A Proposed Heuristic for a Computer Chess Program

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November 13, 2012

Abstract

How might we manage the attention of a computer chess program in order to play a stronger positional game of chess? A new heuristic for estimating the positional pressure produced by chess pieces is proposed. We evaluate the 'health' of a game position from a Systems perspective, using a dynamic model of the interaction of the pieces. The identification and management of stressors and the construction of resilient positions allow effective cut-offs for less-promising game continuations due to the perceived presence of adaptive capacity and sustainable development. We calculate and maintain a database of potential mobility for each chess piece 3 moves into the future, for each position we evaluate. We determine the likely restrictions placed on the future mobility of the pieces based on the attack paths of the lower-valued enemy pieces. Knowledge is derived from Foucault's and Znosko-Borovsky's conceptions of dynamic power relations. We develop coherent strategic scenarios based on guidance obtained from the lowest-scoring of the vital Vickers/Bossel/Max-Neef diagnostic indicators. Initial results are presented.

keywords: complexity, chess, game theory, constraints, heuristics, planning, measurement, diagnostic test, resilience, orientor

Contents

In the course of writing this paper I have become more and more aghast at the number of separate items I have tried to pack into it. Far too many for clearness. And yet I don't know how I could have done otherwise. I wanted to introduce you to a new way of viewing things. And I felt that for my argument to have cogency, I must suggest my whole system and not limit myself to merely one feature about ideas, a feature such as might properly be encompassed in a single paper. The result, as you will see, is the following overstuffed boa constrictor of an affair with contents not wholly digested, and perhaps you will say by very nature indigestible. Anyway, so much for plea and for apology. -Edward Tolman

Life is more fun if you play games. -Roald Dahl

I would like to try out an idea that may not be quite ready, indeed may not be quite possible. But I have no doubt it is worth a try. It has to do with the nature of thought and with one of its uses... For the last several years, I have been looking at another kind of thought... one that is quite different in form from reasoning: the form of thought that goes into the construction not of logical or inductive arguments but of stories or narratives. -Jerome Bruner

The form of a philosophical theory, often enough, is: *Let's try looking over here.* -Jerry Fodor

We dream in narrative, day-dream in narrative, remember, anticipate, hope, despair, believe, doubt, plan, revise, criticize, construct, gossip, learn, hate and love by narrative. In order really to live, we make up stories about ourselves and others, about the personal as well as the social past and future. This long, incomplete and obvious list... points to the narrative structure of acts of mind -Barbara Hardy

thinking in terms of stories must be shared by all mind or minds... Context and relevance must be characteristic... of all so-called behavior (those stories which are projected out into "action") -Gregory Bateson

To solve problems that blind spots have made unsolvable, people need new perceptual frameworks that portray the problematic situations differently. -William Starbuck, Frances Milliken

When you... Think of Things, you find sometimes that a Thing which seemed very Thingish inside you is quite different when it gets out into the open and has other people looking at it. -A.A. Milne

A writer may try his best to draw a map of how things are, that will be equally valid for all; but all he can really do is to paint a picture of what he sees from the unique and transient viewpoint which is his alone... It is for the reader to say how much my view contributes to his own. -Geoffrey Vickers

1 Overview

The complexity present in the game of chess often hinders planning efforts and makes simple questions like "what's going on?" and "which side has the better position?" difficult to answer.

Indeterminate and unexpected events in the near future might make revisions necessary for these plans, often after only a few moves have been played.

We theorize that dynamic planning models based on perceptions of constraints, the management of stress, the readiness of resources to support strategy, resiliency, sustainable development, narrativity, and sensitivity to both incremental progress towards goals and the emergence of new opportunities can be used with greater success. We seek positions which can serve as a platform for future success, in a future that is often uncertain.

A proposed heuristic for a machine playing the game of chess, taking advantage of concepts from multiple disciplines, can be used to better estimate the potential of resources to support strategy and to offer better insight for determining whether progress is being made towards remote goals. In a future that is uncertain, there is a benefit to develop a strategic position full of resilience, flexibility, and structures with the potential for seizing new opportunities as they emerge.

As we evaluate each game position and orient our diagnostic exploration efforts, we now consider the potential to exploit and respond to new opportunities as time passes and new situations emerge from beyond our initial planning horizon. Our flexibility ideally allows a smooth and resilient response to concurrent events as they unfold. We theorize that our focus on the constraints, as well as the development of a resilient position, is a more useful level of abstraction for our game-playing machine.

We examine concepts and values useful for playing a positional game of chess, we develop a perception useful for measuring incremental progress towards goals, and then look at positions in chess games where the heuristic offers insight not otherwise obtainable. We conclude that our orientation/evaluation heuristic offers promise for a machine playing a game of chess, although our limited evidence (at present) consists of diagrams showing the strategic (dynamic) potential of the game pieces and an example of how these 'building blocks' can be combined into vital indicators.

We see the chess position as a complex adaptive system, full of opportunities of emergence from interacting pieces. Our aim in this paper is to reengineer the work performed by our machine, mindful of the values commonly adopted by experts and the principles of Systems thinking, so that it might be done in a far superior way (Hammer and Stanton, 1995).

2 Introduction

This paper is concerned with heuristic algorithms. According to (Koen, 2003) a heuristic is anything that provides a plausible aid or direction in the solution of a problem but is in the final analysis unjustified, incapable of justification, and potentially fallible. Heuristics help solve unsolvable problems or reduce the time needed to find a satisfactory solution.

A new heuristic is proposed which offers better insight on the positional placement of the pieces to a chess-playing computer program.

The heuristic will have usefulness in the orientation/evaluation methodology of a computer program, or as part of a teaching tool which explains to a human user the reasons that one side or the other has an advantage in a chess game.

To the extent that a story can be told about the world around us, sense can be made of its complex relationships, and judgments can be levied upon them. The mental acts of understanding and judging, cognitive psychologists suggest, is achieved through the organization of perceptions into narrative format, and, subsequently, the integration of newly acquired narratives into available, already internalized tales (Thiele, 2006). This capacity arises because narrative, and narrative alone, allows us to forge a coherent temporal/historical context for existence while making sense, and justifying, actions in terms of plans and goals (Thiele, 2006).

Computer chess programs have historically been weak in understanding concepts relating to positional issues. The proposed heuristic offers a method to potentially play a stronger positional game of chess. We conceptualize that an act (such as a move in a game) may be defined as a meaningful, intentional, purposeful effort only if it can be embedded within a story (Thiele, 2006).

3 Principles of Positional Chess

Understanding the principles of positional chess is a necessary starting point before designing concepts useful for a machine implementation. We select the relevant concepts of positional chess which have been addressed by multiple authors.

