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Strictness and connexivity

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1. Preamble

The label ‘connexive logic’ refers to a family of logics that agree on Aristotle’s thesis and Boethius’ thesis. Assuming that $>$ stands for ‘if then’, these theses are phrased as follows:

AT $\sim (\sim p > p)$

AT' $\sim (p > \sim p)$

BT $(p > q) > \sim (p > \sim q)$

BT' $(p > \sim q) > \sim (p > q)$

AT and AT' are alternative formulations of Aristotle’s thesis. BT and BT' are alternative formulations of Boethius’ thesis. Clearly, AT, AT', BT, BT' are not theorems of classical propositional logic, that is, they do not hold if $>$ is replaced by \supset .

In the schemas above, p and q are indicative sentences. From now on we will focus on indicative conditionals, so we will take for granted that

'conditional' abbreviates 'indicative conditional'. This is not intended to suggest that counterfactuals differ in some important respect. On the contrary, most of what will be said about conditionals can be extended, *mutatis mutandis*, to counterfactuals. But for the sake of simplicity we will not deal with such extension.

According to connexivists – the advocates of connexive logic – AT, AT', BT, BT' are highly plausible, so a good theory of conditionals should validate them. The intuitive character of AT, AT', BT, BT' is thus regarded as a main motivation, if not *the* main motivation, for adopting connexive logic.¹

Some connexivists have suggested that the truth conditions of $p > q$ are to be given in terms of a relation between p and $\sim q$, some sort of incompatibility that is not reducible to the impossibility that p and $\sim q$ are true. For example, Nelson has defined such a relation, and Angell has incorporated it into a logical system. A theory of conditionals along these lines validates AT, AT', BT, BT' (Nelson 1930; Angell 1962).

Nelson's definition is not the only option. In fact it is not even obvious that we need some non-standard notion of incompatibility in order to validate AT, AT', BT, BT'. It is reasonable to expect that a definition based on entirely different notions can lead to the same result. So, we will simply call 'connexivist' any theory of conditionals that validates AT, AT', BT, BT', and we will not deal with the differences between the various connexivist theories.²

This paper is about the intuitive basis of connexive logic, so the question it addresses is whether AT, AT', BT, BT' should be treated as theorems in virtue of their intuitive content. The answer it suggests is that there is no reason to think they should: although the core idea behind AT, AT', BT, BT' is essentially sound, it is far from obvious that AT, AT', BT, BT' hold unrestrictedly.

Note that here the qualification 'in virtue of their intuitive content' is crucial, for there may be independent reasons for treating AT, AT', BT, BT' as theorems. A system of connexive logic, just as any formal apparatus, may be motivated in many different ways, and this paper focuses only on one of them.

2. Aristotle's thesis

As we have seen, connexivists think that AT and AT' as highly plausible, so that a good theory of conditionals should validate them. What will be suggested

¹This is what we read in McCall (1966, 2012), Wansing (2016), and in other works.

²McCall (2012) outlines a brief history of connexive logic. For a general survey see Wansing (2016), Wansing, Ferguson, and Omori (2016), Estrada-González and Ramírez-Cámara (2016), Omori and Wansing (forthcoming).

here, instead, is that this way of thinking is not entirely correct. AT and AT' are at most "partly" plausible, in the sense that they include a significantly wide class of plausible truths. Therefore, validating them is not necessarily a virtue.

The key question is where the plausibility of AT and AT' comes from. AT is inspired by a passage of Aristotle's *Prior Analytics*:

I mean, for example, that it is impossible that B is necessarily great if A is white, and that B is necessarily great if A is not white. For if B is not great, A cannot be white. However, if it is necessary that B is great when A is not white, it follows that if B is not great, B is great. But this is impossible.³

In this passage Aristotle makes at least three reasonable claims. The first is that the conditional 'If B is not great, then B is great' is false. The second is that the falsity of this conditional entails the falsity of the conjunction 'If A is white, then B is great, and if A is not white, then B is great', for the first conjunct is equivalent to 'If B is not great, then A is not white', which together with the second conjunct, entails the conditional itself. The third is that what holds for 'A is white' and 'B is great' holds for many other conditionals.

