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CONFLICTS OR SYNERGY WHEN COMBINING MODELING APPROACHES – PERSPECTIVES FROM PSYCHOLOGY

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ABSTRACT

The simulation modeling community consists of several frameworks or approaches that have been developed at different times to handle different problems, and persist in a state of relatively limited interaction. Various forms of hybrid modeling, combining aspects of two or more modeling approaches, have been proposed and used, but these still represent a relatively small part of the world of simulation modeling. In this paper, we will draw on parallels between the current debate around discrete event simulation and agent-based modeling, and the historic conflict between two schools of psychology: behaviorism (human thought considered a "black box", focus restricted to observable behavior), and cognitive psychology (emphasis on conscious thought processes). Through a presentation of different perspectives on what happened in psychology, we will discuss views on the combination of different modeling approaches, and implications of similar perspectives on the future development of simulation modeling.

1 INTRODUCTION

Simulation modelers are typically trained in a specific modeling approach, and apply that in their work, with limited interest in, or regard to, what other approaches could be used. We develop our skills within our area of expertise, and teach the same approach to others in turn. Some get involved with more than one approach, by chance or design, and subgroups of those end up promoting or opposing specific approaches, or advocating the use of "hybrid modeling". The field of simulation modeling may be characterized as being fragmented, consisting of a number of different approaches, several of which appear to be relatively monolithic in nature. Having emerged at different points of time, in response to different challenges, modeling approaches have been developed with roots in different disciplines, and shaped by the available technology and contemporary worldviews. Though the topic of this paper is more general in nature, we will, for the purpose of brevity and clarity, concern ourselves primarily with discrete event simulation (DES) and agent-based modeling (ABM). Other approaches, such as system dynamics, could also have worked well for our examples.

The subject of this paper is to highlight different perspectives that can be taken on the co-existing, sometimes competing, modeling frameworks, and how the choice of perspective can influence the interaction between them, and, eventually, their development. In order to reduce the risk of polarizing the

debate, or being perceived as promoting a particular approach to simulation modeling, we will make use of a historic conflict within the (relatively) unrelated field of psychology as a basis on which to build the discussion. Following this presentation, we will point out similarities and parallels between this historic conflict and the relationship between DES and ABM. We will then illustrate a series of alternative perspectives on the behaviorism/cognitive psychology conflict, with parallels to DES/ABM, and discuss how the perspective can influence the interaction, and thus the development, of the field of simulation modeling.

2 DES AND ABM – A REMINDER

Two types of simulation are the focus of this paper: Agent Based Modelling (ABM) and Discrete Event Simulation (DES). DES was not developed directly in a form easily recognizable today. The mathematical basis for simulation models predates the electronic computer by nearly two centuries. Monte Carlo simulation was developed shortly after World War 2, and programming languages that allowed for more rapid development of simulation models became available in the 1950's (Nance 1993, Goldsman et al. 2009). Methods we would now label DES rapidly became popular in manufacturing and technical industry. While early ABM efforts can be traced back as far as the 1970's, the field evolved properly in the early 1990's. Where DES was used extensively in industrial and technical applications, early notable uses of ABM were related to modeling human interactions and social phenomena (Samuelson 2000). As simulation packages have become more accessible and computational power has become less expensive, the range applications of DES and ABM (and other modeling approaches) have widened, and they are now extensively used to model similar kinds of problems. The degree of overlap between the two approaches is contended (figure 1).

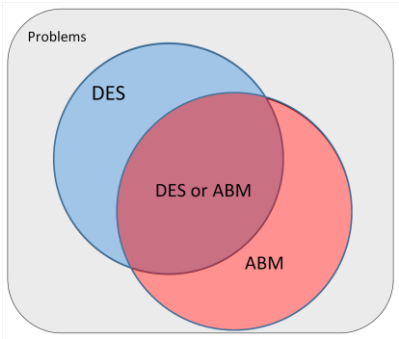

Figure 1: Venn diagram of overlap between applications of DES and ABM. The relative size of the different areas is contended.

