

Probabilizing the end

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Abstract Reasons transmit. If one has a reason to attain an end, then one has a reason to effect means for that end: reasons are transmitted from end to means. I argue that the likelihood ratio (LR) is a compelling measure of reason transmission from ends to means. The LR measure is superior to other measures, can be used to construct a condition specifying precisely when reasons transmit, and satisfies intuitions regarding end-means reason transmission in a broad array of cases.

Keywords Instrumental rationality · Reason transmission · Means-end reasoning · Likelihood ratio · Probability

1 Introduction

If I have reasons to attain some end, then many suppose that I have reasons to take means for that end. I have reason to lose weight, and so I have reason to exercise. Reasons *transmit* from ends to means. Kant's (1785) Hypothetical Imperative can naturally be read as a principle of reason transmission for necessary means—"Whoever wills the end, wills (so far as reason has decisive influence on his actions) also the means that are indispensably necessary to his actions and that lie in his power". Pronouncements of reason transmission have undergone a recent renaissance.¹ An intuitive requirement on a principle of reason transmission, noted most

¹ For statements of various versions of a principle of reason transmission, see Darwall (1983), Raz (2005), Schroeder (2009), Bedke (2009), and Kolodny (forthcoming). Many have taken such a principle for granted, but Korsgaard (1997) and others have argued that Humeans cannot account for the

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recently by Kolodny (forthcoming), is that since means raise the probability of the respective end, reasons transmit only if purported means make the end more probable. In what follows I concern myself with developing this probabilizing condition. Properly construed, a probabilizing condition of reason transmission solves several outstanding problems in recent literature on instrumental rationality.

Before proceeding it is worthwhile to note other domains in which measures of transmission based on a probabilizing condition have been developed in sophisticated detail. Transmission of support from evidence to hypothesis, for instance, and transmission from cause to effect, have been explicated in terms of the probability calculus. Just as means should raise the probability of an end, evidence should raise the probability of a hypothesis, and a cause should raise the probability of an effect. Numerous measures have been proposed to determine the degree of probability raising in these domains, and so for my present purpose I reap the harvest of past labor.

Most important, perhaps, are past critiques which have made explicit various constraints on attempts to explicate transmission in terms of the probability calculus. Achinstein (2001), for instance, argues that raising the probability of a hypothesis is insufficient for something to be considered evidence for that hypothesis: if today I walk to the university then the probability that today I will be hit by lightning increases, but we should hardly call the former *evidence* for the latter. Conversely, Cartwright (1979, 1989) argues that raising the probability of an effect *simpliciter* is an unnecessary (and insufficient) condition for something to be considered a cause of that effect: birth-control pills prevent pregnancy, and pregnancy can cause thrombosis, and so birth-control pills indirectly reduce the probability of getting thrombosis (in the overall population), but birth-control pills themselves can directly cause thrombosis (in a narrower population: say, those women not likely to get pregnant), and so birth-control pills cause thrombosis and yet decrease the probability of thrombosis. Arguments structurally similar to Cartwright's and Achinstein's can show that a simple probabilizing condition is neither necessary nor sufficient to adequately characterize transmission of reason from end to means. As I proceed I further refine the probabilizing condition for reason transmission in ways suggested by Cartwright and Achinstein in order to accommodate such nuances.

To render the probabilizing condition more precise, I argue that the likelihood ratio (LR) is a compelling measure of reason transmission from end to means (Sect. 3). Two other measures—positive relevance (PR) and positive probability (PP)—are unsatisfactory (Sect. 2). The LR measure satisfies intuitions regarding reason transmission in a broad array of cases, and solves several outstanding problems associated with similar principles of reason transmission (Sect. 4).

Footnote 1 continued

normativity of reason transmission, while Humeans respond by arguing that a principle of reason transmission is a brute norm (Beardman 2007) or constitutive of an agent's desire for an end (Finlay 2008). What follows remains neutral on the source of the normativity of reason transmission.

2 PR and PP

An intuitive constraint on a principle of reason transmission is that reasons transmit from an end to a purported means only if those means make the end more probable. Means must probabilize an end. There are an infinite number of possible measures which could represent such an increase in probability to render this probabilizing desideratum more specific and to measure the ‘amount’ of reason transmitted from an end to its means. At first glance, though, one might think that a compelling measure of reason transmission would be the probability of achieving an end (E) given that one has effected the means (M) minus the probability of the end prior to effecting the means: $p(E|M) - p(E)$. I will call this the positive relevance (PR) measure of end-means reason transmission. M is a means for end E by this measure if and only if $p(E|M) > p(E)$. From the PR measure the following condition of reason transmission is constructed:

PR condition Reasons transmit from end E to means M iff $p(E|M) > p(E)$.

It has long been recognized that PR *simpliciter* is not a good measure of the effectiveness of purported means, since the purported means might be correlated with other factors which themselves modify the probability of the end. For this reason Cartwright (1979) requires the inequality in PR to hold over every state description in order to ensure that an M is an *effective strategy* for some end. PR should be modified along such lines:

PR* Reasons transmit from end E to means M in situation L iff $p(E|M \& K_L) > p(E|K_L)$, where K_L is the state description of L which includes the complete set of means relevant to E not including M.²

PR* is a compelling account of effective strategies. If means simply are effective strategies, then it seems that we are done: we have found a compelling and precise measure of reason transmission from end to means.