(Stean, 2002) declares that the most important single feature of a chess position is the activity of the pieces and that the primary constraint on a piece's activity is the pawn structure. (Znosko-Borovsky, 1980) generalizes this principle by declaring that if two opposing, supported pieces mutually attack each other, it is not the weaker but the stronger one which has to give way. (Reshevsky, 2002) notes that a *good* or *bad* bishop depends on placement of the pawns. Pieces should be "working" and engaged, delivering the full force of their potential and avoiding influences which constrain. (Levy, 1976) discusses a game where a computer program accepts a position with an extra piece out of play, making a win difficult, if at all possible. Our evaluation should therefore consider the degree to which a piece is in play or is capable of forcefully contributing to the game.

Stean defines a weak pawn as one which cannot be protected by another pawn, therefore requiring support from its own pieces. This is the *ability* to be protected by another pawn, not necessarily the present existence of such protection. Stean declares that the pawn structure has a certain capacity for efficiently accommodating pieces and that exceeding that capacity hurts their ability to work together.

(Aagaard, 2003) declares that all positional chess is related to the existence of weakness in either player's position. This weakness becomes real when it is possible for the weakness to be attacked. The pieces on the board and their constraining interactions define how attackable these weaknesses are.

(Emms, 2001) declares that one is more likely to have an advantage if a piece is performing several important functions at once, rather than not participating effectively in the game. Emms teaches that doubled pawns can be weak if they are attackable or if they otherwise reduce the mobility of the pawns. Doubled pawns can control vital squares, which might also mean denying mobility to enemy pieces. Isolated pawns require the presence of pieces to defend them if attacked.

(Dvoretsky and Yusupov, 1996) argue that creating multiple threats is a good starting point for forming a plan. Improving the performance of the weakest piece is proposed as a good way to improve your position as a whole.

(McDonald, 2006) gives an example of *good* doubled pawns which operate to restrict the mobility of the opponent's pieces and are not easily attackable. His view is that every position needs to be evaluated according to the unique features present.

(Capablanca, 2002) and (Znosko-Borovsky, 1980) speak of how the force of the chess pieces acts in space, over the chessboard, and through time, in sequential moves. Critical is the concept of *position*, which is valued by greater or lesser mobility plus the pressure exerted against points on the board or against opponent's pieces. Pre-eminence, according to Capablanca, should be given to the element of position. We are also instructed that the underlying principle of the middle game is co-ordinating the action of our pieces.

(Heisman, 1999) discusses the important elements of positional evaluation, including *global mobility* of the pieces and *flexibility*.

(Albus and Meystel, 2001) have written that the key to building practical intelligent systems lies in our ability to focus attention on what is important and to ignore what is not. (Kaplan, 1978) says that it is important to focus attention on the few moves that are relevant and to spend little time on the rest.

The positional style is distinguished by positional goals and an evaluation which rewards pieces for their future potential to accomplish objectives. (Ulea, 2002) quotes Katsenelinboigen as saying that the goal of the positional style of chess is the creation of a position which allows for development in the future. By selecting appropriate placement of pieces, combinations ideally will emerge. (Katsenelinboigen, 1992) further describes the organizational strategy of creating flexible structures and the need to create potential in adaptive systems that face an unpredictable environment.

(Botvinnik, 1984) and (Botvinnik, 1970) attempt in general terms to describe a vision for implementing long range planning, noting that attacking the paths that pieces take towards objectives is a viable positional strategy. Positional play aims at changing or constraining the attack paths that pieces take when moving towards objectives - in effect, creating or mitigating stress in the position.

(Hubbard, 2007) identifies procedures which can be helpful when attempting to measure intangible values, such as the positional pressure produced by chess pieces. (Spitzer, 2007) declares that what gets measured gets managed, that everything that should be measured, can be measured, and that we should measure what is most important.

The virtue of these example rules and principles (Thiele, 2006) arises not from their foundational status alone, but also from their role within a narrative that outlines a development sequence. For Henry James "Character is plot" (Thiele, 2006). The idea is that a writer first creates strong characters, and the events that naturally follow as these characters interact drive the plot. We suggest that "Pieces and positions are plot" - to forecast how the plot develops on the gameboard (given the position of the pieces at hand) is our practical task. We agree with (Thiele, 2006) that practical judgment cannot be distilled into algorithms alone. It is both reliant upon (alternative) narratives in its formation and, retrospectively, is best explained by way of narratives. In effect, practical judgment is grounded in narrative. More on this later. It is also grounded in virtues which enable us to overcome the harms, dangers, temptations and distractions which might otherwise prevent our strategic efforts from obtaining practical results (MacIntyre, 2007).

4 Systems Engineering

A *system* (Kossiakoff and Sweet, 2003) is a set of interrelated components working together toward a common objective. A *complex engineered system* is composed of a large number of intricately interrelated diverse elements. von Bertalanffy is of the opinion (von Bertalanffy, 1968) that the concept of a system is not limited to material entities but can be applied to any whole consisting of interacting components. This description could also apply to the situation faced by an agent playing a game, where the pieces represent the interrelated diverse elements. von Bertalanffy further identifies *dynamic interaction* as the central problem in all fields of reality (which would include playing a game), identifying *system elements in mutual interaction* as the very core issue. Additionally, we are told to suspect systems or certain systems conditions at work whenever we come across something that appears vitalistic or human-like in attribution. We therefore see an opportunity to apply principles of System Theory, and in particular, Systems Engineering, to game theory.

How would we begin? We now apply basic principles of Systems Engineering from (Kossiakoff and Sweet, 2003):

A *needs analysis phase* defines the need for a new system. We ask "Is there a valid need for a new system?" and "Is there a practical approach to satisfying such a need?" Critically, can we modify existing designs, and is available technology mature enough to support the desired capability? The valid need would be to play a stronger positional game of chess, and existing technology has struggled with the concept of positional chess, as reflected in recent correspondence games which use Shannon-based programs. It would seem that we need a different approach, which might be as simple as attempting to emulate the style of play performed by strong human players.

The *concept exploration phase* examines potential system concepts in answering the questions: "What performance is required of the new system to meet the perceived need?" and "Is there at least one feasible approach to achieving such performance at an affordable cost?" We would answer the first question as simply that our software function as an adequate analysis tool, capable of selecting high-quality positional moves (with quality of move proportional to the analysis time spent) when left "on" for indefinite periods of time. As far as the second question, we might speculate that a new approach is needed, which feasibly we could model after humans playing the game.

The *concept definition phase* selects the preferred concept. It answers the question: "What are the key characteristics of a system concept that would achieve the most beneficial balance between capability, operational life, and cost?" To answer this question a number of alternative concepts might be considered and their relative performance, operational utility, development risk, and cost might be compared. The first concept we might consider would be the Shannon approach, which has been the backbone of most software computer chess programs. We present in this paper, defined in another section, another approach. We therefore decide to explore the concept definition phase in more detail, as we look for key system characteristics which conceptually could serve as the base of such a new system.

