T-3
Fluid Dynamics

The Science of Social Diversity

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Diversity in the workplace, organization, even nation, has recently become a much touted goal. Our understanding of social systems has evolved to recognize that diversity includes more than ethnic variety; but also cultural and educational variety—even personality. In fact, diversity in social systems includes any aspect of an individual that leads to a variety of approaches to problem solving. Yet, the scientific basis behind the role of diversity in social systems is largely unknown. Research at Los Alamos is providing support to our intuitive justifications for diversity in social systems.

Much of the past understanding about social diversity is motivated by the analogies to biodiversity in nature. The prevailing research on the role of biological diversity focuses on improvement of system performance (e.g., individual or species survival) by the selection from a pool of genetic diversity, in the process of natural selection or "survival of the fittest." This process is fundamentally competitive between individuals or groups, with explicit winners and losers, and arguably reduces diversity in its application. While a similar selection process may occur in social systems, this is neither an attractive justification for diversity within organizations, nor the only mechanism by which diversity contributes to better organizations or society.

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Current research at Los Alamos has identified an alternative process for higher system performance, which does not involve competition or selection between the individuals. This research stresses the importance of cooperation and communication with maximum participation.

Simulating Collective Problem Solving: We wish to address the question: what is the most simple demonstration of increased performance of a collective above that of the individual? The idealized system examined is the solution of a sequential problem (insert in Figure 1), which has many optimal and nonoptimal solutions, solved by agents that have identical capabilities. Here, an individual can represent a single individual, group, or organization within a greater system. While this maze problem is quite simple, it serves as a representation of more complex problems encountered by individuals and organizations: the solution of a problem that has many decisions points and possible solutions and that has difficulty greater than solvable by one individual. Because the individuals have no global sense of the

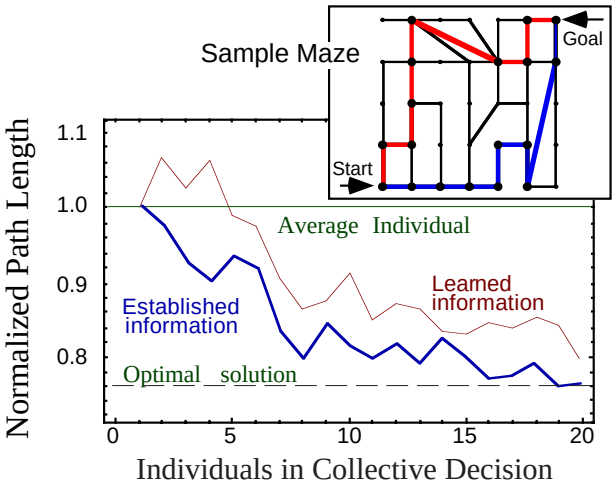

Figure 1: A sample maze (insert) with two optimal paths highlighted and the simulation results (main figure) showing the effect of the collective size on the path length, normalized by the average individual path length (about 12.8 steps).

problem, they initially explore the problem until a solution is found. This "learned" information is then applied by the individual to solve the problem again, often with a shorter path as a consequence of eliminating unnecessary loops. Because the initial search is random, a collection of individuals shows a diversity of experience (regions of the maze), of preferences (preferred paths), and of performance (path lengths), even though they started with identical capability. In repeated solutions to a problem, we tend to remember only the information needed to solve a problem and forget extraneous information associated with unused paths. Here, the equivalent effect is for the individual to contribute to the collective only "established" information along paths used by individual, thereby "forgetting" unused paths. Note that both the learned and established information produce the same path for the individual.

Information for a collective of individuals is then constructed by a linear combination of the each individual's experiences.

Then the same rules are used on this collective information to find a collective solution. As seen in Figure 1, the collective always outperforms the average individual for larger collectives, and the solution using the established information performs better than the learned information. Furthermore, for collectives above 20, the optimal solution is found, even though nothing in the individual's rules seeks a minimal path length. Figure 2 shows one mechanism for the reason that the collective does better than any individual: individual information can be combined to indicate a shorter path for the collective.

Importance of Diversity: To better understand the role and importance of diversity in this simple model and gain insight into social systems, quantitative measures of diversity were examined. The best measure found defines diversity as the degree of unique information in a collection of individuals. If all individuals contribute the same information, even if it is for the entire domain, then this measure of diversity is zero. If each individual contributes unique information not shared by others, then this diversity is high, and the collective out performs the average individual. Consequently, collectives contributing "established" rather than "learned" information exhibit higher diversity, even though less information is available. Not only does this measure of diversity correlate best with collective performance, it also indicates the degree of insensitivity to noise. The performance of a collective with low diversity is poor when valid information is randomly replaced with false information, a measure of the stability of a solution. Hence, diversity not only increases performance of the collective, it also makes the solutions more robust by having contingencies for unexpected situations. If the effect of information exchange is included in the above simulations, such that the individual while learning the maze can benefit from other individual's experiences, we find that individual performance improves, but at the ultimate loss of diversity in the collective. In this case, the robustness of the collective can be severely degraded if the information coherence is too great.

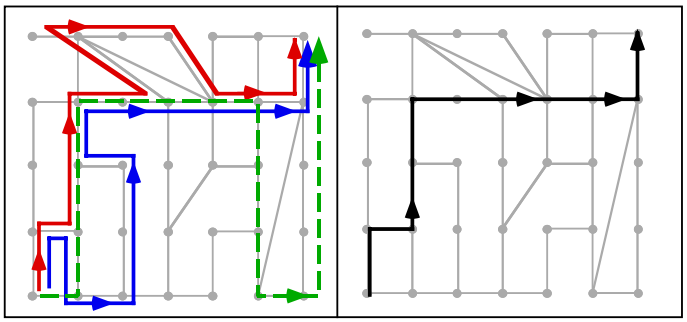

Figure 2: One mechanism for the better performance of the collective. Note that the path length of the collective is better than any individual.

Social and Organizational Implications: The above study illustrates how diversity can arise with individuals of identical capability from experiential differences within a system which contains multiple options. Just the existence of niches in the problem domain creates diversity. Furthermore, higher system performance and robustness occurs by the proper combination of the experiences of individuals, even though each individual solves a problem from a limited perspective. Unlike the discussion of diversity in natural systems, this study indicates that even in the absence of direct competition or selection of individuals, a higher system performance can be achieved with an alternative mechanism: the noncompetitive combination of information from a diversity of individuals. In fact, the idealized system exhibits lower performance or lower stability if any selection is made, either by eliminating participation or reducing their contribution. The simulations also illustrate that if the individuals gain experience randomly (have no "skill"), the collective shows no improvement over the average individual. But they also show a variety of skills is better than a narrow selection of skills.

These results argue for the importance of social behavior that freely exchanges information for both the benefit of the individual, but also for the group or organization. Many economic and social models of human dynamics begin with the assumption of competitive individuals seeking limited resources. In the simple model shown, system performance is found to be greater than the capability of the individuals and to occur from essentially independent individuals sharing information. No assumptions of competition or cooperation are necessary. And the results also show that if the collective dominates the learning of the individual, and thereby reduces the diversity, then group decisions become less robust.

In modern times of organizations facing problems of greater difficulty, centrally directed management of expert resources may not be an optimal approach to problem solving. For organizations to take advantage of increased performance from diversity, these studies suggest that, in addition to a skilled and diverse workforce, it is also necessary to encourage the expression of diverse views and to enable mechanisms for the exchange and processing of these views. The implications for all organizations is to create a work environment in which employees are willing and able to contribute their knowledge and experience to solving the problems facing these organizations.

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