A weaker condition for transitivity in probabilistic support

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ABSTRACT: Probabilistic support is not transitive. There are cases in which *x* probabilistically supports *y*, i.e., $\Pr(y \mid x) > \Pr(y)$, *y*, in turn, probabilistically supports *z*, and yet it is not the case that *x* probabilistically supports *z*. Tomoji Shogenji, though, establishes a condition for transitivity in probabilistic support, that is, a condition such that, for any *x*, *y*, and *z*, if $\Pr(y \mid x) > \Pr(y)$, $\Pr(z \mid y) > \Pr(z)$, and the condition in question is satisfied, then $\Pr(z \mid x) > \Pr(z)$. I argue for a second and *weaker* condition for transitivity in probabilistic support. This condition, or the principle involving it, makes it easier (than does the condition Shogenji provides) to establish claims of probabilistic support, and has the potential to play an important role in at least some areas of philosophy.

1 Introduction

Probabilistic support is *not* transitive. There are cases in which *x* probabilistically supports *y*, i.e., $\Pr(y \mid x) > \Pr(y)$, *y*, in turn, probabilistically supports *z*, and yet it is not the case that *x* probabilistically supports *z*.[1] Suppose, for example, Smith selects a card at random from a standard deck of cards. Let "*h*" be the claim that the card selected is a heart, "*r*" be the claim that the card selected is a red card, and "*d*" be the claim that the card selected is a diamond. Then, *h* probabilistically supports *r*, and *r* probabilistically supports *d*:

$\Pr(r \mid h) = 1 > \Pr(r) = 1/2;$[2]

$\Pr(d \mid r) = 1/2 > \Pr(d) = 1/4.$

But, it is not the case that *h* probabilistically supports *d*:

[1] See, e.g., Eells and Sober (1983, pp. 43-44), Hanen (1971), Hesse (1970, pp. 50-51), and Shogenji (2003, p. 613).
[2] This reads: $\Pr(r \mid h) = 1$, $1 > \Pr(r)$, and $\Pr(r) = 1/2$.

$\Pr(d \mid h) = 0 < \Pr(d) = 1/4$.

Indeed, *h* probabilistically supports $\sim d$:

$\Pr(\sim d \mid h) = 1 > \Pr(\sim d) = 3/4$.

This is *Case 1*.

It seems, though, that in many cases there is transitivity in probabilistic support. Imagine Smith selects a card at random from a standard deck of cards, and Smith, who is highly reliable, testifies that the card selected is a red card. Let "*t*" be the claim that Smith testified that the card selected is a red card, and "*r*" and "*h*" be understood as in *Case 1*. Here, it seems, there is transitivity in probabilistic support: *t* probabilistically supports *r*, *r* probabilistically supports *h*, and *t* probabilistically supports *h*. This is *Case 2*.

Is there a condition for transitivity in probabilistic support, that is, a condition such that, for any *x*, *y*, and *z*, if $\Pr(y \mid x) > \Pr(y)$, $\Pr(z \mid y) > \Pr(z)$, and the condition in question is satisfied, then $\Pr(z \mid x) > \Pr(z)$?[3] It turns out that there are multiple such conditions. Tomoji Shogenji (2003) establishes a condition for transitivity in probabilistic support.[4] I aim to establish a second and *weaker* such condition. This condition, in being weaker (than the condition Shogenji establishes), makes it easier to establish claims of probabilistic support.

2 Shogenji's condition

Shogenji's condition for transitivity in probabilistic support is: *y* "screens off" *x* with respect to *z*. More formally:

(C) $\Pr(z \mid x \,\&\, y) = \Pr(z \mid y)$ and $\Pr(z \mid x \,\&\, \sim y) = \Pr(z \mid \sim y)$.

Shogenji thus establishes the principle:

[3] Better put: Is there a *nontrivial* such condition? Clearly, there is a trivial such condition, e.g., the condition that $\Pr(z \mid x) > \Pr(z)$.

[4] All references to Shogenji are to Shogenji (2003).