5 Systems Thinking

The heart of Systems thinking, which is different from analytical thinking, is the attempt to simplify complexity.

Systems thinking is a discipline for observing wholes (Senge, 2006). It is a framework for observing interrelationships rather than things, for observing the effects of change rather than static snapshots. The heart of Systems thinking, which is different from analytical thinking, is the attempt to simplify complexity (Gharajedaghi, 2006). We see an opportunity to apply principles of Systems thinking to game theory. (Gharajedaghi, 2006) discusses how independent variables are the essence of analytical thinking. We might find, on closer inspection, that our independent variables are not truly independent - that the whole is more than a simple sum of the parts. Emergent properties of a system are a product of interactions and cannot (Gharajedaghi, 2006) be analyzed or manipulated by analytical tools, and do not have causal explanations. We must instead attempt to understand the processes that produce them by managing the critical interactions. One might think of emergent properties as being in the process of unfolding. What makes it possible to turn the systems approach into a scientific approach is our belief that there is such a thing as approximate knowledge (Capra, 1988). Systems thinking also shows that small, well-focused actions can produce significant, enduring improvements, if they are in the right place (de Wit and Mayer, 2010). Systems thinkers refer to this idea as the principle of leverage. Tackling a difficult problem is often a matter of seeing where the leverage lies, where a change - with a minimum of effort - would lead to lasting, significant improvement (de Wit and Mayer, 2010).

(Gharajedaghi, 2006) informs us that understanding consequences of actions (both short- and long-term, in their entirety), requires building a *dynamic model* to simulate the multiple-loop, nonlinear nature of the system. Our model should aim to capture the important delays and relevant interactions among the major variables, but need not be complicated.

We therefore attempt to approach the orientation/evaluation methodology from a Systems perspective. We will look at the interactions of the pieces and their ability to create and mitigate stress. We adopt constraints, vulnerability, dynamic modeling, and resiliency as higher level concepts which will help cut through the complexity and steer diagnostic exploration efforts along the lines of the most promising moves. The technique of *modeling* (Kossiakoff and Sweet, 2003) is one of the basic tools of systems engineering, especially in situations where complexity and emergence obscure the basic facts in a situation.

From (Anderson and Johnson, 1997), we apply Systems thinking to look at the web of interconnected, circular relationships present in a chess position, confident that this is the proper tool for doing so. Our reason for believing this is that everything in a chess position is (Anderson and Johnson, 1997) dynamic, complex, and interdependent. Things are changing all the time, analysis is messy, and the interactions of the pieces are all interconnected.

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As we attempt to construct resilient game positions, we follow (Tierney and Bruneau, 2007) and identify 4 system level components of resiliency: Robustness - the ability of our game-playing agent to withstand our opponent's forces without degradation or loss of performance; Redundancy - the extent to which pieces, structures or moves are substitutable, that is, capable of sustaining operations, if degradation or a surprise move occurs; Resourcefulness - the ability of our agent to diagnose and prioritize candidate moves and to initiate solutions by identifying and mobilizing appropriate amounts of diagnostic exploration time and game resources; and Rapidity - the capacity to restore or sustain functionality in a timely way, containing losses by graceful failure and avoiding other disruptions.

6 Goldratt's Theory of Constraints and Thinking Process

Goldratt (Goldratt and Cox, 2004) has developed a *Theory of Constraints* which postulates that organizations and complex systems are hindered from reaching their goals by the *constraints* placed on that system. Identifying those constraints and removing them can speed progress towards these goals. (Scheinkopf, 1999) describes how Golratt's institute began to modify the original concepts to serve the needs of clients who wanted more generalized procedures to solve a wider variety of problems outside of a factory production environment.

Goldratt's ideas, while seemingly original, can be properly classified as a Systems thinking methodolgy which emphasizes raw human thinking over the construction and implementation of computer models. Each approach is useful. Also emphasized is a vocabulary and terminology which allows groups to construct and discuss analytical diagrams of feedback loops and identify root causes.

Constraints shape and focus problems and provide clear challenges to overcome. -Marissa Mayer

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(Dettmer, 2007) explores Goldratt's *Thinking Process* and identifies procedures to logically identify and eliminate undesirable effects from systems and organizations.

(Dechter, 2003) explains that a model of reality based on constraints helps us to achieve an effective focus for diagnostic exploration efforts, and is similar to the heuristic process that humans use to obtain effective solutions in complex situations. Removing the constraints partially solves the problem, and measured progress towards removing these constraints can orient diagnostic exploration efforts when identifying positions and lines of analysis which are promising.

The realities are these constraints... we turn those constraints into action -Frank Gehry

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(Hollnagel et al., 2006) speak of identifying and monitoring the "barriers" which keep the system response within safe margins. Also, the use of "audit tools" is envisioned as a method to measure the effectiveness of the containment.

7 Soft Systems Methodology

(Checkland and Poulter, 2006) present a modified Systems methodology where complexity and confusion are tackled through organized exploration and learning. We envision the continuous change present in the game of chess as a complex state that needs to be (at least partially) understood in order to make exploration efforts (of an exponentially growing tree) more efficient.

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what we really need is a guiding light - an insightful and informed direction for exploration and a notion for how pressing this direction becomes strategically.

We conceptualize a learning agent which gathers relevant information as it seeks to determine the cumulative stress present in the position, in order to determine the paths of exploration - the ones of promise and the ones of risk mitigation. Our Systems model (making up our orientation/evaluation methodology) will ideally suggest to us what moves are promising or worth our time exploring, as well as to recommend which paths can, justifiably, wait until later. The heuristics which make up this learning and decision making process will be discussed in a later section. Critical to these heuristics is the concept that all dynamic behavior emerges from a combination of reinforcing and balancing feedback loops (Anderson and Johnson, 1997).

Curiously, our orientation/ evaluation 'function' will become a methodolgy rather than a formula. We share Botvinnik's puzzlement with an evaluation "number" (Botvinnik, 1970) when what we really need is a guiding light - an insightful and informed direction for exploration (orientation) and a notion for how pressing this direction becomes strategically.

The insight we obtain by this method is used as a *spring for action* (Checkland and Poulter, 2006), as our software agent decides what to do next, after completing the current evaluation. Our "evaluation" ideally produces candidate directions for exploration, as part of a carefully constructed strategic plan, and indicates which paths are critical and which can wait until later. For Checkland, our model is an *intellectual device* we use to richly explore the future, using stress transformation as our chosen strategy, or worldview. Simply put, our model tells us which paths to explore.

