A FELLOWSHIP ABOUT INTERACTIONS SUCCEEDED BECAUSE OF INTERACTIONS

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My time at the Wissenschaftskolleg was inspiring and motivated me to pursue a number of new directions in my work. This partly reflects interactions with the broad community of Fellows (especially the fantastic collection of people working in similar areas of research), but the most critical contributor to the success of my time at Wiko was being a member of a remarkable working group that include Mike Wade, Tim Linksvayer, and Judie Bronstein. Our collaborative work (which is ambitious, and hence ongoing!)

addresses a variety of important problems, many of which are adjacent to my primary research focus (especially our primary work related to the evolution of species interactions). As a result, this work pushed me to adapt my skills and knowledge from my primary research to develop methods to investigate these new problems. When all members of the group were present in Berlin at the same time, we worked very much as a group, with long brainstorming sessions in which we outlined problems and developed our ideas (see figure 1). The success of this approach comes, at least in part, from the fact that we all have very different areas of knowledge and skills that largely complement one another. It is these collaborative meetings that I will probably miss the most from being at Wiko (at least on the work side of the equation).

Fig. 1. The genesis of ideas. Our ubiquitous whiteboard where facts were consolidated (and history was made?). A) The blank canvas beckoning us for ideas. B) The famous "Linksvayer special", where abstract ideas are captured in diagrammatic format. C) Evidence of real progress (and documentation of the arrival of spring, where the board can be seen in its warm weather habitat).

We generally formalised our thinking by using mathematical models and graphic representations of processes. Therefore, it makes logical sense to formalise my work at Wiko in such a framework. So, let P be the productivity of our group, F be the level of collective

fun, and C the level of intra-group conflict. We partition the contributions of group members to each of these processes (P, F, and C) to understand the nature of our collaboration. Our individual contributions are denoted J_i for me, W_i for Mike Wade, L_i for Tim Linksvayer, and B_i for Judie Bronstein (where the subscript i denotes the characteristic being analysed; i.e. $i = P, F,$ or C). Because components can be influenced by time, we can measure each of these factors on a per unit time scale. The parameter X_i denotes the interaction among group members for process i. Although pairwise interactions between group members can be modelled, their contributions to each of the processes are largely confounded and hence difficult to partition from the higher order interaction terms. Therefore, a single interaction term is included, which captures all lower level interaction effects. Moreover, the use of a single interaction term is particularly important in this context because there were a number of periods when not all group members were present in Berlin, making it difficult to simultaneously evaluate separate terms. An error term is included in each expression that accounts for the lack of fit of the model, which reflects contributions from other Fellows, the Wiko staff, the city of Berlin, and any other factors not captured by the model terms (e.g., table tennis, colloquia, dinners, visits to Christmas Markets, etc.). We can now write expressions out as:

$$P = B_P + J_P + L_P + W_P + X_P + E_P \qquad [1a]$$
$$F = B_F + J_F + L_F + W_F + X_F + E_F \qquad [1b]$$
$$C = B_C + J_C + L_C + W_C + X_C + E_C \qquad [1c]$$

We can start by analysing the productivity (P) expression (1a). With a lack of data, we can evaluate the importance of the terms using the classic mathematical approach known as the "intuition method" (sometimes known as the "gut feeling approach", especially in physics). Detailed analysis of how model parameters contribute to P indicates that the interaction term (X_P) swamps the individual terms, although on a per unit time basis, B_P is of clear importance (simulation of the system indicates that this may reflect a need to bridle group members who may otherwise have a tendency towards "silliness"; see figure 2). Applying the intuition method to analysis of equation (1b), we can similarly evaluate the leading terms contributing to fun (F). We again find an important role for the interaction term (X_F), but find that the primarily deterministic factor governing collective fun is captured in the W_F term (which will be no surprise to many; see figure 2). Interestingly, we find a very large influence of extrinsic factors captured by E_F, which reflects the

importance of the local context (which logically reflects synergistic effects arising from interactions with other Fellows and with the local environment). Again, applying the intuition method to evaluate equation (1c), we find that all deterministic factors (B_C, J_C, L_C, W_C and X_C) are infinitesimally small and hence the level of conflict can be considered a random effect reflecting only extrinsic factors (but note that even these extrinsic factors are close to zero, meaning that we can set $C = 0$ when evaluating the properties of the system).

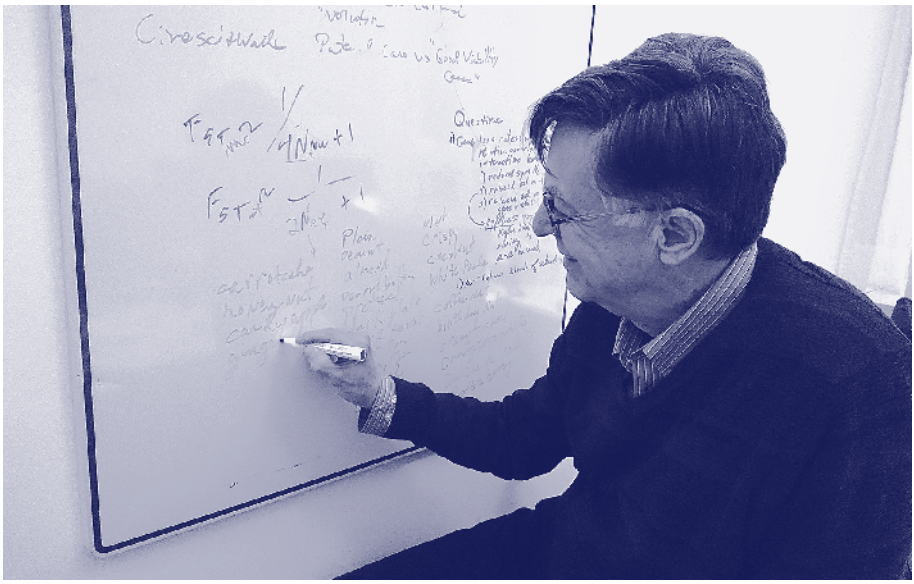

Fig. 2. Our fearless leader (Mike Wade), outlining important ideas to motivate the troops. Note the look of pained concentration on his face as he works out important aspects of our collaborative work.

So, what does this formal framework tell us about my Fellowship at Wiko and, more specifically, the success of collective research endeavours? Obviously, some groups will be more successful than others, and it can be a mystery working out what determines such success. It can be generically said that groups are more than the sum of their parts, but this lack of "additivity" can arise from many different underlying causes. I attribute this greater-than-additivity effect to the remarkable personalities and abilities of the group members, which emphasises the fact that this framework does not capture one key factor,

group composition itself (because it evaluates the success of the group we had, not the success of that specific group in comparison with other possible groups that we could have had). Given the critical importance of group composition, I owe a clear debt of gratitude to Mike Wade (see figure 2), who had the vision to assemble a group that was not only very good scientifically, but was also able to work together with intent and without conflict.

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