The Centrality of Progressive Realism to the Scientific Realism Debate

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We report new findings from an empirical study of scientists from seven disciplines and scholars working in history and philosophy of science (HPS) regarding their views about scientific realism. We found that researchers' general disposition to endorse or reject realism was better predicted by their views regarding scientific progress than their views about the mind-independence of scientific phenomena or other common theses in the realism debate. Age and gender also significantly predicted endorsement of scientific realism. Implications of these findings for philosophical debates about scientific realism and scientific progress are considered.

1. Introduction

In recent years, a number of research teams have been studying scientific realism "in the wild" – i.e., among practicing scientists. Beebe and Dellsén (2020), for example, asked scientists to report their attitudes toward canonical theses in the realism debate and found a stronger inclination to endorse realism among natural scientists than among social scientists, among scientists who use quantitative rather than qualitative research methods, and among scientists in general than among HPS scholars. They also found that scientists' attitudes toward the pessimistic induction and van Fraassen's (1980) form of antirealism, constructive empiricism, were less related than expected to their attitudes toward other prototypical aspects of scientific realism. Employing questionnaire items modeled closely on the ones used by Beebe and Dellsén (2020), Pils and Schoenegger (2024) replicated many of their findings, including that scientists from physics, chemistry, and biology were significantly inclined to agree with statements of scientific realism. They also found that science communicators were significantly less realist than scientists in the fields on which they reported. In a similar vein, Henne et al. (2024) found that physicists solidly endorsed scientific realism and did so to a greater extent than philosophers of science.

In the present paper, we report the results of new analyses on the dataset created by Beebe and Dellsén (2020), providing further insights into the nature of scientific realism in the wild.[1] Our principal finding is that *progressive realism* – the idea that progress in science consists in obtaining successively closer approximations to objective truths about reality – predicted scientists' and HPS scholars' general disposition to endorse realism better than their attitudes toward the mind-independence of the objects and phenomena studied by science, the

[1] Beebe and Dellsén's (2020) dataset can be found on The Open Science Framework at https://osf.io/cevsr.

epistemic merits of our best scientific theories, the no-miracles argument, the pessimistic induction, or constructive empiricism. Progressive realism thus seems to stand at the center of the issues that comprise scientific realism, as those issues are represented in the minds of scientists and HPS scholars and as they were measured by Beebe and Dellsén's (2020) questionnaire.

This result is significant insofar as progressive realism has not been at the forefront of debates between scientific realists and antirealists for several decades. While contemporary philosophical discussions of scientific realism have largely focused on the approximate truth of successful scientific theories and the aims of science, questions about scientific progress and its relationship to truth have shifted into a parallel debate on the nature of scientific progress itself. Historically, the view that scientific progress involves getting closer to the truth was central to the works of Popper (1963), but it was later challenged by antirealists like Kuhn (1970) and Laudan (1977), who instead argued that scientific progress should be understood in terms of problem-solving. The surprising finding that progressive realism lies at the core of working scientists' own scientific realism suggests that the connection between progress and truth remains important in scientific practice. This indicates that future philosophical work on realism would benefit from reintegrating questions about the nature of scientific progress into the scientific realism debate.

Age and gender were also found to be significant predictors of the dispositions of scientists and HPS scholars to endorse scientific realism. These findings mirror those from other studies of scientific realism among scientists (Henne et al. 2024; Pils and Schoenegger 2024; Beebe et al. unpublished manuscript b) and the general public (Beebe unpublished manuscript) and in studies of folk attitudes toward realist theses in other domains (Beebe et al. 2015; Beebe and Sackris 2016). Across different cultures and domains, older participants and men are often observed to make more realist judgments than women and younger individuals. We briefly consider some possible explanations for the effects of these demographic variables and discuss the implications of all the findings for philosophical debates about scientific realism. None of the statistical analyses reported herein (except for item mean calculations) duplicate those reported by Beebe and Dellsén (2020).

2. Method

Beebe and Dellsén (2020) asked 1,798 scholars (ave. age = 47, 37% female) from physics, chemistry, biology, economics, psychology, sociology, anthropology, and history and philosophy of science whether they agreed with the following eight statements that express central theses found in canonical accounts of scientific realism and antirealism (e.g., van Fraassen 1980; Boyd 1983; Leplin 1984; Psillos 1999; Chakravartty 2017).

MR1. The objects and phenomena studied by science exist independently of how we conceive of or think about them.

MR2. Even if we cannot be certain which scientific theories are ultimately true, we can be certain that there is an ultimate truth out there waiting to be discovered.

PR. Progress in science is a matter of getting closer and closer to the underlying truth about reality.

ER. Our most successful and rigorously tested scientific theories are at least approximately true.

NMA. The best explanation for the remarkable success of our best scientific theories is that they accurately depict an underlying reality.

PI. The fact that the history of science contains so many widely accepted theories that turned out to be fundamentally mistaken should make us skeptical about the scientific theories that are currently accepted.[R] vFR1. In order to go about their daily business as scientists, scientists do not need to believe that any of the theories they rely upon provides them with literally correct descriptions of the world.[R]

vFR2. Scientific theories should not be judged on the basis of how accurately they depict an underlying reality but rather on how useful they are in helping us systematize our experiences and develop new technologies.[R]

The first two statements, MR1 and MR2, express broadly metaphysical ideas about the mind-independence of scientific phenomena and the scientific truths that scientific theories aim to capture. The third statement, PR, is intended to capture the sort of progress-focused realism, or *progressive realism*, that was initially proposed by Popper (1963) and which was developed and defended by, among others, Newton-Smith (1981) and Niiniluoto (1984). PR is denied most prominently by Kuhn's (1970), and later Laudan's (1977), antirealist views on which progress consists in a type of problem-solving which neither requires the problems themselves, nor their solutions, to be grounded in an objective reality. Statements ER, NMA, and PI concern broadly epistemic issues regarding our most successful scientific theories and how they are likely to be assessed in the future. The no-miracles argument (NMA) has been treated as one of the most prominent arguments in favor of scientific realism.[2] On the other side of the dialectical divide is said to lie the pessimistic induction (PI), which offers a much less sanguine assessment of the achievements of science.[3] The final pair of questionnaire items, vFR1 and vFR2, articulates central components of the influential form of antirealist

[2] Canonical statements of the no-miracles argument can be found in Smart (1963), Putnam (1975), Musgrave (1988), and Psillos (1999). But cf. Worrall (2011) for defense of the view that the no-miracles argument is more of an intuition than an argument.

