representation of Action (MIRA) is based on the different kinds of injunctive statements. According to this system, there are different logical statements. They may be either unconditional or conditional imperative sentences.
a) Pure unconditional imperative statements are of two kinds.
1. Vidhi – It is a positive unconditional imperative sentence.
2. Niṣedha- It is a negative unconditional imperative sentence.
b) Conditional imperative sentences: Mīmāṁsā admits that a conditional injunctive statement is a combination of an injunctive and non-injunctive statement. For example, If it is cold, then wear a jacket. It has two parts. The first part of the sentence (it is cold) is the ground or reason (hetu) and the second part (wear a raincoat) is an injunction (hetumat). In MIRA three kinds of conditional statements have been admitted.
1. phalavidhi (cig): It is an imperative enjoining goal. The condition in the imperative indicates the intention of the goal clearly. Example: If you want to go to the first floor, climb the stairs. The intention of goal on agent's part plays the pivotal role here.
2. hetu-hetu-madbhava (cir): It is an imperative enjoining reasons. The condition acts as the ground or reason for an action to be performed. Example: If it is cold, wear a jacket. The condition is "it rains".
3. Śrutikrama (cia): It is an imperative enjoining sequence of actions. Here two actions are to be carried out in a sequence. Example: Write the letter, and put it into an envelope. It may be rephrased as "If you write a letter, then put it in an envelope."
Next it has been shown that there may be conjunctions and disjunctions of imperative sentences.
c) samuccaya: It is a conjunction of two imperative sentences. Example, Go to the shop and buy chocolates.
d) Vikalpa: i) It is a disjunction of two imperative sentences. Drink tea or coffee, but not both.It is restrictive and exclusive injunctions (niyamavidhi and parisankhyāvidhi) and not in the inclusive sense. When two or more methods are prescribed to reach the goal, making one of them mandatory is a restrictive injunction. For example, the prescription "Pound the corn to remove the husk" holds that the husk is to be removed by the action of pounding but there may be other ways to remove the husk from the corn.
ii) Exclusive injunction (Parisankhyāvidhi): Exclusion of one from two items that are present simultaneously is an exclusive injunction. For example: Only five animals with five toes may be eaten. It implies that five-toed animals other than the stipulated number must not be eaten.
Syntax: The syntax part of MIRA imperatives in the form of vidhi and niṣedha- positive and negative unconditional instructions includes

$Ł_i = < I, R, P, B >$

a) $I = (I^n \cup I^v)$ where I^n denotes positive unconditional imperatives $\{i_1^+, i_2^+, \ldots i_n^+\}$ and I^v denotes negative unconditional imperatives $\{i'_1, i'_{2\ldots\ldots}i_n\}$. I denotes I^n and I^v.
b) i) R denotes reasons $(r_1, r_2, \ldots r_n)$ and also referred as **τ**
ii) P denotes purpose $(p_1, p_2, \ldots p_n)$ and also referred as θ
iii) R and P – sets of well formed formulae of propositional logic
c) Binary operators: ∧, $\underline{\vee}$, $\rightarrow_r$, $\rightarrow_i$, $\rightarrow_p$ [$\underline{\vee}$ stands for exclusive disjunction]
d) Formation rules: Given the vocabulary of language ($Ł_i$), F_i can be categorized as imperative formulae (F includes the propositional logic connectives)
1. If $i \varepsilon I^v$ then $i' \varepsilon I^n$
2. If $i \varepsilon I^n$ then $i^+ \varepsilon I^v$
3. If $i \varepsilon I$ then $i \varepsilon F_i$
4. If $i \varepsilon I$ and $p_1 \varepsilon P$ and $p_2 \varepsilon P$, then $i \rightarrow_p p_1 \varepsilon F_i$
5. If $i \varepsilon I$, $j \varepsilon I$, $p_1 \varepsilon P$, and $p_2 \varepsilon P$, then $i \rightarrow_p p_1$ and $j \rightarrow_p p_2$, then $(i \rightarrow_p p_1) \wedge (j \rightarrow_p p_1) \varepsilon F_i$ where $i \neq j$ and $p_1 \neq p_2$
6. $i \varepsilon I$, $j \varepsilon I$, $p_1 \varepsilon F_i$, $\theta \varepsilon P$, then $(i \rightarrow_p \theta) \underline{\vee} (j \rightarrow_p \theta) \varepsilon F_i$ where $i \neq j$
7. If $\varphi \varepsilon F_i$, and $\psi \varepsilon F_i$ then $\varphi \rightarrow_i \psi \varepsilon F_i$ where $\varphi \neq \psi$
8. If $\tau \varepsilon R$ and $\varphi \varepsilon F_i$, then $\tau \rightarrow_i \varphi \varepsilon F_i$
e) Deduction Rules

