# The Principle of Sufficient Reason in ordinary cognition

**Scott Partington**[1,2] **(sp933@cam.ac.uk)**
**Alejandro Vesga**[2] **(ajv79@cornell.edu)**
**Shaun Nichols**[2] **(sbn44@cornell.edu)**
[1]University of Cambridge, Department of History and Philosophy of Science, Cambridge, CB2 3RH UK
[2]Cornell University, Department of Philosophy, Ithaca, NY 14853 USA

**Abstract**

The Principle of Sufficient Reason (PSR) has been an influential thesis since the earliest stages of western philosophy. According to a simple version of the PSR, for every fact, there must be an explanation of that fact. In the present research, we investigate whether people presuppose a PSR-like principle in judgment. Across four studies (N = 1,007 in total, U.S., Prolific), we find that participants consistently presuppose PSR in judgments about candidate explananda. Such judgments predictably track the metaphysical aspects relevant to the PSR (Study 1) and diverge from related epistemic judgments (Study 2) and value judgments (Study 3). Moreover, we find participants' PSR-affirming judgments apply to a large set of facts that were sampled from random Wikipedia entries (Studies 4). These findings suggest that certain metaphysical judgments play an important role in our explanatory activities, one that is distinct from the role of the epistemic and value judgments that have been the focus of much recent work in cognitive psychology and philosophy of science.

**Keywords:** explanation; modal thought; judgment; cognitive psychology; experimental philosophy

## Introduction

Explanation is essential to the way we understand and act in the world around us. Often, we expect to find an explanation for what we experience, accept or dismiss evidence that bears on candidate explanations, and so on. We also typically want to find an explanation, deem the search for explanations worth our effort, and so on. Much work in cognitive psychology and philosophy of science emphasizes the importance of these *epistemic* and *value* judgments during explanatory inquiry. However, an intriguing possibility is that a distinctive *metaphysical* judgment is also ever-present: perhaps, we always suspect that an explanation must exist—even if we cannot come to know it or it would not be valuable for us to know it. If so, we presuppose a version of the *Principle of Sufficient Reason* (PSR), which states, roughly: for every fact, there has to be an explanation of that fact.

The PSR has a prominent place in the history of western philosophy since the Presocratic era (e.g., Parmenides; see Pruss, 2006). Most notably, it lies at the core of rationalist metaphysics, old (Leibniz, 1989; Spinoza, 1985; Wolff, 2009) and new (Amijee, 2021; Dasgupta, 2016; Della Roca, 2010). Versions of the PSR have been crucial to arguments in favor of the existence of God (Leibniz, 1989; Avicenna, 2005), the identity of indiscernibles (Leibniz, 1989), and the conviction that we live in a deterministic universe (Spinoza, 1985), just to name a few of its many applications (see, e.g., Amijee, 2020; Melamed & Lin, 2021 for review). Even those who deny its strength or relevance (prominent detractors include Bennett, 1994; Hume, 1739/2007; Van Inwagen, 1983) would concede the PSR has been a crucial premise for argumentation across history and areas of debate.

But is the PSR just an analytic tool for full-time metaphysicians, or might a PSR-like presumption also be present in ordinary cognition? With this paper, we set out to investigate the extent to which people presuppose the PSR in judgment. Across four studies, we find that people indeed make PSR-affirming judgments that (i) predictably diverge from their epistemic and value judgments (Studies 1-3) and (ii) apply to a large set of facts sampled from random Wikipedia entries (Study 4). To begin, we briefly review related psychological research, which will help to delineate the ways in which explanatory judgment can be epistemic, evaluative, or metaphysical.

There are important precedents in cognitive and developmental psychology that bear on the examination of the PSR in ordinary cognition. A consistent theme in work on explanatory cognition is that people in general—and children in particular—have an abiding drive for explanation (cf. Gopnik, 1998). For example, children are prone to generate explanations for unexplained facts and reject answers that leave salient facts unexplained (Woolley & Cornelius, 2017), or recruit miracles to explain otherwise improbable or even impossible events (Woolley & Dunham, 2017). Likewise, recent studies show that adults evaluate candidate facts-to-be-explained ('explananda') on a wide variety of dimensions, for example: whether the fact 'demands' explanation (Liquin et al., 2020), whether science can possibly explain the fact (Gottlieb & Lombrozo, 2018), and whether explaining the fact would achieve desirable moral or social ends (Davoodi & Lombrozo, 2021).