(TPS) For any x, y, and z, if $\Pr(y \mid x) > \Pr(y)$, $\Pr(z \mid y) > \Pr(z)$, and (C) holds, then $\Pr(z \mid x) > P(z)$.[5]

Consider *Case 1*. Recall that $\Pr(r \mid h) > \Pr(r)$, and $\Pr(d \mid r) > \Pr(d)$. (C) holds only if:

$\Pr(d \mid h \,\&\, r) = \Pr(d \mid r)$.

Since $\Pr(d \mid h \,\&\, r) = 0 < \Pr(d \mid r) = 1/2$, it follows that (C) fails to hold.[6] Hence, *Case 1* is not a counterexample to (TPS).

Shogenji argues that (TPS) has application in a certain special kind of case:

> The result [viz., (TPS)] often allows us to dispense with complex case-by-case examinations of transitivity. In particular, the relevant screen-off condition [viz., (C)] holds, and hence probabilistic support is transitive, when the original evidence is testimonial, memorial or perceptual (i.e., to the effect that such and such was testified to, remembered, or perceived), and the intermediary proposition is the representational content of the testimony, (apparent) memory or (apparent) perception (i.e., the proposition is to the effect that the such and such actually occurred). For, once the truth/falsity of Y [i.e., the intermediary proposition] is given, it is unreasonable to let the testimony, (apparent) memory or (apparent) perception that Y affect the probability of Z, even if the testimony, (apparent) memory or (apparent) perception would otherwise affect the probability of Z. (pp. 615-616)

Case 2 is a case in which the first claim (the original evidence) is testimonial and the second claim (the intermediary proposition) is the representational content of the testimony, hence, by Shogenji's argument, a case in which (C) holds. So, since $\Pr(r \mid t) > \Pr(r)$, and $\Pr(h \mid r) > \Pr(h)$, it follows, by (TPS), that $\Pr(h \mid t) > \Pr(h)$. This, it seems, is the right result.[7]

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[5] A similar principle, though about probabilistic *causality*, not probabilistic support, is established by Ellery Eells and Elliott Sober (1983). Also, see Reichenbach (1956, Ch. IV, sec. 19) and Sober (2009). For discussion of (TPS) as it relates to the transmission of confirmation by *coherence*, see Dietrich and Moretti (2005).

[6] Further, since $\Pr(h \,\&\, {\sim}r) = 0$, and since, thus, $\Pr(d \mid h \,\&\, {\sim}r)$ is undefined, it follows that it is not the case that $\Pr(d \mid h \,\&\, {\sim}r) = \Pr(d \mid {\sim}r)$.

[7] Shogenji considers a more controversial case of the sort in question, where the first claim says that there is testimony that a certain miracle occurred, the second claim says that the miracle in question occurred, and the third claim says that God exists. Shogenji

There is a crucial footnote (n. 4) to the above quoted passage. Shogenji cautions that there are some exceptions to the claim that (C) holds in cases in which the first claim is testimonial and the second claim is the representational content of the testimony. I shall return to this issue below (section 4).

3 A weaker condition

Consider the condition:

(C*) $\Pr(z \mid x \,\&\, y) \geq \Pr(z \mid y)$ and $\Pr(z \mid x \,\&\, {\sim}y) \geq \Pr(z \mid {\sim}y)$.

(C*) is *weaker* than (C). If $\Pr(z \mid x \,\&\, y) = \Pr(z \mid y)$ and $\Pr(z \mid x \,\&\, {\sim}y) = \Pr(z \mid {\sim}y)$, it follows that $\Pr(z \mid x \,\&\, y) \geq \Pr(z \mid y)$ and $\Pr(z \mid x \,\&\, {\sim}y) \geq \Pr(z \mid {\sim}y)$. But not *vice versa*.

I aim to establish the principle:

(TPS*) For any x, y, and z, if $\Pr(y \mid x) > \Pr(y)$, $\Pr(z \mid y) > \Pr(z)$, and (C*) holds, then $\Pr(z \mid x) > P(z)$.[8]

(TPS*) is *stronger* than (TPS), in that if (TPS*) is correct, it follows that (TPS) is correct, but not *vice versa*.

Shogenji's argument for (TPS) can be modified so as to yield an argument for (TPS*). So let's consider Shogenji's argument for (TPS).

