Computer Simulation of Dental Professionals as a Moral Community

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Abstract

Current empirical studies of moral behavior of healthcare professionals are almost entirely focused on self-reports, usually collected under the assumption that an ethical disposition characterizes individuals across various contexts. It is well known, however, that individuals adjust their behavior to what they see being done by those in their peer group. That presents a methodological challenge to traditional research within a community of peers because the behavior of each individual is both the result of norms and a contributor to the norms of others. Computer simulations can be used to address this methodological challenge. A Markov replicator model that runs on an Excel spreadsheet was used to investigate a community with four agent types in the dental community: devious practitioners, ethical practitioners who avoid involvement in the poor ethics of others, ethical practitioners who accept it as part of their professional responsibility to challenge colleagues who act unprofessionally, and those who enforce ethical standards. A panel of leaders in the profession independently estimated parameters for the model and criteria for a possible distribution of agent types in the community. The simulation converged on distributions of the agent types that were very similar to the expectations of the panel. The simulation suggests the following characteristics of such moral communities: The structure of such communities is robust across a wide distribution. It appears that reduction in unethical behavior is more sensitive to the way ethical practitioners interact with each other than to sanctions the enforcement community imposes on unethical practitioners and that large external interventions will be short lived.

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One of the insights of the TQM movement in the 1970s and 1980s was that the number of defects thrown off by any process is independent of the proportion of those defects that are identified or corrected (Crosby, 1979; Deming, 1986; Juran, 1988). Rework and rejection decrease the number of problems reaching consumers. Making the inspection standards tighter increases the number of found problems, but it does not make them less likely. Efforts to elevate the ethical tone of the professions have tended to focus on remediating the bad actors and raising standards generally. A wiser strategy, or at least a necessary complementary one, would be to understand the profession as a dynamic system and to make those adjustments first that promise the greatest improvements. The Japanese master of quality in the automobile industry Genichi Taguchi was fond of the analogy that no improvement in learning would necessarily follow from teachers raising the standard for a B grade from 78% to 82% (Taguchi, 1993).

The dominant theoretical framework in bioethics and professionalism is normative, and usually grounded in principles (Beauchamp & Childress, 2009). On this approach, practical problems arise when acting on one principle causes moral regret because an alternative principle must be compromised. Such problems are usually worked out by carefully defining contexts where a single agent is best served, on balance, by pursuing a certain principled course of action. These analyses are the stock in trade of bioethics. The *Principles of Ethics and Code of Professional Conduct* of the American Dental Association is explicitly organized into five sections: respect for autonomy, beneficence, nonmaleficence, justice, and veracity. The *Belmont Report*, which is the foundation for Institutional Review Board (ethical committee) oversight of patient-based research in the United States, is also grounded in the principles approach.

The customary method for teaching ethics in dental schools, at least in the United States, and typical discussions of dilemmas in the literature works with the relationship between general normative principles and individuals. The principles are accepted; only their application is debated. The goal is to increase individual's conformance with these principles. The assumption is that moral communities are enhanced by increasing the proportion of members adhering to these principles.

The prospect that appropriate behavior could be situation-specific or that individuals interpret what is ethically appropriate by (at least partial) reference to the values of their peers is discomforting to some. The early work by Hartshorne and May (1930) and subsequent work summarized by Ross and Nesbitt (2011) cast doubt on the position that ethical disposition is uniform across contexts. More recently, it is becoming clear that professionals provide a dynamic context in which they judge the professional acceptability of their behavior at the same time their behavior is part of the standard for their colleagues (Ariely, 2012; Callahan, 2004; McCabe et al, 2006).

The aim of this paper is to open a conversation about methods for exploring the dynamics of multi-agent ethical situations where each agent's choice of the best response depends on the choices available to other agents and where the results of agents' action at a given time have the potential to change what is most appropriate to do in future. For example, the presence of "grey market" drugs may serve to hold down the cost of brand-name or even generic drugs to the benefit of larger numbers of low-income patients who do not purchase "grey market" drugs. The concept of "grey markets" is ethically objectionable in principle. The Harvard GoodWork Project is an example of how ethical behavior at one time changes ethical behavior at another (http://www.thegoodproject.org/). Genetics researchers and other professionals frequently report that "bending the rules" regarding conduct and publication of research is required to establish a career, while the same individuals denounce such practices once they have achieved prominence in their fields (Fischman et al, 2004).