Let $i^+, j^+ \varepsilon I^+$; $i', j' \varepsilon I^n$, $i \varepsilon I; \tau \varepsilon R$; $\varphi, \psi \varepsilon F_i$, $\theta \varepsilon P$

1. Conjunction introduction (ci): This rule connects two imperatives with a conjunction operator. -

$(i \rightarrow pP_1)$ $(j \rightarrow pP_2)$

$(i \rightarrow pP_1) \wedge (j \rightarrow pP_2)$

2. Conjunction elimination (ce): If two imperatives are connected by the conjunction operator, one of the imperatives can be deduced.

$(i \rightarrow pP_1) \wedge (j \rightarrow pP_2)$
--- (ce1)
$(i \rightarrow pP_1)$

$(i \rightarrow pP_1) \wedge (j \rightarrow pP_2)$
--- (ce2)
$(j \rightarrow pP_2)$

3. Disjunction elimination (de): When two imperatives are connected by disjunction operator, one can be deduced based on the assumption that the other imperative is not followed.

$(i^+ \rightarrow_p \theta) \veebar (j^+ \rightarrow_p \theta)$ $(i^+ \rightarrow_p \theta)$
--- (de_nv)
$(i^+ \rightarrow_p \theta)$

$(i^+ \rightarrow_p \theta) \veebar (j^+ \rightarrow_p \theta)$ $(j^+ \rightarrow_p \theta)$
--- (de_pv)
$(j^+ \rightarrow_p \theta)$

4. Conditional introduction and conditional elimination (cni,cne):

i) For conditional imperative enjoining reason (cir) $\tau \rightarrow_r \varphi$, let X= τ, Y= φ and w= r.
ii) For conditional imperative enjoining reason (cig) $\varphi \rightarrow_p \theta$, let X= τ, Y= φ and w= p.
iii) For conditional imperative enjoining reason (cia) $\varphi \rightarrow_i \psi$, let X= τ, Y= φ and w= p.

[X]……Y

$X \rightarrow_w Y$ (cni)

X $X \rightarrow_w Y$
--- (cne)
Y

Semantics : The semantics of MIRA starts with the values of imperatives.

A. i) **Values of an imperative:** An imperative has three values:

1. satisfaction (S)
2. violation (V)
3. No intention to reach the goal (N)

It may be symbolically represented as

$\varepsilon (\varphi) \varepsilon \{S,V,N\}$ (φ is an imperative).

ii) Propositional formulas are either true or false.

$\varepsilon (\tau) \varepsilon \{T,F\}$
$\varepsilon (\theta) \varepsilon \{T,F\}$ (τ and θ are well-formed formulae propositional logic)

B. Evaluation of an imperative:

Let $i^{+} \in I^{n}$ and $i' \in I^{v}$

If $\varepsilon (i^{+}) = S$, $\varepsilon (i') = V$

If $\varepsilon (i') = V$, $\varepsilon (i^{+}) = S$,

C. Tables for imperatives

i) **Imperatives enjoining goal (cig)**

Φ	Θ	$\varphi \rightarrow_{p} \theta$
S	T	S
S	F	N
V	T	V
V	F	N
N	T	N
N	F	N

ii) Imperatives enjoining sequence of actions (cia)

φ^{1}	ψ^{2}	$\varphi \rightarrow_{i} \psi$
S	S	S
S	V	V
V	S	V
V	V	V
N	S/V	N
S/V	N	N

iii) Imperatives enjoining reason (cir)