DES and ABM two approaches tend to be taught in isolation, with excellent texts introducing DES alone (Law et al. 1991, Zeigler et al. 2000), and ABM alone (Epstein and Axtell 1996, Gilbert and Troitzsch 2005, Miller 2009).

With DES and ABM increasingly being used to address the same types of issues, academic discussion about the similarities and differences from a technical and a philosophical perspective have appeared in the literature (Siebers et al. 2010, Brailsford 2013), along with a growing literature on hybrid models. , mixing two or more modeling approaches (Chahal 2010, Alvanchi et al. 2011, Morgan et al. 2011, Swinerd and McNaught 2012).

Some proponents of ABM claim that it is superior under most circumstances, that DES is restrictive and, essentially, obsolete (Siebers et al. 2010). Others argue that the two approaches can be seen as being complementary, and that practical implementation blurs the lines between models based on the two

frameworks (e.g. Brailsford 2013). Siebers et al. (2010) list a set of properties that distinguish the prototypical approaches, shown here in Table 1.

Table 1: Differences between DES and ABM from Siebers et al. (2010).

DES	ABM
Process oriented; focus is on modelling the system in detail, not the entities	Individual based; focus is on modelling the entities and interactions between them
Top down modelling approach	Bottom up modelling approach
One thread of control (centralised)	Each agent has its own thread of control (decentralised)
Passive entities, i.e. something is done to the entities while they move trough the system; intelligence (e.g. decision making) is modelled as part in the system	Active entities, i.e. the entities themselves can take on the initiative to do something; intelligence is represented within each individual entity
Queues are a key element	No concept of queues
Flow of entities through a system; macro behaviour is modelled	No concept of flows; macro behaviour is not modelled, it emerges from the micro decisions of the individual agents
Input distributions are often based on collect/measured (objective) data	Input distributions are often based on theories or subjective data

The distinctions and similarities between DES and ABM models can be discussed at length. However, for the purpose of this paper, a certain level of overgeneralization is acceptable. DES uses models in which the logic determining how entities move is part of the model structure - entities are passive objects the faith of which is determined by properties of structures in the model. ABM, on the other hand, places the logic of action (agency) in the entities (agents), usually with a limited and passive model structure.

3 A BRIEF HISTORY OF BEHAVIORISM AND COGNITIVE PSYCHOLOGY

3.1 Behaviorism

Although it is not really true, the general perception is that modern psychology was invented by Sigmund Freud. Freud had an enormous impact on how humanity views itself, even though many or most of his theories have later been proven wrong, and that his ideas, in the views of some, have set back the science of psychology by as much as 50 years (Eysenck 1991). Freud founded psychoanalytic theory, in which the mind consists layers upon layers of conscious and unconscious parts. To investigate the layer-cake of the psyche, psychoanalysts recommended introspection. The influence of psychoanalytic theory and individual psychoanalysts grew throughout the late 1800s and early decades of 1900. Over time, however, the theory and practice was increasingly criticized as being non-scientific and unfalsifiable (Popper 2014). This is the world in which behaviorism emerged. It started with animals.

Ivan Petrovich Pavlov was a Russian physiologist who eventually received the Nobel prize in 1904 for his work on the digestive system. As part of his studies, he mounted equipment to collect saliva from

dogs, and noted that they started to salivate before the food arrived, specifically when they heard the footsteps of their feeder. Driven by curiosity, he systematically described what was later known as *classical conditioning*: the transfer of a response from a potent stimulus (e.g. food) to a previously neutral stimulus (the classical case is a bell), achieved by systematic pairings of the two stimuli. Pavlov performed increasingly complex experiments, mapping out how such conditioning occurs (Asratyan 2001). Importantly, the observations of classical conditioning were limited to behavior – a stimulus-response system – in which what happened in the mind (of the dog, in this case) was not observed, and did not play any part.

