

Why Is Safe Science Good Science?

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In science, safety can seem unfashionable. Satisfying safety requirements can slow the pace of research, make it cumbersome, or cost significant amounts of money. The logic of rules can seem unclear. Compliance can feel like a negative incentive. So besides the obvious benefit that safety keeps one safe, why do some scientists preach "safe science is good science"? Understanding the principles that underlie this maxim might help to create a strong positive incentive to incorporate safety into the pursuit of groundbreaking science. This essay explains how safety can enhance the quality of an experiment and promote innovation in one's research. Being safe induces a researcher to have greater control over an experiment, which reduces the uncertainty that characterizes the experiment. Less uncertainty increases both safety and the quality of the experiment, the latter including statistical quality (reproducibility, sensitivity, etc.) and countless other properties (yield, purity, cost, etc.). Like prototyping in design thinking and working under the constraint of creative limitation in the arts, considering safety issues is a hands-on activity that involves decision-making. Making decisions leads to new ideas, which spawns innovation.

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Why Is Safe Science Good Science?

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Greater Control = Reduced Uncertainty = Safety + Quality

- **Better statistics** of the experimental data (reproducibility, sensitivity, coverage, etc.)
- **Other improved properties** of the experiment (yield, purity, viability, sample sizes, cost, etc.)
- **Innovation** --- considering safety issues is a hands-on activity analogous to prototyping in design thinking and creative limitation in the arts
- **Reduced risk**

1 In science, safety can seem unfashionable. Satisfying safety requirements can slow the pace of
2 research, make it cumbersome, or cost significant amounts of money. The logic of rules can
3 seem unclear. Compliance can feel like a negative incentive. So besides the obvious benefit that
4 safety keeps one safe, why do some scientists preach that “safe science is good science”?
5 Understanding the principles that underlie this maxim might help to create a strong positive
6 incentive to incorporate safety into the pursuit of groundbreaking science.

7

8 Many highly experienced researchers say anecdotally that doing an experiment safely causes a
9 scientist to do it well. Safe science does not *guarantee* good science --- a safe experiment can
10 be scientifically meaningless. But usually safe science seems to be “good” science. Why would
11 this be the case? What does safety have to do with the quality of an experiment and with other
12 sought-after outcomes?

13

14 First, being safe in the laboratory can improve the statistical quality of one's data. An
15 experiment can have better sensitivity, reproducibility, coverage, etcetera. This relationship
16 exists because being safe induces a researcher to have **greater control** over an experiment,
17 which reduces the **uncertainty** that characterizes the experiment. For example, writing a
18 detailed protocol will lessen the uncertainty surrounding one's physical actions, helping the
19 researcher to avoid mistakes that could be dangerous. **Safety** is increased (which is the same
20 thing as reducing risk). But a detailed protocol will also enable the researcher to conduct the
21 experiment in exactly the same way in the future, making repeated trials more accurate and
22 precise. **Statistics** will improve, e.g., "error bars" will be smaller.

23
24 Second, a relationship between safety and quality exists because greater control over an
25 experiment improves **countless other properties**. Examples include the yield and purity of a
26 product, the viability of living cells, the sizes of samples (e.g., smaller sizes being desirable), and
27 cost (e.g., lower being better).

28
29 The third relationship is between safety and **innovation**. When considering issues about safety,
30 one obtains new ideas about how to conduct an experiment. New ideas lead to innovation. This
31 process is analogous to **prototyping** in design thinking, where physically building something
32 brings one to points where decisions need to be made and new ideas emerge. **Creative**
33 **limitation** (1) has the same effect in the arts. In poetry and screenwriting, for example, the
34 artificial barriers of rhymes and genres, respectively, force an artist to make decisions that are
35 unrelated to the art's content. New ideas form and the art takes unexpected turns. Like
36 prototyping and creative limitation then, the hands-on nature of **considering safety** is a
37 decision-making process that can foster innovation in research.

38
39 Recently chemists at Eli Lilly reported a continuous manufacturing process that demonstrated
40 how safety and innovation can go hand-in-hand (2). As one of many advantages of the new
41 process, safer operating conditions permitted the chemists to run this reaction step **faster**:

42
43 The flow process included a step involving hydrazine—a compound used in rocket fuel—that
44 would have been too dangerous to run in a batch reactor. Because flow chemistry uses a small
45 amount of the reagent continuously instead of a large amount all at once in a batch process, the
46 chemists could run the step safely at **high temperature and pressure** [bold emphasis ours] (3).

47
48 Let us return to the original question, "Why is safe science good science?" Greater control over
49 one's experiment reduces the uncertainty that characterizes the experiment. Less uncertainty
50 improves both safety (by reducing risk) and the quality of the experiment (better statistics and

51 other improved properties). Considering safety issues is a hands-on activity that spawns
52 innovation.

53

54 If you are a researcher, this point should be clear: Safety is good for your science!

55

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57 between safety and reproducibility. Brad A. Palanski illustrated the concept of “greater control”
58 by allowing CMK to shadow his experiments.

59

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