So far there is nothing controversial. It is clear that Aristotle makes these three claims, and each of these three claims seems reasonable. In particular, the inference from $(q > p) \wedge (\sim q > p)$ to $\sim p > p$ that justifies the second claim is legitimate if conjunction elimination (CE), contraposition (CO), and transitivity (TR) hold:⁴

1	[1]	$(q > p) \wedge (\sim q > p)$	A
1	[2]	$q > p$	CE 1
1	[3]	$\sim q > p$	CE 1
3	[4]	$\sim p > \sim q$	CO 2
3	[5]	$\sim p > p$	TR 3,4

What is not equally clear is whether Aristotle makes a further claim which is stronger than the third, namely, that every conditional of the form $\sim p > p$ is false and consequently that every conjunction of the form $(p > q) \wedge (\sim p > q)$ is false. If he makes this further claim, AT can rightfully be ascribed to him, and the same goes for Aristotle's 'second' thesis, which is entailed by AT:

$$AST \sim ((q > p) \wedge (\sim q > p))$$

If not, Aristotle's suggestion is simply that, for some suitable class of substitution instances of p and q which resemble 'B is great' and 'A is white' in

³Aristotle, *Prior Analytics* 57b3-14.

⁴The fact that this argument relies on CO and TR does not imply that a connexive theory of conditionals must preserve CO and TR. For example, Wansing's idea that connexivity can be achieved via falsity conditions does not require the validity of CO, see Omori and Wansing (forthcoming).

some respects, $\sim(\sim p > p)$ is true, and consequently $\sim((q > p) \wedge (\sim q > p))$ is true. Since the passage does not provide conclusive evidence for the first interpretation, it is not entirely obvious that Aristotle endorsed AT and AST.⁵

The point here is not really about Aristotle. Independently of what Aristotle had in mind, the crucial fact that emerges from the discussion of his statement is that a particular example – the apparently false conditional ‘If B is not great, then B is great’ – can be generalized in more than one way. More specifically, the apparent falsity of a conditional formed by a contingent sentence and its negation can be understood in at least two ways. One is to take it to illustrate that $\sim p > p$ is false for every contingent p , the other is to take it to illustrate that $\sim p > p$ is false for every p . The second generalization is stronger than the first, in that it entails the first but is not entailed by it.

This distinction is important because the examples provided in favour of AT typically involve contingent sentences, which are by far the most common constituents of conditionals. For example, it is quite natural to think that (1) is false:

(1) If it is not raining, then it is raining

The same goes for the conjunction of (2) and (3), which entails (1) for the reason explained:

(2) If it is snowing, then it is raining

(3) If it is not snowing, then it is raining

But it is not equally obvious that $\sim p > p$ is false when p is necessary:

(4) If it is not the case that either it is raining or it is not raining, then either it is raining or it is not raining

Consider the conjunction of (5) and (6), which entails (4) for the same reason:

(5) If it is snowing, then either it is raining or it is not raining

(6) If it is not snowing, then either it is raining or it is not raining

Unlike the conjunction of (2) and (3), the conjunction of (5) and (6) is not clearly false, for it is not implausible that (5) and (6) are both true. This makes the falsity of (4) less obvious.

⁵McCall (2012) adopts the first interpretation: ‘Aristotle seems to be saying that it is never possible for a proposition to be implied by its own negation’, 415. Lenzen (forthcoming), instead, argues for the second interpretation.

Of course, connexivists may contend that (5) and (6) are both false because in neither of them the antecedent and the consequent are connected in the right way. However, there are cases in which this move strikes as counterintuitive. Consider (7) and (8):

(7) If it is raining, then either it is raining or it is not raining

(8) If it is not raining, then either it is raining or it is not raining

In this case there is a clear sense in which the antecedent and the consequent of both conditionals are connected in the right way. So, even in a connexivist perspective, it is hard to see why (7) and (8) should be false. But again, this makes the falsity of (4) less obvious, given that the conjunction of (7) and (8) entails (4). It seems that connexivists face a dilemma: either they deny that a conditional of the form $p > (p \vee q)$, or $q > (p \vee q)$, is true, which is quite implausible, or they deny AST, and consequently AT. This is essentially the problem raised by Kilwardby in his commentary on *Prior Analytics* (McCall 2012, 417–418).