Edward Thorndike, one of the other fathers of behaviorism, also studied animals, trying to determine the extent to which animals could learn through observation and imitation. He created puzzles that required specific actions, such as pushing or pulling levers or buttons, for animals to escape confinement. Unlike what could be expected if animals figured out the puzzles through observation and insight, he generally observed a learning curve, that animals gradually increased the frequency of, initially random, actions that resulted in escaping, learning over time what was required through chance-based trial and error (Miltenberger 2011). This work was later greatly expanded upon by B.F. Skinner, who mapped out what is now known as *operant conditioning*; a general tendency to increase frequency of actions that result in good outcomes (actions that are reinforced, either by increase in a positive stimulus, or decrease in a negative stimulus), and to decrease frequency of behavior that result in punishment (i.e. the reduction in access to positive stimuli or increase in negative stimuli) (Staddon and Cerutti 2003).

Supported by rapid strides in the development of the natural sciences, and with a growing belief in society that all things could and should be investigated using "hard scientific methods", Thorndike and others rejected introspection as a means of gaining information on psychology. Scientific investigation of psychological phenomena be limited to the observable, the replicable, and the falsifiable; i.e. behavior.

Behaviorism was a scientific success story, able to describe and explain a wide variety of phenomena. Based predominantly on experiments conducted on pigeons, Skinner made mathematic descriptions of what kind of stimulus conditions would maximize the increase in specific behavior. For example, he found that uniform reinforcement is not the strongest motivator by far; once a pigeon has figured out that triggering a specific mechanism means getting seeds or other foods, it turns out that randomized benefits, with many tries not resulting in any pay-out, but large prizes in a few cases, will result in the pigeon manically triggering the device as if addicted. For an interesting and entertaining read, we recommend looking up "superstitious pigeons" on your search engine of choice. Most of these animal observations transfer nicely to humans; for instance, the output algorithms of modern gambling machines match the most addicting reward conditions observed for pigeons (Lewis 2014).

Due to its success in modifying behavior of animals, Skinner's methods are now used as the basis of most professional animal training. Keller and Marian Breland, two psychologists influenced by Skinner, made a business out of training animals for use in TV, among other feats making a highly popular TV show called "Priscilla the Fastidious Pig", in which a pig would do typical human things like eating at a table, doing laundry, etc. The children watching the show were unaware that they were watching not one, but many trained pigs, since pigs grow at such rates that new ones had to be trained every few months (Breland and Breland 1951).

The ability to modify behavior applies also to humans much in the same way as animals. This forms much of the basis of behavioral therapy; psychological counselling in which the tools gleaned from animal studies are used to systematically alter behavior, and consequently, the psyche. Examples include systematic desensitization – one of the most commonly used approaches to treating phobias. It is based on the observation that combining a threatening stimulus with stimuli incompatible with fear (or more generally, in psychology-lingo, arousal) will reduce the arousal, and thus the fear. Systematic desensitization involves exposing the patient to weak representatives of what they are afraid of, in a setting in which they manage to remain calm. For example, a patient with arachnophobia (fear of spiders) may be shown a drawing of a small spider, while instructed to breathe steadily and behave as if the situation is completely harmless (which it is). When able to deal calmly with the stimulus, a slightly more

threatening stimulus is introduced. This is repeated until the patient can comfortably handle the threatening stimulus in itself. Social skills can be trained through the use of operant conditioning, by enforcing wanted behavior and neglecting or punishing unwanted behavior. Though not intended as such, common methods of child-rearing are strongly influenced by behaviorism. As an example, teaching small children to try to sleep, rather than to cry, when they have been put to bed, is a process of operant conditioning, where the act of crying is intentionally uncoupled from the desired outcome (getting picked up). Bedtime ceremonies serve as classical conditioning cues.