T	Φ	$\tau \rightarrow_{r} \varphi$
T	S	S
T	V	V
T	N	N
F	S	N
F	V	N
F	N	N

iv) Conjunction of imperatives

$i_1 \rightarrow_{p} p_1$	$i_2 \rightarrow_{p} p_2$	$(i_1 \rightarrow_{p} p_1) \wedge (i_2 \rightarrow_{p} p_2)$
S	S	S
S	V	V
S	N	N
V	S	V
V	V	V
V	N	N
N	S	N
N	V	N
N	N	N

v) Disjunction of imperatives

$i \rightarrow_{p} p$	$j \rightarrow_{p} p$	$(i \rightarrow_{p} p) \underline{\vee} (j \rightarrow_{p} p)$
S	S	V
S	V	S

S	N	N
V	S	S
V	V	V
V	N	N
N	S	N
N	V	N
N	N	N

MIRA is the logical formalism based on Mīmāṁsā school of Indian philosophy. It takes injunctions or vidhi mentioned in Vedas as the fundamental unit of the logical system for imperatives. It is a unique attempt to formalize imperative sentences in the sense that it considers a goal oriented approach in dealing with imperative sentences. An injunctive statement is concerned with motivation (bhāvanā). The performance of an action depends on the goal of an action. The formalism admits the distinction between the unconditional and conditional imperatives. It also admits the logical connectives like conjunction, exclusive disjunction, for imperative sentences. It interprets the conditional imperatives as cig, cia and cir. It also shows the soundness and completeness of the system.

But there are some issues in this system which I find a little bit uncomfortable and need to be addressed.

a) i) In Mīmāṁsā system three kinds of actions have been considered as extremely significant, namely, nitya karma, naimittika karma and kamya karma. MIRA takes naimittika karma and kamya karma in formulating the logical system of imperatives but nitya karma has been kept outside the scope of the logical formalism of MIRA as in it, the goal is not explicitly known. MIRA considers actions as goal-oriented.

ii) Although MIRA admits the distinction between unconditional and conditional imperatives, unconditional imperatives do not possess any significant role except as being a constituent part of a conditional imperative. Simple unconditional imperatives are not taken into account as a basic unit of this logical formalism. In the semantic interpretation of this system when tables have been formed, the unconditional imperatives have not been entertained or unconditional imperatives have not been considered as the primary elements in dealing with conjunctions and disjunctions of imperatives. When the conjunctions and disjunctions have been represented with tables, the conjunction and disjunction of conditional imperatives are shown.

b) This is regarding the notion of conditional statements in MIRA. It admits three kinds of conditional statements.

1. Imperative enjoining goal (cig): $\varphi \rightarrow_p \theta$

Example, To go to the first floor, climb the stairs.

2. Imperative enjoining reasons (cir) $\tau \rightarrow_r \varphi$:

Example, If you want to get good marks in exam, work hard.

3. Imperative enjoining sequence of actions (cia): $\varphi \rightarrow_i \psi$

Example: Write the letter, then put it into an envelope.

In logic, the form of a conditional statement is ‘if p, then q’. In general, in an imperative sentence is such that the former part is an indicative sentence and the later part is an imperative sentence. Taking this form for a conditional imperative sentence, it may be said that the conditional imperative enjoining reason may be an appropriate interpretation of it. But the problem is with other two forms.

i) θ is considered to be the indicative part of a conditional imperative. It is difficult to place θ in the consequent part following the form of conditional statement as ‘if p, then q’ as it is there in ‘cig’.

ii) The situation is more serious in ‘(cia)’. A question may arise in this context. How can two unconditional imperative be placed in former and the later where the main operator is ‘→’.

In the next section I have attempted to deal with these issues.

III

Now it is the time to take the issues mentioned in the previous section.

1. Nitya karma is a daily obligatory action that must be performed by everyone every day. Performance of these actions does not result in merit but non-performance results in sin. Performance of these actions makes every individual a better human being. It is performed to remove suffering and attain God. By performing this karma one can develop strong will power, ability to concentration and self determination to do any kind of action. For example, snāna, sandhā bandanā, etc.

My observation is that Nitya karma is also goal oriented. It should be included within the scope of logical formalism of imperative sentences. All schools of Indian philosophy except Carvaka system aim at ultimate goal of moksa or liberation. In nitya karma if the goal is not an immediate one to achieve but it helps an individual to become a better

human being by performing rituals and yognas to pay off all his debts towards his forefathers, sages, God and even to his society and environment in the wider aspect. By performing nitya karma one is able to be free from the bondage of life-chain and to attain liberation. Hence nitya karma is directed to goal though not explicit but implicit. Moreover, if we admit that actions can be formalized which are goal oriented, then nitya karma may be rephrased as "If you want to avoid sin, perform your sandhā bandana regularly. The goal is to avoid sin. The reframing of nitya karma in this way will facilitate MIRA to deal with nitya karma as a basic unit of it and it will easily fit in within the domain of MIRA and all three kinds of actions may be formalized. It will make the system more comprehensive and exhaustive one.