However, Kolodny (forthcoming) argues against PR, not because of a worry regarding confounding correlates, but because he claims that PR “implies, oddly, that the more likely one is to M, the less reason there is for one to M.”³ That is, as $p(M)$ goes up, one loses reason to do M, which seems paradoxical. This is because as the probability of M increases, the probability of E conditional on M, $p(E|M)$, approaches the prior probability of E, $p(E)$, and so the PR measure approaches 0. In short, according to Kolodny, as $p(M)$ approaches 1, the conditional probability in PR approaches the unconditional probability, and so the difference between the two probabilities approaches 0.

This is correct, though it should be interpreted with care. Since the first term on the left side of the inequality in PR is a conditional probability, PR can be

² Cartwright’s complete definition takes into account the expected probabilities of all state descriptions K_J consistent with L by multiplying both conditional probabilities in the inequality by $p(K_J)$ summed over all J (see her 1979 for details). From here on I will drop the added notation for the sake of simplicity.

³ I was first introduced to the idea of a probabilizing condition for reason transmission in a colloquium talk by Niko Kolodny. His associated paper will not appear in print for some time (personal communication).

reformulated by substituting for this conditional probability its Bayes' Theorem equivalence, as follow:

PR Reasons transmit from end E to means M iff $p(M|E)p(E)/p(M) > p(E)$.

Which of course is identical to:

PR Reasons transmit from end E to means M iff $p(M|E)p(E)/p(M) - p(E) > 0$.

As $p(M)$ approaches $p(M|E)$, the value of the left term approaches the value of the right term and so the PR measure approaches 0. PR thus holds that if $p(M) = p(M|E)$, then M is not a means for E, and reasons do not transmit from E to M (which is highly intuitive). Kolodny is correct that it follows from PR that the amount of reason transmission is inversely correlated with the prior probability of M.⁴

However, this is not paradoxical. Contrary to Kolodny's worry, as $p(M)$ goes up, one does not necessarily *lose* reason to do M, but rather the *transmission* of reasons from E to M decreases. One might still have plenty of reason to do M regardless of reasons transmitted from E. Consider an M with high $p(M)$, like breathing. Given most ends, $p(E|M)$ will be roughly the same as $p(E)$, but this matches linguistic usage rather well: we do not call quotidian activities like breathing an effective strategy for some end except in very particular circumstances: a physiologist might say that breathing is an effective strategy for cellular energy transformation, but no one would say that breathing is an effective strategy for getting married, despite the fact that breathing is a necessary condition for getting married.⁵ That is because breathing is also a necessary condition for nearly everything else. For breathing, $p(M)$ is indeed high, but this does not thereby imply that one has little reason to breath, but rather it implies that one does not *gain* much reason to breath by a transmission of reason from the end of getting married. These considerations suggest that perhaps we should not assume that all means are effective strategies (though quite obviously all effective strategies are means).

One might call an unspecific but necessary condition for some end a *means* for that end while refraining from calling it an effective strategy for that end. PR* returns a positive verdict for *specific* means (like finding a spouse to get married) but a negative verdict for *unspecific* means (like breathing as a condition to get married). It is true that breathing is not an *effective strategy* for getting married—Cartwright's condition for effective strategies returns the right verdict regarding this—but, one might say, breathing is a *means* (albeit a very weak means) for getting married. After all, breathing is both a necessary condition for, and raises the probability of, marrying. If you are inclined to this linguistic distinction between *means* and *effective strategies*, PR* does not give the favored verdict on

⁴ Moreover, anytime $p(M) > p(M|E)$, then $PR < 0$, and according to PR, M is not a means for E, and so reasons do not transmit from E to M.

⁵ To relate this to my case of high $p(M)$ below (Sect. 4.4): simply because Deb has a high prior probability for studying does not mean that Deb has little reason to study. That would be perverse. Indeed, Deb evidently has plenty of reasons for studying. The PR measure simply indicates that whatever reasons Deb has for studying, these reasons are comprised only modestly from reasons transmitted from her desire to do well on the logic exam.

breathing, but the LR measure, introduced in (Sect. 3), does return the favored verdict (Sect. 4).

Kolodny is right, then, to be unsatisfied with PR, but he is right for the wrong reason. Given his worry regarding PR, Kolodny proposes the following condition:

PP condition Reasons transmit from end E to means M iff $p(E|M) > 0$.

In other words, the probability that E will occur given M must be positive in order to consider M as a means for E. One will immediately see a problem with PP: it is too expansive. PP is satisfied by any two actions as long as the first, M, does not make the second, E, impossible. For instance, there is a slight probability that the leader of the island nation of Kiribati will be assassinated conditional on my writing this paper. According to PP, my writing this paper can thereby be considered as means to assassinating the leader of Kiribati. This is odd, obviously, and not just because the probability that the leader of Kiribati being assassinated is small, but because my writing this paper has no causal relevance to such an end. Indeed, $p(E|M)$ can be very large even if we do not think that M is a substantive means for E; indeed, this can be the case even if M substantively *inhibits* E. It all depends on what the prior probability of E, $p(E)$, is. The probability that I will live until past midnight is high, even if I drink copious amounts of whiskey and end the evening with a barfight; although $p(E|M) \gg 0$, it is absurd to call my whiskey-soaked barfight a means to living until past midnight. In other words, there are uncountably many cases in which we ought not think that reasons transmit from E to M, and even cases in which we ought to think that reasons transmit from E to $\sim M$, and yet $p(E|M) > 0$. Call these ‘countermean cases’, which should be considered a *reductio* against PP.