In behaviorism, the mind is considered a black box. This is not an exaggeration; the most stalwart proponents of behaviorism explicitly excluded any study or investigation into whatever processes occur between introducing a stimulus and eliciting a response. While they may not have rejected the experience of consciousness, thoughts, emotions, and other internal mental activity, the fact that such experiences cannot be objectively observed removes them from the domain of scientific enquiry. Several influential behaviorists, including John B. Watson, dismissed private events as epiphenomena: by-products or parallel experiences to the "real" phenomena of behavior. Behaviorists considered their study a natural science, an objective analysis of the natural world, aimed at revealing the underlying laws of nature. This perspective was inspired by the rapid advancements within the natural sciences that occurred in the late 1800s and early 1900s, which was accompanied by a sense in society and in academia that all the mysteries of the world were finally being unraveled. Analyzing private thoughts was a threat to the image of psychology as a natural science, and was therefore strongly discouraged.

Some behaviorists were less extreme in their rejection of private events. For instance, B.F.Skinner introduced what is referred to as radical behaviorism, in which genetics and biological endowment were included, and private experiences, including thoughts and emotions, were considered specific forms of behavior with the person experiencing them as the only observer. Though some individuals took such radical stances, the conflict between behaviorism and cognitive psychology makes little sense without understanding that the view of the mainstream behaviorist movement discarded the mental world from the purview of science.

3.2 The cognitive revolution

The post-war era of the 1950s saw great leaps in a several sciences, including a redefinition of linguistics by Chomsky, a growing field of cybernetics, the first forays into artificial intelligence, computer-simulated cognitive processes, and improvements in technology facilitated the advent of neuroscience as a field of study. All these fields were conceptually related, and, though relatively rare in academic history, there was a growth in interdisciplinary work within what has later been referred to as the cognitive sciences. In this world, behaviorism came up short, and investigations of the inner workings of the mind were increasingly accepted (Miller 2003).

Beyond sharing a focus on what happens in the conscious and unconscious mind, cognitive psychology bears little to no resemblance with psychodynamics and the psychoanalytic ideas of Freud: cognitive psychology is theory-driven and experimental in nature. Emphasis has been on modelling mental processes and how they affect behavior, with strong ties to neuropsychology and neurology. For example, cognitive psychologists have extended great effort in mapping out and modelling various facets of memory, perception, metacognition, and language.

Between 1950 and 1980, behaviorism went from being considered the pinnacle of psychological sciences to being virtually eradicated as a scientific approach (Friesen 2010). Developments in information sciences, computer technology, and imaging technology supported a rapidly growing interest in, and ability to, investigate the former black box of the mind (or, possibly more accurately, the brain). The insights brought by the experimental behaviorist psychology, such as classical and operant conditioning, while acknowledged, were increasingly considered as superficial curiosities. With the shift of perspective from behavior to cognition, careers were made and destroyed.

Alongside the advent of the cognitive sciences arose cognitive therapy: a form of psychological therapy targeting dysfunctional cognitive processes. Where behavioral therapy targeted only behavior, cognitive therapy aimed to identify the automatic thought processes preceding and accompanying psychological problems such as anxiety and depression (Beck 1979). For instance, psychological problems are typically accompanied by a tendency to automatically make negative assumptions ("I could go to the party, but I'll still feel miserable." "There's no point in studying; I am hopeless and will fail the test regardless.") Thus, one method used in cognitive therapy involves helping the client find ways of challenging the veracity of such automatic thoughts ("When you have gone to parties, did you feel miserable?", "When previously you have studied for tests, did you fail?") When successfully applied, a variety of cognitive exercises are used to teach clients to question and control the way they think about their life, resulting in therapeutic change.