[3] Cf. Laudan (1981a), Poincaré (1905), and Stanford (2006).

instrumentalism defended by van Fraassen (1980, 8), which is marked by a rejection of the idea that “[s]cience aims to give us, in its theories, a literally true story of what the world is like” and that “acceptance of a scientific theory involves the belief that it is true.”

Beebe and Dellsén (2020) asked participants to indicate the extent to which they agreed with each of the statements above by selecting an answer on a seven-point scale that ranged from ‘Completely disagree’ to ‘Completely agree.’ Agreement with any of the first five statements represented a realist response, while disagreement with one of the last three indicating a realist response. Antirealist responses followed the opposite pattern. For purposes of analysis, a response of ‘Completely disagree’ to one of the first five statements was coded as a 1, ‘Mostly disagree’ as 2, and so on. For the reverse-scored items (marked with a superscript ‘R’), ‘Completely disagree’ was coded as 7, ‘Mostly disagree’ as 6, and so on. Higher scores on all items thus represent more strongly realist responses.

3. Results

3.1 Descriptive statistics

Means and standard deviations were calculated for all questionnaire items and can be found in Table 1.[4] The means for MR1, MR2, PR, ER, and NMA are notably higher than those for PI, vFR1, and vFR2. The high scores on the first five items represent strongly realist judgments about the mind-independence of scientific phenomena and the truths which scientific theories are meant to describe, scientific progress, and the epistemic status of our best scientific theories. High scores on the final three items would have indicated strongly realist rejections of the pessimistic induction and van Fraassen-style instrumentalism.

[4] The distribution of standard deviations reveals that there was a much narrower range of opinion about ER than any other issue.

However, what we observe instead are slight inclinations toward antirealist attitudes on these issues. In their replication and extension of Beebe and Dellsén's (2020) work, Pils and Schoenegger (2024) observed the same pattern of responses.

We compared the means of MR1, MR2, PR, ER, and NMA to the means of PI, vFR1, and vFR2 and found that the mean difference in each pairwise comparison was significant at the .001 level. The magnitudes of these differences were measured using Cohen's *d* and are represented in Table 2. A Cohen's *d* value of 1 means that the difference between two statistics is one standard deviation in size. On the conventional interpretation, values above 0.2 are considered small, values above 0.5 medium, and values above 0.8 large (Cohen 1988). Thus, we can see that almost all mean differences are medium to large.

Table 1

Item means and standard deviations

	MR1	MR2	PR	ER	NMA	PI	vFR1	vFR2
$\bar{X}$	5.1	4.8	5.2	5.5	5.2	3.5	3.1	3.9
SD	1.9	1.9	1.7	1.3	1.5	1.8	1.8	1.8

Table 2

Effect sizes for mean differences

	MR1	MR2	PR	ER	NMA
PI	.68	.52	.73	.98	.82
vFR1	.82	.69	.92	1.13	1.01
vFR2	.52	.37	.61	.78	.68

Note. Effect sizes were measured using Cohen's *d* and are significant at the .001 level.

We then categorized each participant's response to each questionnaire item as either realist (for scores ranging from 5 to 7), antirealist (scores from 1 to 3), or neither (for a score of 4) and found that 55% of scientists and 45% of HPS scholars gave a realist response to at least 3 of the first 5 items (MR1, MR2, PR, ER, NMA) while giving an antirealist response to at least 1 of the last 3 (PI, vFR1, vFR2). 68% of scientists and 68% of HPS scholars gave antirealist responses to PI. Among these participants, 76% of scientists and 54% of HPS scholars gave a realist response to at least 3 of the first 5 items. The fact that a substantial portion of scientists and HPS scholars apparently have no problem combining what have traditionally been labeled as realist theses with theses that have traditionally been characterized as antirealist suggests that the received narrative needs correction insofar as it often bundles together the former with rejections of the latter. It is particularly noteworthy how frequently participants combined realist responses with an endorsement of the most prominent argument against scientific realism, the pessimistic induction. These findings seem to indicate the real-world viability of moderate positions in the scientific realism debate, on which one combines a PI-motivated skepticism about the unqualified truth of current theories with a realist attitude about other issues.

One possible interpretation of these results is that many scientists may be inclined toward some form of selective realism, such as entity realism (Hacking 1983), structural realism (Worrall 1989), or semi-realism (Chakravartty 2007). On these views, the fallible and provisional nature of scientific inquiry can be reconciled with a realist perspective on science by recognizing that while many parts of our best scientific theories are likely to be discarded in the future, other parts of these theories – especially those most directly responsible for their success – will be retained because they are correct. Of course, another possible interpretation is that a large proportion of scientists – and a somewhat smaller proportion of HPS scholars – are simply incoherent in endorsing the pessimistic induction together with various realist theses. Our data do not allow us to fully discriminate between these possible interpretations. However, we are not inclined to favor interpretations that attribute massive incoherence when other, more charitable options are available.

3.2 Correlations

Pearson correlations were calculated for each pairwise relationship between the eight questionnaire items and are depicted in Table 3.[5] Strong positive correlations were observed

[5] Beebe and Dellsén (2020) calculated non-parametric Kendall's tau correlation coefficients for pairs of questionnaire items because there was some non-normality in the data. However, we employed the more familiar, parametric Pearson's correlation because simulation research has shown it to be robust to violations of normality when data have skew less than |2.0|, kurtosis less than |9.0|, and $N > 10$ (Bishara and Hittner 2012; Edgell and Noon 1984; Havlicek and Peterson 1977). The distributions of SR scores for each discipline had skew and kurtosis less than |1.31|, and the distributions of scores for the 8 questionnaire items had skew and kurtosis less than |1.23|.

between pairs of responses to the first five items, which had an average inter-item correlation of .44. In other words, (dis)agreement with one statement from the set containing MR1, MR2, PR, ER, and NMA was strongly associated with (dis)agreement with another statement in this set.[6]

[6] On the conventional interpretation of correlation coefficients, correlations above .3 but below .5 should be viewed as medium. Textbook statements of these conventions always include an oft-forgotten caveat about different fields of research calling for different interpretations (e.g., Field 2018 596). Thus, Gignac and Szodorai (2016) recommend that in individual differences research, correlations above .1 but below .2 should be considered small, correlations above .2 but below .3 typical, and correlations above .3 relatively large. Therefore, the .27 correlation between MR1 and ER and the .35 correlation between MR1 and NMA should be considered typical (or medium) and large, respectively.