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argues that, in such a case, (C) holds and so, supposing that the first claim probabilistically supports the second, and that the second claim probabilistically supports the third, it follows, by (TPS), that the first claim probabilistically supports the third. Cf., e.g., Holder (1998), Otte (1993), and Schlesinger (1987).

[8] Mary Hesse (1970, pp. 54-55) establishes a similar principle. It can be put as follows: If (i) $\Pr(y \mid x) > \alpha$, (ii) $\Pr(z \mid y) > \beta$, and (iii) $\Pr(z \mid x \,\&\, y) \geq \Pr(z \mid y)$, then $\Pr(z \mid x) > \alpha\beta$. The antecedent of this principle, like the antecedent of (TPS*), does not require that $\Pr(z \mid x \,\&\, y) = \Pr(z \mid y)$, and does not require that $\Pr(z \mid x \,\&\, {\sim}y) = \Pr(z \mid {\sim}y)$. But note: It is not the case that when the antecedent of Hesse's principle is satisfied, and when $\alpha = \Pr(y)$ and $\beta = \Pr(z)$, it follows that $\Pr(z \mid x) > \Pr(z)$. Suppose Smith selects a card at random from a standard deck of cards. Let "d," "h," and "r" be understood as in *Case 1*. Then, $\Pr(h \mid r) > \Pr(h)$, $\Pr({\sim}d \mid h) > \Pr({\sim}d)$, and $\Pr({\sim}d \mid r \,\&\, h) \geq \Pr({\sim}d \mid h)$. Thus, by Hesse's principle, $\Pr({\sim}d \mid r) > \Pr(h)\Pr({\sim}d)$. But, $\Pr({\sim}d \mid r) < \Pr({\sim}d)$.

The argument, in outline (see pp. 614-615 for details), runs as follows.[9] $\Pr(z \mid x)$ is equal to:

(a) $\Pr(z \mid y \,\&\, x)\Pr(y \mid x) + \Pr(z \mid {\sim}y \,\&\, x)\Pr({\sim}y \mid x)$.

If (C) holds, then (a) is equal to:

(b) $\Pr(z \mid y)\Pr(y \mid x) + \Pr(z \mid {\sim}y)\Pr({\sim}y \mid x)$.

$\Pr(z)$ is equal to:

(c) $\Pr(z \mid y)\Pr(y) + \Pr(z \mid {\sim}y)\Pr({\sim}y)$.

(b) minus (c) is equal to:

(d) $([\Pr(z \mid y) - \Pr(z)] \times [\Pr(y \mid x) - \Pr(y)]) / [1 - \Pr(y)]$.

If $\Pr(y \mid x) > \Pr(y)$ and $\Pr(z \mid y) > \Pr(z)$, then (d) is greater than 0, hence (b) is greater than (c). Thus, (TPS).

Suppose, now, (C*) holds. Then, exactly one of the following claims is true:

(e) $\Pr(z \mid x \,\&\, y) = \Pr(z \mid y)$ and $\Pr(z \mid x \,\&\, {\sim}y) = \Pr(z \mid {\sim}y)$;

(f) $\Pr(z \mid x \,\&\, y) > \Pr(z \mid y)$ and $\Pr(z \mid x \,\&\, {\sim}y) = \Pr(z \mid {\sim}y)$;

(g) $\Pr(z \mid x \,\&\, y) = \Pr(z \mid y)$ and $\Pr(z \mid x \,\&\, {\sim}y) > \Pr(z \mid {\sim}y)$;

(h) $\Pr(z \mid x \,\&\, y) > \Pr(z \mid y)$ and $\Pr(z \mid x \,\&\, {\sim}y) > \Pr(z \mid {\sim}y)$.

If (e) is true, (a) is equal to (b). If (f), (g), or (h) is true, (a) is *greater than* (b). Hence, if (C*) holds, then (a) is greater than or equal to (b). $\Pr(z \mid x)$ is equal to (a), and so if (C*) holds, it follows that $\Pr(z \mid x)$ is greater than or equal to (b). $\Pr(z)$ is equal to (c), and (b) minus (c) is equal to (d). If $\Pr(y \mid x) > \Pr(y)$ and $\Pr(z \mid y) > \Pr(z)$, then (d) is greater than 0, hence (b) is greater than (c). So, if (C*) holds, and $\Pr(y \mid x) > \Pr(y)$ and $\Pr(z \mid y) > \Pr(z)$, it follows that $\Pr(z \mid x)$ is equal to (a), which is greater than or equal to (b), which is greater than (c). Therefore, (TPS*).

