How to Cross-pollinate Ideas Productively to Nurture Innovation

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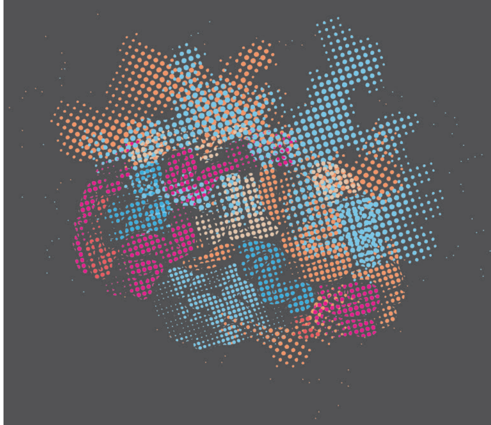
exaptive

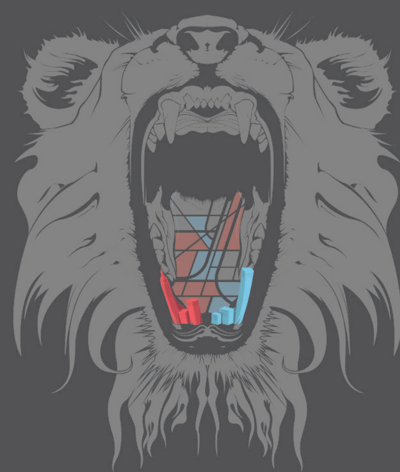
The Power of Cross-pollination

Had Gutenberg not seen grapes squeezing through a wine press, he might never have invented the printing press. Newton's laws of motion apply equally to astronomy and the military, for understanding the movement of planets as well as ballistic missiles and bullets. Maxwell was able to complete his equations on electromagnetism when he thought about how gears and idle wheels function.

Examples abound among data practitioners, as well, e.g.:



Astronomers use MRI software to for three dimensional imaging of supernovas.



Political scientists and anthropologists use ecological models to understand organized crime in urban settings.

Geneticists use data visualization invented to show patterns in music to see patterns in gene sequences.

How does insight from one field lead to discovery in another discipline? Two forces are key for this kind of innovation: exaptation and multidisciplinary collaboration. There are, however, technological and organizational barriers to crossover of ideas. The solution requires intention and perspective. Teams must connect related ideas and the people behind them that would not normally connect.

Exaptation as Innovation

In nature, exaptation is defined as a biological adaptation in which a trait is repurposed for a completely different use, with big evolutionary implications (Gould 1982)[1] . Gould and Vrba argued that a new term was needed to distinguish changes that were not mere adaptations. They noted that while the feather was first designed for thermoregulation, it was later exapted to make flight possible. They also cited bones in early vertebrates, which were initially used for storing phosphate and later provided skeletal structure.

[1] *Gould, S.J., Vrba, E.S. 1982. Exaptation; a missing term in the science of form. Paleobiology 9:4-15.*

Applying this same phenomenon to human innovation yields interesting if not extraordinary discoveries that might otherwise have gone unrealized. In fact, the concept of exaptation has gained a stronger foothold with technology and human innovation than as a biological concept (Parry 2013)[2] . Technological exaptation can be seen in the compact disc (CD), which was originally created to improve music sound over vinyl, but was then exapted for its superior storage of digital data (Villani et all 2007)[3] . Laser technology has also been exapted. It was first created for telecommunications, but has since been applied to microsurgery, measurement systems, barcode scanning, and cutting devices (Bonifati 2010)[4] .

Such exaptations are created from a combination of adjacent pieces – whether of material, information, or ideas. While the scientist Stuart Kauffman coined the term “adjacent possible” to describe first-order combinations that make something new, author Steven Johnson applies it more broadly, arguing that “ideas are works of bricolage. They are, almost inevitably, networks of other ideas.”[5] The more one explores, particularly the more broadly and diversely, the more the “adjacent possible” expands and opens more possible combinations.

Innovators who look to other domains for inspiration often find the solution to their current challenge – in the adjacent possible. For example, the wing design of SpaceShipOne, the first private spacecraft, solved atmospheric re-entry problems by exapting engineering concepts from the badminton birdie. Neurologists studying the chaotic swimming patterns of fish had a breakthrough when they applied algorithms that were invented for tracking hurricanes. And geneticists looking for a way to visualize gene sequences appropriated Martin Wattenberg’s arc diagram, which originated to show patterns in music.[6]

Multidisciplinary Collaboration

While innovation certainly arises from within disciplines and narrow focus, there is widespread recognition that multidisciplinary collaboration is also needed to fuel creativity and groundbreaking discovery. Blackwell et al. (2009)[7] state that “the right knowledge to solve a problem is in a different place to the problem itself, so interdisciplinary innovation is an essential tool for the future.”