3.3 Status quo

Behaviorism and cognitive psychology are, at least on the surface, polar opposites; in behaviorism, the inner workings of the mind are disregarded, while they are the focus cognitive psychology. Similarly, behavioral therapy targets behavior, and cognitive therapy targets thought. The conflict between behaviorism and the cognitive sciences lasted for decades; prior to the 1950s, investigation of the inner world of thought was frowned upon, or even ridiculed. Three decades later, investigation of behavior without a cognitive model was considered pointless. Cognitive psychology is a central part of the curriculum in psychology, while behaviorism is, for the most part, taught only as part of courses on the history of psychology.

By around 1980, behaviorism was all but routed. However, in the decades to follow, the notion that the two perspectives were incompatible, and that the cognitive revolution was, in fact, a paradigm shift have been increasingly questioned. While there is no doubt that the shift in focus took the form of a sometimes harsh academic conflict, it is argued that cognitive psychology can be considered as behaviorism with a new language, that behaviorism was a necessary developmental step distancing the science of psychology from pseudoscientific approaches, or that cognitive models and methods of analysis were largely impossible in the heyday of behaviorism, due to limitations in the technology available at the time (Roediger 2004, Watrin and Darwich 2012, Staddon 2014).

Paralleling the academic softening of the lines between behaviorism and cognitive psychology, therapeutic traditions have also changed; behavioral therapy as a stand-alone approach is rarely taught at all, but neither is pure cognitive therapy: most educational institutions now teach cognitive-behavioral therapy (CBT), an eclectic mix of the two approaches previously thought to be incompatible. Some problems may be more readily remedied using behavioral interventions, while others can more easier be tacked using tools drawn from cognitive therapy. In CBT, cognitive and behavioral interventions are considered as complimentary, and the appropriate combination of interventions is one that is likely to generate the required change through the least effort. For example, training in methods to question automatic negative thoughts may be reinforced by behavioral interventions, increasing the likelihood and rate of successful change. If a patient, for various reasons, does not respond well to cognitive interventions, the therapist is free to emphasize behavioral interventions, and vice versa.

4 PARALLELS AND PERSPECTIVES

4.1 Initial parallels

Let us consider some apparent similarities between this story and the current DES/ABM divide. Behaviorism and cognitive psychology have been taught, developed, and used separately. During the cognitive revolution, behaviorists branded cognitive psychology as being anti-scientific, while cognitive psychologists claimed that behaviorism was obsolete. Similarly, DES and ABM have been developed,

and are still usually taught and used separately. There is an ongoing debate between proponents of DES and ABM as to what approach is superior. Behaviorism focuses exclusively on the overt behavior of the agents in question (animals or humans), and investigates how altering outer stimuli will result in systematic changes to the response. Since individuals are modelled as stimulus-response entities, they have no real agency. Similarly, DES presents a structure of external logic through which passive entities are channeled. Cognitive psychology investigates how the internal structure/logic, strengths and limitations of the human mind influences behavior, and how manipulating the internal structure alters behavior/performance. ABM emphasizes the agent's logical properties, and assigns control over interaction to the entities. We also have a chronologic similarity: cognitive psychology emerged in a field dominated by behaviorism, and ABM was developed long after DES.

4.2 Stories and perspectives – a history of dominance or redundancy

One of the reviewers considering the initial version of this manuscript pointed out that in comparing behaviorism/cognitive psychology to DES and ABM, we appeared to be suggesting that ABM would supplant DES, and that DES would be delegated to the history books. While this was not our intention, the observation was apt: we told a story of an old school of thought being overthrown by a new one, and then proceed to point out similarities between this history and what will most likely be construed as the conflict between DES and ABM. By the logic of the story, ABM should supersede the outmoded DES approach.

The way we presented history suggests that behaviorism and cognitive psychology were mutually exclusive perspectives in natural competition for dominance. This is not a result of inventive story-telling, as it matches the way in which this part of the history of psychology is generally presented. Moreover, given that this was largely an open conflict, and that a written record exists in the form of contemporary teaching books, scientific papers, as well as employment records, there is ample evidence to support that the individuals involved perceived the conflict as a battle for dominance at the time.

