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My view

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We agree with the view of analysis of variance expressed by Palmquist (Weed Sci. 1997;5:745), especially with regard to checking homogeneity of variance. However, we disagree with the emphatic statement that one should never test main effects in the presence of significant interaction.

It is true that most statisticians recommend against such tests, because usually, testing main effects in the presence of interaction is of little practical value. We also agree with the importance of making sense of interactions. However, there are situations in which one is justified in performing main effect tests in the presence of interaction and may not be able to address original objectives otherwise. There are also practical considerations involving recommendations to those who put our research into practice.

As a general example of such situations, consider a two-way factorial experiment, where one factor represents a true treatment factor and the second is a quantitative environmental factor that is under control in the experiment but not in practice. For example, a weed scientist could be evaluating herbicide rates in conjunction with postapplication temperature. Here, we have a controllable factor (herbicide rate) being examined with an environmental factor (temperature) that is not controllable in practice. Now, suppose there is a significant interaction between herbicide rate and postapplication temperature. Following the standard recommendation for analysis, we would look at the herbicide-rate simple effects at each temperature and then decide which rate is best at a specific temperature. We would then tell the producer: if you are going to have postapplication temperature 1, use rate A; otherwise, use rate B. This may be a reasonable recommendation in an environment with stable temperature but otherwise is unhelpful.

In addition, in factorial experiments, although we hope otherwise, experience might lead us to expect a significant interaction. Taking the argument of never testing a main effect in the presence of significant interaction to its logical extreme suggests that we should not bother with factorial structures if we expect interaction and instead should do independent series of single factor experiments. Clearly, this is unreasonable, as there is important information in the interaction(s). But we still may be interested in the behavior of the main effects.

What, then, are the practical ramifications of testing main effects in the presence of interaction? There are two main considerations: the pattern of the significant interaction and the interpretation of the significant main effect, given the significant interaction. To examine the first, consider the case of no interaction and two cases of interaction as exemplified by the mean plots in Figure 1. Figure 1A shows for a three by two factorial the situation of no interaction, where the profile of means for Level 1 is parallel to Level 2. Figure 1C shows an interaction where the profiles cross. In this case, the "best" level of treatment factor for Level 1 of the environmental factor is not the best for Level 3, and at Level 2 of the environmental factor, the two treatments may not be different. This is most researchers' view of an interaction. It must be admitted that, if one's primary interest is in the main effects, Figure 1C is disconcerting. However, Figure 1B also represents an interaction, without crossover, and it is much more congenial for interpretation of a significant treatment factor main effect. In both cases of significant interaction, we can still test for a significant main effect, but we must recognize that the interpretation of that significant main effect changes.

If the treatment factor main effect test is significant, we can make one (or more) of the following interpretations: a level of the treatment factor is (1) better on average over all levels of the environmental factor, (2) always better over all levels of the environmental factor, or (3) uniformly better over all levels of the environmental factor.

Clearly, (3) is the strongest interpretation and logically implies (2) and (1), and (2) implies (1). Thus, in the case of no interaction (Figure 1A), we can conclude (3) and hence (2) and (1). In the case of the "no crossover" form of interaction (Figure 1B), we can conclude (2) and hence (1), while in the case of the "crossover" form of interaction (Figure 1C), we can only conclude (1).

In the context of the weed example, consider Figure 1 with the treatment factor being herbicide rate and the environmental factor being postapplication temperature with a significant rate main effect. The weed scientist would like to recommend a rate that is effective over a range of temperatures. If there is no interaction (Figure 1A), then one rate is uniformly better no matter what the postapplication temperature is. If there is a "no crossover" interaction (Figure 1B), then one rate is always better than the other, although not by the same amount over the different temperatures. Finally, if there is a "crossover" interaction (Figure 1C), one rate is better than the other, on average, over the temperatures, a weak recommendation but the best possible given uncertain postapplication temperatures. If reliable information about postapplication temperatures is available, then a more specific (and possibly different) herbicide rate

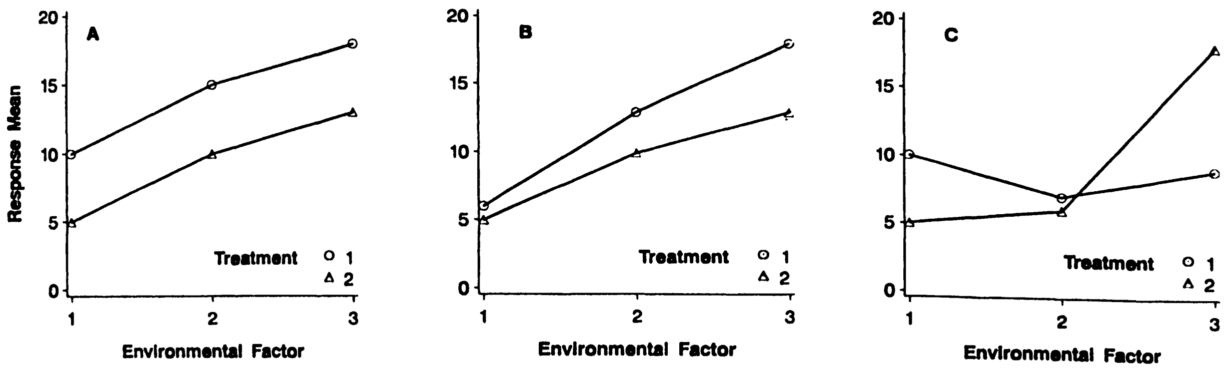

FIGURE 1. (A) No two-factor interaction. (B) No crossover two-factor interaction. (C) "Crossover" two-factor interaction.

recommendation tailored to temperature and based on the results of the usual simple effects analysis can be made.

The answer to many questions in science, especially when dealing with complex systems, is, "It depends." This includes the question of whether to test main effects in the presence of significant interaction. We recommend that you think about your objectives and your audience, proceed with caution, and present your results fully.