A commonly given explanation for cheating – in health professions schools, professional practice, and society at large – is the perception that others are also cheating (Andrews et al, 2007; Brass et al, 1998; Callahan, 2004; Fischman et al, 2004; Jones, 1991; Koerber et al, 2007; McCabe et al, 2006; Olson, 1965; Zey-Ferrell et al, 1982). That makes the empirical investigation of cheating especially difficult. It is not possible to isolate a single independent and dependent variable relationship. Diagrammatically, $X \rightarrow Y$ becomes $X \rightarrow (Y \leftrightarrow Y)$, where the arrows indicate influence. A more complete picture of moral behavior in professional communities can be gained by considering the interactions within the community as well as the effects of isolated interventions on single members (Lynch, 1996).

Research on college students, dental and medical students, and practicing physicians and dentists variously place the level of cheating at between 60% and 80% of individuals (Andrews et al, 2007; McCabe et al, 2006; Beemsterboer et al, 2000; Fuller et al, 1979; McCabe, 2001; 2005; McCluggage et al, 1960; Trevino, 1992). It is risky to interpret these studies and draw meaningful comparisons across groups or over time. The literature is entirely self-report and cross-sectional. Even more problematic is the lack of standardization on the stimulus question. “Cheating” is variously defined or often left undefined in such studies. In the case of questions such as “do you know of any incidents of cheating?” a 100% in a community response could be reported based on a single, highly published incident (Beemsterboer et al, 2000). There are no experimental or observational studies of cheating among professionals (other than where sanctioned licenses are involved) (McCluggage et al, 1960; Papadakos et al, 2005; Yates et al, 2010), and other than the early landmark studies by Hartshorne and May (1928-30) virtually no investigations that explore the way cheating in one area affects propensity to cheat in others.

The research reported here explores the ways bad professional behavior responds to the dynamics within a professional community over time. The work draws on non-linear methods, ones that cumulatively feed back the results of early effects and do not assume that subjects are independent from each other, are common in quantum mechanics, environmental science, and increasingly so in organizational research (Blum et al, 2010; Clayton et al, 2006; Fisher, 2009; Johnson, 2004; Waldrop, 1992).

Method

Very simple non-linear systems can be described using calculus. More complex ones are addressed via computer modeling (Holland, 1995; Gilbert, 2008; Gleick, 1987; Goldstein et al, 2010; Kauffman, 1995; Miller et al, 2007; Nicolis et al, 1989; Page, 2011). The latter approach involves hypothesizing an effect for each variable on each other variable. Next, the computer calculates the total impact of all such effects taken simultaneously. The new state that emerges as a result of the first interactions alters the system, creating a new baseline which becomes their context for the next iteration. This process is repeated, and in many cases (but not all), an equilibrium is eventually reached where no further changes occur. All of the random influence that existed at the beginning of the process, largely as a result of selection bias, has been absorbed and what remains is the true but complex and continuous effect of all the variables on each other. This is the steady state of the professional community. External interventions – new ethical principles or education for individuals – will either cause a systemic realignment within the community or will eventually be "absorbed" into the equilibrium of the community.

The simulation reported here is a Markov replicator model (Dawkins, 1989; Maynard Smith, 1982; Skyrms, 2004; 2010; Sober, 2008). Markov processes continuously update the baseline as a result of information obtained in the previous stage. In a replicator model individuals are considered "carriers" of behavioral propensities (in this case cheating or devious behavior). Those moral traits that are successful in a community are passed on (replicated) in the form of increasing proportions of agents demonstrating the traits in subsequent interactions. Moral traits that are unsuccessful are subsequently found in a smaller proportion of the community. Professionals are not once and for all cheats or paragons of virtue; they can acquire or shed such characteristics depending on what is happening in the environment. One might think of an individual who has cancer, but is not a cancer. For this reason, I will speak of "agent types" rather than individuals or professionals.

Two datasets are required to populate the model, which is depicted in matrix form in the appendix: (a) the vector describing the proportion of agent types at each time, initially and after each iteration, and (b) the 4 x 4 matrix that describes the effect of encounters among each pairing of agents. The base distribution of agents is simply proportions of the four types in the population totaling to 1.0. The values in the 4 x 4 matrix drive the replicator function. Values of 1.0 represent situations where encounters have no future effect. Values below 1.0 represent comparative disadvantage and carry through in the simulation as reductions in the proportion of such agent types in the future. In standard simulations such as this, the 4 x 4 matrix of effects remains fixed and the distribution of proportions of agent types is updated at each iteration. An primary outcome of interest in this type of research is changes in proportions (dispositions to cheat, for example) as the community absorbs external influences or settles into a steady state.