Thus AT is not as plausible as connexivists tend to believe. Certainly, when p is an ordinary contingent sentence, $\sim p > p$ seems false, so $\sim (\sim p > p)$ seems true. But this is not quite the same thing as to say that $\sim (\sim p > p)$ seems true for every p . As we have seen, when p is necessary, it is not obvious that $\sim p > p$ is false. Similar considerations hold for AT'. Although $\sim (p > \sim p)$ seems true when p is an ordinary contingent sentence, this does not mean that $\sim (p > \sim p)$ seems true for every p .⁶

3. Boethius' thesis

The point just made about Aristotle's thesis can be extended to Boethius' thesis. Although connexivists regard BT and BT' as highly plausible, BT and BT' are at most "partly" plausible, in the sense that they include a significantly wide class of plausible truths.

The examples offered in favour of BT and BT' typically involve contingent sentences. For example, it is quite natural to think that if (9) is true, then (10) is false:

(9) If it is snowing, then it is cold

(10) If it is snowing, then it is not cold

⁶Wansing, Ferguson, and Omori (2016) points out that the counterexamples to AT and AT' form a very restricted class of conditionals, namely, those with impossible antecedents or consequents. But this does not prevent them from being counterexamples.

But it is not equally obvious that the same holds for two conditionals whose antecedent is impossible. For example, it is not implausible that (11) and (12) are both true:

- (11) If it is snowing and it is not snowing, then it is cold
- (12) If it is snowing and it is not snowing, then it is not cold

Of course, connexivists may contend that (11) and (12) are both false because in neither of them the antecedent and the consequent are connected in the right way. But again, there are cases in which this move strikes as counterintuitive. Consider (13) and (14):

- (13) If it is snowing and it is not snowing, then it is snowing
- (14) If it is snowing and it is not snowing, then it is not snowing

In this case there is a clear sense in which the antecedent and the consequent of both conditionals are connected in the right way. So, even in a connexivist perspective, it is hard to see why (13) and (14) should be false. Here connexivists face a dilemma similar to that raised in connection with (7) and (8), that is, either they deny that a conditional of the form $(p \wedge q) > p$ or $(p \wedge q) > q$ is true, which is quite implausible, or they deny BT.⁷

Thus BT is not as plausible as connexivists tend to believe. Certainly, when p is an ordinary contingent sentence, $(p > q) > \sim (p > \sim q)$ seems true. But this is not quite the same thing as to say that $(p > q) > \sim (p > \sim q)$ seems true for every p . As we have seen, when p is impossible, it is not obvious that $(p > q) > \sim (p > \sim q)$ is true. Similar considerations hold for BT'. Although $(p > \sim q) > \sim (p > q)$ seems true when p is an ordinary contingent sentence, this does not mean that $(p > \sim q) > \sim (p > q)$ seems true for every p .⁸

4. The strict conditional view

What has been suggested in Sections 2 and 3 is that our intuitions about the apparent falsity of conditionals of the form $\sim p > p$ or $p > \sim p$ do not fully justify AT and AT', and similarly that our intuitions about the apparent falsity of conjunctions of the form $(p > q) \wedge (p > \sim q)$ do not fully justify BT and BT'. These intuitions essentially concern the

⁷Angell (1962), Routley (1978) and Thompson (1991) follow the first route, in that they reject conjunction simplification. Wansing and Skurt (2018), instead, argue that connexive logic does not entail commitment to conjunction simplification.

⁸Again, the fact that the counterexamples to BT and BT' form a very restrict class of conditionals, as noted in Wansing, Ferguson, and Omori (2016) does not prevent them from being counterexamples.

contingent instances of the schemas considered. Therefore, Aristotle's thesis and Boethius' thesis are plausible only insofar as they entail the following claims, which may be called *Restricted Aristotle's Thesis* and *Restricted Boethius' Thesis*:

RAT If it is possible that $\sim p$, then $\sim (\sim p > p)$

RAT' If it is possible that p , then $\sim (p > \sim p)$

RBT If it is possible that p , then $(p > q) > \sim (p > \sim q)$

RBT' If it is possible that p , then $(p > \sim q) > \sim (p > q)$

To illustrate the distinction, we will consider a specific view – the *strict conditional view* – that preserves RAT, RAT', RBT, RBT' but not AT, AT', BT, BT'. On this view, the truth conditions of $p > q$ are given relative to a possible world w as follows:

Definition 4.1: $p > q$ is true in w if and only if, for every w' , either p is false in w' or q is true in w' .