Such studies show that people can appraise candidate explananda in sophisticated ways, but the extant findings can be distinguished from the hypothesized PSR presumption in at least two major ways. First, note the PSR's scope. According to the PSR, *every* fact must have an explanation. Second, note the PSR's modal strength. The PSR says that every fact *must* have an explanation. This is a claim about the necessity of an explanation, not merely the expectation or value of an explanation. The PSR is said to yield proof of the existence of God, the truth of causal determinism, etc. because every fact *must* be explained and not simply because



In J. Culbertson, A. Perfors, H. Rabagliati & V. Ramenzoni (Eds.), *Proceedings of the 44th Annual Conference of the Cognitive Science Society.* 

we expect to find explanations, or we value having explanations.

As suggested above, there are two key requirements for positing a PSR presumption in ordinary cognition. The first is **Divergence**: judgments in accordance with a metaphysical, PSR-like principle should predictably diverge from related epistemic and value judgments. The second is **Generality**: judgments in accordance with a PSR-like principle should apply to facts in general. The present research[1] investigates whether people's PSR-affirming judgments indeed meet these requirements. In Studies 1-3, we test for Divergence by measuring participants' judgments about a curated set of explananda that we predict are likely to elicit differences in metaphysical, epistemic, and evaluative judgments. In Study 4, we test for Generality by measuring participants' judgments about a large, comprehensive set of explananda that were sampled from randomly selected Wikipedia entries. Throughout, we find that people's judgments display the predicted Divergence and Generality.

## Studies 1-3: Evidence for Divergence

To show that people's judgments conform to PSR and display the right sort of Divergence, we first need to validate a measure of metaphysical judgment. Such a measure should (1) capture a commonsense metaphysical notion of explanation and (2) distinguish it from other, non-metaphysical senses of explanation.

With respect to (1), this means translating the technical sense of 'sufficient reason'—where *y* has an *explanatory relation* to *x*—into ordinary English. A good place to start is with the words 'explanation' and 'reason.' However, differences in usage of 'explanation' and 'reason' across different areas of discourse can be a complicating factor. A simplistic, yet notable, example is how 'reason' allows for teleological considerations to serve an explanatory purpose in religious contexts (Kelemen, 2004), whereas certain areas of contemporary science do not allow for teleological explanations (Keil, 2019). "God punished Job in order to test Job's faith" is an acceptable explanation to the question "Why did God punish Job?", whereas an 'in order to' answer is not acceptable for questions like "Why do objects fall to ground?". In this research, we are interested in investigating a version of the PSR that permits both sorts of explanatory relations.

With this in mind, we designed a simple measure using strong modal language and a disjunctive phrasing (scale: 1 - Strongly disagree, 7 - Strongly agree):

> **Simple:** There must be an explanation or reason why [balloons lose helium].

Simple is ecumenical with respect to teleological and non-teleological explanation. A possible problem, however, is that it may fail to differentiate explanations in an epistemic sense (an explanation can be known) and in a metaphysical sense (there has to be an explanation, independently of whether anyone can know it). Given this possibility, we designed another measure that explicitly contrasts the epistemic and non-epistemic readings (scale: 1 - [Bert]: It is possible there is no explanation or reason., 7 - [Rich]: There must be an explanation or reason):

> **Explicit:** [Bert] and [Rich] were both convinced that [balloons lose helium]. But they disagreed with each other about whether there has to be an explanation or reason for why [balloons lose helium]. [Bert] said it's possible there is no explanation, end of story. [Rich] said of course there must be an explanation, even if we don't know it.
>
> Who do you agree with?

Explicit provides a more precise test of whether people use a metaphysical notion of explanation. By including Explicit in Study 1, we are able to compare participants' responses with Simple. Insofar as Explicit is a valid measure of metaphysical judgments and displays high internal consistency with Simple, then we are warranted in concluding that Simple is also a valid measure of metaphysical judgments.

Such validation requires not only showing that scale ratings are internally consistent (i.e., higher ratings on Simple reliably correspond to higher ratings on Explicit), but also showing that scale ratings are responsive to the relevant theoretical criteria. By analogy, a valid thermometer needs to produce higher readings in hot environments and lower readings in cool environments, in addition to readings that are consistent with other thermometers. To this end, we needed to show that our measures can produce ratings that affirm *and* ratings that deny the core metaphysical claim. Otherwise, we have no way of distinguishing evidence that confirms a genuine PSR-like presupposition from evidence that merely confirms a positive response bias. This is challenging, given the scope and modality of the PSR. It is supposed to apply to every fact, but to test it we need items that elicit negative ratings to our measures.