2. My suggestion for including nitya karma in which the goal is not explicitly manifested, within the scope of logical formalism called MIRA, is strengthened in another way when the distinction between unconditional and conditional imperatives is taken into account. In this context the question which arises is that if the intention of reaching the goal in performing an action is the prime requirement of instruction execution, then logical formalism of MIRA is based on the fact that instructions are executed only with the intention of achieving the goal. In that case pure imperative instruction or unconditional instructions lack significance as no goal, reason or sequence is attached here. In the semantics part of this model it is found that the conjunction table of two imperatives has been shown on this notion that both conjuncts are conditional imperatives. (See the table)

But there may be a conjunction two unconditional imperatives where the goal is absent or not immediately or explicitly goal oriented. This model is inadequate to deal such cases.

Hence in order to restore the worth of unconditional instructions it is advisable to include both pure and unconditional instructions as two basic independent units of imperative logic. In MIRA, an unconditional imperative is evaluated as S or V. As MIRA is based on the intention of goal as the prime factor behind any action, a third value of no intention to reach the goal (N) is suggested for unconditional imperatives in addition to S and V.

3. Next, I have some reservations regarding the conditional imperatives.

a) It is about the two forms of conditional imperatives, namely, 'cig' and 'cia'.

1. 'cig' takes the form of $\varphi \rightarrow_p \theta$ where is φ an imperative and θ is an indicative sentence. For example, walk 30 minutes every day to stay healthy. But in a conditional imperative indicative part comes first and then the imperative part. In that case here this conditional imperative may be read as φ, if $_p\ \theta$. The concrete example would be "walk 30 minutes every day if you want to stay healthy" or "if you want to stay healthy, then walk 30 minutes every day". It may be reduced to 'cir'. It may be shown by the following table.

T	φ	$\tau \rightarrow_r \varphi$	φ	θ	$\varphi \rightarrow_p \theta$
T	S	S	S	T	S
T	V	V	S	F	N
T	N	N	V	T	V
F	S	N	V	F	N
F	V	N	N	T	N
F	N	N	N	F	N

The value remains same in both the semantic tables.

φ^1	ψ^2	$\varphi \rightarrow_i \psi$	$i_{1\rightarrow p}P_1$	$i_{2\rightarrow p}P_2$	$(i_{1\rightarrow p}P_1) \wedge (i_{2\rightarrow p}P_2)$
S	S	S	S	S	S
S	V	V	S	V	V
V	S	V	S	N	N
V	V	V	V	S	V
N	S	N	V	V	V
S	N	N	V	N	N
V	N	N	N	S	N
N	V	N	N	V	N
N	N	N	N	N	N

2. The symbolic form of 'cia' is $\varphi \rightarrow_i \psi$ where both the former and the later parts are imperative sentences. But two unconditional imperatives themselves cannot be connected with the operator →. For example, Take the paper and then write. A question may be raised: is it a conditional imperative at all? My understanding is that it is not a conditional imperative. Rather it may be treated as a conjunction of two unconditional imperatives which this particular formalism does not allow. It may not be used in the same sense that is found in classical logic but it may be a case of non-commutative conjunction. So as a result, in the variety of conditional imperative cig has been reduced to in terms of cir and cia has been considered as a variety of conjunction.

On the basis a revised system of MIRA may be constructed by interpreting purpose as reason on the one hand and conditional sequence as non commutative conjunction. There will be some changes in the syntax, formation rules as well as in deduction rules. As the system is proved to be sound with three kinds of conditional imperatives, the revised version of MIRA, with only one kind of conditional imperative, remains to be sound.

Representation and reasoning of action is a wide spread area in the domain of Artificial Intelligence. (AI). In Artificial Intelligence (AI), actions play a major role in domains such as planning, understanding natural language instructions and robotics. An action is a change in the state, then an action is performed. There may be a huge scope of future study in this area. Humans use instruction to specify an action. Actions are represented through imperatives.

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