To restate this problem, there are an infinite number of countermean cases in which

$$(i) \quad p(E|M) > 0$$

and thus PP is satisfied; and yet we do not think M is a substantive means for E, because

$$(ii) \quad p(E|M) = p(E) \quad \text{or} \quad p(E|M) < p(E)$$

Kolodny’s way of dealing with countermean cases is to appeal to his second desideratum meant to explicate a principle of reason transmission from ends to means—this is his ‘effectiveness’ desideratum: an M must “*help to bring it about or to make it the case*” that E. Kolodny could say that countermean cases do not exist because the effectiveness desideratum rules out all cases in which (ii) is true. But then the natural question to ask is what work, if any, the probabilizing desideratum does apart from the effectiveness desideratum. PP does not determine *when* reasons transmit from end to means, since countermean cases show that PP alone is insufficient to characterize reason transmission from ends to means. The effectiveness desideratum is required to rule out countermean cases. PP does not determine the *amount* of reason transmission, since it does not take into account a comparison of the conditional probability of E on M with the prior probability of E or with the

conditional probability of E on $\sim M$. That is, there is no *measure* of reason transmission by PP.⁶

Moreover, using a ‘help to bring it about’ clause to resolve problems with a probabilizing condition involves aiding a clear notion (*increasing probability*) with an opaque notion (*bringing about*).

In sum, PP is not sufficient as a condition for making precise the desideratum that means probabilize their associated end. PP is too promiscuous, and requires the effectiveness condition to chaperone. Given the difficulties with PR noted above, and given the difficulties with PP noted here, some might be inclined to give up on the probabilizing condition altogether and simply rely on other properties (like Kolodny’s effectiveness condition) to characterize reason transmission from end to means. Such a resignation would be uncalled for, since, as I argue below, LR is a compelling measure of reason transmission and thereby a compelling realization of the probabilizing condition.

3 LR measure

Consider the likelihood ratio (LR) measure of reason transmission from end to means:

LR measure

$$LR = p(M|E)/p(M|\sim E).$$

From the LR measure the following condition is constructed:

LR condition Reasons transmit from end E to means M iff $LR > 1$.

The more LR is above 1, the more that reasons are transmitted from an end to its means. Conversely, reasons do not transmit from E to M iff $LR \leq 1$.

In the following section I demonstrate the appeal of the LR measure as a precise condition for the desideratum that means probabilize an end. Nevertheless, several of the following cases show that LR as it stands must be refined.

4 Testing LR

LR tracks intuition on a broad array of cases of transmission of reasons from end to means. Moreover, the LR condition resolves extant problems associated with reason

⁶ Is PP necessary to characterize reason transmission? Necessity in this context—the requirement that a means render the probability of the end at least greater than 0—is *prima facie* such a weak condition that it is hardly worth mentioning. Nevertheless, there is some reason to think that PP is in fact not necessary to characterize transmission of reasons from end to means. Any situation in which one thinks that reasons transmit from end to means and yet $p(E|M) = 0$ would show that PP is not necessary to characterize reason transmission from ends to means. Futility, for instance, might be characterized this way. One might think that a more egalitarian distribution of the world’s resources would be a means toward achieving world peace, even if one thinks that world peace is impossible to achieve. That is, $p(E|M) = 0$ despite thinking that M is a means for E.

transmission discussed by Ross (1941), Broome (2005), Bedke (2009), Kolodny (forthcoming), and others.

In the following illustrative cases M and E are understood as ‘do M’ and ‘achieve E’ and the probabilities come from hypothetical frequencies. Nothing much hangs on this. One could construe the probabilities in epistemic terms, and for some of the cases it might be more natural to do so. What does matter, though, is that the frequencies come from the largest population which is homogeneous with respect to the complete set of means relevant to E but not including M. In other words, the frequencies should be determined by parsing the relevant population based on ‘confounding’ means for E, but not on any irrelevant properties which are not means for E. This is a recognized condition for probabilistic causality (see Cartwright 1979) and its importance will become clear.

4.1 Exercising to lose weight: moderate LR

I have reasons to lose weight. Do I thereby have reason to exercise? Suppose 80 % of people who lose weight have been exercising, and 60 % of people who do not lose weight have been exercising. Thus we have $p(M|E) = 0.8$, and $p(M|\sim E) = 0.6$, and so $LR = 1.3$. Exercising, then, is a minor means for losing weight, and whatever reason I have for losing weight transmits moderately to reasons to exercise.

4.2 Get rich: low LR

I have reasons to get rich. Do I thereby have reason to purchase a lottery ticket? Suppose that, of all rich people, 0.1 % gained their wealth by winning the lottery (and so they must have purchased a lottery ticket), and suppose that of all people who are not rich, 30 % of them have purchased lottery tickets. Then $p(M|E) = 0.001$, and $p(M|\sim E) = 0.3$, and $LR = 0.0033$. In other words, according to LR, reasons to get rich do not transmit to reasons to purchase a lottery ticket. (I hope readers find this intuitive!)