Table 3

Correlation matrix

	MR1	MR2	PR	ER	NMA	PI	vFR1	vFR2
MR1	-							
MR2	.45***	-						
PR	.39***	.58***	-					
ER	.27***	.32***	.44***	-				
NMA	.35***	.45***	.59***	.54***	-			
PI	.13***	.11***	.15***	.17***	.18***	-		
vFR1	.05	.12***	.15***	.06*	.16***	.18***	-	
vFR2	.15***	.21***	.30***	.14***	.29***	.10***	.31***	-

Note. *$p < .05$. ***$p < .001$. Cases where there was a statistically significant difference between the correlation coefficients for scientists and HPS scholars are highlighted.

Notably, responses to PI and vFR1 did not strongly correlate with responses to other questionnaire items and the correlation between realist responses to PI and realist responses to NMA was not very large. Realist responses to vFR2 correlated to a theoretically significant extent with only some of the other sets of realist responses. Thus, these three items neither strongly cohered with the first five items nor formed a tightly knit group of their own. Using a much smaller sample, Pils and Schoenegger (2024) found that realist responses to the first five items correlated negatively with realist responses to PI and correlated either negatively or negligibly with realist responses to vFR1 and vFR2. Although we did not observe negative correlations between realist responses to PI and agreement with other realist items, both sets of findings have in common that no strong positive correlation was observed.

Correlations between questionnaire items were then calculated for scientists and HPS scholars separately. In 26 out of 28 cases, the correlation coefficients for HPS scholars were larger than those for scientists, with an average numeric difference of .13. In 9 of these cases, the difference was statistically significant.[7] These are highlighted in Table 3. There were few significant differences between pairs of correlation coefficients among the first five items in the questionnaire, again suggesting strong coherence among them. A possible explanation for the stronger correlations observed among the responses of HPS scholars is that, given that their professional activities centrally involve reflecting carefully upon issues like the ones represented in the scientific realism questionnaire, they are likely to have developed a coherent set of attitudes towards the various theses on which they were queried. Another possible explanation, however, is that HPS scholars have been trained or indoctrinated not to stray from certain clusters of views associated with ‘realism’ and ‘antirealism’ respectively – not because these clusters are genuinely any more coherent but rather because these particular clusters have been championed by the more prominent or senior HPS scholars by which they are influenced.[8]

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[7] Statistical significance was tested using the Fisher *z*-transformation (Fisher 1950).

[8] This would mean that HPS scholars might be subject to a kind of polarization that Dellsén (2024) calls ‘interthematic polarization.’ Closely related phenomena have been labelled ‘belief convergence’ (Bramson et al. 2017, 129-130) and ‘epistemic factionalization’ (Weatherall and O’Connor 2020).

3.3 Exploratory factor analysis

To further examine the ways in which the eight questionnaire items clustered or failed to cluster together, an exploratory factor analysis (EFA) was conducted.[9] When IBM SPSS Statistics 29 was directed to select factors on the basis of having eigenvalues greater than one, it returned a two-factor solution with the first five questionnaire items loading strongly onto the same factor. These results indicate that there appears to be a single underlying disposition to endorse scientific realism that is measured by these items. The relationship between the underlying factor and the questionnaire items is like that between extraversion and the observable behaviors that are indicators of this personality trait – e.g., being gregarious, talkative, energetic, or enthusiastic. Extraversion is hypothesized both to give rise to and to be inferable from these behaviors.

The factor loadings from the EFA represented in Table 4 correspond to correlations between each item and its respective latent variable. The factor underlying the first five questionnaire items explained 63% of the variance in PR and 28% in MR1, meaning that the relationship between SR and PR was estimated by the EFA to be more than twice as strong as that between SR and MR1. The fact that PR loaded more strongly onto the first factor than other items (and had more of its variance explained by that factor) means that it was the best indicator of the hypothesized underlying disposition to endorse or reject scientific realism.

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[9] A Kaiser-Meyer-Olkin test of sampling adequacy confirmed the suitability of the set of items for factor analysis with a value of .80, which according to Hutcheson and Sofroniou’s (1999) criterion is ‘meritorious.’ Bartlett’s test of sphericity was also significant, providing further indication of suitability for factor analysis, $df = 28$, $\chi^2 = 3{,}227.85$, $p < .001$ (Field 2018). The EFA employed the maximum likelihood extraction method with promax rotation.

The fact that among the five items loading strongly onto this factor, MR1 was the weakest means that knowing someone's response to MR1 is much less informative about the nature of their general disposition toward realism or antirealism than knowing their response to other items. Items PI and vFR2 did not load strongly together onto any factor, while item vFR2 alone loaded strongly onto an hypothesized second factor. Weak factor loadings indicate that items are not reliably measuring the same latent variables as other items.

In accord with our findings, Pils and Schoenegger (2024) report that PR had the strongest loading onto a latent factor representing realism in general, although they do not highlight this fact. They also found that MR1 had the weakest loading and NMA the second strongest loading, while vFR1 and vFR2 failed to load strongly onto this variable at all. In addition, they found that PI loaded negatively onto the latent variable. As before, although we did not observe such a negative relationship, both sets of findings have in common that no strong positive association was observed.

Table 4

Pattern matrix

	Factor 1	Factor 2
PR	.792	.039
NMA	.727	.062
MR2	.670	.019
ER	.592	-.032
MR1	.527	-.034
PI	.170	.167
vFR1	-.078	.943
vFR2	.266	.297

Note. Factor loadings are sorted according to size, and strong factor loadings are highlighted.

3.4 Confirmatory factor analysis

Guided by theory and the correlational and exploratory factor analyses reported above, we performed a series of confirmatory factor analyses (CFAs) using IBM SPSS Amos 29 to obtain quantitative measures of the degree to which different models fit the data and to examine important relationships between model components. Table 5 presents standard fit indices for the best performing measurement models. Smaller values for the model chi-square test statistic (χ^2) tend (with some qualifications) to represent better fit (Kline 2023). For the comparative fit index (CFI) and the Tucker-Lewis index (TLI), values above .90 represent adequate fit, with values above .95 indicating good fit. On the conventional interpretation of the root mean square error of approximation (RMSEA), values below .08 represent adequate fit, and values below .05 represent good fit. Standardized root mean square residual (SRMR) values below .08 are considered good (Hu and Bentler 1999). According to these benchmarks, all of the models in Table 5 fit the dataset well. Nevertheless, some fit the data better than others.