[9] The labeling below, "(a)," "(b)," etc., is mine, not Shogenji's.

In section 4, below, I shall discuss the significance of (TPS*). First, though, I want to provide a case of transitivity in probabilistic support in which (C*) holds but (C) does not.

Suppose a ball is randomly selected from a standard set of billiard balls (not including a cue ball). Let "*w*" be the claim that the ball selected is a low-numbered ball (1-ball, 2-ball, . . . , 7-ball),[10] "*d*" be the claim that the ball selected is an odd-numbered ball (1-ball, 3-ball, . . . , 15-ball), and "*e*" be the claim that the ball selected is the 1-ball. Then, $\Pr(d \mid w) > \Pr(d)$, $\Pr(e \mid d) > \Pr(e)$, $\Pr(e \mid w) > \Pr(e)$, and (C*) holds but (C) does not:

$\Pr(d \mid w) = 4/7 > \Pr(d) = 8/15$;

$\Pr(e \mid d) = 1/8 > \Pr(e) = 1/15$;

$\Pr(e \mid w) = 1/7 > \Pr(e) = 1/15$;

$\Pr(e \mid w \,\&\, d) = 1/4 > \Pr(e \mid d) = 1/8$;

$\Pr(e \mid w \,\&\, {\sim}d) = \Pr(e \mid {\sim}d) = 0$.

This is *Case 3*.

It should be noted that *Case 3* is *not* a counterexample to (TPS). *Case 3* shows just that (C)'s holding is *not required* for transitivity in probabilistic support. (TPS) does not say otherwise.

4 Discussion

I noted above that Shogenji cautions that there are some exceptions to the claim that (C) holds in cases in which the first claim (the original evidence) is testimonial and the second claim (the intermediary proposition) is the representational content of the testimony. Here Shogenji describes one such exception:

> Suppose the proposition that the Dalai Lama lives in India probabilistically supports the proposition that he speaks Hindi. Even if it is already known that the Dalai Lama lives in India, it may still be the case that the testimony that the Dalai Lama lives in

[10] The 8-ball is neither low-numbered nor high-numbered. The high-numbered balls are: 9-ball, 10-ball, . . . ,15-ball.

> India probabilistically supports the proposition that he speaks Hindi—for example, if the testimony is given by the Dalai Lama himself in Hindi. (p. 615, n. 4)

This case, as it turns out, serves as a rather interesting example of a case of transitivity in probabilistic support in which (C*) holds but (C) does not. Let "t" be the claim that the Dalai Lama testified in Hindi that he lives in India, "i" be the claim that the Dalai Lama lives in India, and "h" be the claim that the Dalai Lama speaks Hindi. It seems that $\Pr(i \mid t) > \Pr(i)$, and that $\Pr(h \mid i) > \Pr(h)$. Further, it seems that $\Pr(h \mid t) > \Pr(h)$. (C), though, does not hold, for $\Pr(h \mid t \,\&\, i) > \Pr(h \mid i)$, and $\Pr(h \mid t \,\&\, {\sim}i) > \Pr(h \mid {\sim}i)$.[11] By contrast, (C*) holds. So, by (TPS*), but not by (TPS), it follows that, as it seems, $\Pr(h \mid t) > \Pr(h)$. This is *Case 4*.

Cases of this sort are not uncommon. Imagine your neighbor bought a new automobile. You have yet to see it, but your daughter, Sally, has. Sally, highly reliable, tells you that your neighbor's new automobile is a Ferrari. Let "t" be the claim that Sally testified that your neighbor's new automobile is a Ferrari, "f" be the claim that your neighbor's new automobile is a Ferrari, and "s" be the claim that your neighbor's new automobile is a sports car. It seems that $\Pr(f \mid t) > \Pr(f)$, and that $\Pr(s \mid f) > \Pr(s)$. Also, it seems that $\Pr(s \mid t) > \Pr(s)$. But, though $\Pr(s \mid t \,\&\, f) = \Pr(s \mid f)$, $\Pr(s \mid t \,\&\, {\sim}f) > \Pr(s \mid {\sim}f)$. So, (C*) holds but (C) does not. Therefore, by (TPS*), but not by (TPS), it follows that, as it seems, $\Pr(s \mid t) > \Pr(s)$. This is *Case 5*.[12]

Cases such as *Case 4* and *Case 5* illustrate the significance of (TPS*). Since (C*) is weaker than (C), (TPS*) makes it easier than does (TPS) to establish claims of probabilistic support.