Addressing the question of whether one has reason to buy a lottery ticket if one’s end is to win the lottery, Kolodny claims that “although it may sound odd ... it does seem true that one has some reason to buy a ticket.” That is because, notes Kolodny, despite the slim chances of winning, reason is transmitted to means only *pro tanto*—such reasons can be outweighed by countervailing reasons. However, it is not odd to claim that one has a reason to buy a lottery ticket if one’s end is to win the lottery, since it is a necessary condition of winning the lottery that one buy a ticket, and as Kolodny notes, if reasons ever transmit from an end to means they must transmit from an end to *necessary* means.⁷

But what if one has the more general end of getting rich, rather than the more specific end of getting rich by winning the lottery? Here the PP measure states that reasons transmit from the end of getting rich to the means of buying a lottery ticket, since although the probability of achieving the end given the means is very low, it is

⁷ This is widely accepted—see, e.g., Darwall (1983), Schroeder (2009), and Bratman (2009). The LR, PP, and PR measure all return the result that reasons transmit from the end of winning the lottery to the means of buying a lottery ticket. Of course such reasons can be outweighed by countervailing reasons, such as the costs associated with doing M or norms constraining M.

still positive; as Kolodny notes “At least *this* much can be *said for* doing so, whatever else can be said against it: there is *some* chance, if one does [buy a ticket], of winning a lot of money as a result.” In short, $PP > 0$, and so reasons transmit from E to M. As we saw above, this contrasts with LR, which stipulates that reasons do not transmit from the end of getting rich to the means of buying a lottery ticket. If one thinks that buying a lottery ticket is a bad way to get rich (as LR suggests), then one could save PP’s verdict by appealing again to the fact that reasons only transmit *pro tanto*. However, it is a virtue of LR, in contrast to PP, that LR delivers the correct verdict on how (not) to get rich without appealing to ad hoc countervailing reasons.

The PR measure also returns a positive verdict on having reason to purchase a lottery ticket if one has the end of getting rich, since purchasing a lottery ticket very slightly increases the probability that one will get rich, and so reasons to get rich transmit (albeit slightly) to reasons to purchase a lottery ticket. This aspect of the PR analog in confirmation theory is objected to by Achinstein (2001). Here is his example. Suppose an Olympic swimmer is swimming off the shores of La Jolla. If our hypothesis is that she will drown, then the fact that she is swimming off the shores of La Jolla very slightly increases the probability of the hypothesis, and yet we should not call the fact that she is swimming off the shores of La Jolla *evidence* for our hypothesis; Achinstein takes this to be an argument against the PR definition of evidence. His solution is to add a condition to the PR definition of evidence which stipulates a threshold for the posterior probability of the hypothesis.⁸ But we have seen that LR does not require such a threshold condition for rare events (like purchasing lottery tickets if one has the end of getting rich). The LR condition returns the correct verdict without additional conditions such as probability thresholds.

4.3 Landing a job in philosophy: high LR

Tamara has reasons to land a tenure-track job in philosophy. Does she thereby have reasons to get a PhD from a top-ranked university? Suppose 98 % of tenure-track jobs in philosophy are given to people with such PhDs, and suppose 0.1 % of all other jobs in society are held by people with such PhDs. Thus $LR = 0.98/0.001 = 980$. A very high LR (say, in the three digits or more) indicates “practical necessity”. It is practically necessary to get a PhD from a top-ranked university in order to land a tenure-track job in philosophy. Given this high LR, whatever reasons Tamara has for landing a tenure-track job in philosophy strongly transmit to her getting a PhD from a top-ranked university.

4.4 Slacker Sara and Diligent Deb: low $p(M)$ versus high $p(M)$

Suppose Sara and Deb both have reasons to do well on the impending logic exam. Deb is diligent—regardless of the exam, she studies every night—whereas Sara is a slacker—she watches television every night. Given their reasons to do well on the logic exam, do Sara and Deb have reasons to study?

⁸ That is, in order to consider e as evidence for H, both $p(H|e) > p(H)$ and $p(H|e) > x$ must be the case. Achinstein suggests that a natural threshold value for x is 0.5.

To determine the specific means that Sara and Deb should take to do well on the logic exam, we should take into account their respective idiosyncrasies: to advise the means of studying would be facile for Deb (since she is already so inclined) but would be prudential for Sara. With respect to studying as a means, Deb has a high $p(M)$ and Sara has a low $p(M)$.

We saw in Sect. 2 that according to PR, as $p(M)$ increases it is not quite right to say that one loses reason to do M *tout court*, but rather, reasons transmit from E to M to a lower degree. One might still have plenty of reason to do M despite such a decrease in transmission of reason from E . In any case, the LR measure adequately handles cases of high $p(M)$.

To see this, assume the following about Deb: the probability that Deb studied if she did well on the logic exam, $p(M|E)$, is close to 1, since the prior probability that she studied is anyway so high; moreover the probability that Deb studied if she did *not* do well on the exam, $p(M|\sim E)$, also is close to 1, since the prior probability that she studied is anyway so high and so if she did not do well on the exam there must be an explanation more likely than her not studying, such as an illness. So for Deb studying as a means to doing well on the logic exam has a LR very little above 1. Conversely, assume the following about Sara: the probability that Sara studied if she did well on the logic exam, $p(M|E)$, would be moderately high, say 0.7, since despite the fact that the prior probability that she studied is so low, the logic exam is hard and so if she did well it is likely that she studied; moreover the probability that Sara studied if she did *not* do well on the exam, $p(M|\sim E)$, is low, since the prior probability that she studied is anyway so low, and the fact that she flunked the exam is consistent with her lazy ways. So for Sara, studying as a means to doing well on the logic exam has an LR much greater than 1. Thus, the LR measure of reason transmission nicely satisfies intuition regarding prudential advice for Deb and Sara, taking into account their respective idiosyncratic study habits. More importantly, perhaps, is that the LR measure is not sensitive to $p(M)$ in the way that Kolodny argues that the PR measure is.⁹

4.5 Brainy Beth: superfluous means

Beth also has reason to do well on the impending logic exam. But unlike Sara and Deb, Beth is naturally brainy. She aces all her exams without studying. Do reasons transmit from her end of doing well on the logic exam to the means of studying? Studying, after all, is a superfluous means for Beth's end, since she is almost surely going to do well on the logic exam without studying.