Estimates of parameters for the baseline vector and the 4 x 4 matrix were determined in three ways. First, a "representative model" was created by the author, based on knowledge of the dental profession and on social psychology literature (Crant, 2000; Grant & Ashford, 2008; Parker, Bindl, & Strauss, 2010). For example, in Table 1, the top line of the 4 x 4 matrix shows projected effects on Devious dentists when they interact with the other agents in the model. Irving Goffman (1959, 1963), in his remarks on con artists, noted that their effectiveness decreases when their numbers increase because prominence erodes the public confidence in trustworthy relationships. Devious dentists are a self-limiting type because they count on the presence of a sufficient number of reputable colleagues to give them cover. Since Devious dentists do well in communities with Good-Passive practitioners, they have an interaction weight slightly above 1.0 for this type of interaction. Good dentists who are willing to speak up, however, represent a threat to Devious dentists. They can shun these practitioners, deny referrals, spread rumors, and, by the Code of the American Dental Association, are expected to report the Devious dentists to appropriate authorities. Hence, the Devious dentist gets a score less than 1.0 when these encounters occur. The worst interaction for the Devious dentist involves dealing with those who are indemnified to investigate and take action against them. This can result in the Devious dentist having to move to a different jurisdiction to continue practice, and even when exonerated, there are monetary and psychological costs in defending one's reputation.

Good-Passive dentists are so much the norm that they define the standard (1.0) for interaction within the practicing community (Epley & Dunning, 2000; Leary, 2007). By nature, they do not take an active role to create change (Tangney et al, 1996). They are aware that a few bad apples may tarnish their reputations, but are willing to accept this as a cost of practice free from other outside interference.

Effects on Good-Active dentists who are willing to speak up are slightly more noticeable, but not large because their behavior is also recognized as being close to the norm and because their speaking up is typically occasional and often indirect (Fowler & Christakis, 2010; Weber & Murnigham, 2008). There is a cost to confronting the Devious dentist. Often this is psychological, but sometimes a practitioner may tolerate marginally bad actors out of fear of legal, reputational, or other reprisal. There are also small costs in the community to the dentists who speak out if they are seen as tattle-tales, and becoming involved with enforcement authorities as witnesses in licensure disputes is at the least time consuming. The contribution of the Good-Active dentist to the profession in general terms is recognized in this model by the tiny 1.01 weight.

Enforcement agents help the profession and protect the public, and are rewarded for doing so. Appointments to state dental boards are generally sought-after political appointments and expert witnesses in malpractice trials are well compensated. The slight negative effect on Enforcers is a reflection of their being a public symbol of flaws in the profession, their being perceived as imposing nuisance compliance, and their cost to the profession (enforcement activities are partially supported by fees candidates pay for the licensure examinations and by taxes) (Ashforth et al. 1999).

See the appendix for a more formal description of the model.

The estimated baseline proportions of the four agent types in the population are prudent "guesses"; perhaps painting an overly positive picture of the profession. It will become obvious as the results are presented that such systems are robust and self-correcting concerning such initial estimates. The proportion of Enforces is approximately accurate in empirical terms. There are about 12 dental and 24 staff officers per state approximates 1% of dentists. What constitutes "devious" or "active" behaviors are substantially determined by definition.

A "representative model" – a working approximation of the 4 x 4 interaction matrix – was created by the author. First approximations were based on personal knowledge of the profession, and these were adjusted when implausible outcomes emerged. Examples of implausible outcomes included more Devious than Good dentists or profiles where one or more of the agent types was missing entirely. By repetitive titration, a small band of plausible parameter values emerged and middle of these ranges was chosen. No claim is made that the representative model is the "real" descriptive mean for these interaction effects under all circumstances. (Such parameters are likely, per definition, unknowable other than for defined samples at fixed times.) The representative model does, however, provide a workable description of how dentists interact that supports meaningful exploration of system dynamics in a moral community.

The second consideration in developing a representative model for the simulation involved reasonableness of outcomes. It quickly becomes obvious that large deviations from the standard of 1.0 are implausible. They lead to outcomes where one type of agent or another becomes 100% of the community. It is obvious that all dentists cannot be Good, or Devious, or Enforcers. It is also expected that such models will converge on a steady state. A model that wanders indefinitely has no theoretical value. Operationally convergence was defined as finding no differences in any proportion of agent types at the tenth decimal point comparing iteration 40,000 with iteration 50,000.