(TPS*) has the potential to play an important role in at least some areas of philosophy, in particular, areas where certain claims of probabilistic support are at issue. One such area is *epistemology* (broadly construed). An important issue in epistemology is of when it is that *evidential support* (in the relevance sense) transmits across *entailment*.[13] More precisely, and on one way of understanding the expression "transmits," the issue is

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[11] I am assuming that $\Pr(t \,\&\, {\sim}i) > 0$.

[12] I thank Shogenji (private communication) for suggesting to me a case of this sort. Some of the cases of "useful false beliefs" given in Klein (2008), e.g., the case of "Mr Butterfingers" (p. 51), can be modified so as to have all the relevant features of *Case 5*.

[13] For discussion of the distinction between evidential support in the *relevance* sense versus evidential support in the *absolute* sense, and of the related distinction between *having evidence* in the relevance sense versus having evidence in the absolute sense, see Okasha (1999).

of when it is that: If $\Pr(y \mid x) > \Pr(y)$, and y entails z, then $\Pr(z \mid x) > \Pr(z)$.[14] One thing is clear: There are cases in which $\Pr(y \mid x) > \Pr(y)$, y entails z, and yet $\Pr(z \mid x) \leq \Pr(z)$.[15] (TPS*) can be of help in determining whether a given case is of this sort. Let's consider an example (adapted from Dretske 1970, pp. 1015-1016). Let "a" be the claim that it appears to me as if the animal before me is a zebra, "z" be the claim that the animal before me is a zebra, and "m" be the claim that the animal before me is a cleverly disguised mule. Suppose $\Pr(z \mid a) > \Pr(z)$, and z entails $\sim m$, where $\Pr(\sim m) < 1$, hence $\Pr(\sim m \mid z) > \Pr(\sim m)$. It might seem that, despite all this, $\Pr(\sim m \mid a) \leq \Pr(\sim m)$,[16] indeed, that $\Pr(\sim m \mid a) < \Pr(\sim m)$.[17] (TPS*) provides some guidance here. (TPS*) implies that what needs to be determined is whether $\Pr(\sim m \mid a \,\&\, \sim z) < \Pr(\sim m \mid \sim z)$. For, by (TPS*) it follows that $\Pr(\sim m \mid a) \leq \Pr(\sim m)$ only if $\Pr(\sim m \mid a \,\&\, \sim z) < \Pr(\sim m \mid \sim z)$; if $\Pr(\sim m \mid a \,\&\, \sim z) \geq \Pr(\sim m \mid \sim z)$, then, since $\Pr(\sim m \mid a \,\&\, z) = \Pr(\sim m \mid z) = 1$, it follows that (C*) is satisfied and, thus, that $\Pr(\sim m \mid a) > \Pr(\sim m)$.

A second, and perhaps less obvious, potential application of (TPS*) in epistemology concerns justification and truth-conduciveness. Consider, say, coherentism, the view (roughly) that *S*'s belief in *p* is justified just in case *S*'s belief system is coherent. A crucial test of coherentism is whether coherentist justification is truth-conducive at least in the sense that coherentist justification implies an *increase* in the probability of truth.[18] Suppose the background information codified in Pr includes the information that *S* believes *p*. Then the test, more precisely, is whether Pr(*p* | *S*'s belief system is coherent) >