To address this issue, we opted to measure participants' judgments about facts that are typically considered apt for explanation as well as coincidences, which are typically not considered as apt for explanation (cf. Lando, 2017; Sober, 2012). For example, consider the coincidence that Darwin and Lincoln were born on the same day. Darwin's birth and Lincoln's birth can be separately explained as unique events, but, intuitively, there is no further explanation for the conjunction of the two events. That Lincoln was born on February 12th of 1809 *and* Darwin was born on February 12th of 1809 has no independent explanation beyond the explanations of each of these conjuncts—or, in commonsense

[1] For each study, sample size was determined according to *a priori* power analysis to ensure power > 90% for all confirmatory analyses (cf., Lakens, 2021). Pre-registrations for Studies 1-4, all study materials, data, and analysis code can be found at OSF. All participants were adults living in the US who were recruited via Prolific.

terms, it is just a coincidence. Hence, we expect coincidences to yield negative ratings in both Simple and Explicit.

Does this mean that coincidences are exceptions to PSR? We think not. What we are calling "coincidences" are just arbitrary conjunctions of facts that happen to be salient in the real world. We generate them by selecting facts that call for independent explanations and arbitrarily bringing them together in a sentence of our own making. Therefore, one may suggest, these conjunctions are not *in themselves* facts. If so, this would explain why coincidences are not apt for explanation and also why they do not count as exceptions to the PSR, as it only applies to facts.

Say, however, that one wants to insist that coincidences are facts. If so, to make sense of why they do not call for explanation, we may appeal to the following recursive construal of the PSR:

> PSR*: for every *x*, if *x* is a fact, either there is a *y* such that *y* explains *x*, or *x* is composed of facts that each have an explanation.

Under this account, coincidences fall under the second disjunct of the principle. Although they are facts, they do not call for explanations in themselves. Crucially PSR* is still committed to the strong conclusion that there are no brute facts; there are no facts that bottom out the chain of explanations.

Either of these paths allows us to use coincidences as foils to the PSR for the purposes of validating our measures without yielding counterexamples to the PSR itself. In summary, if our measure is capturing the relevant notion of explanation, participants should give (i) similar ratings on Simple and Explicit and (ii) higher ratings when the candidate explananda are facts and (iii) lower ratings when the candidate explananda are coincidences.

## Study 1: Measurement validation

In a fully within-subjects design, participants ($n$ = 319) made judgments about 30 candidate explananda. Twenty-six of these explananda (7 scientific, 7 health-related, 3 mathematical, 3 psychological, 3 supernatural, and 3 religious) have been in used in previous research on explanatory judgment (Liquin et al., 2020). Participants also made judgments about 4 coincidences that we devised for this study. The full set of explananda can be viewed at OSF.

The procedure had three main parts. In Part 1, participants first judged whether each candidate explanandum was true on a 7-point scale (e.g., It is true that [balloons lose helium]. 1 - Strongly disagree, 7 - Strongly agree). If participants gave a truth rating greater than 4 (the scale midpoint), they then gave a rating on the Simple measure. Participants' judgments were 'truth-piped' in this manner since, for our purposes, PSR-relevant judgements only apply to facts that people judge to be true. After going through this piping procedure for all 30 phenomena (order randomized), participants proceeded to Part 2. In Part 2, participants repeated the piping procedure for all 30 explananda and the Explicit measure, with the order randomized and different names assigned to the disagreeing parties in each case.

In Part 3, participants made judgments about the general formulations of the PSR. We included these measures to get a sense for whether people endorse the general formulations, and, if so, how this tendency is related to their judgments about specific events. We developed four measures (presented in random order within 'happens' and 'exists' blocks, all scales: 1 - Strongly disagree, 7 - Strongly agree): *Happens*: "To what extent do you think there has to be a [reason/explanation] for anything that happens?" and *Exists*: "To what extent do you think that for anything that exists there has to be a [reason/explanation] for why it exists?"

### Study 1: Results

To assess whether participants' ratings depended on explananda type, we used a mixed-effects linear regression model with rating score as the dependent variable. We included measure (Simple or Explicit) and explanandum domain (coincidence, science, health, math, psychology, supernatural, religious) as fixed-effect independent variables. We included random slopes for measure and domain, and we included a random intercept term for participant. As predicted, model results indicate a significant main effect of explananda domain ($F(6) = 329.92$, $p < .001$), whereas there was not a significant main effect of measure type ($F(1) = 0.05$, $p = .83$). Differences across domains follow the predicted pattern, with the coincidences receiving lower scores than scientific ($b = 4.02$, $se = 0.09$, $p < .001$), health ($b = 4.00$, $se = 0.09$, $p < .001$), math ($b = 3.76$, $se = 0.10$, $p < .001$), psychology ($b = 3.42$, $se = 0.09$, $p < .001$), supernatural ($b = 2.38$, $se = 0.13$, $p < .001$), or religious ($b = 2.76$, $se = 0.13$, $p < .001$) explananda across both the Simple and Explicit measures.

