Appendix A

Formal Logic and Truth Tables

What follows is a brief description of the logical rules governing validity and the truth-values of the atomic declarative schemas: the conjunction, the disjunction, the material conditional and the bi-conditional. Also, there is a brief description of the universal and existential quantifiers. This summary is informed by Wittgenstein's (1921) infamously complex *Tractatus*. What follows is a very basic explication of his truth tables in order to provide the reader with a usable guide.

Firstly, logical validity is a matter of when:

An inference is valid if it is not possible for the conclusion to be false and (all) the premises true at the same time.

Another way of thinking about this impossibility is that in a valid inference, you would contradict yourself if you held that the conclusion was false and all the premises true. However, in the case of an invalid inference you might be wrong if you asserted that the conclusion was false while accepting the premises as true but you would not, in this case, be contradicting yourself. A good way to think about what makes an inference *invalid* is that it is invalid if it *is possible* for the conclusion to be false even though the premises are all true.

Following is a description of the rules governing and the truth tables for the atomic declarative schemas: the conjunction, the disjunction, the material conditional and the bi-conditional.

J. Warr, *An Introduction to Criminological Theory and the Problem of Causation*, DOI 10.1007/978-3-319-47446-5

Conjunction

The conjunction is a connective that denotes a relationship between two atomic sentences. The most common use of the conjunction is the use of 'and'. However, synonymous terms are: 'coupled with' and 'conjoined'. Validity does not depend at all on what the individual sentences are about. The truth-value of the compound sentence can be determined once the truth-values of the components are known. Any conjunction is true only if both conjuncts are true, and is false otherwise (that is, the conjunction is false if *either* conjunct is false [or both are]). If *p* and *q* are the individual atomic sentences, then the truth-value of the sentence '*p* and *q*' is 'true' if and only if the truth-values of *p* and *q* are both 'true'. Ludwig Wittgenstein developed a graphic device, known as a *truth table*, to demonstrate this. The symbol '^' means 'and'.

Truth Table for Conjunction

p	*q*	*p* ^ *q*
T	T	T
T	F	F
F	T	F
F	F	F

Disjunction

The disjunction is a compound sentence using the either/or construction, for example *either x* is the case *or y* is the case. Any compound disjunction is true in any circumstance where at least one of the atomic sentences is true. The disjunction is only false if both atomic sentences are false. A sentence such as *either p or q* will be true in all circumstances where one of the atomic sentences is true. The shorthand symbol for 'or' in this inclusive sense is 'v'. So we have the following:

Truth Table for Disjunction

p	*q*	*p* v *q*
T	T	T
T	F	T
F	T	T
F	F	F

Conditionals

Another way in ordinary language of making a compound sentence out of simple atomic ones is by the 'if/then' construction. This is called a *conditional sentence* and, just to have some handy terminology, the sentence after the 'if' is the *antecedent* of the conditional and the sentence after the 'then' is called the *consequent* of the conditional. The truth of this conditional sentence too is dependent on the truth-values of its components. So, symbolising any sentence of the form 'if p then q' as '$p \rightarrow q$', we have the following:

Truth Table for the Conditional

p	q	$p \rightarrow q$
T	T	T
T	F	F
F	T	T
F	F	T

There are four lines in this truth table corresponding to each of the different possible *combinations* of truth-values of the conjuncts. The final column gives the overall truth-value of the compound for the corresponding truth-values of the components.

Bi-conditionals

The final way of compounding atomic sentences that we shall consider is found more often perhaps in scientific and mathematical contexts than in ordinary discourse, but – maybe because of this – is another straightforward case like conjunction. This involves connecting sentences using the phrase 'if and only if'. (Synonymous phrases to 'if and only if' are 'exactly when' or 'in case of'.) The 'if and only if' connective (often abbreviated to 'iff') and symbolized as '↔' is again clearly truth-functional: the truth-value of the compound $p \leftrightarrow q$ is dependent on the truth-values of p and q. In fact, $p \leftrightarrow q$ is true whenever p and q have the *same* truth-value and false whenever they have *different* truth-values.

Truth Table for the Bi-conditional

p	q	$p \leftrightarrow q$
T	T	T
T	F	F
F	T	F
F	F	T

The Universal and Existential Quantifiers

The notions of quantifiers are taken from First Order Predicate Logic and are designed to denote the extent the declarative statements capture the elements within the domain referred to by the sentence. The domain, usually represented by the indicator x, is the subject of which the predicates in the sentence relate.

The Universal Quantifier

The universal quantifier, symbolised by $\forall x$, represents every element in the referred domain. As such a sentence that is quantified over by the universal will read: for every instance of, or for all, x such and such is the case.

The Existential Quantifier

The existential quantifier, symbolised by $\exists x$, represents the notion that there is at least one instance within the domain. As such a sentence that is quantified over by the existential will read: there is at least one instance of x where such and such is the case.

Logical Equivalence

Logical equivalence, represented by the symbol $\equiv$, refers to a situation where one or a set of atomic compound sentence[s] is logically equivalent to some other atomic compound sentence.

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J. Warr, *An Introduction to Criminological Theory and the Problem of Causation*, DOI 10.1007/978-3-319-47446-5

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Index

J. Warr, *An Introduction to Criminological Theory and the Problem of Causation*, DOI 10.1007/978-3-319-47446-5