Table 5

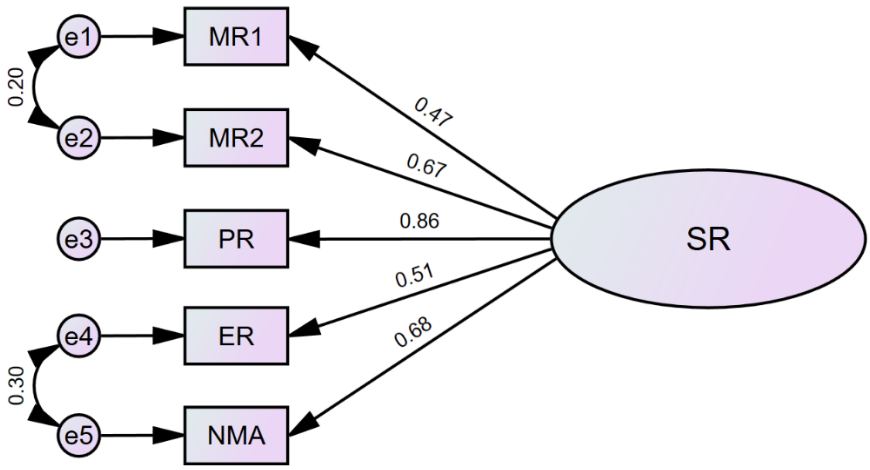
Fit indices for measurement models

Model	Omitted items	χ^2	*df*	CFI	TLI	RMSEA	SRMR
1	–	104.25	17	.973	.942	.053	.033
2	–	64.53	15	.985	.963	.043	.023
3	PI, vFR2	25.84	7	.993	.979	.039	.017
4	PI, vFR1, vFR2	9.90	3	.997	.987	.036	.012

In the first CFA, a model with a single latent variable underlying all eight items was tested and found to fit the data better than expected. This is represented as Model 1 in Table 5. Model 2 featured a single latent variable underlying items MR1, MR2, PR, ER, and NMA but no latent variable for PI, vFR1, or vFR2, with the latter items correlating freely with each other and the latent variable. Model 3 retained the latent variable underlying the first five items but omitted items PI and vFR2, leaving vFR1 to correlate with the latent variable. In Model 4, there was a single latent variable underlying the first five items, and all three poorly performing items were omitted. In addition to having the best fit indices, Model 4 was also the most parsimonious in structure. The results of the CFAs show that the first five items on the scientific realism questionnaire do a good job of measuring a single construct – viz., participants' general disposition to endorse scientific realism – but that the remaining three items contribute more noise than quality measurement. Model 4 was thus selected for use in subsequent analyses and is depicted in Figure 1.

Figure 1

Measurement model 4



Note. All coefficients are standardized estimates and significant at the .001 level.

In Figure 1, the path coefficients from the latent scientific realism (SR) variable to the first five questionnaire items represent factor loadings and are roughly equivalent to regression coefficients. As before, a general disposition to endorse or reject scientific realism (represented by the latent variable SR) is hypothesized both to give rise to and to be inferable from agreement or disagreement with questionnaire items. The largest coefficient is the one from the latent variable to PR, meaning that the best indicator of someone's general disposition to endorse scientific realism is their attitude toward PR.[10] The difference in size

[10] In another empirical study of scientific realism in the wild, Beebe et al. (unpublished manuscript a) found that NMA was the best predictor of scientists' realism

between the coefficient on PR and the other coefficients is both notable and statistically significant ($p < .001$).[11] The latent variable SR accounted for 73% of the variance in PR but only 22% in MR1, meaning that the relationship between SR and PR was estimated by the CFA to be more than three times as strong as that between SR and MR1.[12] Thus, with regard to the way that scientists and HPS scholars mentally represent the issues that feature in Beebe and Dellsén's (2020) questionnaire, progressive realism appears to stand at the psychological center.[13]

Someone might object or at least wonder whether the reason our analyses show that PR is a better predictor of scientists' general attitude toward scientific realism than other items is not that PR is more central to scientists' thinking but rather that PR includes components of other items within it.[14] Heart disease, for example, predicts heart failure better than arterial blockage, hardening of the arteries, or an irregular heartbeat taken individually simply because heart disease encompasses each of these conditions. The central idea in MR2

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using a questionnaire that did not measure progressive realism. Our result is consistent with this finding because when PR is removed from our measurement model, NMA was the best predictor of participants' SR scores.

[11] Statistical significance was tested using the procedure outlined by Cumming (2009). The same pattern was observed both within each discipline and in pooled data across all disciplines.

[12] Thanks to an anonymous reviewer for prompting us to provide further clarification of these results.

[13] This should not be taken to mean that progressive realism is necessarily philosophically central or taken by HPS scholars to be so in their philosophical theories.

[14] Thanks to an anonymous reviewer for raising this issue.

that there is an ultimate truth out there waiting to be discovered can be plausibly viewed as being included within PR’s claim that scientific progress is a matter of getting closer to such an underlying truth. The idea in PR that there are truths underlying scientific inquiry but which are imperfectly captured by it might overlap with the idea in MR1 regarding the mind-independence of scientific phenomena, although this is less clear. However, PR does not seem to include the idea in ER that our best theories are approximately true or the explanation offered in NMA for the success of such theories.

Furthermore, items other than PR also include ideas from other parts of the questionnaire. ER and NMA, for example, both concern the approximate truth of our best scientific theories. The underlying reality that NMA suggests is depicted by our best theories has much in common with the mind-independent scientific phenomena referenced in MR1 and the ultimate truth that MR2 says is waiting to be discovered. In addition, the ultimate truth in MR2 is plausibly viewed as presupposing the mind-independence of this truth, of which MR1 offers a characterization. While PR correlates more strongly with other items than MR1 or ER do, items MR2 and NMA correlate with other items to a comparable degree. The correlation between PR and MR1 (.39) is lower than that between MR1 and MR2 (.45), and the correlation between PR and ER (.44) is lower than that between ER and NMA (.54). Thus, the uniquely strong predictive power of PR with regard to SR does not seem to be explainable in terms of PR subsuming a uniquely greater number of ideas from other items.