Average ratings for coincidence explananda were significantly below the scale midpoint ($m = 2.46$, $sd = 2.02$, $t(1602) = -30.7$, $p < .001$). In contrast, the average ratings for all other explananda were significantly above the scale midpoint (Science: $m = 6.58$, $sd = 0.75$; Health: $m = 6.55$, $sd = 0.71$; Math: $m = 6.32$, $sd = 1.14$; Psychology: $m = 5.99$, $sd = 1.19$; Religion: $m = 5.55$, $sd = 1.69$; Supernatural $m = 5.06$,

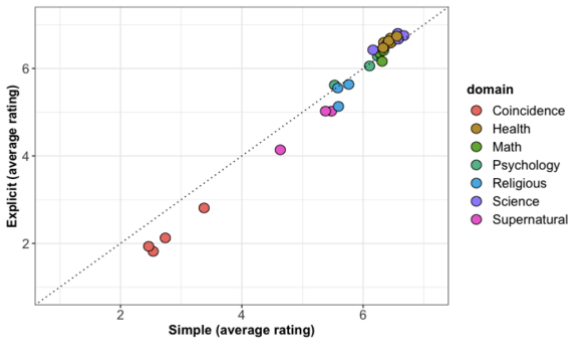


Figure 1. Average ratings on Simple (x-axis) and Explicit (y-axis). Colors correspond to explanandum type. The dashed line indicates a perfect linear relationship.

*sd* = 1.76; all comparisons to μ = 4 are significant $p < .001$). (See Fig. 1).

To assess the reliability of the Simple and Explicit measures, we fit our proposed measurement model via confirmatory factor analysis using the R package *lavaan* (Rosseel, 2012). The model posits three latent constructs to explain the variance in participants' judgments across the PSR-relevant measures: a tendency to presuppose the PSR in judgments about specific explananda (Specific), a tendency to endorse the general formulations of the PSR as it pertains to reasons (Reason), and a tendency to endorse the general formulations of the PSR as it pertains to explanations (Explanation). This 3-factor model displayed excellent fit across all absolute fit indices (RMSEA = .01, SRMR = .005, CFI > .99 TLI > .99), and outperformed a 2-factor model that collapsed Reason and Explanation (3-factor: AIC = 130657, BIC = 130772; 2-factor: AIC = 132448, BIC = 132549).

From the fitted measurement model, we can compute the composite reliability between Simple and Explicit to assess whether these measures are internally consistent. Composite reliability is a metric of the shared variance, relative to the total scale variance, among the observed variables that indicate a latent construct (Bacon et al., 1995; Raykov, 1997). The composite reliability for Simple and Explicit was *CR* = .892, which corresponds to Simple and Explicit sharing approximately 79% of the total scale variance. Thus, insofar as the Explicit measure reliably tracks people's metaphysical judgments, the Simple measure also reliably tracks people's metaphysical judgments.

## Study 2: Metaphysical-epistemic divergence

Having validated a simple measure of PSR-affirming judgments, next we demonstrate how participants' metaphysical judgments predictably diverge from their epistemic judgments. If people do presuppose the PSR in their metaphysical judgment, then these judgments should be able to be teased apart from epistemic judgements about the reach of our own knowledge. For instance, we might accept that it will forever remain a mystery why Stonehenge was built, or more dramatically, why the universe exists. Nevertheless, we may still think these facts must have explanations. Along these lines, our prediction is that participants' epistemic judgments will substantially vary across epistemically accessible explananda (e.g., like 'balloons lose helium') and epistemically *inaccessible* explananda (of the Stonehenge or universe variety), whereas participants' metaphysical judgments will vary to a lesser degree.

In Study 2, participants ($n$ = 104) made judgments about 28 candidate explananda. We pre-registered the six science- and six health-related explananda from Study 1 as the 'epistemically accessible' subset (Accessible), the three religious and three supernatural explananda from Study 1 with eight new explananda as the 'epistemically inaccessible' subset (Inaccessible).