This definition implies that $p > q$ is adequately formalized in a modal language as $\Box(p \supset q)$, and that its logic is nothing but classical modal logic.⁹

The strict conditional view can be elaborated and refined in different ways. As is natural to expect, the set of possible worlds that constitutes the domain of quantification may vary from context to context. So one may wonder how the contextual restrictions on possibility are to be understood, or how are they to be represented at the level of logical form. However, these questions may be left aside, since Definition 4.1 will suffice for the purposes at hand.¹⁰

First consider Aristotle's thesis. Definition 4.1 invalidates AT and AT'. For any w , if p is true in every world, $\sim p > p$ is true in w , so $\sim (\sim p > p)$ is false in w . Similarly, if p is false in every world, $p > \sim p$ is true in w , so $\sim (p > \sim p)$ is false in w . In other words, the following holds in classical modal logic:

$\not\models \sim \Box(\sim p \supset p)$

$\not\models \sim \Box(p \supset \sim p)$

However, definition 4.1 validates RAT and RAT', as it entails that $\sim (\sim p > p)$ and $\sim (p > \sim p)$ are true whenever p is contingent. For any w , if p is false in some world, then $\sim p > p$ is false in w , so $\sim (\sim p > p)$ is true in w . Similarly, if p is true in some world, then $p > \sim p$ is false in

⁹Iacona (2018) provides some general arguments for the strict conditional view.

¹⁰Lycan (2001), von Fintel (2001), Gillies (2009), Kratzer (2012), Iacona (2018), among others, address such questions.

w , so $\sim(p > \sim p)$ is true in w . RAT and RAT' are expressed as follows in classical modal logic:

$$\begin{aligned} \diamond \sim p &\models \sim \Box(\sim p \supset p) \\ \diamond p &\models \sim \Box(p \supset \sim p) \end{aligned}$$

Now consider Boethius' thesis. Definition 4.1 invalidates BT and BT'. For any w , if p is false in every world, $p > q$ and $p > \sim q$ are both true in w , so $(p > q) > \sim(p > \sim q)$ is false in w , and the same goes for $(p > \sim q) > \sim(p > q)$. In other words, the following holds in classical modal logic:

$$\begin{aligned} \neq \Box(\Box(p \supset q) \supset \sim \Box(p \supset \sim q)) \\ \neq \Box(\Box(p \supset \sim q) \supset \sim \Box(p \supset q)) \end{aligned}$$

However, definition 4.1 validates RBT and RBT', as it entails that $(p > q) > \sim(p > \sim q)$ and $(p > \sim q) > \sim(p > q)$ are true whenever p is contingent. For any w , if $p > q$ is true in w and there are worlds in which p is true, then q is true in any such world, so $p > \sim q$ is false in w . Similarly, if $p > \sim q$ in w and there are worlds in which p is true, then q is false in any such world, so $p > q$ is false in w . RBT and RBT' are expressed as follows in classical modal logic:

$$\begin{aligned} \diamond p &\models \Box(\Box(p \supset q) \supset \sim \Box(p \supset \sim q)) \\ \diamond p &\models \Box(\Box(p \supset \sim q) \supset \sim \Box(p \supset q)) \end{aligned}$$

Thus, the strict conditional view preserves RAT, RAT', RBT, RBT'. Since AT, AT', BT, BT' are plausible only insofar as they entail RAT, RAT', RBT, RBT', the strict conditional view is as plausible as any connexivist theory of conditionals.

5. Vacuous truth and apparent falsity

According to the strict conditional view, AT, AT', BT, BT' are falsified by vacuously true conditionals, that is, conditionals with necessary consequents or impossible antecedents. So, they are not logical truths. This section aims to explain why one may be apt to think otherwise, as it offers an error theory of the apparent falsity of vacuously true conditionals.