Our estimate of the winning chances of a candidate position critically depends on the identification and exploration of the critical candidate sequences of moves, and the correct classification of the worthiness (for timely exploration) of such candidate positions. A heuristic estimate of the cumulative stress present in the position, at the end of our principal variation, can be correlated, if desired, with winning chances. However, our operational use of this value is for (cybernetically) steering diagnostic exploration efforts.

8 Attention

We have stated in our Abstract that we wish to manage the attention of our machine in order to play a stronger positional game of chess. We therefore need to look in depth at the concepts involved. The first of which will be the concept of *attention*.

For Posner and Petersen (Posner and Petersen, 1990), three major functions are prominent in cognitive accounts of attention: 1. orienting to sensory events, 2. detecting signals for processing, and 3. maintaining a vigilant or alert state. We feel that our design for a chess playing computer program will be ineffective without placing these concepts at the forefront and taking the majority of our time as a designer and philosopher in constructing an approach or method of attacking the problem. We will specifically address all three concepts in the following way.

As we strategically explore the consequences of the current position (and replace our *vicarious estimate* of what we would get by trial and error exploration with the results from an actual exploration), we will orient ourselves by the critical success factors which drive competitive success. Our attention will be directed to the results of diagnostic tests which indicate that performance in one of several critical areas is below that of other critical factors, or is changing. This can be applied to our position or our opponent's position.

Critical to these efforts, a detection phase will attempt to extract cues of relevance from our position in order to make our orienting efforts meaningful. The cues will be used in the construction of leading indicators of sustainability - early warning signs, so to speak, that the sustainability or health of the position is solid or less than solid.

We maintain a vigilant or alert state by constructing a critical path of strategic, consequential, exploratory moves which produces as output a number (or marker) which we will use as the *threshold of our attention when constructing strategic challenge lines.* In the competition for attention resulting from all these lines, the challenge lines which approach the score of our marker will be awarded more attention, those that do not (yet have demonstrated sustainability) will be awarded less attention. We think that completely "cutting off" exploration efforts is not quite correct - an initially unpromising line might "turn around" due to emergent effects.

We will rely on the cues present in our detection phase and our useful critical success factors to make our diagnostic tests meaningful and relevant.

Properly constructed, the results of our diagnostic explorations will specifically point to the lines which need more attention, and those which (out of strategic necessity) must get by with less. We strategically allocate attention where it is needed - *expanding the depth* of the shallow, quickly-constructed challenge lines or *deepening the critical path* to uncover the consequences of the consequences of the consequences. We are constructing a diagnostic test of adaptive capacity which (ideally) is useful in selecting a move to play in a social game.

We cannot even get underway in this approach without first looking at the concept of measurement.

9 Measurement

Measurement plays a dual role (DiPiazza and Eccles, 2002): it focuses attention on what is important, as determined by strategy, and it monitors the level of performance along those dimensions in the effort to turn strategy into results. Certain measures can be predictive in nature, and we aim for successful use of those measures as a management tool in steering diagnostic exploration efforts.

Measurement systems create the basis for effective management, since you get what you measure. Management therefore needs to focus its attention on the measures that really drive the performance or success they seek (Spitzer, 2007). Spitzer also speaks about the critical need to develop metrics which are predictive and which measure strategic potential. We seek to measure how "ready" our pieces are (and the structures they form) for supporting strategy (Kaplan and Norton, 2004), especially when the future positions we face are not entirely determinable. An asset (such as a game piece) that cannot support strategy has limited value. Part of our orientation/evaluation of the promise of a position should ideally include the readiness of the pieces and structures to support future developments. We embrace the principle that what you look for is what you find.

For (Zeller and Carmines, 1980), measurement clarifies our theoretical thinking and links the conceptual with the observable. For measurement to be effective, we must first construct a valid sensor. In our attempts at measurement, we seek empirical indicators which are valid, operational indicators of our theoretical concepts. We desire to construct a diagnostic indicator which gives, as a result, a useful predictive measure of future promise and a direction for future exploration.

Although it would seem that a perception based on simplicity would yield the best all-around results, (Blalock, 1982) points out the difficulties trying to simultaneously achieve simplicity, generality, and precision in our measurement. If we have to give up one of these three, it is Blalock's opinion that *parsimony*, or the scientific idea that the simplest explanation of a phenomenon is the best one, would have to be sacrificed in order to achieve the other two. Laszlo (Laszlo, 1996) suggests that science must beware of rejecting the complexity of structure for the sake of simplicity. Therefore, our attempts to describe a complex orientation/evaluation methodology are grounded in the two-fold goals of generality (it must be applied to all positions we encounter) and precision (otherwise, diagnostic exploration efforts are wasted on less promising lines).

We remind ourselves of Eric-Hans Kramer's clever insight (Kramer, 2007) that there is no perfect way of dealing with dynamic complexity - systems that are prepared to act and are able to make sense of their experiences and are able to discredit their existing insights are better able to deal with dynamic complexity than others.

Essentially, oversimplifying complex problems is dangerous and can mislead an analyst to offer a detrimental judgment (Fleisher and Bensoussan, 2007). Parsimony is a virtue for theorists, but a vice for storytellers (Thiele, 2006) - the rich detail of narrative provides judgment its key resource. Narrative is not forged from thinly articulated generalities, but from the thick description of specific circumstances that house distinctly specific opportunities and obstacles (Thiele, 2006). It takes a complex sensing system to register (and regulate) a complex object (Weick, 1995). Starbuck and Milliken's reference to "perceivers who understand themselves and their environments" reaffirms the importance for sensemaking of complex sensors with sufficient variety to comprehend complex environments (Starbuck and Milliken, 1988) (Weick, 1995).

While it is not naive or unreasonable to try to encompass most of another's behavior under a very few rules, the more complete information available later usually shows that the behavior was the product of more numerous and complex forces than contemporary observers believed (Jervis, 1976). And, more important from our standpoint, *the predictions that the highly oversimplified model yields are often misleading* (Jervis, 1976) - hindering our aim to develop a system that will enable us to sense change earlier and respond to it more rapidly than our opponent (Haeckel, 1999). Ashby (Ashby, 1962) goes so far to say that any quantity K of appropriate selection demands the transmission or processing of quantity K of information - there is no getting of selection for nothing. For example, a simpler evaluation heuristic might need to be coupled with a "pruning" method which requires the examination of many, many positions to determine effective cut-offs. There is no getting of selection for nothing.

Ashby goes about explaining his own theory of the origin of adaptation (Ashby, 1960) - noting that theories are of various types. At one extreme is Newton's theory of gravitation - at once simple, precise and true. Darwin's theory of evolution, on the other hand, is not so simple. Ashby simply states, as we now do in this work, that the type of theory proposed is of the latter type.