As in Study 1, participants were presented with the explananda in a randomized order, and, for each explanandum, participants were first asked to judge whether they thought the explanandum was true. If the participant gave a truth rating above 4 (the scale midpoint), they next provided a metaphysical and epistemic judgment about the explanandum (order randomized between-subjects, both scales: 1 - Strongly disagree, 7 - Strongly agree):

**Metaphysical**: There must be an explanation or reason why [ancient people built the monuments at Stonehenge].

**Epistemic**: It is possible for us to know why [ancient people built the monuments at Stonehenge].

### Study 2: Results

To assess whether participants' ratings of the Accessible and Inaccessible explananda differed across measures in the predicted manner, we used a mixed-effects linear model with scale ratings as the dependent variable. We included explananda type (Inaccessible, Accessible) and measure type (Epistemic, Metaphysical) as fixed-effect independent variables. We also included random slopes for explanada type and measure type, and we included a random intercept term for participant. As predicted, the model results indicate a significant *measure type* x *explananda type* interaction ($F(1, 130) = 76.93$, $p < .001$). Post-hoc tests confirmed the predicted pattern of judgments whereby participants gave lower scale ratings on the Epistemic measure to Inaccessible explananda than Accessible explananda ($b_{\text{measure x type}} = -0.90$, $se = 0.10$, $p < .001$; summaries, Inaccessible: $m_{\text{Epistemic}} = 4.63$, $sd_{\text{Epistemic}} = 1.77$, $m_{\text{Metaphysical}} = 5.51$, $sd_{\text{Metaphsical}} = 1.46$; Accessible: $m_{\text{Epistemic}} = 6.39$, $sd_{\text{Epistemic}} = 0.74$, $m_{\text{Metaphysical}} = 6.39$, $sd_{\text{Metaphysical}} = 0.80$). (See Fig. 2).

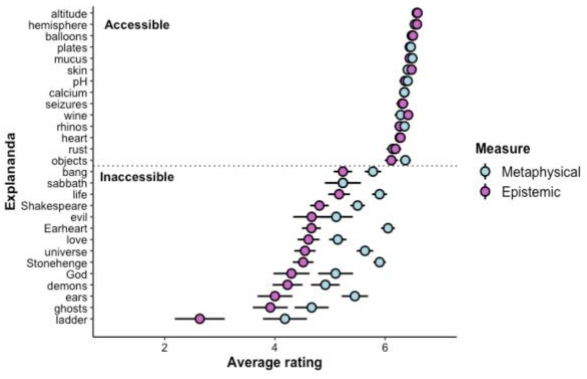


Figure 2. Average ratings (x-axis) on Metaphysical (light blue) and Epistemic (purple) measures for each explanandum (y-axis), arranged by type and sorted by average rating. Error bars indicate standard error.

## Study 3: Metaphysical-value divergence

Study 2 demonstrates that participants' metaphysical judgments diverge predictably from their epistemic judgments. In Study 3, we examine whether the same holds true for participants' value judgments. To show this, we make use of a common distinction between *token* explanation and

*type* explanations (cf., Wetzel, 2018). For example, a person might value knowing why people enjoy holding dogs *in general* but also not value knowing why a particular person enjoys holding a particular dog. Nevertheless, this disinterested observer may still believe there has to be an explanation for why *this* person enjoys holding *this* dog. Thus, our prediction is that participants' value judgments will vary according to whether the candidate explanandum requires a token explanation or type explanation, whereas participants' metaphysical judgments should remain similar across both cases. If so, this finding will help guard against worries about a "value" confound in the earlier studies, that people judge that a fact must have an explanation because they find some value in knowing what that explanation is.

In Study 3, participants ($n$ = 254) were randomly assigned to either the Type condition or the Token condition. In the Type condition, participants made judgments about explananda regarding types (e.g., 'people enjoy holding dogs'). In the Token condition, participants made judgments about explananda regarding token instances matched to the types in the Type condition (e.g., 'this woman enjoys holding this dog'). Within each condition, participants made a series of judgments about 20 explananda (order randomized within-subjects).

Each explananda was presented with a corresponding image sourced from free stock photo libraries on the internet[2]. To construct this set, first we randomly sampled 20 nouns from a list of over 6,700 English nouns[3]. We used each noun as a search string at the stock photo library and selected an image from the first page of search results. Lastly, we annotated each image to pick out a token and type event depicted in the image (see OSF for full image set).

For each explanandum, participants made three value judgments:

**Normative**: We should try to answer why [people enjoy holding dogs / this person enjoys holding this dog].

**Value**: It would be good for us to know why [people enjoy holding dogs / this person enjoys holding this dog].

**Motivational**: It would be worth the effort to find out why [people enjoy holding dogs / this person enjoys holding this dog].