A third approach to ensuring that the input datasets for parameters were plausible involved seeking the opinions of an outside panel of experts. All 22 regents and officers of the American College of Dentists (ACD) were invited to respond to an e-mail survey where they were asked to estimate the base distribution of agent types and the 4 x 4 encounter effect matrix. They were also asked to estimate the proportion of Good-Passive, Good-Active, Devious dentist, and Enforcer agent types in the American dental community. Nineteen individuals provided numerical estimates of these values. A definition of "deceptive dentist" was provided: "Deceptive dentists engage in actively promoting or passively allowing patients and others to believe that they are serving only the patients' best interests when in fact fully knowledgeable third parties would conclude that the deceptive dentist is gaining strategic advantage that is not being mentioned to the patient. Examples include: any amount of overtreatment, modifying treatment plans based on insurance availability, claiming unsubstantiated benefits for treatment alternatives, misrepresentation of eligibility or work done on insurance applications, and exaggeration of outcomes to patients or colleagues. An alternative definition is practice that, if know by another dentist, would be embarrassing (although perhaps not even close to being illegal) to have to explain to a formal panel of peers and the lay public. For present purposes, a Deceptive dentist is anyone who has engaged in any of the above practices twice in a month."

The aim of this research was not to estimate the proportions of dentists who can be classified by various ethical roles in the community or to provide definitive quantification of the impact of various agents in the community on each other. The goal was to demonstrate that *given plausible approximations of interactions within a moral community*, the internal dynamics of the community reveal dependencies that extend beyond the focal effects, that well-intended interventions may not be sustainable, that some interactions have larger impact on the entire community than others do, and that the community tends toward a stable and self-enforcing equilibrium.

The simulation runs on an Excel spreadsheet. Users are allowed to adjust ad lib both the base distribution of proportion of agent types and the 4 x 4 matrix of encounter effects. The simulation automatically performs 50,000 iterations and provides graphic display of the first 1,000 iterations. The simulation is available from the author upon request.

The research was approved as an exempt project by the IRB at the University of the Pacific, # 09-98.2.

Results

Table 1 displays the starting distribution of proportions, the 4 x 4 matrix of encounter effects, and stable outcomes at 50,000 iterations of the simulation based on a representative model. Following some minor shifts at the beginning, a steady state emerged where the proportions of Devious dentists and Enforcer types rose to a small, but appreciable portion of the population, and the proportion of Good-Active dentists declined. The same equilibrium was reached regardless of almost any combination of starting values in the distribution of agent types. The first 1,000 iterations in this model are displayed in Figure 1.

Table 2 displays average and standard deviation comparison data from the regents and officers of the ACD. There was similarity between the proportion of agent types in the dental community as estimated by the expert panel and as modeled using the representative model parameters as input for the computer simulation. For Devious dentists, the simulation estimated 15% and the panel estimated 14%; the simulation estimated 61% Good-Passive dentists while the panel placed the number at 64%; for Good-Active dentists the estimates were 17% and 18%; for Enforcers the estimates were 7% and 4%.

The differences between the author and the panel were slightly greater for the 16-cell matrix describing the effects of agent encounters than for the outcomes. Eleven of 16 values had the same sign (above or below 1.0 norm, representing advantage or disadvantage). A simulation was run using the values provided by the ACD panel. It quickly defaulted to a stable but unsatisfactory two-agent community (not shown) with 53% percent of dentists being ethical but passive and 47% of dentists being devious.

A single interaction value seemed to be responsible for the peculiar outcome in the ACD panel estimates. The average opinion of the panel was that encounters between Good-Passive practitioners and Devious colleagues would produce a huge benefit to the ethical dentist (1.388). This value was replaced by the value from the author's simulation (.97, meaning that Devious dentists undermine the public's confidence in the profession) and a new simulation was performed using all of the expert panel estimates save the modification just mentioned. The outcome values appear in Table 2 and which are graphed in Figure 2. The graph shows wide swings in the early stages because of harmonics arising from tight interacting positive and negative feedback loops. This is a graphic display of an overly sensitive system where agents react to each other rather than their own self-interests. Ultimately the system becomes stable but with few Devious dentists, making the curve for this agent type appear as a flat line at the bottom of the graph area, and 150 Enforcers for every such questionable colleague.