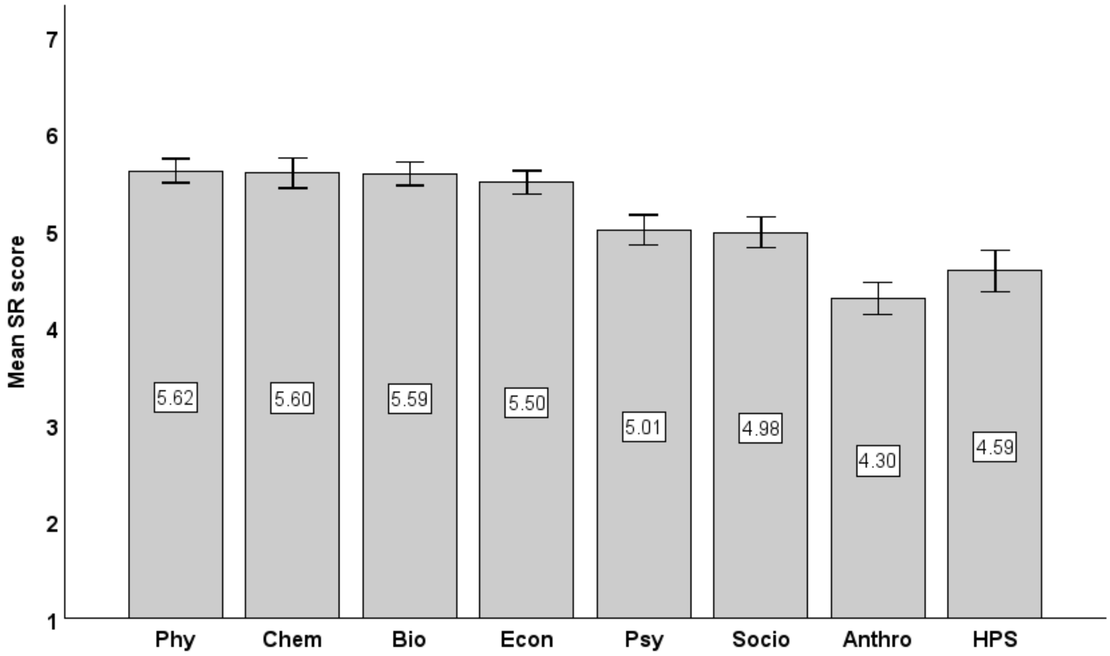
3.5 Factor scores

Overall scientific realism (SR) scores were calculated for each participant by averaging their responses to the five items in the final measurement model.[15] The grand mean and standard deviation were 5.17 and 1.24. The degree to which the mean of 5.17 fell above the neutral midpoint was large (d = .94). Mean SR scores for each discipline are represented in Figure 2, all of which were significantly above the midpoint. Effect sizes for the differences between these mean scores and the neutral midpoint are depicted in Table 6 and indicate a strong inclination toward scientific realism in all disciplines except anthropology and HPS. The average SR score for HPS scholars was significantly lower than average SR scores from all other disciplines except anthropology. In accord with the pattern reported by Beebe and Dellsén (2020) on the basis of different statistical analyses, natural scientists were found to have higher SR average scores than social scientists, and anthropologists were found to have lower SR scores than other social scientists.

[15] Due to problems such as factory indeterminacy (Grice 2001; Bobko et al. 2007; DiStefano et al. 2009), weighted sum and regression approaches to calculating factor scores were eschewed.

Figure 2

Mean scientific realism SR scores across disciplines



Note. Error bars represent 95% confidence intervals.

Table 6

Effect sizes for differences between mean SR scores and the neutral midpoint or HPS SR scores

Compared to	Phy	Chem	Bio	Econ	Psy	Socio	Anthro	HPS
Midpoint	1.43	1.48	1.74	1.55	.95	.87	.22	.41
HPS	.84	.81	.87	.78	.34	.31	-.20	

Note. Effect sizes were measured using Cohen's *d*.

3.6 Age

Age (*M* = 47, *SD* = 15.6, min. 21, max. 94) was found to significantly predict the SR scores of both scientists and HPS scholars, with greater realism associated with increasing age. Correlations between age and each of the items in the final measurement model are represented in Table 7. Age differences were more strongly associated with differences in participants' endorsement of NMA than with their responses to other items. Age failed to correlate with participant responses to PR, meaning that participants' judgments about PR were the most stable across different age groups.

Table 7

Correlations between age and item or SR score

Item					SR score	
MR1	MR2	PR	ER	NMA	Scientists	HPS
.11***	.08***	.04	.12***	.16***	.14***	.16***

Note. ****p* < .001.

Beebe et al. (unpublished manuscript b) and Henne et al. (2024) and also report positive correlations between scientists' age or years of experience working in the field and their endorsement of scientific realism (r = .12; Spearman's rho = .26). Pils and Schoenegger (2024) controlled for rather than analyzed the relationship between age and scientific realism among the scientists they studied. However, we reanalyzed their data and found a positive correlation between these two variables (r = .17).

These age effects mirror recent findings on folk realism in various domains. Beebe (unpublished manuscript) reports that members of the general public who were given Beebe and Dellsén's (2020) questionnaire reported more endorsement of scientific realism with increasing age. Beebe and Sackris (2016) found that older Americans were somewhat more likely to judge that if two people disagreed about a scientific or factual matter, at least one of them had to be mistaken, and Beebe et al. (2015) observed a similar pattern among Chinese participants.

In work on folk realism in other domains, Beebe and Sackris (2016) and Beebe et al. (2015) found that increasing age was associated with stronger moral realism among American, Chinese, and Polish participants and stronger realism about aesthetic judgments among Chinese and Polish individuals. An association between realist thinking and age thus appears to be moderately robust across domains and cultural contexts.

