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Rejoinder

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We thank both Roger Hoerl and David Steinberg for their (mostly complimentary) remarks. Here, to avoid writing another paper, we reply to only a few of their comments and questions.

ROGER HOERL

Roger and his coauthor Ron Snee have made a major contribution in defining and clarifying the new discipline statistical engineering (SE). We are happy that he sees StatEng and QPDAC (Question, Plan, Data, Analysis and Conclusion) as two examples of SE. We have struggled for years to convince our colleagues and others that we need a strategy for reducing variation and a separate tactic for formulating, planning, and implementing any statistical study. QPDAC applies within StatEng and also more broadly in any situation where we need empirical learning. And we agree with his assessment that neither of these examples is optimal or all-encompassing—we can always improve. See Chatfield (1995) for a competitor to QPDAC.

We think that it is important to note that StatEng and QPDAC are both set out as processes. One of the basic tenets of statistical thinking is that work is a process. We should apply process thinking to problem solving and process improvement and perhaps to any application of statistics. SE is the discipline that deals with these metaprocesses.

Roger poses a significant challenge. How can we compare the approaches, strategies, and tactics within SE to identify what works best in each situation? It is hard to imagine several teams each with a different approach trying to solve the same real problem. One imperfect possibility is to use a complex simulation such as Watfactory (Steiner and MacKay 2009) to compare approaches to variation reduction. We can perhaps build other such simulations for different types of problems to test and compare strategies and tactics. It would be difficult not to bias the results by the design of the simulation. For example, Watfactory was built to help people learn StatEng.

DAVID STEINBERG

David poses a number of challenging questions and makes many useful suggestions.

We agree that there are more loops in StatEng than are shown explicitly in Figure 2 of our paper (Steiner and MacKay 2014). We perhaps should go further and point out that all applications of StatEng are not successful.

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Failures occur for many reasons—for example, if there are no dominant causes of variation, StatEng will fail.

Sequential learning is an essential part of StatEng but is often a hard sell. We have been rebuffed more than once by process managers when we suggested that to solve a problem we will need a series of studies. The standard thinking (almost certainly false) is that one big study will lead to a solution faster and more cheaply.

We developed StatEng for variation reduction in discrete high-volume processes. David raises a good question on how we can approach time-based families of varying inputs in continuous processes. There is no family corresponding directly to part-to-part variation in a discrete process. We think that there is valuable information in a multi-vari study of a continuous process useful to determine the full extent of variation and to eliminate some potential causes of the variation. The problem is how to decide on the shortest time for sampling in the study.

David also points out a problem with our suggestion of using only two or three parts for a measurement system study when the repeatability variation is a function of the part. That is, measurement errors are larger on some parts than others. If we use only a few parts in the measurement system study, we may be badly misled. We agree that this could be a serious problem and, if suspected, we should use more parts in the study. By choosing a small and large part for the assessment study we are better able to detect cases where repeatability variation depends on part size. In any case, we would still use the baseline estimate of the overall variation as a basis for comparison.

David raises some important issues with robust parameter design. Note that we separate the tactics of robustness and desensitization. If we have identified a dominant cause of the variation (an important noise factor in Taguchi's jargon), we can carry out a desensitization experiment where we deliberately vary both normally fixed inputs and the noise factor in an experimental study. If we have not identified a dominant cause, we can carry out an experiment where, within each run, we can estimate the long-term variation. Normally fixed inputs are varied over the runs. The barrel temperature experiment is an example of desensitization. David clarifies an important point that the barrel temperature is both a noise and control factor in this example.

David notes at the end of his discussion that many problems involve, among other things, one-sided specifications, complex responses involving multiple outputs or curves. There are many opportunities to see whether StatEng and its tools can be adapted to these scenarios. If not, then within SE we need new strategies and tactics to solve such problems.

We again thank Roger and David for their stimulating and insightful comments.

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