The LR measure of reason transmission identifies studying as superfluous for Beth. To see this, consider version (2) of LR in footnote 9. The superfluity of studying for Beth suggests that studying will not significantly change the probability

⁹ Proof: applying Bayes' Theorem to LR results in:

- (1) $[p(E|M)p(M)/p(E)]/[p(\sim E|M)p(M)/p(\sim E)]$ (from LR and Bayes' Theorem)
- (2) $[p(E|M)/p(E)]/[p(\sim E|M)/p(\sim E)]$ (from (1), $p(M)$ terms cancel)

Since the prior probability of M , $p(M)$, appears in both the numerator and the denominator of (1), and (1) is equivalent to LR, $p(M)$ cancels out in LR to give (2). Thus the degree of reason transmission as measured by LR is not sensitive to $p(M)$.

of her doing well (or poorly). Colloquially, Beth's intelligence implies that her studying won't change much (that is just what it means to say that studying is superfluous for Beth). Formally, Beth's intelligence implies that $p(E|M)/p(E) \approx p(\sim E|M)/p(\sim E)$. Applying Bayes' Theorem results in an LR of roughly 1.

In short, the LR measure adequately represents the notion of superfluous means.

4.6 Avoiding thrombosis: confounding causes

Suppose Anne has reason to avoid thrombosis. Does Anne thereby have reason to take the birth control pill? After all, the birth control pill inhibits pregnancy, and pregnancy tends to cause thrombosis. But birth-control pills also directly cause thrombosis, perhaps by creating some chemical intermediary which happens to cause thrombosis. Cartwright (1989) argues:

The net result for thrombosis of all these changes is unpredictable without the numbers ... Anything can happen to the overall probability. If the processes that operate through the prevention of pregnancy dominate, the number of cases of thrombosis will go down when contraceptives are taken; conversely, if the processes operating through the chemical dominate, the number will go up; and in cases where the two processes offset each other, the number will stay the same. But this does not in any way indicate that contraceptives have no power to cause or to prevent thrombosis, any more than the dominance of their good effects would show that they had no negative influence, or vice versa. No matter how the relative frequencies work out, the pills are both to be praised and blamed. In any case, they will have caused a number of women to get thrombosis who would otherwise have been healthy; and this fact is in no way diminished by the equally evident fact that they also prevent thrombosis in a number of women who would otherwise have suffered it.

Suppose that the processes that operate through the prevention of pregnancy dominate the processes that operate through the chemical intermediary; that is, suppose that the efficacy of birth-control pills to inhibit thrombosis via the pregnancy route is greater than the efficacy of birth-control pills to cause thrombosis via the chemical intermediary route. In the population of women who take the birth control pill, the probability of getting thrombosis would then be lower than in the population of women who do not take the birth control pill. Thus taking the birth control pill would raise the probability of avoiding thrombosis. But nevertheless it remains correct to say that birth-control pills cause thrombosis, for in the population of women who would not otherwise get pregnant, taking the birth control pill raises the probability of getting thrombosis.

Given Anne's reason to avoid thrombosis, does Anne have reason to take the birth control pill? Prima facie the means probabilize the end. In terms of the measures I introduced in Sect. 2, given the supposition that the processes that operate through the prevention of pregnancy dominate the processes that operate through the chemical intermediary, $PP > 0$, $PR > 0$, and $LR > 1$. But Anne might be one of those women for whom the birth control pill causes thrombosis but who would otherwise have been healthy had she not taken the pill. If Anne were a nun,

then although Anne has reason to avoid thrombosis, and although taking the birth control pill raises the probability of avoiding thrombosis in the overall population, Anne nevertheless should not take the birth control pill. Reasons do not transmit from Anne's end to this means, despite the fact that in the overall population the means probabilize the end. LR, as discussed thus far, fails to account for this (as does PP, PR, and all other simple probabilizing measures).

To modify the probabilizing desideratum to account for Anne, we can import the same solution proposed by Cartwright (1979) which I used to modify PR* above: we could require that means probabilize the end in all background contexts (B). Or we could use an alternative proposed by Skyrms (1980): we could require that means probabilize the end in at least one background context while not lowering the probability of the end in any background context.¹⁰ The version of LR based on Cartwright (1979) would then be:

Reasons transmit from E to M iff $\forall B: p(M|E \ \& \ B)/p(M|\sim E \ \& \ B) > 1$.

Alternatively, the version of LR based on Skyrms (1980) would then be:

Reasons transmit from E to M iff $\exists B: p(M|E \ \& \ B)/p(M|\sim E \ \& \ B) > 1$ and $\nexists B: p(M|E \ \& \ B)/p(M|\sim E \ \& \ B) < 1$.

I will not referee between these two versions of LR. The point is that the simple version of LR, and all other specific measures of the probabilizing desideratum, must be modified in one of these ways to take into account any case like Anne's (any case in which means for an end are correlated with other means which are potential confounders).¹¹

¹⁰ I use 'background context' here as shorthand for the state descriptions K_L of situation L which include the complete set of means relevant to E not including M.