Jim Davies, author and associate professor of cognitive science at Carleton University, says there is general agreement that one human mind is insufficient to solve many of today’s challenges. “The low-hanging fruit of science has been plucked,” he says. “We need more people breaking up the problem into subparts and working on it.” He cites the Higgs Boson discovery as “an amazing feat of collaboration” among theoretical and experimental physicists to solve a 40-year-old mystery.

[2] *Parry, W. (2013). Exaptation: How Evolution Uses What’s Available. [Online] Livescience.com. Available: http://www.livescience.com/39688-exaptation.htm [2013, September 16].*

[3] *To contrast exaptation with adaptation, the CD as an entertainment device was adapted from an audio device for music to a digital video disc (DVD) for movies, which was later eclipsed by digital MP3 files (Voices.com 2016).*

[4] *Bonafati, G. 2010. More is Different: exaptation and uncertainty: three foundational concepts for a complexity theory of innovation. Economics of Innovation and New Technology 19:8, 743-760.*

[5] *Johnson, Steve. “The Genius of the Tinkerer.” The Wall Street Journal 25 Sept. 2010: wsj.com. Web. April 2016*

[6] *Visit www.exaptive.com/exaptations for more information.*

[7] *Blackwell, A.F., Wilson, L., Street, A., Boulton, C., Knell, J. 2009. Radical innovation: Crossing knowledge boundaries with interdisciplinary teams. University of Cambridge Computer Laboratory Technical Report No. 760. Web. www.cl.cam.ac.uk/techreports/*

Famous for a TED talk on "how ideas have sex," science journalist Matt Ridley believes humans are wired to exchange ideas and information that create a stronger "collective brain." The pharmaceutical industry is demonstrating its faith in the collective brain: Hoping to grow their pipelines, many pharma companies are breaking down functional barriers by co-locating chemists, biologists, clinicians, and others in newly designed facilities to encourage interaction and diversity of thinking.

Reinforcing the point, Neilsen (2012)[8] , in Reinventing Discovery: The New Era of Networked Science, argues for more connection and collaboration – a conversational critical mass – to revolutionize knowledge creation. He says technologies are needed to connect people with problems to those who can solve them, as well as to make data more easily and freely available to more people.

Why Is It Difficult?

If truly disruptive innovation relies on different perspectives and the cross pollination of knowledge, in which ideas and methods can be exapted for big implications, what's standing in our way? We live, after all, in the Internet era of smart devices and supercomputing. The culprits are both organizational and technological.

Among the organizational challenges is a rise in specialization. While labor specialization can drive productivity, it can also hamper communication and understanding. Specialists dive more deeply into their subjects, leaving less time for broader understanding or exchanges outside their specialties. Davies, the cognitive scientist at Carleton University, adds that the abundance of scientific and academic papers in a single field can make it impossible to read them all, let alone papers in other domains. In addition, only successes are generally promoted and published, not failures – from which much could be learned.

Language is another challenge of specialization. Jargon, domain-specific terms, and complex topics can isolate the experts within the field from those outside it, who are less familiar with the terminology. Specialization can create, in the words of one Nobel Prize winner, an environment in which "it's hard to understand what anybody else is doing."

Communication also passes through a filter bubble, both human and technological. Eli Pariser (2011)[9] introduced the concept of the filter bubble as an Internet phenomenon, in which information is presented to individuals based on online behavior and interest. In his research, search engines presented one selection of results to a liberal-minded searcher and another set to someone of a more conservative nature. The risk of such "personalization" is a decrease in perspective.

Humans also filter information. Someone with a certain expertise or knowledge makes assumptions about those to whom they pass information, for the purpose of deciding what and how much to share. This conscious or unconscious filtering affects shared learning, understanding, and opportunities for discovery, either because it is not always accurate or precise or because the walls created by specialization just get reinforced.

[8]*Nielsen, M. 2012. Reinventing Discovery: The New Era of Networked Science. New Jersey. Princeton University Press.*

[9]*Pariser, Eli. 2011. The Filter Bubble: How the New Personalized Web Is Changing What We Read and How We Think. New York. The Penguin Press.*

Technological Obstacles

The tools humans use to innovate also pose problems for discovery. Proprietary and monolithic software can impose roadblocks, and the data collected is too often siloed. In collaborative software development, programmers and developers working furiously on code may make rapid decisions without chronicling their thought processes, rejected ideas, and bits of knowledge that result in the final product. Those artifacts and throwaways, which could inform future development, are lost. This leads to quite a bit of reinvention and not enough reuse of valuable code.