The representative model developed by the author is robust, in the sense that adjustments simulating large interventions (as for example massive increases in the number of ethical dentists through education or large decreases in bad actors by heavy enforcement) are quickly "regressed out." In the base model it required 2,859 iterations to reach equilibrium of 61.2% for Good-Passive dentists. At that point, the model was "tweaked" to increase Good-Passive dentists by an unrealistic additional 20% (up to 73.4%). Operationally, this is achieved by inserting a new arbitrary base proportion vector and continuing the simulation. This might be analogous to a massive continuing education effort. The original equilibrium reestablished itself, wiping out all gains, in just 77 additional iterations. A 20% increase in Good-Active dentists is a somewhat better investment. They reach equilibrium earlier at 17.3% of the population after 1,813 iterations. The 20% bump lasted for 1,081 iterations before it entirely disappeared – about 14 times larger than the boost for Good-Passive practitioners.

Devious dentists are insidious. If their numbers were reduced by 20% from equilibrium, they returned to regular strength in only 66 iterations. We could go to great extremes. Assume that Devious dentists are scrubbed from the system entirely. We would allow for mutations with odds of 1:1000 and if a mutation were to appear, it would be a single dentist in a pool of 170,000 practitioners – the current number of active dental practitioners in the United States. Within an average of 862 iterations the equilibrium proportion of 15% Devious dentists would be reestablished – thus demonstrating that the system cultivates the proportion of Devious dentists it can accommodate.

The case of Enforcers is more straightforward. They are a function of the proportion of Devious dentists. Lagging Enforcers 50 iterations following Devious dentists during the first 500 periods of the simulation produced a correlation r-value of .530. Reversing the order of lag (Enforcers coming before Devious dentists) results in r = .128.

It is customary to examine the robustness of simulation models by sensitivity analysis. This is a procedure wherein each of the parameters is adjusted slightly, while holding other parameters constant, in order to gauge the extent to which various parameters play a large or small role in the model. Usually, arbitrary adjustment values are chosen, but it is possible to improve on this practice where realistic external estimates are available for how much each parameter varies in actual practice. We would like to equate, if possible a large absolute change in a variable that fluctuates across a wide range with a small change in a variable with a restricted range, as is done with beta weights in regression analysis. The standard deviation of the estimates provided by ACD board members in Table 2 provided such an approximation of baseline stability for each parameter.

A Bayesian approach was used for sensitivity analysis, shifting the normal density function for each parameter for an increase and a decrease of 1% and for an increase or decrease of 10% for each of the 16 values in the 4 x 4 matrix of encounter effects. Each of the 64 outcomes (an increase and a decrease of either 1% or 10% for the matrix of four agent types interacting with each of the four types of agents) was evaluated against two criteria: (a) a net deviation from the base model after 50,000 iterations amounting to more than 1% on average for each agent and (b) elimination of one or more agent types from the model. Either outcome would be evidence of the model being hyper-sensitive to the involved encounter.

The model is robust for the 1% sensitivity analysis. There were no cases of eliminating an agent type, and only two of a possible 32 changes of more than 1% in agent mix (both cases involving changes in the interaction between Good-Active and Good-Passive dentists. In 25 of 32 cases, 10% variations in parameters produced cumulative changes greater than 1% in the agent mix. Thirty-two variations of 10% were available for testing. About half of these (13) resulted in outcomes that eliminated one or more agent type.

The matrix shown in Table 1 is arranged with interactions among ethical dentists (Good-Active and Good-Passive) clustered in the four central cells. Interactions among Devious dentists and Enforcers are displayed on the corners. This arrangement highlights the fact that relationships among ethical dentists are highly sensitive and that relationships among Devious dentists and Enforcers are slack variables (relatively insensitive to adjustments in the model). All cases of 10% adjustment involving ethical dentists led to significant changes in proportions of agent types, and 75% of such changes produced system collapse (elimination of one or more agent type). By contrast, three of eight potential adjustments among Enforcers and Devious dentists produced changes in agent type proportions and only one produced system collapse.

Discussion

Systems of even moderate complexity may have stable levels of characteristic behaviors and these are determined primarily by details of interaction among the components of the system. Given a set of agents representative of common types encountered in a professional community and a matrix of the outcomes of interactions among these agent types, the community converges over time to equilibrium. This steady state is self-organizing and robust in the sense that external interventions are absorbed and the “wisdom of the system” (Sarowiecki, 2005) reasserts itself in a relatively short period of time.

This simulation of iterative adjustments in a community based on a representative set of parameters produced a stable estimate of the proportion of various agent types that closely approximated the mean estimates made by leaders in the profession. Moreover, dynamic analysis of the model suggested that the system is stable and capable of absorbing external interventions. Demonstration of the short-term effectiveness of isolated interventions, regardless of their design rigor and statistical measures of effect, may be overly optimistic in complex systems. It is likely that systems have their own logic that controls the proportion of elements – such as devious practitioners – and that the ethical professionals that dominate the system have a substantial influence on the level of deviation tolerated.