[14] I do not mean for this to be an adequate formalization of the issue Crispin Wright (2002, 2003) has in mind in speaking of when it is that warrant transmits across entailment. For discussion of how to formalize the issue Wright has in mind, see Chandler (2010), Moretti (forthcoming), and Okasha (2004). Cf. Pynn (forthcoming).
[15] See, e.g., Mackie (1969, p. 36), Okasha (1999, p. 45), and White (2006, sec. 5). Note, however, that there are no cases in which $\Pr(y \mid x)$ is *high*, y entails z, and yet $\Pr(z \mid x)$ is not *high*. See Okasha (1999) and Salmon (1965).
[16] Dretske (1970) can be read along these lines; see Okasha (1999).
[17] See White (2006, sec. 5) for defense of this sort of point.
[18] I am assuming, as seems plausible, that justification is truth-conducive at least in the sense that justification implies an increase in the probability of truth. The question of whether coherentist justification implies an increase in the probability of truth is to be distinguished from the question of whether coherentist justification implies a *high* probability of truth, and from the question of whether, *ceteris paribus*, *greater* coherence implies a *greater* probability of truth.

$\Pr(p)$.[19] Suppose, for some claim x, it can be shown that $\Pr(x \mid S\text{'s belief system is coherent}) > \Pr(x)$ and $\Pr(p \mid x) > \Pr(p)$. Suppose it is unclear whether $\Pr(p \mid S\text{'s belief system is coherent} \,\&\, x) = \Pr(p \mid x)$, and unclear whether $\Pr(p \mid S\text{'s belief system is coherent} \,\&\, {\sim}x) = \Pr(p \mid {\sim}x)$. Suppose, however, it is clear that $\Pr(p \mid S\text{'s belief system is coherent} \,\&\, x) \geq \Pr(p \mid x)$, and clear that $\Pr(p \mid S\text{'s belief system is coherent} \,\&\, {\sim}x) \geq \Pr(p \mid {\sim}x)$. Then, by (TPS*), but not by (TPS), it follows that $\Pr(p \mid S\text{'s belief system is coherent}) > \Pr(p)$. What I have said about coherentism can also be said *mutatis mutandis* about other theories of justification.

I showed above (section 3) that (C)'s holding is not required for transitivity in probabilistic support. A natural question at this point is: Is (C*)'s holding required for transitivity in probabilistic support? Answer: No. Suppose a ball is randomly selected from a standard set of billiard balls. Let "w" and "d" be understood as in *Case 3*, and "r" be the claim that the ball selected is the 1-ball or the 3-ball. Then, as can be readily checked, $\Pr(r \mid w) > \Pr(r)$, $\Pr(d \mid r) > \Pr(d)$, and $\Pr(d \mid w) > \Pr(d)$. But (C*) fails to hold, since $\Pr(d \mid w \,\&\, {\sim}r) < \Pr(d \mid {\sim}r)$.[20]

The point remains, however, that (TPS*) is correct, and that (TPS*) makes it easier than does (TPS) to establish claims of probabilistic support.[21]

5 Conclusion

Shogenji shows that, though probabilistic support is not transitive, there is a condition for transitivity in probabilistic support, viz., (C). Shogenji thus establishes (TPS). I have shown that there is a weaker condition for transitivity in probabilistic support, viz., (C*), and so have established (TPS*). (C*) is weaker than (C), and so (TPS*) makes it easier than does (TPS) to establish claims of probabilistic support.

[19] What information is to be included in the background information codified in Pr is a difficult issue. I discuss it elsewhere (2010, forthcoming).

[20] This case improves on the case I had in its place in a prior version of this paper. Thanks to an anonymous reviewer for help here.

[21] A different sort of case is where (C*) holds, and $\Pr(z \mid x) > \Pr(z)$, but $\Pr(y \mid x) < \Pr(y)$ and $\Pr(z \mid y) < \Pr(z)$. Suppose a ball is randomly selected from a standard set of billiard balls, "w" and "e" are understood as in *Case 3*, and "n" is the claim that the ball selected is an even-numbered ball. It follows that $\Pr(e \mid w \,\&\, n) \geq \Pr(e \mid n)$, $\Pr(e \mid w \,\&\, {\sim}n) \geq \Pr(e \mid {\sim}n)$, and $\Pr(e \mid w) > \Pr(e)$, but $\Pr(n \mid w) < \Pr(n)$ and $\Pr(e \mid n) < \Pr(e)$. Cases of the sort in question are interesting but do nothing to undermine the point that (TPS*) is correct and makes it easier than does (TPS) to establish claims of probabilistic support.

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