For Pfaff, the mechanism of alertness or *arousal*, which moves an entity toward readiness for action (from a state of inactivity), provides the fundamental force for activity and responsiveness (Pfaff, 2006) - we feel a little complexity in this area has a greater payback in terms of reducing the required exploration space in the exponentially grown tree of possibilities. A more complex sensor permits us to make finer distinctions (among the cues present in a position) in order to determine (strategically) which lines to postpone (or do a less thorough job of) exploration. The combinatorial explosion of possible game paths (from a given position) penalizes consequential exploration techniques which are not strategic - we simply do not have the time to examine every path in detail. We will settle instead on a critical path and on strategic challenge lines - limiting our attention when our diagnostic tests of sustainability return an acceptable margin for risk for the unlikely continuations.

Browne, looking at the future sustainability of cities (Browne, 2006), points out that current indicator methods often fail to: 1. Integrate the complex issues intrinsic in sustainable development in a *holistic* sense 2. Model the complex dynamics of systems 3. Represent the reality of the situation and 4. Model the "environmental implications". Each of these shortcomings points to a possible consideration of sets of more complex indicators. The need for accurate sustainability assessment methods is urgent, as (prioritized) defensive expenditure and information awareness should be focused on the least sustainable sectors (Browne, 2006).

We might pause to examine the "Ockham's Razor" itself by considering the (somewhat sharp) ideas of Gernert. The principle of simplicity (no matter in which version) does not make a contribution to the selection of theories (Gernert, 2007). Beyond trivial cases, the term *simplicity* remains a subjective term. What is compatible with somebody's own pre-existing world-view, will be considered simple, clear, logical, and evident, whereas what is contradicting that world-view will quickly be rejected as an unnecessarily complex explanation and a senseless additional hypothesis. In this way, *the principle of simplicity becomes a mirror of prejudice*, and, still worse, a distorting mirror, since this origin is camouflaged (Gernert, 2007). We agree with Gernert that the principle of that honorable medieval philosopher (who mainly opposed an unjustified creation of new terms in philosophy) should not be misused as a secret weapon destined to smuggle prejudice into the discussion and to easily dismiss unwelcome concepts.

The alternative view is presented by (Gunderson et al., 2010), who declare that experience has suggested to be as ruthlessly parsimonious and economical as possible *while still retaining responsiveness to the management objectives and actions appropriate for the problem.* Additionally, we are advised that the variables selected for system description must be *the minimum that will capture the system's essential qualitative behavior in time and space.* We are further cautioned that the initial steps of bounding the problem determine whether the abstract model will usefully represent that portion of reality relevant to policy design. We must therefore aim to simplify, but not so much as to impact the usefulness of the tool for predicting promising paths of exploration. We hypothesize that the use of competition itself as an aid in constructing the measurement model will allow complexity to grow as long as overall tournament performance does not decrease.

Starbuck and Milliken (Starbuck and Milliken, 1988) essentially have it both ways - declaring that *sensemaking* and *noticing* interact as complements in effective problem solving: sensemaking focuses on subtleties and interdependencies, whereas noticing picks up major events and gross trends. Noticing determines whether people even consider responding to environmental events. If events are noticed, people make sense of them; and if events are not noticed, they are not available for sensemaking.

For Heylighen (Heylighen, 1991), it is missing the point to consider only simple heuristics. The larger the variety of *potential perturbations* faced by an entity, the larger the variety of *compensations* the system must be capable of executing. This can be understood from Ashby's (1958) *Law of Requisite Variety.* We should in fact be seeking to increase the variety of disturbances that must be regulated against or paid attention to by our opponent (Ashby, 1957). Only variety can destroy variety (Ashby, 1957), which for Ashby is fundamental in the theory of regulation. We feel that simple heuristics might not allow the full effects of trial and error exploration, allowing an opponent to create a position with more variety of critical strategic response, leading indirectly to more (emergent) adaptive capacity.

It's the law of requisite variety, which says that if you want to make sense of a complex world, you've got to have an internal system that is equally complex. - Karl E. Weick

For Ashby, an adapted organism must be guided by information from the environment and must seek to control its essential variables. This proceeds by trial and error, or by vicarious trial and error, when we predict what the exploratory outcome might be by using knowledge itself arrived at by previous trial and error explorations. Adaptation by trial and error is sometimes treated in psychological writings as if it were merely one way of adaptation, and an inferior way at that. For Ashby, the method of trial and error holds a much more fundamental place in the methods of adaptation. When the organism has to adapt (to get its essential variables within physiological limits) by working through an environment that is of the nature of a Black Box, then the process of trial and error is necessary, for *only such a process can elicit the required information* (Ashby, 1960).

Knowledge for Heylighen can be defined as *the ability to choose adequate actions from the repertoire*, where "adequate" means *securing the survival of the system within its environment.* When an entity attempts to cope with a complex environment, its cognitive control mechanism will have to represent (as much as possible) the features of the environment that are relevant for survival. To suggest that only simple approaches are relevant for survival in a game (and to be dismissive of more complex approaches) is to suggest that simple approaches can counter any complex feature necessary for survival, or that these more complex features cannot be exploited or successfully leveraged for advantage. Specifically, we feel that a more complex heuristic might find use in a more complex strategy for building adaptive capacity - which we in fact will outline later. We remind ourselves of Heylighen's clever speculation (Heylighen, 1991) - the fact that a controlled sequence of combinations can be *generated* and *explored as to its consequences* might be defined as rationality - our mission now becomes the refinement of the "generation" and "exploration of consequences".

Perhaps what we should aim to minimize instead is the *minimum of total information* (Lloyd, 1995) - a learning process which minimizes total information can be shown (Lloyd declares) to be the maximum likelihood model (Lloyd, 1995), the most concise and arguably make the best possible prediction given data.

We will be measuring adaptive capacity, which critically will be accomplished by performing diagnostic tests of our ability to coordinate our forces to simultaneously attack our opponent while resisting his or her attacks on our position. This will involve "stress testing of the position", and responding to those parts of the position which are (or can become) *vulnerable.*

10 Vulnerability

Critical to the success of a computer chess program that attempts to play in the positional style is the concept of vulnerability. The pieces and structures that are or have the potential to become vulnerable will at least be *noticed* as we pursue our diagnostic exploration efforts and strategically estimate *adaptive capacity.*

We follow (McCarthy et al., 2001) and conceptualize vulnerability as a function of exposure, sensitivity, and adaptive capacity. Consequently, the sensor we develop should attempt to measure exposure to threats, the sensitivity to the effects of stimuli, and the ability to adapt and cope with the consequences of change. We envision a sensor that produces a forecast of potential vulnerability as an output. This forecast can guide exploration efforts by identifying targets for the useful application of stress and serve as one indicator of a promising position.