In contrast with the very open conflict that took place between behaviorists and cognitive psychologists, there is less conflict between the DES and ABM communities, in part because there is less direct interaction. Nevertheless, there is friction at the intersection between the two approaches, as exemplified by the title of the previously mentioned paper by Siebers et al. (2010): "Discrete-Event Simulation Is Dead, Long Live Agent-Based Simulation!". However, this is not the only possible perspective.

A less extreme conflict perspective is also plausible: that the different approaches were both viable as alternatives, but that one was, at least by its proponents, considered superior. For instance, it has been suggested that behaviorism became redundant with the advent of cognitive psychology, since behavior is secondary and subsequent to cognition, or that cognition is "mental behavior" that has been neglected by behaviorists (Roediger 2004). Drawing parallels to DES and ABM, this view corresponds with the idea that ABM can be used for all the purposes of DES, and more. In terms of the Venn diagram in Figure 1, this would mean that the DES circle should be inside the ABM circle. From this perspective, DES should be abandoned in favor of ABM.

4.3 Eventual synergy

While the conflict in psychology was ongoing, and in most historic presentations, the predominant perspective was and is that behaviorism and cognitive psychology were mutually exclusive approaches with no room for common ground. However, the subsequent development and success of CBT, now one of the largest therapeutic directions in psychology, suggests that a different perspective may be more appropriate. Behavioral and cognitive therapy components appear to complement each other, rather than compete, and CBT is a synthesis of the two. This perspective may be more appealing to advocates of hybrid models. Drawing the parallels to DES and ABM, we suggest that there is a potential for progress and benefit if the two approaches are used together in a fashion that draws on the strengths of each. From

this perspective, the lesson from history is that psychology got it wrong, that decades were spent in academic conflict rather than developing what is now a dominant therapy form. By analogy to DES/ABM, promoting the perspective that the two approaches are complimentary has the potential to enable the field of simulation modeling to leapfrog over the decades psychologists wasted by fighting, directly to a potential state of synergy.

4.4 Separate domains

We started this paper by characterizing the field of simulation modeling as consisting of several semi-monolithic frameworks, each with a separate history of development, being taught in isolation, having semi-separate branches of literature. When cognitive psychology had ousted behaviorism, the scientific and practical insights and achievements of behaviorism were largely trivialized by relegating them to the status of curiosities of little to no practical significance. Interestingly, this can be taken to indicate that behaviorism was not concerned with the same kinds of problems as was cognitive psychology. If cognitive psychology and behaviorism were not concerned with the same domains of interest, they could, in theory, have had a peaceful coexistence. The decade-long conflict would then have to be explained away as a misunderstanding, or as a struggle for power and funding masked as something else. Here, CBT would be the equivalent of educating the same group of people to be both plumbers and electricians – two distinct skillsets applied to separate problems that often occur together.

Drawing a parallel to simulation modeling, the apparently monolithic separation of approaches we observe in the community could be taken reflect that the various approaches are, at the core, designed and intended for fundamentally different purposes. From this perspective, areas of contention, in which two or more approaches can be used to address the same issues, are the result of these fundamentally different approaches being applied outside their "core domains".

The idea that different simulation modeling approaches are tailored to address separate domains of issues would go a long way towards supporting their relative isolation from one another. However, it rests on the existence of separate core domains of problems that can only be addressed properly with each framework, a *raison d'être* for each. To use the analogy of plumbers and electricians, plumbing and pipes do not fix the electrical system, and electrical wires do not fix the plumbing. This does not preclude the potential for benefit in systematic collaboration, or the potential market value of "hybrid plumber/electricians". In terms of the diagram in Figure 1, combining DES and ABM would allow coverage equal to the union of the two circles. This perspective does not suggest that different approaches should be merged.