Participants also provided ratings for the Metaphysical and Epistemic measures from Study 2 (judgment order randomized within-subjects).

### Study 3: Results

To assess whether participants' metaphysical judgments diverged from their value judgments, we used a mixed-effects linear regression model with scale rating as the dependent variable. We included condition (Token, Type) and measure type (Metaphysical, Epistemic, Normative, Value, Motivational) as independent variables. We also included random slopes for condition and measure type, and we included a random intercept term for participant. As predicted, the model results showed a significant *measure* x *condition* interaction for each of the value judgments and the metaphysical judgment (see Fig. 3), whereby participants gave higher ratings on the value judgment in the Type condition than in the Token condition, compared to their metaphysical judgments (*Normative*: $b$ = 0.29, $se$ = 0.13, $p$ = .02; *Value*: $b$ = 0.34, $se$ = 0.13, $p$ = .005; *Motivational*: $b$ = 0.29, $se$ = 0.13, $p$ = .02).

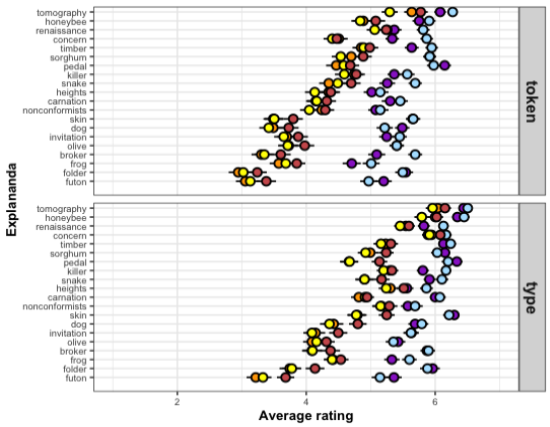


Figure 3. Average ratings on Metaphysical (light blue), Epistemic (purple), Value (red), Motivational (orange), and Normative (yellow) for each explanandum (y-axis) across conditions (top panel: Token, bottom panel: Type). Error bars indicate standard error.

In addition, scale ratings on all three value measures showed significant, positive partial correlations with each other (Normative-Value: $r$ = 0.40, $p$ < .001; Normative-Motivational: $r$ = 0.52, $p$ < .001; Motivational-Value: $r$ = 0.41, $p$ < .001), and near-zero partial correlations with the epistemic and metaphysical ratings. If a person gave a high scale rating on Normative (we should try to answer why $p$), they were also more likely to give a high scale rating on Value (it would be good for us to know why $p$) and Motivational (it would be worth the effort to find out why $p$), all else equal. But giving a high scale rating on Normative (or Value, or Motivational) had nearly zero unique association with a person's rating on Metaphysical (there must be a reason or explanation for why $p$).

## Study 4: Evidence for Generality

Studies 1-3 establish that people's metaphysical explanatory judgments predictably diverge from related epistemic and value judgments. The next step for demonstrating that people reason according to an intuitive PSR is demonstrating that people's metaphysical judgments apply generally to a widely sampled set of facts. In order to do so, we need to have greater confidence that our set of candidate explananda is more representative of facts in general.

For this reason, we assembled a large set of facts that were selected from random Wikipedia entries. Using the same list

[2] We used the following websites: https://www.pexels.com, https://pixabay.com, https://unsplash.com