Even outside of coding, the need to document and report on the activities of experimentation and work can disrupt the work itself, so it often gets short shrift. Users resent, or even resist, the time it takes to report on individual and group activities in collaboration solutions, despite understanding its benefit to the organization. In situations, like pharmaceutical research and development, where knowledge capture is a requirement for intellectual property protection, the knowledge can still be siloed or trapped in slide decks and spreadsheets.
In addition, whether homegrown or off-the-shelf, the collection of ideation platforms, social networks, and linguistic or text mining tools rely on the user's personal knowledge and networks to discover information; visibility into the unknown remains challenging.

"Systems that can actually say, 'There are other people who are interested in the topics you're working on, and they're in China or Canada or Europe,' – systems that facilitate those connections, I would say are highly underdeveloped," says one pharmaceutical IT executive. The situation calls for an ability to willfully facilitate serendipity – to create the mechanisms for encounters that spark innovation. What's needed are technologies and tools that break down barriers and grow idea networks so that innovation can flourish. Andre et al (2009) say "the ideal model would enable the idea to be set free for others to use with appropriate acknowledgement or be part of a collaboration." Not only that, Andre says such encounters and connections must be productive – "to arrive at a valuable insight." They point to the discovery of penicillin 30 years before Alexander Fleming's failed experiment. Although Ernest Duchesne documented penicillin in 1897, there was no one – no network – adding "the insight to recognize the discovery and the infrastructure to publish the finding to make it available to be mechanized for delivery as a drug."

A Cognitive Network

People are already heavily networked – via personal and professional connections, through social media and from conferences and seminars. But networks like these, while influenced by ideas and tasks, are based on social connections first. They do not connect people, like Ernest Duchesne, to unknown ideas, unless by serendipity. To gain the benefits of multidisciplinary collaboration and exposure to new methods of working, from which ideas can be exapted, people need a cognitive network – facilitated serendipity. Such a network would make connections based on what people do, not what they say. It would also let people work on what they are good at and expose that work to other people who can figure out what it may be good for.

Andre et al believe in the power of computers to foster such serendipity, "by surfacing interesting connections, by providing mechanisms to enhance the expertise of the would-be discoverer to be better attuned to recognizing such connections, and by supporting the means for enabling either the growth of the idea or the sharing of it so it can be developed by those more keenly interested in the connection."

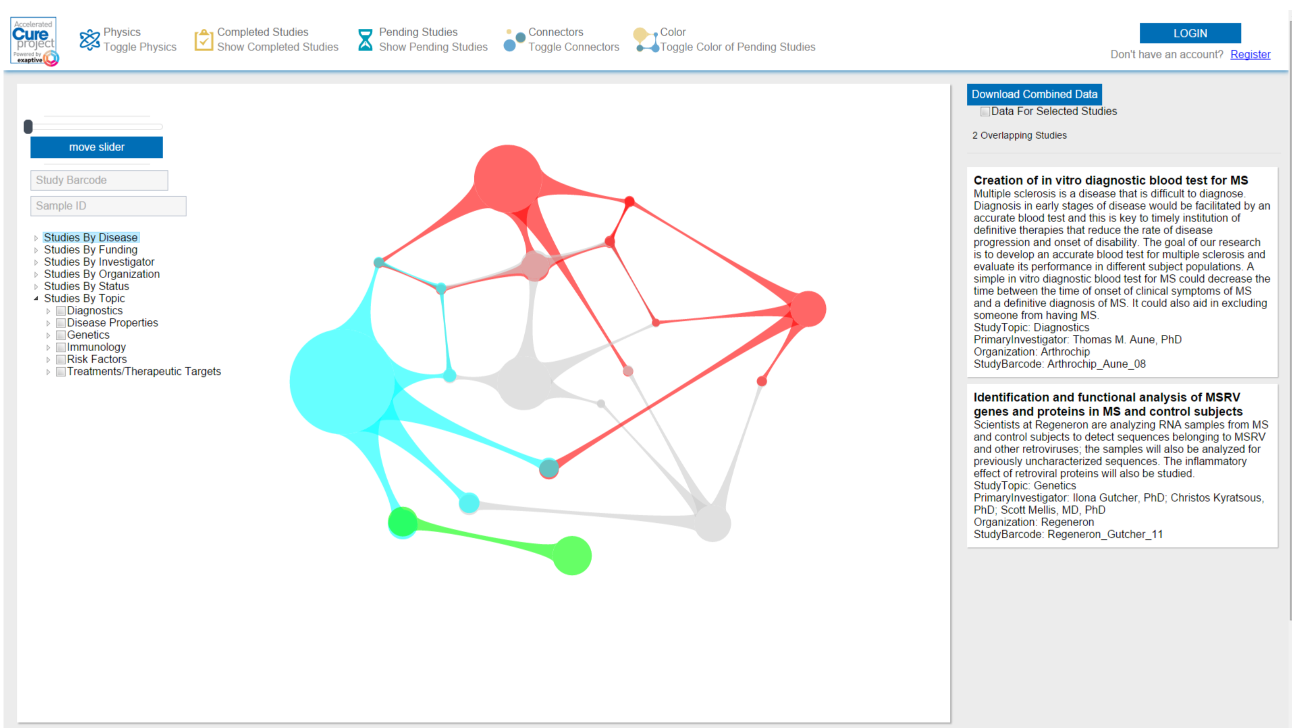
Another advantage of cognitive networks is they can spare scientists and other end users from duplicating efforts. “Theories and concepts are hard won in a particular discipline, and if they can just be exapted to a different one, there’s a huge efficiency savings; you don’t have to reinvent the wheel,” notes Davies, the cognitive sciences professor. “It’s interesting, but also kind of sad, when you hear about two fields independently working for years to come up with the same solution… when, if they’d been talking or had some way to understand this was going on, they would have been able to stand on the shoulders of giants a bit better.”