The results of the sensitivity analysis may appear counterintuitive. The most sensitive relationships in the simulation, the ones where small changes can have the most impact involve the ethical professionals. Because they are most numerous and because they influence others most, the level of tolerance for unethical behavior that ethical professionals agree among themselves emerged as the most powerful lever affecting ethics in the profession. The finding that the least sensitive relationship was the effect of Enforcers on Devious dentists is actually exactly what the literature would predict. Empirical studies of the deterrent effect of punishment consistently finds that whether cheating is challenged has an effect, but the magnitude of the punishment makes little difference (Jones, 1991; McCabe et al, 2006; McCabe, 2001; Gneezy et al, 2004).

Although it is certainly true that individual practitioners can enhance their understanding of ethical issues – both at a theoretical level and by seeing better ways to manage concrete ethical issues – this will not tell the whole story of ethics in the profession. Professionals who recognize that colleagues are cutting corners will respond to this as they believe their colleagues would. Several studies report that the typical response to lapses in academic integrity is to let the matter pass without comment (Andrews et al, 2007; McCabe, 2005; Trevino, 1992). This is especially true if it is perceived that others are also reluctant to engage expedient practitioners. The dominance of passive over active ethical practitioners is consistent with Schrader's research on cheating among college students: "Most students resolve dilemmas by letting the issue drop, doing nothing, by going along with the situation or with others in it, and by letting the problem resolve itself" (Schrader, 1999, page 48).

The model suggests that it would be insufficient to concentrate on the bad actors, perhaps with a view toward converting a large proportion of them through ethics training. Without changing the conditions that allow bad actors to flourish, the expectation is that their numbers would rebound to the level the system will support. The better policy would be making it easier for ethical professionals to confront their less-then-upright colleagues. The social economics of whistle-blowing are that those who speak up are not always appreciated and they bear personal costs for the benefit of the profession as a whole (Batson et al, 2001; Beene et al, 2009; Bok, 1980; Diamond, 2005; Giacalone, 2007; Henle, 2006; Pinto et al, 2008). There is a need for professions as a whole to distribute the costs and benefits more evenly.

Research on “decoupling” in organizational ethics has found that formal approaches to ethics such as hiring an ethics officer, providing training, and promulgating codes is more apt to engender cynicism than improved ethical climate (MacLean & Behnam, 2010).   The way specific situations are handled on a day-to-day basis appears to be the driving factor in building organizational ethics (MacLean, 2008).

There are some who will find this paper offensive because a certain level of devious behavior appears to occur as an inevitable outcome of the plausible models. There are likely more who cannot accept that some level of bad behavior is inevitable. The director of the ethics think tank, the Hastings Institute, David Callahan, in his *The Cheating Culture* summarizes 350-pages of examples of decay committed by “typical citizens” as well as the arrogant elite. The popularizer of behavioral economics, Dan Ariely, calls this the “fudge factor” (Ariely, 2012) and provides evidence that it is ubiquitous among ordinary individuals. The idealism of calling for general effort to achieve ethical perfection may not be as effective, ultimately, as the realism of identifying the patterns of interaction among practitioners that could be adjusted to achieve a small improvement in the ethical tone of the profession. That should probably be the first goal.

Ethics is certainly one of the fields of research where our understanding of what individuals do under controlled circumstances needs to be supplemented with a study of how we behave naturally as a group. Complexity theorist John Holland mentions something he calls the Third Harvard Law of Biology: “With a careful research plan, controlled conditions, using selected agents, complex adaptive systems do pretty much as they please” (Holland, 1995, page 96).

Conclusion

This paper offers a demonstration of one method to begin exploring complex moral situations where others form part of the context in which agents make ethical choices and where the outcomes of an agent's ethical choices have the potential to alter the prospects that agent faces in future. It is expected, based on this modeling, that local changes in ethical behavior are possible within a range, but that the general context places limits on change. There are forces that pull behavior toward equilibrium and it is not always apparent which changes will move the equilibrium in the desired direction or whether changes that make theoretical sense in isolation will be stable.

Professional communities, like all complex systems, have their own "wisdom" that works over time to bring about a steady state. Modifying some individuals in these communities to align them with external norms may lead to disappointing results if the relationships between individuals and communities are not understood. Focus exclusively on the relationship between prototypical individuals and an ethical principle is insufficient.

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Figure 1. Output of first 1000 iterations of a replicator model containing four agent types in a professional community – Author's representative model.