Additionally, we predict that any machine-based attempt to zero-in on vulnerability that does not address this conceptual base runs the risk of missing opportunities in exploring the exponentially growing tree of possibilities that exist for each game position. A missed opportunity might equally prevent us from increasing positional pressure on our opponent, or instead, might dissipate the pressure that we have carefully accumulated over time. Our orientation/evaluation of the winning chances present in the position might not be as accurate as it could be unless we explore the promising positions and consider the vulnerabilities that are present.

We conceptualize that the reduction of vulnerability and the pursuit of sustainable development are interrelated aims (Smith et al., 2003).

11 Resilience

When something unexpected happens, it is resilience we fall back on - resilience provides the capacity to sustain strategy change (Välikangas, 2010). Vulnerability is the condition that makes adaptation and resilience necessary as a mitigation (Worldwatch, 2009). The scientific study of resilience began in the 1970s when Norman Garmezy studied well-adapted children who had overcome the stress of poverty (Lukey and Tepe, 2008). Resilience is also an important research area in military science (Friedl, 2007) and in the study of ecosystems (Folke et al., 2002). We find this concept useful in game theory.

In our view, adapted from (Luthar, 2003), resilience refers to an ongoing, dynamic developmental process of strategically positioning resources that enables the player in a game to negotiate current issues adaptively. It also provides a foundation for dealing with subsequent challenges, as well as recovering from reversals of fortune.

We desire a generic, continuous ability (both during crisis and non-crisis game situations) to cope with the uncertain positions that arrive from beyond our planning horizon.

We desire a generic, continuous ability (both during crisis and non-crisis game situations) to cope with the uncertain positions that arrive from beyond our planning horizon. Ideally, we seek to create a useful positional pressure to force these arriving positions to be in our favor, or minimally, to put a "cage" of constraints around the enemy pieces. Flexibility, adaptive capacity, and effective engagement of available resources will be our weapons against the dynamic changes which will unfold in our game (Hollnagel et al., 2008).

Ideally, we will look for and manage the heuristic early warning signs of a position approaching a "tipping point", where a distinct, clear advantage for one side emerges from an unclear array of concurrent piece interactions. We agree with (Walsh, 2006) that resilience cannot be captured as a snapshot at a moment in time, but rather is the result of an interactive process that unfolds over time.

The failure to include resilience measurements like this in planning efforts might cause a house-of-cards effect, as the weakest link in our plan might collapse, due to effects we cannot initially perceive. This might create a situation from which we cannot recover, or from which we cannot continue to mount increasing positional pressure on our opponent.

A central concept is the construction of a *resilient position*, one that ideally 1. possesses a capacity to bounce back from disruption in the event of an unforeseen move by our opponent, 2. produces advantageous moves in light of small mistakes by our opponent, or 3. permits us to postpone our diagnostic exploration efforts at early points for less promising positions, with greater confidence that we have sufficient resources to handle future unforeseen developments if the actual game play proceeds down that route. In simplest form, we might just measure the ability to self-organize.

When change occurs, the components that make up resilience provide the necessary capacity to (minimally) counter and (ideally) seize new opportunities that emerge (Folke et al., 2002). Resilience is (minimally) insurance against the collapse of a position and (ideally) an investment that pays dividends in the form of better positions in the future. With no pun intended, we see the struggle to control the unknown, emerging future positions as a "Red Queen's Race", where in tough-fought games against a talented opponent, it might take all the effort possible to maintain equal chances. Extraordinary efforts involving hundreds of hours of analysis *per move* (such as in correspondence games) might be required to maneuver to an advantage (Jerz, 2007).

For (Reivich and Shatte, 2002), resilience is the basic strength. (Hollnagel et al., 2006) suggest that "incidents", which for us might be the construction of short sequences of just the top few promising moves (diagnostic probing), might reveal insight to boundary conditions in which resilience is either causing the system to stretch to adapt, or buckle and fail. Emergency response teams use practice incidents to measure resilience as unforeseen events emerge during operations. Fire drills, random audits and security searches, even surprise tests are diagnostic tools used to detect and correct situations lacking in resilient capabilities.

We speculate that the ability to construct a resilient position and the ability to perceive oriented stress in a position are two primary conceptual differences between a game-playing man and machine.

We acknowledge the reality that our ability to handle an unexpected move or critical situation in a game depends on the structures already in place (Weick and Sutcliffe, 2007). We desire (Weick and Sutcliffe, 2007) to pay close attention to weak signals of failure that are diagnostic indicators of potential problems in the system. We also perform diagnostic probing to uncover and steer game play towards positions where there are multiple good moves - an additional sign of resilience.

We speculate that the ability to construct a resilient position and the ability to perceive oriented stress in a position are two primary conceptual differences between a game-playing man and machine. We believe that these abilities can be emulated through the use of appropriate diagnostic tests.

Humans construct resilient positions (in strategic situations) almost by instinct and often without conscious thought (Fritz, 2003), in diverse situations such as driving automobiles, playing sports games, conducting warfare, social interaction, and managing resources in business or work situations. Humans have such refined abilities (Laszlo, 1996) to make predictions, interpret clues and manipulate their environment, that using them is frequently effortless, especially if performed daily or over extended periods of time. (Aldwin, 2007) points out that humans appear to be hard-wired physiologically to respond to their perceptions of stress - so much so that effective responses can be generated continuously with little conscious thought. We therefore see the machine-based perception of stress as critical to successful performance in a game.

Additionally, much has been written (Fagre and Charles, 2009) (Folke et al., 2002) concerning ecosystems, resilience, and adaptive management that has direct application to game theory.

Conceptually, we desire the equivalent of a "mindset" that can successfully cope with problems as they arise, as we attempt to 1. examine the promising positions, 2. evaluate the corresponding winning potential and 3. orient our diagnostic exploration efforts through an exponentially growing "tree" of strategically important move sequences. This process is aided by the heuristic measurement of adaptive capacity, as the thousands of unexamined positions that lie just beyond the point of our diagnostic exploration cut-offs must be resilient enough to counter whatever unknown events emerge. Before we cut-off our diagnostic exploration efforts, we critically seek evidence of *readiness*, which depends on the perceived ability to quickly adopt, adjust, or abandon initiatives and investments once new conditions materialize (Beckham, 2002). Readiness describes an organization that can be viable across a variety of conditions (Beckham, 2002).

Rather than thinking about resilience as "bouncing back" from a shock or stress, it might be more useful to think about "bouncing forward" to a position where shocks and stresses have less effect on vulnerabilities (Walsh, 2006) (Worldwatch, 2009). Integral to the definition of resilience are the interactions among risk and protective factors (Verleye et al., prepub) at an agent and environmental level. Protective factors operate to protect assets, such as pieces in a game, at risk from the effects of the risk factors.