3.7 Gender

A significant association between gender and SR score was observed, with men being more inclined than women to endorse scientific realism among both scientists (r = .22) and HPS scholars (r = .30). As with age, Pils and Schoenegger (2024) controlled for rather than analyzed the relationship between gender and scientific realism among the scientists they studied. In a reanalysis of their data, we found a similar positive correlation between gender and realism (r = .17). These findings again match the results of other research on folk realism. Beebe and Sackris (2016) found that American men were more likely to endorse realism about factual matters than American women. In work on folk metaethics, Beebe and Sackris (2016) and Beebe et al. (2015) found that American and Chinese men were more likely to make realist judgments than American and Chinese women.

4. Discussion

In new analyses performed on the dataset created by Beebe and Dellsén (2020), we found that the attitudes of scientists and HPS scholars regarding progressive realism were the best predictors of their overall responses to theses that appear in canonical descriptions of scientific realism. Participants' judgments about the mind-independence of scientific phenomena were found to be considerably less central to the way they represented the issues, and their responses to the pessimistic induction and constructive empiricism proved to be largely unrelated to their responses to other core aspects of the scientific realism debate. In addition, men and older individuals were found to express more strongly realist intuitions.

What is the significance of these findings for philosophical theorizing about scientific realism? First, we would like to note that many of the theses that comprise the debate are ones that working scientists are well equipped to evaluate. ER and PI, for example, articulate theses about the approximate truth of our most successful and rigorously tested scientific theories and how these theories are likely to fare in the future. Scientists whose job is to rigorously test, apply, and improve our best theories are clearly in a good position to have something informative to say about these matters. Importantly for our purposes, a similar point applies to PR. Since it is scientists' job to contribute to the progress of science, we should expect working scientists to have a decent grasp of what it is to make scientific progress. It seems implausible to think that scientists who are regularly contributing to the progress of science would be fundamentally confused about what such progress requires. None of this is to say that the opinions of scientists who lack philosophical training can somehow resolve longstanding philosophical debates on their own. However, we do think these considerations indicate that the judgments of scientists about issues such as those expressed by ER, PI and PR should be seen as highly relevant to those debates.

4.1. The Centrality of Progressive Realism

The finding that responses to PR are most predictive of scientists' general disposition to endorse realism or antirealism is both surprising and significant. Progressive realism has not been at the forefront of debates between scientific realists and antirealists for several decades. Since roughly the mid-1980s, the realism debate has primarily centered on two clusters of issues. First, and most prominently, the debate has concerned the epistemic thesis that our most successful scientific theories are at least approximately true (e.g., Leplin 1997; Psillos 1999); as well as various arguments for and against this thesis, such as various versions of the no-miracles argument (e.g., Boyd 1984; Musgrave 1988) and the pessimistic induction (Laudan 1981a; Stanford 2006); and on numerous ways of modifying this epistemic thesis in light of these arguments (e.g., Worrall 1989; Chakravartty 2007). Secondly, albeit less prominently, some of the debate has been about the axiological thesis that science aims to deliver theories that are at least approximately true, and the related thesis that acceptance of a scientific theory involves the belief that it is true (e.g., van Fraassen 1980; Churchland and Hooker 1985; Dicken 2010). Neither of these clusters of issues directly concerns whether the progress of science involves getting closer to the truth.

However, if we go further back in time, i.e., to before the mid-1980s, we find the discussion of this issue among self-described realists and antirealists to be much more prominent. The view that scientific progress consists in getting closer to the truth was influentially proposed and defended by Karl Popper (1963) as part of a broadly-speaking realist view of science, albeit one that is coupled with a skeptical attitude towards the epistemic status of scientific theories at a given time (i.e., a radical form of fallibilism).[16] Defending this view involved the careful development of the notion of *verisimilitude*, or

[16] Popper was, of course, famously skeptical of all forms of non-deductive reasoning in science, arguing that good science only uses deductive reasoning to falsify previously-proposed theories. Thus, Popper would presumably have rejected ER and NMA, and possibly accepted PI (although only if the PI is viewed as a *reductio* rather than an inductive argument; see, e.g. Psillos 1999, 102-4) while combining all this with a realist stance on the other questionnaire items (with the possible exception of vF1).

truthlikeness, as a quantitative measure of the intuitive idea of ‘closeness to the truth’ (e.g., Miller 1974; Tichý 1974; Popper 1976; Oddie 1986; Niiniluoto 1987). Work on verisimilitude/truthlikeness continues to this day and has led to a number of technical advances that can be employed for other purposes than the defense of Popper’s progressive realism (see Oddie and Cevolani 2022).

Meanwhile, those with more antirealist sympathies resoundingly rejected any involvement of truth, or closeness thereto, in the progress of science. Most famously, Kuhn’s hugely influential *The Structure of Scientific Revolutions* (1970) argued that it’s not possible to compare scientific theories’ closeness to truth before and after a scientific revolution (Kuhn 1970, 198-207). In line with virtually all other philosophers writing on the topic, Kuhn took it for granted that scientific change is typically progressive; and in particular that there was usually scientific progress during scientific revolutions. From Kuhn’s perspective, this meant that scientific progress of science could not involve closeness to truth or truthlikeness. Instead, Kuhn (1970, 160-73) hinted at an account of scientific progress on which it involves solving ‘puzzles’ generated by the scientific paradigm in play at a given time, regardless of whether this gets the relevant scientists any closer to the underlying truths.

Kuhn’s suggestive idea was then developed in much greater detail by another prominent antirealist, Larry Laudan (1977). On Laudan’s problem-solving account, scientific progress occurs when the number and/or importance of unsolved scientific problems is reduced over time – where what counts as a *problem*, what makes it more and less *important*, and what counts as a *solution* to a given problem, are all determined by the opinions of the scientific researchers who dominate a scientific discipline at a given time. In this way, Laudan deliberately avoided any reference to any sort of objective truth, or closeness thereto, in his detailed account of scientific progress. In so doing, Laudan took himself to be outlining a notion of progress that can actually be achieved in science, while criticizing realists for defining progress in a way that makes it unattainable (Laudan 1981b, 145).

For Laudan, the issue of whether progress involves truth was tightly connected to other debates between himself and scientific realists. In his famous paper on the pessimistic induction, Laudan's explicit target is a thesis he refers to as *convergent realism*, which involves (inter alia) the claim that "more recent theories are closer to the truth than older theories in the same domain" (Laudan 1981a, 20). To be sure, Laudan's target also involved several other theses, some of which resemble ER and NMA much more closely than PR; but it's clear from Laudan's presentation that he took PR to be an integral part of a package of realist theses.