4.5 Specific cases of a more general phenomenon

CBT represents an example of synergy between two separate approaches to psychological treatment, combining aspects of cognitive and behavioral therapy. This can be taken one step further: Behaviorism concerns how people act, and cognitive psychology concerns how people think. Instead of seeing these as complementary perspectives, we can think of both as incomplete; as narrow sub-phenomena representing parts of a greater whole, with focus trained in such a way as to ensure that the full picture cannot be captured. Construed in this manner, CBT can represent a perspective of the whole, addressing both cognition and behavior. Alternatively, CBT could be seen as a somewhat more comprehensive perspective of a greater whole: for example, while both behavioral and cognitive therapy techniques are extensively used to address and modulate problems related to emotion, neither approach is *about* emotion. An even more complete form of therapy could hypothetically combine CBT with emotion-focused therapy techniques. This could be extended further by adding social interventions, and so on.

DES, ABM, and other modeling approaches have been shaped by the time in which they were developed, by the available technology, the contemporary problems, and by the development of other adjacent fields of study. Given their separate developmental histories and the relative isolation in which the approaches have existed, it is possible to construe them as specific sub-domains of a larger common

super-structure of modeling approaches, each with idiosyncrasies stemming from historical happenstance, and demarcation lines that are, to some extent, arbitrary. From this perspective, each approach, while great for handling certain classes of problems, is also essentially blind to parts of the greater whole represented by the super-structure. Given this model of reality, the current state of separation of the different approaches, in that they are taught and used in isolation, is potentially severely limiting. If this perspective is correct, combining different modeling approaches should have a greater-than-additive benefit, as the combination would allow for more comprehensive approaches to problem solving, allowing for solutions that could not be implemented using either approach in isolation. In terms of the Venn diagram in Figure 1, this perspective opens for a situation in which the combination of approaches will allow more than the union of the two spheres.

5 AN ACTIVE CHOICE OF PERSPECTIVE

Perspectives have power. We are, of course, not claiming that taking a particular perspective will magically alter the world of simulation modeling. Rather, we suggest that the manner in which we present and talk about issues such as potentially conflicting, potentially synergistic relationship between different modeling approaches can have subtle, yet profound, influence on their future development. Prevailing perspectives are not fixed entities. Over the last many decades, the dominant story of the conflict between behaviorism and cognitive psychology has changed substantially, starting with the cognitive groups as rebellious upstarts, slowly turning to the behaviorists as outmoded, to a very mixed picture at present.

What constitutes the prevailing perspective is not normally something that can unilaterally be declared and controlled. Nevertheless, key individuals or groups exert substantial influence on the dominant perspectives taken in a field. If a group of influential psychologists around 1960 had advocated the idea that there were potential synergies between cognitive and behavioral psychology, something along the lines of CBT could have emerged earlier. However, such perspectives appear not to have been entertained until relatively recently.

We do not claim that any one of the presented perspectives is the true for the modeling community as a whole. If we consider the full range of modeling approaches currently in use, it is unlikely that the same perspective will prove correct for all combinations. Most likely, there are modeling approaches currently in use that are actually redundant or obsolete, and that may (or should) over time be replaced by other approaches as this becomes apparent. It is also likely that other modeling approaches are complimentary in the sense that they can be used to address separate issues, with potentials for gain in combinations that increase the range of problems that can be properly addressed. Finally, we believe that there are approaches that, when combined, have a potential for synergies beyond the additive, such that the amalgamation of approaches could result in insights and methods that cannot be conceived of within the separate sup-approaches.

However, not knowing with certainty what perspective is correct does not necessarily mean that we have no basis for making a conscious decision to promote a specific view. For instance, we can try to analyze the consequences of each alternative given that we are wrong. Today, with the advantage of hindsight, many psychologists will claim that the cognitive revolution went too far, and that the power struggle delayed development of new methods substantially. In retrospect, we can see that the climate of the debate was such that any moderating voices would most likely have been attacked, effectively prevented moderating forces from emerging. It appears that promoting perspectives that incite conflict, such as portraying one approach as being superior, may foster a climate in which it is difficult to detect if the perspective is wrong. Conversely, let us consider what would happen if the community was convinced to engage in a concerted effort to combine and blend approaches in the search for possible synergies. At worst, these efforts would result in the knowledge that certain approaches do not blend well, and that some may be redundant. We would see this as a benefit, not a loss. There is an apparent inequality of consequences: efforts to merge approaches could reveal that this is not worthwhile, while efforts to get rid

of what is perceived as worthless alternatives may contribute to an environment in which it becomes impossible to identify potential synergies.