We agree and conceptualize that, while risk factors do not automatically lead to negative outcomes, their presence only exposes a game-playing agent to circumstances associated with a higher incidence of the outcome; protective or mitigating factors such as constraints can contribute to positive outcomes - perhaps regardless of the risk status.

We accept as an operational concept of resilience, the fourth proposal of Glantz and Sloboda (Glantz and Johnson, 1999), which involves the adoption of a systems approach. We consider both positive and negative circumstances and both influencing and protecting characteristics and the ways in which they interact in the relevant situations. Additionally, this conceptualization considers the cumulation of factors and the influences of both nearby and distant forces. In addition, (Elias et al., 2006) discuss a model of resilience in which specific protective influences (which we see as constraints) moderate the effect of risk processes over time, in order to foster adaptive outcomes.

We propose (Gunderson et al., 2010) an approach based on resilience, which would emphasize the need to keep options open, the need to view events in a larger context, and the need to emphasize a capacity for having a large number of structural variations. From this we recognize our ignorance of, and the unexpectedness of future events. The resilience framework does not require a precise ability to predict the future, but only a capacity to devise systems that can absorb and accommodate future events in whatever unexpected form they may take. If we could cram

MacGyver into our software, we would certainly do so.

12 Inventive Problem Solving

Our chess program attempts to be, like MacGyver, an inventive problem solver. We see effective problem solving as an adaptive process that unfolds based on the nature of the problem, rather than as a series of specific steps (Albrecht, 2007). We agree with (Browne, 2002) that knowing the difference between what's important and what isn't is a basic starting point.

We attempt to navigate an exponentially growing tree of possible move sequences, selecting those paths for exploration that are promising, interesting, risk-mitigating, and resilient in the face of an unknown future. We are concerned at all times with the potential of a position to serve as an advancing platform for future incremental progress towards positional goals (Fritz, 2007). We will accomplish this by knowing the outcomes we want and looking tirelessly for them. (Savransky, 2000) lists three major requirements for a problem-solving methodology, which we modify slightly for the purposes of a machine playing a game:

1. It should focus on the most appropriate and strongest solutions

2. It should produce, as an output, the most promising strategies

3. It should acquire and use important, well-organized, and necessary information at all steps of the process

(Savransky, 2000) additionally suggests that we should focus on gathering the important information, information which characterizes the problem and makes it clear, including contradictions. Any simplifications we perform should aim at reducing the problem to its essence and be directed towards our conceptual, strategic solution.

As an example, typical American news reports each day announce the results of the *Dow Jones* index of stocks. This weighted index of 30 representative companies serves as a good indicator of overall market performance and can help answer the question "How did the markets do today?". To obtain this numerical value, you just sum the prices of each of the 30 specific companies and divide by a number which takes into account stock splits and stock dividends.

We seek an equivalent summary numerical representation of reality (March, 1994) which can serve as a guiding light and a measure of progress towards our distant positional goals. We are not restricted to the use of a single scoring metric, and can combine multiple, critical metrics in creative ways, including the selection of the lowest score from several indicators to provide a diagnostic exploration focus. We should first form a concept of what should be measured, then create a *sensor array* which allows us to measure and perform diagnostic exploration efforts (in an exponentially growing tree of possible continuations) with reasonable efficiency.

13 Strategy and the Strategic Plan

I do not claim that strategy is or can be a "science" in the sense of the physical sciences. It can and should be an intellectual discipline of the highest order, and the strategist should pre-

pare himself to manage ideas with precision and clarity and imagination...

The core of strategy work is always the same: discovering the critical factors in a situation and designing a way of coordinating and focusing actions to deal with those factors (Rumelt, 2011). A good strategy honestly acknowledges the challenges being faced and provides an approach to overcoming them (Rumelt, 2011). Strategy is about action, about doing something. The coordination of action provides the most basic source of leverage or advantage available in strategy (Rumelt, 2011). A *new* strategy is, in the language of science, a hypothesis, and its implementation is an experiment. Practically, our hypothesis is built on functional knowledge about what works, what doesn't, and why (Rumelt, 2011). Meaningful action (Kramer, 2007) can therefore be described as acting on the basis of hypotheses, which implies acting on the basis of fallible, partial, and preliminary knowledge of the environment.

...Thus, while strategy itself may not be a science, strategic judgment can be scientific to the extent that it is orderly, rational, objective, inclusive, discriminatory, and perceptive. -J.C. Wylie

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We feel that strategy will forever struggle to become a true science because it is, at its core, the collection and study of what are essentially *tricks and the circumstances under which they might work*. From merchants displaying merchandise in stores to a basketball player faking left then moving right, to an American football quarterback pumping the ball, then running down field, we feel that strategy involves a consideration of multiple methods that might work, derived from experience, theory, observation, or play, then the selection of one or more based on cues or side information which hint that *one* might be more effective than *another*. One might refer to the trick selection method (and the make-up of the tricks themselves) as *knowledge* - which practically is anything deemed to be potentially useful in determining how to "go on".

We follow Beckham (Beckham, 2000) and Wylie (Wylie and Wylie, 1989) and define strategy as *a plan for using leverage to get from a point in the present to some point in the future in the face of uncertainty and resistance.* We concur that without a future that involves some uncertainty and resistance, there is no need for a strategy. A strategy has lasting power - its *effects* are sustained over a time *horizon* (Beckham, 2000). Strategy is a kind of investment in that it aims to create or sustain significant value. Strategy deals with the important in a way that is deemed necessary for sustainable success.

Leverage is critical for Senge (Senge, 1990), as the leverage in most management situations lies in understanding dynamic complexity, not detail complexity. Dynamic complexity arises when cause and effect are distant in time and space, and when the consequences over time of interventions are subtle and not obvious.

More specifically, Rumelt (Rumelt, 2011) declares that a strategy is a coherent set of analyses, concepts, policies, arguments, and actions that respond to a high-stakes challenge. For Rumelt, the kernel of a strategy contains three elements: a diagnosis, a guiding policy, and coherent action. A strategy is a way through a difficulty, an approach to overcoming an obstacle, a response to a challenge. If the challenge is not defined, it is difficult or impossible to assess the quality of the strategy (Rumelt, 2011). A good strategy doesn't just draw on existing strength; it creates strength through the coherence of its design. The most basic idea of strategy is the application of strength against weakness (Rumelt, 2011).