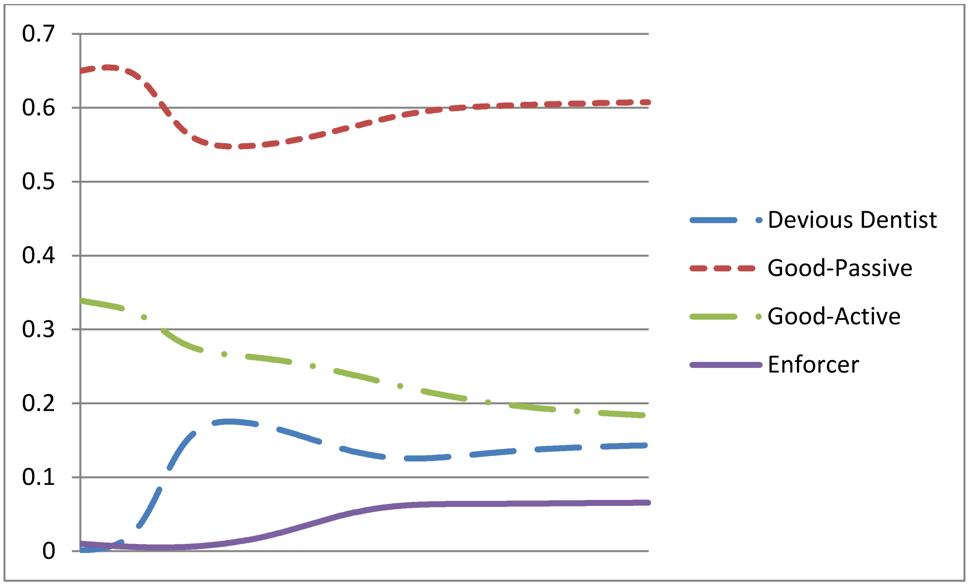

Figure 2. Output of first 1000 iterations of a replicator model containing four agent types in a professional community – American College of Dentists panel perspective.

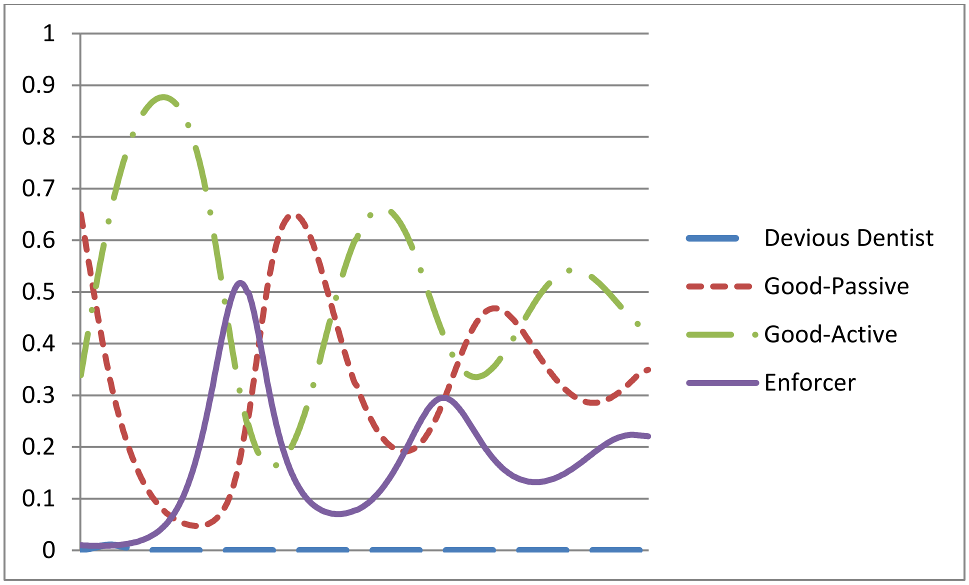

Table 1. Input and output parameters for a replicator model of four agent types in a professional community – Author's representative model.

	Devious Dentist	Good-Passive	Good-Active	Enforcer
Baseline proportions	.1%	65%	33.9%	1%

Estimated effect of interaction matrix

	Result for . . . Devious Dentist	Good-Passive	Good-Active	Enforcer
Interaction with				
Devious Dentist	.80	1.10	.92	.70
Good-Passive	.97	1.00	1.00	1.00
Good-Active	.97	1.01	.98	.99
Enforcer	1.06	.97	1.04	1.00
Result of simulation	14.9%	61.2%	17.3%	6.7%
Norm panel estimates	14.2	64.3	17.8	3.8

Table 2. Input and output parameters for a replicator model of four agent types in a professional community – American College of Dentists panel perspective.