Cognitive Networks at Work

Subject matter domains with no apparent relationship can “stand on the shoulders of giants” when connected by idea, or cognitive, networks. Real-world examples include visualizations shared by software developers working on Multiple Sclerosis studies and earthquake experiments, and a public health organization’s use of algorithms for music files and, later, gene and protein sequences, to study malnutrition.

Connecting Personalized Medicine and Geology

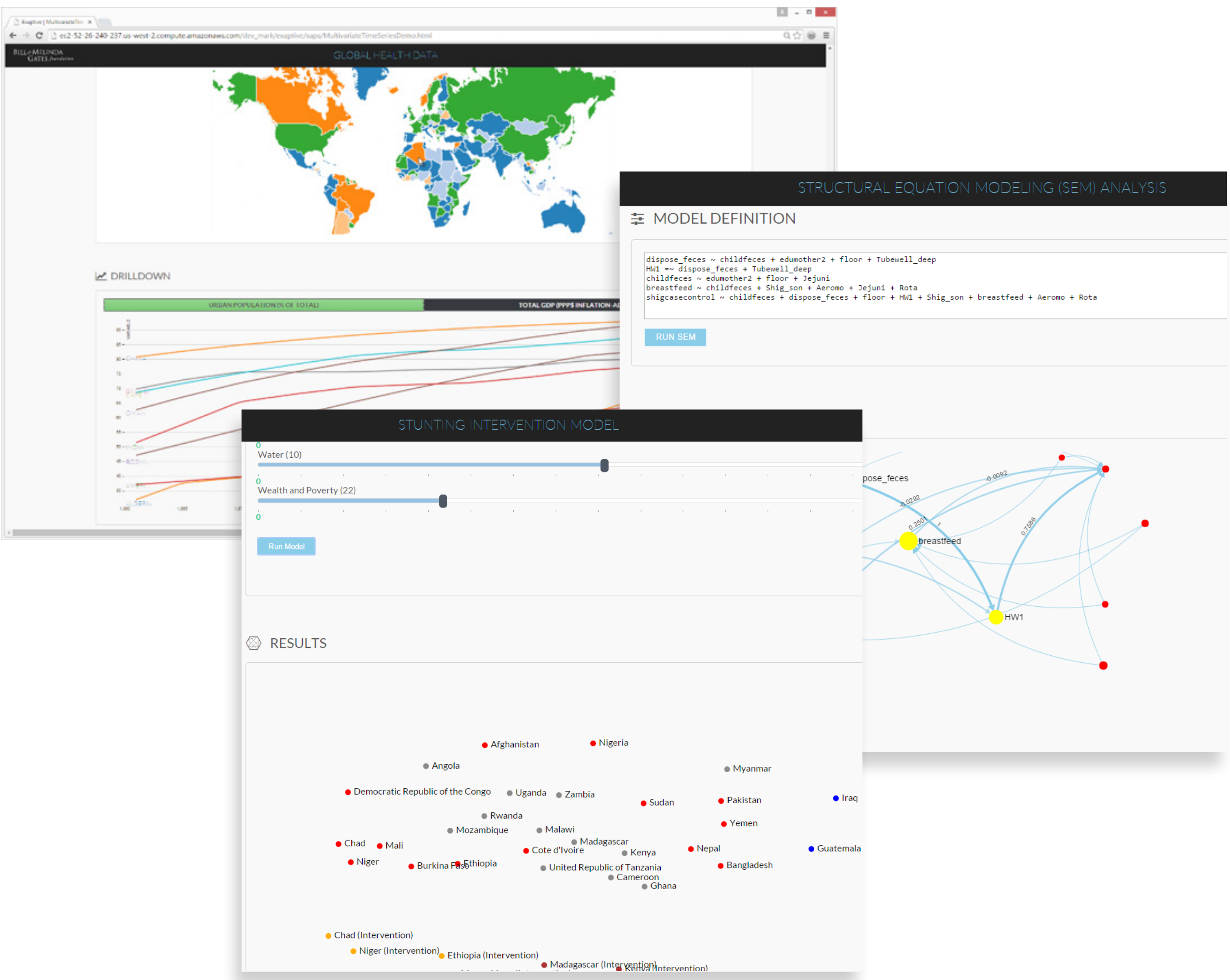
To create an interactive data application for a medical research organization, a software developer created a custom visualization to see the overlap of patients in dozens of Multiple Sclerosis research studies. The visualization was a hybrid of a Venn diagram and a network diagram. Another developer working on an application to interact with data from earthquake experiments used the MS visualization for earthquake data. Insights from using the visualization on the geologic samples then drove improvements in the diagram for use in MS studies.