¹¹ Properly stratifying the population from which we determine the relevant probabilities also resolves a concern raised by Kolodny (forthcoming), who considers a boxer who always 'telegraphs' his intention to punch by gritting his teeth: "In spite of inadvertently warning his opponent, he nevertheless sometimes connects. So the probability, conditional on telegraphing, of connecting is positive. However, intuitively, no reason transmits to telegraphing". If we let E = 'hit opponent' and T = 'telegraph', then $p(E|T) > 0$, and so PP *prima facie* returns the wrong verdict. This is why Kolodny adds his effectiveness clause to PP (discussed in Sect. 2): telegraphing does not help to bring about hitting the opponent. Kolodny also notes that $p(E|T) > p(E|\sim T)$, which contradicts a seemingly attractive measure of probability raising (such a measure is defended in the probabilistic causality literature). However, recall the single constraint stipulated on determining the relevant probabilities: they must be calculated from the largest population which is homogeneous with respect to the complete set of means relevant to the end but not including the particular means in question. To determine if telegraphing is a means for landing a punch, we should calculate the probabilities among *all* boxers (stratified by other means for E); calculating the relevant probabilities for *this particular boxer* would be to over-stratify the relevant population. Since telegraphing warns one's opponent amongst boxers generally, we have $p(E|T) < p(E|\sim T)$, and so the measure that Kolodny was opposed to is saved. LR also returns the correct verdict: since $p(T|E)$ is zero or nearly so, while $p(T|\sim E)$ is a bit larger, since there are some non-hitting ends which raise the probability of telegraphing (such as training a boxer, feigning a punch with a friend, goofing around with the kids, etc.), $LR < 1$, which is exactly what intuition says about the case, with no added clauses: whatever reasons a boxer has to land a punch do not transmit to telegraphing. Another nice thing about LR is that it is symmetric—that is, an LR measure can show a countermean—an $LR < 1$ implies that reasons to hit transmit to not telegraphing.

4.7 Light switch: sufficient means

Suppose I have reason to light the room, and suppose that flipping the light switch is a sufficient means (SM) for lighting the room. Do I then have reason to flip the light switch? Any account of reason transmission must surely answer ‘yes’ to this question. Prima facie, LR does not fare well in cases of SM.

If M is a SM for E then it follows that if we do M, then it must be the case that we attain E—that is, $p(E|M) = 1$ when M is sufficient for E—and so it must be the case that we do not attain $\sim E$; in other words, the probability that $\sim E$ is the case when M is done and M is sufficient for E is 0. More succinctly:

Sufficient means (SM) If M is SM for E, then $p(\sim E|M) = 0$.

A worry follows. If E is not guaranteed to happen anyway—if the prior probability of E is less than 1—and if M is a SM for E, then LR is undefined.¹² If E is guaranteed to happen anyway, then M is superfluous and $LR = 1$. Thus LR faces a dilemma: when M is SM for E, then either LR is undefined or else M is superfluous. One might balk at this aspect of LR. If I have reason to light the room, and flipping the light switch is sufficient to light the room, then LR cannot determine if my reasons transmit to flipping the light switch. This seems to be a mark against LR.

One might respond by claiming that flipping the light switch *alone* is not sufficient to light the room. Many helping factors have to be in place: the bulb must be fresh enough, the electrical wiring must be operational, and my electricity bill must be paid. To light the room, the light switch is an inus condition—an insufficient but necessary part of an unnecessary but sufficient condition—and an inus condition on its own is (obviously) insufficient to achieve the end in question. Only in conjunction with all the necessary helping factors can an inus condition achieve the effect in question. And if an M alone is never sufficient for E, then the antecedent of (7) is never met, and so the worry of LR being undefined is avoided. This would be a superficial response, however, since one could simply call an M ‘all those factors required to be sufficient for E’; in inus terms, one could call M the set of insufficient but necessary parts of an unnecessary but sufficient condition for E. With the conjunction of such jointly sufficient factors we

¹² Proof:

(1)	if M is SM for E then $p(M \sim E)p(\sim E)/p(M) = 0$	(SM, Bayes’ Theorem)
(2)	$p(M \sim E)p(\sim E)/p(M) = 0$ iff $p(M \sim E) = 0$ or $p(\sim E) = 0$	(by definition)
(3)	if M is SM for E then $[p(M \sim E) = 0$ or $p(\sim E) = 0]$	(from 1 and 2)
(4)	if $p(M \sim E) = 0$, then LR is undefined	(division by zero)
(5)	$p(\sim E) = 0$ iff $p(E) = 1$	(by definition)
(6)	if M is SM for E then $[LR$ is undefined or $p(E) = 1]$	(from 3, 4, 5)
(7)	if M is SM for E and if $p(E) \neq 1$, then LR is undefined	(from 6)

would have a sufficient condition (a SM) for E, and thus LR would remain undefined.

A better solution is merely algebraic: rather than measure reason transmission using the ratio of likelihoods, one could use the likelihood difference (LD):

LD measure

$$LD = p(M|E) - p(M|\sim E).$$

From the LD measure the following condition is constructed:

LD condition Reasons transmit from end E to means M iff $LD > 0$.

The more LD is above 0, the more that reasons are transmitted from an end to the means. Conversely, reasons do not transmit from E to M iff $LD \leq 0$. Since LD is not a ratio, LD is defined even when $p(M|\sim E) = 0$.

An alternative and attractive solution is Humean: speaking strictly, no evidence can show that there exists an M which satisfies the antecedent of (7). Talk of means and ends has tended to occur in the domain of practical reasoning, in which the notion of a SM is understandable and in which neglect of the history of epistemology is forgivable. But to claim that there is an M such that $p(E|M) = 1$ is to presuppose a solution to the problem of induction. Epistemic modesty requires us to hold that, no matter how much evidence one has acquired thus far, for all E and all M, it is necessarily the case that $p(E|M) < 1$.¹³ It follows that, for all E and all M, $p(M|\sim E) > 0$. The antecedent of (7) is never met, then, and LR is thereby always defined. Ironically, a Humean gets the correct answer to a practical quotidian question: if I have reason to light the room, I do indeed have reason to flip the light switch.