The explanation that will be provided develops an idea articulated by Williamson in connection with counterpossibles, that is, counterfactuals with impossible antecedents. The idea is that, although counterpossibles

are true, they may appear false as a result of the effect of fallible heuristics. Williamson starts from the hypothesis that, when we assess a counterfactual 'If it were the case that p , then it would be the case that q ', we reason in accordance with the following procedure, "the suppositional procedure": first we counterfactually suppose that p ; then, if within the scope of the counterfactual supposition we get that q , outside the scope of that supposition we accept the counterfactual; similarly, if within the scope of the counterfactual supposition we do not get that q , outside the scope of that supposition we reject the counterfactual. The suppositional procedure, which constitutes our normal and unreflective way of evaluating counterfactuals, supports the following heuristics:

- HCC If q is inconsistent with r , treat 'If p were the case, then q would be the case' as inconsistent with 'If p were the case, then r would be the case'
- HCC* If you accept one of 'If p were the case, then q would be the case' and 'If p were the case, then $\sim q$ would be the case', reject the other.

The suppositional procedure licenses HCC because it treats combining q and r under the counterfactual supposition of p as tantamount to combining 'If p were the case, q would be the case' and 'If p were the case, r would be the case'. Given this equivalence, an inconsistency between q and r amounts to an inconsistency between the two counterfactuals. The rationale behind HCC* is basically the same. If one accepts 'If p were the case, q would be the case', one accepts q under the counterfactual supposition of p , so one rejects $\sim q$ under that supposition, which means that one rejects 'If p were the case, $\sim q$ would be the case'. Similarly, if one accepts 'If p were the case, $\sim q$ would be the case', one rejects 'If p were the case, q would be the case' (Williamson 2017, 215–225).

Williamson's point is that these heuristics are reasonable but fallible. HCC and HCC* are reasonable because normally, when counterfactuals arise in practice, their antecedents are possible, and in those cases HCC and HCC* yield correct results. If p is possible and q is inconsistent with r , then 'If p were the case, q would be the case' is inconsistent with 'If p were the case, r would be the case'. Similarly, if p is possible and we accept one of 'If p were the case, q would be the case' and 'If p were the case, $\sim q$ would be the case', we should reject the other. But HCC and HCC* are fallible, for there are independent reasons to expect them to fail for counterpossibles.

The heuristic account can be extended to a wider range of phenomena, as Williamson himself observes:

A more general underlying cognitive pattern may explain these heuristics. For example, it is plausible that we use analogues of them for indicative as well as subjunctive conditionals, and for generic as well as universal quantifiers. We ignore the issue of the empty case. We continue using heuristics that do so even when the empty case is obviously relevant, until we resort to conscious reflection (Williamson 2017, 223).

What will be suggested here is that vacuously true conditionals resemble counterpossibles, in that their apparent falsity can be explained as the product of our reliance on fallible heuristics.

Let us consider the following heuristic, which is an indicative version of HCC*:

HC1 If you accept one of $p > q$ and $p > \sim q$, reject the other.

Since it is very likely that the suppositional procedure characterizes our use of 'if then' independently of the distinction between indicative and subjunctive, it is reasonable to expect that HC1, just as HCC*, plays a central role in our normal and unreflective way of assessing conditionals with contradictory consequents. HC1 is reasonable because it works perfectly well in normal circumstances, that is, when p is possible. For example, it correctly implies that either (9) or (10) is false. But HC1 breaks down when p is impossible. For example, it incorrectly implies that either (11) or (12) is false, and that either (13) or (14) is false. In particular, the case of (13) and (14) provides a vivid illustration of its fallibility.

A similar heuristic is the following:

HC2 If you accept one of $p > q$ and $\sim p > q$, reject the other.

HC2 works perfectly well in normal circumstances, that is, when q is contingent. For example, it correctly implies that either (2) or (3) is false. However, HC2 breaks down when q is necessary. For example, it incorrectly implies that either (5) or (6) is false, and that either (7) or (8) is false. In particular, the case of (7) and (8) provides a vivid illustration of its fallibility.

Thus, there is a coherent way to explain why the vacuously true conditionals that falsify AT, AT', BT, BT' may seem false: their appearance of falsity is the product of our reliance on HC1 and HC2, which are reasonable but fallible heuristics. As Williamson says, since we normally ignore the empty case, we continue using heuristics that do so even when this case is obviously relevant, until we resort to conscious reflection.