The original visualization, for MS, was not made with earthquake experiment data in mind. The data – from patients and experiments – was organized incongruently and the formats were different; patient data was stored in dozens of spreadsheets while the earthquake experiments were in a SQL database. Yet the shared visualization was useful in both instances.

Connecting Genetics and GIS

When an international public health organization was trying to analyze malnutrition research from more than 100 research teams around the world, it borrowed from music and gene sequencing algorithms to make sense of the data. The organization's software developers, data scientists, and researchers needed to analyze and visualize over 150 years of time-series data that involved 519 metrics from more than 200 countries. A data scientist converted the data to letter strings and applied algorithms created for music files to identify patterns. Then, collaborating with a computational biologist, he adjusted his algorithms based on gene and protein sequencing algorithms. The result is a nuanced, data-driven view on global malnutrition – a major advance over the typical developed/developing nation dichotomy. Such a breakthrough was enabled by accumulated knowledge from collaboration across several surprising disciplines.



The project also overcame several technological barriers. It required integration of disparate, sparse data sets in different schema with API calls to machine learning algorithms in Python and Java. The output was visualized with d3.js.

A Platform for Cognitive Networking

How does a software developer working on Multiple Sclerosis meet one involved in earthquake studies, or even recognize a shared application? Through Cognitive networks.

Exaptive has built Cogntive Networks for customers and among its community of users. Researchers, analysts, data scientists, and technologists contribute to a knowledge base of expertise, data, and techniques and how each is being used together. The larger the community grows and the more components that are shared, the stronger the network becomes to make unexpected introductions. Such viral network growth increases its value for combinatorial creativity – the very activity that drives radical innovation.

"If you can incentivize teams to use the system, then it becomes self-perpetuating – you actually build stronger networks," says one executive, who has deployed various ideation platforms throughout his pharmaceutical industry career. "You get more knowledge funneling in. As long as people get a benefit out of something, then the barrier to using it becomes very much lower."

"Exaptive is not really focused on people collaborating on a shared task," says Davies, of Carleton University. "It is more networking someone who is doing something similar that might be useful, even if they are working on a very different problem."

Suggestion engine technology searches for and delivers information on what components are frequently connected or have implications for work. Importantly, the Network can introduce the creator of the components to potential users, thus facilitating interaction instead of relying on serendipity. Davies envisions such a network, distributed over the Internet, as "reducing the friction or expense of communicating. A cognitive network can span the entire globe."

Beyond the traditional conditions conducive for innovation, cognitive networks ease multidisciplinary collaboration and the exaptation of ideas. Such a network can create the conditions and make the connections for discovery that were previously left to serendipity by exposing people to the surprising or unanticipated work, methods, and ideas of others that leads to genuine breakthroughs.