	Devious Dentist	Good-Passive	Good-Active	Enforcer
Baseline proportions	.1%	65%	33.9%	1%

Estimated effect of interaction matrix: averages and (standard deviations)

	Result for . . . Devious Dentist	Good-Passive	Good-Active	Enforcer
Interaction with				
Devious Dentist	1.141	1.240	.959	.931
	(.130)	(.123)	(.125)	(.294)
Good-Passive	1.388*	1.018	1.051	1.092
	(.149)	(.040)	(.096)	(.289)
Good-Active	.857	1.056	1.072	.972
	(.076)	(.141)	(.136)	(.164)
Enforcer	.650	.994	1.102	1.010
	(.117)	(.156)	(.197)	(.187)
Result of simulation	.1%	45.5%	34.7%	19.7%

	Devious Dentist	Good-Passive	Good-Active	Enforcer
Estimated proportion of agents in community	14.237	64.263	17.842	3.816
	(13.36)	(16.96)	(12.45)	(3.43)

* Value replaced by .971 in simulation.

Side Bar

General findings of a computer simulation of moral behavior of four types of dentists in a moral community.

1. Because of the interaction of components, it is almost impossible to determine from inspection what the result of change in a single component will be in the entire system.

2. Small changes in sensitive relationships in the system can cause greater disruptions in equilibrium than large changes in slack variables can.

3. Systems are often more responsive to relationships among components than to initial proportions of the components.

4. Core agents and their interactions establish the system capacity for less central agents. Ethical dentists determine the profession's tolerance for Devious dentists.

5. Complex systems in equilibrium can absorb external interventions and quickly return to the previous steady state.

6. In the base model, Good-Active dentists were driven to virtual extinction while Good-Passive dentists retained an essentially undiminished high proportion. This reflects the fact that agents playing similar roles can be substituted functionally for each other to a certain extent and under suitable circumstances.

7. Agents that depend on others are highly responsive to changes in the proportion of those agent types. Changes in proportions of Enforcers depend more on changes in proportions of devious Dentists than vice versa.

8. Parasite agents depend on the health of others in the system so they will flourish only if conditions are favorable to those they depend on. They cannot achieve dominance, however, because they would destroy the base on which they depend. Small proportions of Devious dentists and Enforcers are expected to always exist.

Appendix

The method used here is standard for such research (Dawkins, 1989; Maynard Smith, 1982; Skyrms, 2004; 2010; Sober, 2008) and involves multiplying a four-element vector containing the proportion of each agent in the community by itself to produce a four-by-four matrix. This matrix describes the proportion of 16 different types of interactions in the community, on the assumption that interactions are random but proportional to the agents. The four-by-four matrix of proportion of encounters is multiplied by a second four-by-four matrix that describes the effect of each interaction. This multiplication produces a four-element vector of the proportion of each element – adjusted simultaneously for the double effect of impact on other agent types and for the likelihood of encountering them. The "replicator" nature of such models refers to the fact that "successful" encounters increase the proportion of agents following that strategy. The "Markov" nature of such models refers to the fact that the final vector of proportion of each agent type becomes the input vector for the subsequent iteration of the model. Input in the simulation consists of a one-time specification of the initial vector of proportion of agents and a one-time specification of the matrix of the effects of the interactions among agents. The model is depicted below in matrix format, where A = proportion of agents types, O = proportion of opportunities for encounters, and E = effect of encounters.

$$\begin{bmatrix} A_1 \\ A_2 \\ A_3 \\ A_4 \end{bmatrix} \times \begin{bmatrix} A_1 & A_2 & A_3 & A_4 \end{bmatrix} = \begin{pmatrix} O_{11} & O_{12} & O_{13} & O_{14} \\ O_{21} & O_{22} & O_{23} & O_{24} \\ O_{31} & O_{32} & O_{33} & O_{34} \\ O_{41} & O_{42} & O_{43} & O_{44} \end{pmatrix} \times \begin{pmatrix} E_{11} & E_{12} & E_{13} & E_{14} \\ E_{21} & E_{22} & E_{23} & E_{24} \\ E_{31} & E_{32} & E_{33} & E_{34} \\ E_{41} & E_{42} & E_{43} & E_{44} \end{pmatrix} \times \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} = \begin{bmatrix} A'_1 \\ A'_2 \\ A'_3 \\ A'_4 \end{bmatrix}$$