Users of specific approaches are likely to present a perspective assigning the different approaches roles as superior and inferior, or as being mutually exclusive. But what perspectives are being presented by endorsing hybrid models? The word “hybrid”, the original meaning of which appears to be "offspring of a tame sow and a wild boar" (http://www.etymonline.com/index.php?term=hybrid) suggest the combination of two or more different species of phenomena. While not likely to be the intention behind the use of the word, “hybrid model” may inadvertently serve to emphasize the distinctions between the “parent” approaches. This way of referring to combining modeling approaches could present an image of a hybrid modeler as something akin to the combination of electrician and plumber mentioned earlier. If we believe that there is potential for benefits greater than those that could otherwise be achieved simply through good co-operation between experts with separate skillsets, this terminology might not be ideal. Fortunately, the term “hybrid model” is only a name, and while it may convey a particular perspective, a name alone does not set anything in stone.

Advocates of hybrid modeling approaches see a potential for synergies. If the aim is to nudge the modeling community to expend the effort required to achieve the potential benefits of blending approaches, hybrid endorsers need to present and promote perspectives that are non-threatening to the sub-communities in question, that communicate the need for mutual respect, and that emphasize the potential benefits from bringing the approaches in question together. Importantly, we need to appeal to the human nature of modelers, by identifying common ground. We will point to two characteristics of modelers that should be taken into account. First, modelers, like all humans, are to a certain extent lazy. By this, we do not mean lazy in the sense that they are unwilling to expend any effort, or that they shirk their duties, but most programmers and modelers are lazy in the sense that they wish to make general solutions that save work in the future, and that they most likely wish to limit the volume of coding required. Thus, by identifying how merging approaches can make the resulting models more generally applicable is likely to be appealing, as would be examples illustrating time-saving in the coding of hybrids. Second, modelers appreciate elegance. What constitutes an elegant model may not be completely universal, but there is reason to believe that simplicity or parsimony plays a large part. Combination approaches that can be shown to be more elegant than equivalent models produced using a single approach are likely to be appealing.

Among the most powerful tools available for influencing future development is education. If the next generation of simulation modelers are taught single, stand-alone approaches, the current fragmentation of the modeling community is likely to persist for at least one more generation. Teaching institutions have different philosophies for how to organize their courses, with some building the curriculum around particular theoretical works, and other building more on software. Most modeling software packages are currently tailored to one specific modeling approach. However, there exists modeling packages that allow, and to a certain extent promote, the use of various approaches in a single model. When such packages are used in teaching, they inherently present the students with a perspective implying that there is, at the very least, room for synergy between the available modeling approaches. If, in reality, one approach were to be distinctly superior to another, students will most likely tend to gravitate towards the superior solution at the cost of the inferior one. We do not wish to endorse any specific modeling packages. Rather, we wish to point out that if we, as customers, choose packages that cater to several approaches in combination, we create a market incentive for developing such products.

6 CONCLUSION

We have presented the history of behaviorism and cognitive therapy, and used it to present several alternative perspectives that can be applied to the fragmented world of simulation modeling. We argue that perspectives encouraging efforts to combine different approaches are superior in the sense that they will contribute to revealing which approaches can be successfully combined, but also which should

possibly be abandoned. Advocates of hybrid modeling approaches are encouraged to consciously choose perspectives that can be advanced in the wider modeling community, in order to influence the future direction of development in the field.

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