6. Empirical evidence

The heuristic account can also explain the empirical evidence that is sometimes invoked in support of the connexivist theses. McCall presents the results of a questionnaire which contains the following sentences, mixed randomly with a list of other sentences:

- (15) It is not the case that (if Hitler is dead, then Hitler is not dead),
- (16) If (if Hitler is dead, then von Rümer is a liar), then it is not the case that (if Hitler is dead, then von Rümer is not a liar)

Since (15) and (16) received a high percentage of positive answers, McCall takes this result to support AT' and BT (McCall 2012, 421–424).

However, the same result is explained equally well by the hypothesis that people normally reason in accordance with HC1 and HC2. As we have seen, (15) and (16) are plausible instances of AT' and BT, but their plausibility must not be confused with the plausibility of AT' and BT themselves.

Other experiments about Aristotle's thesis have been made by Pfeifer. Some of the questions in Pfeifer's tests are analogous to McCall's questions, in that they concern particular instances of AT. Others instead are more abstract, in that they concern the following schema:

- (17) It is not the case, that: If not-A, then A

Pfeifer asked whether (17) is guaranteed to be true, guaranteed to be false, or if one cannot infer its truth or falsity. The test shows that (17) is mostly accepted, which is certainly an interesting result (Pfeifer 2012).

However, this does not necessarily mean that most students endorse AT, or that classical logic predicts that most students are irrational, as Wansing, Ferguson, and Omori (2016, 284) have suggested. An alternative explanation is that people normally reason in accordance with HC2, so they tend to ignore the empty case when they assess (17). Note, among other things, that when Pfeifer explains the test to the participants, he says that 'the letter A denotes a sentence, like "It is raining"', which makes it natural for them to assume that they are reasoning about ordinary contingent sentences.

7. Restricted connexivity

The foregoing sections suggest that AT, AT', BT, BT' are plausible only insofar as they entail RAT, RAT', RBT, RBT'. If we call *full connexivity* the conjunction of AT, AT', BT, BT', and *restricted connexivity* the conjunction of RAT, RAT', RBT, RBT', this means that an account of conditionals that preserves restricted connexivity – such as the strict conditional view – is at least as plausible as a fully connexivist account.¹¹

The distinction between full connexivity and restricted connexivity seems well grounded. As we have seen, the hypothesis that restricted connexivity holds provides a straightforward explanation of the reasonableness of the heuristics that we normally adopt when we assess conditionals. In this sense, restricted connexivity might aptly be called 'default connexivity', as has been suggested by Unterhuber (2016). Kapsner uses the expression 'humble connexivity' to refer to the idea that the connexive theses are restricted in the way suggested here, and contrasts humble connexivity with (strong and weak) connexivity. He argues that this restriction is well motivated, and explores some ways to implement it at the formal level (Kapsner 2019).

It is important to realize that, although restricted connexivity is weaker than full connexivity, it is anything but trivial. Restricted connexivity implies a significant departure from the truth-functional view, that is, the view according to which \supset means \supset . The truth-functional view invalidates restricted connexivity, which may be regarded as an undesirable result. Consider again (1). On the truth-functional view, (1) is true when it is raining, so our pretheoretical judgement that there is something wrong in (1) can be correct only when it is not raining. But this is an odd thing to say. The impression of falsity that we get when we look at (1) has nothing to do with the weather. If we feel that there is something wrong in (1), it is not because we look out the window. It seems that (1) is false *no matter whether* it is raining or not. This is exactly what RAT predicts.

The interesting fact about restricted connexivity is that, despite its non-triviality, it is far from revolutionary. In this respect, the difference between full connexivity and restricted connexivity is crucial. If what we want to preserve is restricted connexivity, rather than full connexivity, then there is no need to abandon classical logic, for conditionals can adequately be formalized as strict conditionals by using the expressive resources of classical modal logic. Even if

¹¹The label 'restricted connexivity' appears in Lenzen (forthcoming).

we were not satisfied with such formalization and wanted to follow a different route, it would still be a route that does not lead to connexive logic.¹²

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¹²It is interesting to note, among other things, that the contingency condition stated in RAT, RAT', RBT, RBT' can be defined by using standard modal operators, as shown in Pizzi (1991). See also Pizzi and Williamson (1997).

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