Those on the other side of the debate at the time, i.e. the realists, seem to have had a similar sense of how these issues hang together. For example, Boyd's (1983, 45) influential characterization of scientific realism includes the claim that "[t]he historical progress of mature sciences is largely a matter of successively more accurate approximations to the truth about both observable and unobservable phenomena." Similarly, Leplin (1984, 2) summarizes the core of scientific realism as involving the idea that "scientific change is, on balance, progressive," coupled with the clarification that although antirealists may also accept this claim, they will do so only if "progress is understood in purely pragmatic terms."

In contemporary philosophy of science, by contrast, the issue of progressive realism seems somewhat peripheral in the most prominent characterizations and discussions of scientific realism. Psillos (1999), for example, explains scientific realism in terms of a metaphysical thesis that is equivalent to MR1, an epistemic thesis that closely matches ER, and a semantic thesis on which scientists were not directly queried by Beebe and Dellsén (2020). Chakravartty (2017) follows Psillos (1999) and offers roughly the same account. Although these authors occasionally presume that progressive realism will be part of a realist perspective on science (cf., e.g., Psillos 1999, ch. 5; Chakravartty 2017, sec. 3.4), they do not specifically mention it in their accounts of the core features of scientific realism.

There are certainly some exceptions to this general trend. For example, Rowbottom (2019b) defends a form of scientific antirealism which denies, among other things, the claim that "science makes progress primarily when its theoretical content increases in truthlikeness" (Rowbottom 2019b, 2).[17] Kuipers (2009) defends what he calls 'comparative realism,' which may be seen as a combination of NMA and PR in so far as it claims that the fact that scientific theories are becoming increasingly empirically successful is best explained by their increasing truthlikeness. Finally, while Niiniluoto (2017, 3291-95) characterizes scientific realism in terms of five features (ontological, semantical, epistemological, theoretical, and methodological) none of which explicitly concern progress, he nevertheless emphasizes connections between scientific progress and realism, e.g. in a defense of 'optimism' about scientific progress (Niiniluoto 2017, 3305-7).

Furthermore, something very much like progressive realism has also been discussed – albeit somewhat indirectly and implicitly – in the recent debate about the nature of scientific progress. The 20th century debate between progressive realists, such as Popper and progressive antirealists, such as Laudan, went through something of a revival in the 21st century with a number of new accounts being offered and debated.[18] Most prominently, Bird (2007, 2022) has argued that scientific progress consists in the accumulation of knowledge, while Dellsén (2016, 2021) argues that increasing understanding lies at the heart of scientific

[17] It's also worth noting that in an overview article about scientific realism, Rowbottom (2019a, 479) quite unusually includes a brief discussion of scientific progress.

[18] For further discussion of the various accounts on offer, see, e.g., Bird (2016), Dellsén (2018), and Niiniluoto (2024).

progress. However, while some of this more recent debate has concerned the involvement of objective truth in scientific progress (see, e.g., Stegenga 2023; Dellsén and Norton 2025), it's rare for contributors to this debate to make more than a cursory mention of scientific realism more generally and how progress relates to it.[19]

Taking a step back from the various scholarly developments and literatures, it should be clear that the issue of progressive realism, which was once at the heart of the philosophical debate realists and anti-realists, has become rather peripheral in the contemporary realism debate. To the extent that this discussion survives at all, it has found a place in discussions of the nature of scientific progress that detach it from other ideas debated by realists and anti-realists. Meanwhile, the results of our new analyses of Beebe and Dellsén's (2020) data show that in the minds of contemporary working scientists, progressive realism is the most central issue in the cluster of issues discussed under the heading of scientific realism. Thus, far from being the peripheral issue one might think it should be from perusing the contemporary literature, it lies at the heart of the working scientist's own scientific realism.

These points in turn suggest that, insofar as the scientific realism debate is meant to line up with the issues that are likely to concern scientists themselves, it should be made to include at least some systematic discussion of the relationship between scientific progress and objective truth. Fortunately, the recent debate about scientific progress has already laid the groundwork for such discussions, as this debate already contains various accounts and arguments with immediate implications for progressive realism. For instance, while Bird

[19] There are of course some exceptions to this rather sweeping generalization, but it's noteworthy that even when connections between scientific progress and scientific realism are explicitly mentioned, they tend to be discussed in a cursory manner (see, e.g., Bird 2007, 79; Dellsén 2018, 8).

(2007, 2022) argues that getting closer to the truth is not by itself sufficient for progress – since not all true claims, let alone all truthlike claims, are knowledge – his account implies that truth is an important necessary condition for progress – since knowledge requires truth. Similarly, Dellsén's (2016, 2021) understanding-based account requires increased accuracy for progress – albeit a way that allows progress to be made via the introductions of falsehoods in some cases, most importantly as idealizations in model-building. Finally, Shan's (2019) recent incarnation of the problem-solving account holds that progress should be defined in terms of usefulness of problem-defining and problem-solving in which no reference is made to objective truth. Thus, while Bird's account apparently implies a robustly realist stance on scientific progress, Dellsén's account may be viewed as a more moderate form of progressive realism, and Shan's account seems most clearly to imply, or at least be compatible with, a form of progressive antirealism. Our results suggest that connections of this sort, not only from these accounts but also others that have been and are yet to be developed, are worth exploring in more detail in future work on scientific realism.

On a related note, we would like to call attention to a recent attempt to reorient the scientific realism debate that we think deserves greater consideration in light of our results. Saatsi (2019a, 3990) argues that "anti-realists have persistently operated with an unnecessarily demanding conception of realism in mind" – one that includes overly strong epistemic commitments to the accumulation of theoretical knowledge or the explanatory success of our best scientific theories. He argues that the versions of the pessimistic induction articulated by Laudan (1981a) and Stanford (2006) only succeed to the degree that they do by taking scientific realism to include surplus epistemic commitments. Saatsi (2019a, 3990) contends that scientific realism should instead be understood merely in terms of a minimal commitment to progress in science being a matter of "latching better and better onto reality."[20] As others have also pointed out (e.g., Bird 2007, 73; Niiniluoto 2017), the pessimistic induction need not undermine the idea that scientific theories are getting closer and closer to the truth, i.e. that science makes progress as understood by progressive realism.