4.8 Breathing to get married: necessary but unspecific means

Suppose Centralia has reasons to get married. Does she thereby have reasons to breath? We saw in Sect. 2 that if one wishes to answer yes, then one might be dissatisfied with PR as a condition for transmission of reasons from the end of getting married to the means of breathing. But LR satisfies. Since breathing is a necessary condition for getting married, $p(M|E) = 1$. And since breathing is a necessary condition for nearly everything else (except, say, free diving and being connected to an artificial ventilator after a whiskey-soaked barfight), $p(M|\sim E)$ is very, very close to 1. The relevant LR, then, is just barely above 1: breathing is, according to LR, a very weak means for the end of getting married. (Breathing is not, though, as we saw above, an effective strategy for getting married—for *that* one should find a suitable spouse.)

¹³ Some might think that epistemic modesty should render us wary of any specific probability. I have much sympathy with this view, but a full discussion of it would take this paper far afield.

4.9 Suicidal hunger: imprudent means

A challenge to a principle of reason transmission (at least as characterized by Raz's 'facilitative principle') has been raised by Broome (2005).¹⁴ Consider:

Suppose you have an undefeated reason to avoid feeling hungry this afternoon. There are two alternative plans by which you can facilitate that result. You can eat the tasty and nutritious lunch that is already set on the table in front of you, or you can kill yourself. According to the facilitative principle ... it would follow that you have reason to kill yourself. But plainly it does not follow. Suppose you have some reason to stay alive, perhaps a very slight one. Then you ought to stay alive. The fact that killing yourself would be a way to avoid feeling hungry does not count in the least degree against your reason to stay alive. You have no reason to kill yourself.

The means (killing yourself) seem to render the end (avoiding hunger) more probable. Since we should find this absurd, according to Broome, we should reject a probabilizing principle of reason transmission.¹⁵ If one shares Broome's intuition, the PP and PR measures will not satisfy you, but thankfully the LR measure returns an intuitive verdict.

To see this, let E = 'avoid hunger' (in the context of Broome's case: quotidian, western hunger potentially sated by a nutritious lunch, and not profound, irremediable hunger), L = 'eat lunch', S = 'commit suicide', and suppose with Broome that L and S are exclusive and exhaustive means for E. It is, I hope, obvious that:

$$(i) \quad p(E|S) > p(E)$$

$$(ii) \quad p(E|S) > 0$$

$$(iii) \quad p(S|E) < p(S|\sim E)$$

(i) and (ii) are trivially true and suggest that PR, measured in (i), and PP, measured in (ii), sit awkwardly with intuitions held by Broome and anyone else who thinks suicide is a bad way to avoid hunger. (iii) is true because there are some non-E ends—such as political protest by self-immolation, piloting a Kamikaze mission, or ending unbearable and unmitigated suffering—which require suicide. So of those who successfully achieve non-E ends, some small percentage committed suicide as a successful means to their end. But of those who successfully achieve E (in the context of Broome's case) it is fair to assume that very few (and certainly no one in

¹⁴ Raz's (2005) facilitative principle is: "When we have an undefeated reason to take an action, we have reason to perform any one (but only one) of the possible (for us) alternative plans that facilitate its performance".

¹⁵ Commenting on this case, Bedke (2009) writes "Unlike Broome, however, I am inclined to think that I do have some reason to kill myself in this case. It is just massively outweighed." A virtue of LR is that one can share Broome's intuition that, contra Bedke, one does not have any reason to kill oneself at all, and yet avoid Broome's conclusion that there is a problem with a principle akin to Raz's facilitative principle.

their right mind) committed suicide as a means to their end. So from (iii) it follows that, considering suicide as a means to avoid hunger this afternoon, $LR \ll 1$, which is perfectly in line with Broome's stated intuition (and mine, and I hope yours, too).

4.10 Ross's letter: imprudent disjoined means

Kolodny (forthcoming) notes a paradox introduced by Ross (1941). If my end is that my letter reach its destination (E), then reasons transmit to the best means possible, say, to mailing the letter (M). But M entails "M or else burn (B) the letter". Thus a principle of reason transmission seems to be faced with the odd result that if I have reasons for the letter to reach its destination then I have reasons to mail the letter or burn the letter.

The LR condition again provides an attractive resolution. Clearly:

$$(i) \quad p(M|E)/p(M|\sim E) \gg 1$$

But what about the disjunction? One might be interested in two distinct questions: (1) do reasons transmit from E to MvB? And (2): do reasons transmit from E to MvB to a lesser degree than they do to M alone? To answer (1), we must compare

$$(ii) \quad p((MvB)|E)$$

with

$$(iii) \quad p((MvB)|\sim E)$$

There are non-E ends—such as lighting my fireplace, committing arson, and destroying all traces of my letter—which B can help achieve, and so (iii) is greater than zero, but not by much. On the other hand, (ii) is very high, given that $p(M|E)$ is itself so high and $p((MvB)|E)$ is necessarily greater than or equal to $p(M|E)$.¹⁶ Thus LR of MvB with respect to E is high. Reasons strongly transmit from E to MvB. Some might consider this counter-intuitive. Others might merely consider this a logical consequence of the disjunction operation.