[3] Source: http://www.desiquintans.com/nounlist

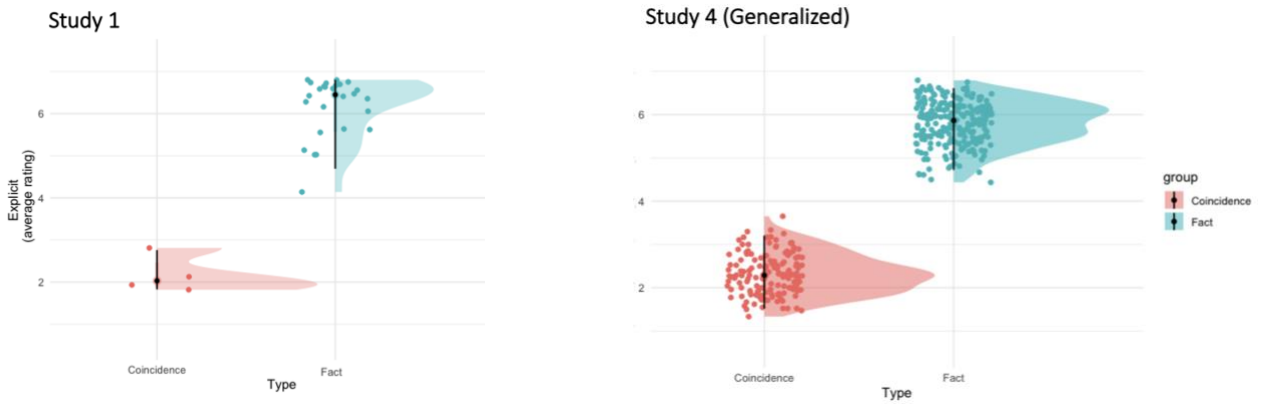


Figure 4. The distribution of average Explicit ratings for coincidences (red) and facts (blue). Points correspond to ratings for individual explananda, and the shaded region corresponds to the density of ratings. Error bars correspond to 95% HDIs.

of 6,700 English nouns as we used in Study 3, we randomly sampled 100 words and used each as a search string on Wikipedia. On the resulting page, we selected up to three facts that met the following criteria. First, the fact had to be actual (i.e., it could not express a statement of possibility). Second, the fact had to be comprehensible (i.e., not excessively jargonistic or esoteric). Third, the fact had to be non-definitional. Our rationale for these criteria was assembling a large set of facts that pertained to actual events or existents, thus keeping with the focus of the earlier studies. In total, we assembled a set of 230 facts from Wikipedia (for brevity, 'Wikipedia facts'), which was nearly ten times larger than the set of facts we had assembled from previous research (see OSF for all Wikipedia facts).

To have an appropriate contrast set, we also created a set of 150 coincidences that were either 'linguistic' (75 in total) or 'historical' (75 in total). The linguistic coincidences were constructed by randomly sampling a word from the list of 6,700 English nouns and either matching it with (a) another word that began with the same letter (e.g., "the words 'sleet' and 'sunglasses' have the same first letter (s)") or (b) another word that had the same total number of letters (e.g., "the words 'slang' and 'roast' have the same number of letters (5)"). The historical coincidences were constructed by searching https://www.history.com/this-day-in-history for events that happened on the same date across different years (e.g., "Calvin Coolidge became president of the United States (1923) and "The Macarena" became the #1 song in the US pop charts (1996) on the same day of the year (August 3)").

**Study 4: Generality of the fact-coincidence distinction**

Now that we have a larger, more representative set of facts and a corresponding set of coincidences, with Study 4 we set out to generalize the key finding from Study 1 that established participants' metaphysical judgments are appropriately sensitive to the fact-coincidence distinction.

In a fully within-subjects design, participants ($n$ = 323) made judgments about 30 candidate explananda sampled randomly from the full set of 360 in total (230 Wikipedia facts and 150 coincidences). For each explananda, participants made a rating on the Truth and Explicit measures from Study 1.

**Study 4: Results**

To assess whether participants' scale ratings depended on explananda type, we used a random-effects linear regression model with rating score as the dependent variable. We included explananda type (fact or coincidence) as fixed-effect independent variable, a random slope for explananda type, a random intercept for participant, and a random intercept for explananda (nested within type). As predicted, model results indicate a significant main effect of explananda domain ($F(1) = 1359.8$, $p < .001$). Post-hoc comparisons show the differences across domains follow the predicted pattern, with the Wikipedia facts receiving higher scores than the coincidences ($b = 3.50$, $se = 0.09$, $p < .001$). Average ratings for coincidences were significantly below the scale midpoint ($m = 2.31$, $sd = 1.85$, $t(3775) = -55.87$, $p < .001$), and the average ratings for the Wikipedia facts were significantly above the scale midpoint ($m = 5.81$, $sd = 1.40$, $t(5913) = 99.09$, $p < .001$) (See Fig. 4).

## General Discussion

The present research indicates that people make distinctively metaphysical explanatory judgments about the world. Across four studies, we found that participants consistently presupposed a PSR-like principle in their judgment. These judgments predictably tracked the metaphysical considerations relevant to the PSR (Study 1), predictably diverged from related epistemic judgments (Study 2), value judgments (Study 3), and applied to a large set of facts selected from random Wikipedia entries (Study 4).

Of course, the PSR is a universal principle, and we can hardly ask participants about every fact there is. Nonetheless, the present research suggests that these metaphysical judgements are elicited across an impressive range of facts. From the fluid dynamics of party balloons to the existence of God and the universe, participants reliably judged that facts must have an explanation. Future developmental and cross-cultural studies will be crucial for understanding the relation between this PSR-like presumption and the other epistemic and value judgments that people routinely make about explanations. In the meantime, it seems that the PSR—an ancient and deep philosophical principle—indeed holds a place in ordinary thought.