The present findings do not speak to the question of whether scientific realism should jettison strong epistemic commitments or whether philosophical explanations of realism should take progressive realism to be foundational. However, the fact that they provide reason for thinking that a realist approach to scientific progress is psychologically central in the minds of scientists and HPS scholars suggests that progressive realism may not only be the most *defensible* form of realism in light of the pessimistic induction, as Saatsi is effectively suggesting, but that it would also be a form of realism *worth defending*. Prior to the results of our analyses, one could have responded to Saatsi's suggested reorientation by retorting that his 'minimal realism' is very minimal indeed – *too* minimal to deserve the realist label in the first place. Our results, however, arguably make such a response untenable, because something very much like Saatsi's minimal realism turns out the lie at the heart of the scientific realism that scientists and HPS scholars themselves endorse. Such a view, even if it's a great deal less ambitious than some other realist theses, is surely worth defending and worthy of the realist label.

4.2. Age and Gender Effects

The present study is not well equipped to provide insight into why age and gender predicts attitudes toward scientific realism. However, we will briefly mention a few considerations that might figure in future explanations of them. First, we should note that our analyses do not directly show that scientists' dispositions to endorse realism grow stronger

[20] Cf. also Saatsi (2019b).

with age, since it is possible our finding is driven by generational or cohort differences, where people who grow up or are trained at different times receive culturally variable perspectives on the nature of science. However, we do not think an explanation of this sort is likely to be correct due to the fact that associations between age and realism in other domains and among the folk have been observed across cultures. It seems unlikely that different generations of people in different cultures would have been taught a uniform perspective about different domains of thought and that each generation would be taught a different perspective from the preceding one that was uniform across cultures and domains.

A realist-friendly explanation for the age effect might begin by noting that with increasing age and experience working as a scientist comes greater knowledge and understanding of the nature of science. On this basis, someone could argue that these acquired epistemic goods might enable older scientists to better appreciate the truth of realism. Research in other domains has shown that wisdom often increases with age. Wisdom about social dilemmas and conflicts, for example, has been observed to increase with age, despite other aspects of cognitive decline (Grossman et al. 2010). Future research could potentially shed light on this possibility by examining in some detail the ways in which years of experience can shape scientists' understanding of scientific inquiry. However, findings from general measures of wisdom often reveal negative relationships between wisdom and age, which suggests there is no guarantee an investigation of scientific wisdom would uncover realist-friendly findings (Glück 2024).

A speculative, antirealist-friendly explanation for the age effect we observed concerns a possible connection between the commonsense tenor of scientific realism and cognitive aging. Consider how many philosophers of science point to what they think is the naïveté or down-home commonsense spirit of a realist perspective on science. Dicken (2016, 66, 1), for example, describes scientific realism as “a kind of naive realism” that “might even seem like nothing more than just good common sense.” Giere (2006, 4) writes:

> Everyone starts out a common-sense realist…. For most people most of the time, common-sense realism works just fine. The realism of scientists may be thought of as a more sophisticated version of common-sense realism.

In a similar vein, Saatsi (2018, 1) writes:

> Outside the realism debate many naturally adopt an uncritical stance according to which science unquestionably provides us knowledge of quarks, electrons, DNA, black holes, quantum entanglement, and other mind-independent, unobservable features of reality that centrally feature in our best science. This arguably naïve stance is widely shared and unsurprising given the astonishing predictive and instrumental successes of science, but it is attacked from all sides in the realism debate. Although science commands authority as a source of empirical knowledge, there are serious philosophical challenges to any unsophisticated realist position. Defending anything like the uncritical stance quickly turns out to be hard work!

If the heart of scientific realism in the wild is a relatively unsophisticated commonsense attitude, one might expect such an attitude to be more prominent among those who are less able to engage in subtle or sophisticated reasoning. Cognitive aging is marked by diminished capacities for fluid intelligence, sustained attention, working memory, problem-solving, decision-making, both deductive and inductive reasoning, and much else (Harada et al. 2013; Institute of Medicine 2015; Salthouse 2004). Fluid intelligence is the ability to engage in reasoning and problem-solving about new information or novel situations that less familiar and different from what one has learned in the past. As someone’s reasoning abilities and fluid intelligence decline, their representations of complex features of the world often become simpler and less sophisticated and make it more difficult to grasp complex perspectives that run contrary to common sense.[21] Cognitive aging may thus predict greater endorsement of perspectives that scholars take to be naïve.

We acknowledge that this antirealist friendly explanation for the age effect is highly speculative and offer it simply to spur reflection and possible research on the age effect we report. Whether or not the scientific realism, as measured here, is indeed naïve or commonsensical as compared to scientific antirealism is very much open to debate. However, it is important to note that the present suggestion does not imply that the articulations or defenses of scientific realism one finds in the philosophical literature are essentially naïve or simplistic. After all, as Saatsi makes clear in the quotation above, the philosophical defense of common sense can involve rather complex and sophisticated theoretical explanations and maneuvers, even if the underlying factors that cause scientists to endorse realism are simpler and less sophisticated.

It is radically unclear what might lead more men to endorse scientific realism than women. The most well-established gender differences in cognitive abilities concern verbal fluency and visuospatial abilities (Halpern et al. 2007), but these seem to have no bearing on individuals' attitudes toward realism in any domain. By themselves, the gender differences we observed might not be worthy of mention. However, given the fact that other research teams have uncovered similar patterns in other studies of realist attitudes, it seemed worth noting here as a datum for future investigation.

[21] Open-mindedness and openness to new experiences are known to significantly decrease with age (Edgcumbe 2022; McCrae et al. 2000; Soto and John 2012). So, even if older individuals did not have diminished abilities to think in new ways that diverged from common sense, they might be markedly less open to doing so.

5. Conclusion

Historical and observational studies of science have enjoyed an important place within history and philosophy of science and related disciplines for some time. Studies of the attitudes of scientists may be less common, but the present findings are offered in same spirit as more familiar studies of important episodes in the history of science. That is, it is hoped that these results can contribute to a better understanding of the practice of science and the people who practice it in a way that productively informs philosophical theorizing about the nature of science. We hope, in particular, that our finding concerning the centrality of progressive realism will inform discussions of what forms of scientific realism are worth developing and defending and will lead to a reintegration of questions about the nature of scientific progress into the realism debate.

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