In contrast, though, the LR verdict on (2) is more clearly intuitive. To apply LR to (2) we must determine if

$$(iv) \quad p(M|E)/p(M|\sim E) > p((MvB)|E)/p((MvB)|\sim E)$$

If (iv) holds then reasons transmit from E to M to a greater degree than to MvB according to LR. And (iv) does in fact hold.¹⁷ So, according to LR, reasons transmit

¹⁶ This is axiomatic. Immediately below I argue that the two conditional probabilities are in fact equal in this case.

¹⁷ Proof: rearrange (iv) as follows.

$$(iv) \quad p(M|E)p((MvB)|\sim E) > p((MvB)|E)p(M|\sim E)$$

We know that $p(M|E) = p((MvB)|E)$, because necessarily $p((MvB)|E) \geq p(M|E)$, and conditioning on E does not raise the probability of (MvB) compared with M alone. So (iv) reduces to $p((MvB)|\sim E) > p(M|\sim E)$. We have noted that there are non-E ends, like destroying all traces of my letter, which raise the probability of B, so in fact it is true that $p((MvB)|\sim E) > p(M|\sim E)$.

from my end of having my letter reach its destination to the means of mailing the letter to a greater degree than to the means of mailing the letter or burning the letter.

4.11 Helga's house: disjunctive necessary and sufficient means

Suppose Helga wants to enter her house. She can enter by the front door or the back door, and if she does not enter by the front door she will enter by the back door, and vice versa. Let E = 'enter house', F = 'enter by the front door', and B = 'enter by the back door', and by supposition B and F are exclusive and exhaustive means for E . One of B or F is necessary for E , and either one is sufficient for E . Note that:

$$(i) \quad p(E|(F \text{ or } B)) \gg p(E|\sim(F \text{ or } B))$$

Thus, a condition of reason transmission based on a measure that I have only briefly considered (in footnote 11)—namely, $p(E|M) - p(E|\sim M)$ —returns, in one sense, an intuitive result: “reasons strongly transmit from the end of entering the house to the means of entering either by the front or the back”. However Kolodny (forthcoming) raises this case to argue that the above measure returns the following unintuitive result:

$$(ii) \quad p(E|B) - p(E|\sim B) = 0$$

A straightforward application of this measure seems to hold that if Helga wants to enter the house, no reason is transmitted from this end to the means of entering by the back door. Same with the front door. I agree with Kolodny that this is, at least at first glance, odd. However, the oddness of (ii) can, perhaps, be mitigated by appealing to (i). It is not so odd (to my ears at least) to claim that “if Helga has the end of entering the house, no reasons transmit from that end to the means of entering the back door (since the front door would do just as well), but reasons *do* strongly transmit to the means of entering either the back door or the front door.” Of course, even if (ii) were true Helga could have plenty of other reasons for entering the back door, like the warm kitchen atmosphere at the back of the house, or the photo of her grandmother on the wall. But no additional reasons for B are transmitted to B *simpliciter* from E , but instead reasons are transmitted to $(B \text{ or } F)$ from E .

It is not my intention to salvage the above measure, though. Thankfully, LR gets exactly the right verdict, because evidently:

$$(iii) \quad p(F|E) > p(F|\sim E) \text{ (mutatis mutandis for } B)$$

If Helga has non-house-entering ends ($\sim E$), like going immediately to the pub, then she is more likely to achieve them if she does not enter the house through the front door. And same with the back door. So $p(F|\sim E)$ is low, lower at least than $p(F|E)$, and same with $p(B|\sim E)$. From (iii), it is obvious that

$$(iv) \quad p(F|E)/p(F|\sim E) > 1 \text{ (and, mutatis mutandis, } p(B|E)/p(B|\sim E) > 1)$$

Thus LR matches our intuitions about the transmission of reasons from the end of entering the house to the means of entering through the front door. And same with

the back door.¹⁸ So which door should Helga enter? The transmission of reasons from E does not help decide. Both are fine. She might have a higher probability of preferring the front, because it is closer, or the back, because of the photo of her grandmother on the wall. But the end in question does not transmit reasons to prefer one over the other. A fine way to decide, sometimes, is to plump.

5 Conclusion

I have argued for the superiority of LR over PP and PR as a measure of the degree of transmission of reasons from end to means. But in exploring test cases of end-means reason transmission I have noted several constraints on such a probabilizing condition: reasons transmit only *pro tanto*; the probability of the end must be raised by the means in all background contexts, or at least in one background context and not decreased in any background context; and to be strict Humeans we should not speak of means which are sufficient for an end, or means which render the probability of an end as 1. The LR measure adequately represents reason transmission in cases of probable means, improbable means, superfluous means, specific necessary means, unspecific necessary means, disjunctive means, imprudent means, and disjunctive imprudent means; for ends often achieved (like doing well on logic exams), and for ends rarely achieved (like winning the lottery).

Recent work in confirmation theory—in which the support that evidence provides a hypothesis is measured with probabilities—suggests that there are multiple desiderata for measures of confirmation, and no single measure best satisfies all desiderata (Fitelson 1999). In other words, there is no ‘perfect’ measure of confirmation. It might turn out that there is no single best measure of transmission of reasons from end to means which satisfies intuition on all cases. Nevertheless, to render precise the condition that reasons transmit from an end to means if and only if means raise the probability of that end, I have argued that LR is compelling, satisfies intuition in a diverse array of cases, and resolves several extant puzzles of instrumental rationality.

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¹⁸ But not both! Because:

$$p((F \& B)|E) \ll p((F \& B)|\sim E)$$

There are some non-E ends—such as playing hide and seek, or chasing one’s disobedient puppy—that make entering the house sequentially via both doors more probable than does the end of entering the house simpliciter.

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