## Acknowledgments

This research was partially supported by funding from the Templeton Foundation to S.N. For helpful comments and feedback, thanks to David Rose, Carlotta Pavese, Derk Pereboom, Rachana Kamtekar, David Pizarro, Tamar Kushnir, Emily Liquin, Tania Lombrozo, members of the Concepts and Cognition Lab at Princeton University, members of the Explanation Research Group at Cornell University, and four anonymous reviewers. Thanks to Tyler Weisman for research assistance.

## References

Amijee, F. (2021). Explaining Contingent Facts. *Philosophical Studies*, 178(4), 1163–1181.

Amijee, F. (2020). Principle of Sufficient Reason. In M. J. Raven (Ed.), *The Routledge Handbook of Metaphysical Grounding* (pp. 63–75). New York: Routledge.

Avicenna. (2005). *The Metaphysics of the Healing* (M. E. Marmura, Ed.).

Bacon, D. R., Sauer, P. L., & Young, M. (1995). Composite Reliability in Structural Equations Modeling. *Educational and Psychological Measurement*, 55(3), 394–406.

Bennett, J. (1984). *A Study of Spinoza's Ethics*. Hackett.

Dasgupta, S. (2016). Metaphysical Rationalism. *Noûs*, 50(2), 379–418.

Davoodi, T., & Lombrozo, T. (2021). Explaining the existential: Scientific and religious explanations play different functional roles. *Journal of Experimental Psychology: General*.

Della Rocca, M. (2010). PSR. *Philosophers' Imprint*, 10(7).

Gopnik, A. (1998). Explanation as orgasm. *Minds and Machines*, 8(1), 101–118.

Gottlieb, S., & Lombrozo, T. (2018). Can science explain the human mind? Intuitive judgments about the limits of science. *Psychological Science*, 29(1), 121–130.

Hume, D. (2007). *A Treatise of Human Nature: A Critical Edition* (D. F. Norton & M. J. Norton, Trans.). Clarendon Press.

Keil, F. (2019). The challenges and benefits of mechanistic explanation in folk scientific understanding. *Advances in Experimental Philosophy of Science*, 41–57.

Kelemen, D. (2004). Are Children "Intuitive Theists"?: Reasoning About Purpose and Design in Nature. *Psychological Science*, 15(5), 295–301. https://doi.org/10.1111/j.0956-7976.2004.00672.x

Lando, T. (2017). Coincidence and common cause. *Noûs*, *51*(1), 132-151.

Lakens, D. (2021). Sample size justification. *PsyArXiV*.

Leibniz, G. W. (1989). *Leibniz: Philosophical Essays* (R. Ariew & D. Garber, Trans.). Hackett.

Liquin, E. G., Metz, S. E., & Lombrozo, T. (2020). Science demands explanation, religion tolerates mystery. *Cognition*, 204, 104398.

Mayo, D. G. (2018). *Statistical Inference as Severe Testing: How to Get Beyond the Statistics Wars*. Cambridge University Press.

Melamed, Y., & Lin, M. (2021). Principle of Sufficient Reason. In *Stanford Encyclopedia of Philosophy*.

Pruss, A. R. (2006). *The principle of sufficient reason: A reassessment*. Cambridge University Press.

Raykov, T. (1997). Estimation of Composite Reliability for Congeneric Measures. *Applied Psychological Measurement*, 21(2), 173–184. https://doi.org/10.1177/01466216970212006

Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling and more. Version 0.5–12 (BETA). *Journal of Statistical Software*, 48(2), 1–36.

Sober, E. (2012). "Coincidences and How to Reason about Them", in H. de Regt, S. Hartmann, & S. Okasha (eds.), *European Philosophy of Science Association* 2009. Springer, Amsterdam, 355–74.

Spinoza, B. (1985). *The Collected Works of Spinoza* (E. Curley, Trans.). Princeton University Press.

Van Inwagen, P. (1983). *An Essay on Free Will*. Oxford University Press.

Wetzel, L. (2018). Types and Tokens. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Fall 2018).

Woolley, J. D., & Cornelius, C. A. (2017). Wondering how: Children's and adults' explanations for mundane, improbable, and extraordinary events. Psychonomic Bulletin & Review, 24(5), 1586–1596.

Woolley, J. D., & Dunham, J. A. (2017). Children's Beliefs about Miracles. Journal of Cognition and Culture, 17(1–2), 73–93. https://doi.org/10.1163/15685373-12342192