The only kind of strategy that makes sense in the face of unpredictable change is a strategy to become adaptive... the real objective: successful and systemic adaptation. Adaptation implies more than agility. It requires appropriate organizational response to change. And when change becomes unpredictable, it follows that the appropriate response will be equally so. In this environment, therefore, planned *responses do not work. -Stephan Haeckel*

Anyone or anything lacking a strategy is undertaking a journey without a map. Its actions will be an incoherent series of ad hoc and perhaps mutually conflicting responses to new events (Murphy, 2005). A competing entity's competitive capability depends upon the resources at its disposal and how efficiently they are used. Winners need to combine a sound strategy with a fitting level of resources - they must also correctly identify the *critical success factors* for the environment in which they choose to compete (Murphy, 2005). A strategy delivers significant improvements in the key indicators of success (Beckham, 2000). We need to get into a loop linking action, perception and thinking towards continual learning. An effective strategy is one that triggers our successful launch into that learning loop (van der Heijden, 2005). From a scenario planning point of view, the best strategy is the one that gives the organization the greatest degree of flexibility. As the future takes shape (whichever future it happens to be), we will want room to maneuver (Wade, 2012).

We see a strategic plan (Bradford et al., 2000) as a simple statement of the few things we really need to focus on to bring us success, as we define it. It will help us manage every detail of the game-playing process, but should not be excessively detailed. It will encapsulate our vision and will help us make decisions as we critically choose, or choose not, to explore future positions in our diagnostic exploration tree. We see the formation and execution of the strategic plan as the most effective way to get nearer to the goal state, especially in a competitive environment where our opponent is also attempting to do the same. The simple principles that govern strategy are not chains but flexible guides leaving free play, in situations that are themselves enormously variable (Castex and Kiesling, 1994). Wylie's general theory of strategy, applicable in any conflict situation, is a worthwhile starting point and overall guide (Wylie and Wylie, 1989).

We see the role of the machine as merely that of an executor of a strategic plan... we simply ask the machine to do what it is told.

We see the role of the machine (in playing a game such as chess) as merely that of an executor of a strategic plan, where we have previously defined (through programmed software instructions) the specific answers to the questions "Where do we want to be?" "How will we know we have reached it?" "What is changing in the environment that we need to consider?" "Where are we right now?" and "How do we get from here to our desired place?" (Haines, 1998). In our vision, the intelligence is located in the strategic answers to these questions and in the skill of the programmer in implementing them - we simply ask the machine to do what it is told. We borrow a cleverism from Foucault and declare that the machine "cares" about what it does - mostly loading, storing, adding, comparing, branching, and logical operations on chunks of data *on command* - it just does not "care" (or understand) what *what it does* does.

computers... cannot understand symbols (or indeed anything else either), though they can manipulate symbols according to formal rules with consummate speed and accuracy, far surpassing our own fumbling efforts... they do not understand the questions they are asked or the answers they provide. - Richard Gregory

If one game-playing computer program is better than another, as demonstrated in a tournament of many games played, we speculate that the reason is either a better strategic plan or a better software implementation of that plan. Therefore, improvements in computer chess programs ideally should focus on these two areas, including answers to the questions presented above. For Haines, all types of problems and situations (which include selecting a move in a game) can benefit from a strategic approach.

Before we develop our strategic plan, we ask ourselves and ponder three critical questions (Jorgensen and Fath, 2007): 1. what are the underlying properties that can explain the responses we see on the game board to perturbations and interventions, 2. are we able to formulate at least building blocks of a management theory in the form of useful propositions about processes and properties, and 3. can we form a theory to understand the playing of chess that is sufficiently developed to be able to explain observations in a practical way for choosing a move? We do not see the need to construct mathematical proofs - the autonomous, skillful, rational action we desire is its own explanation (Shotter, 1980). The concepts of useful propositions and effective strategic principles allow us flexibility in choosing an approach and allow us to consider multiple options before settling on one with the most promise. We return to these critical questions whenever we seek direction or clarification in an approach, or consider starting over. We look to other disciplines - as suggested by (Boyd, 1987) - and to other professionals who have sought answers to the same questions, which must be asked in a general way to any management problem.

Central to our strategic plan are the following concepts (Jorgensen and Fath, 2007): system behavior frequently arises out of indirect interactions that are difficult to incorporate into connected models, that we may not know exactly what happens, but approximately what happens, and that we can use holistic metrics to measure the growth and development of a position in a game.

A vision involves... "anticipative shaping" that seeks to discern not only the powerful currents of the future but also how those currents can be leveraged... it's foolhardy to assume you can control the future... The future will consist of powerful flows that, like the weather, can be leveraged and ridden but can never be controlled...

We acknowledge that systems have a complex response to disturbances, and that constraints play a major role in interactions. As a strategy we seek a method to determine (and to resolve uncertainty concerning) 1. the promising candidate moves in a given position, and 2. the chances of sustainable development in a position, allowing us to postpone (if necessary) the exploration of future consequences.

...Trips to the future begin with a struggle to see and understand these powerful currents: their general direction, their power, and where they may collide and coalesce. - J. Daniel Beckham

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In a building block for our strategic plan, we examine the position under inspection for the presence of *stressors* (Glantz and Johnson, 1999) and determine their contribution to the *cumulative stress* in the position. A *stressor* is a real object on the game board, such as a piece, or an object or property that might become real in the future, such as a Queen from a promoted pawn, a stone in the game of Go, or a King in the game of draughts/checkers. Using our stressors, we seek to establish a *structural tension* (Fritz, 1989) that, if resolved, leads to positions that favor us.

In a building block for our strategic plan, we examine the position under inspection for the presence of stressors*... We attempt to cope with the stressors of our opponent by weakening them or reducing their influence to a manageable level*

The stress we seek to place on our opponent (Glantz and Johnson, 1999) is the kind that interferes with or diminishes the development of our opponent's coping repertoire, diagnostic exploration and planning abilities, expectations and potential resilience. This stress is ideally so effective that we create a platform from which we can apply even more stress. We force our opponent to divert additional resources to containing our threats, making fewer resources available for threats of his own.

We attempt to cope with the stressors of our opponent by weakening them or reducing their influence to a manageable level (Snyder, 2001) - there is no compelling need to make their effects go away completely. For (von Bertalanffy, 1968), stress is a danger to be controlled and neutralized by adaptive mechanisms. We gather diagnostic information that is used to determine the readiness of the pieces to inflict stress on the opponent and lessen the stress imposed by the enemy pieces on our weak points. The creation of effective stress and the perceived mobilization of forces to mitigate it will become a central concept in our orientation/evaluation.

Our orientation/evaluation looks not so much to goal seeking/optimizing a "score" as to sustaining relationships between/among the pieces and learning what happens as stress is moved from one area of the board to another. What is relevant cannot be known until later. The kinds of predictions we most want to make, we feel, require us to first determine which of all the things that might happen in the future will turn out to be relevant, in order that we can start paying attention to them now (Watts, 2011). We acknowledge openly (Watts, 2011) that there are limits to what can be predicted - we therefore seek to develop methods for planning that respect those limits.

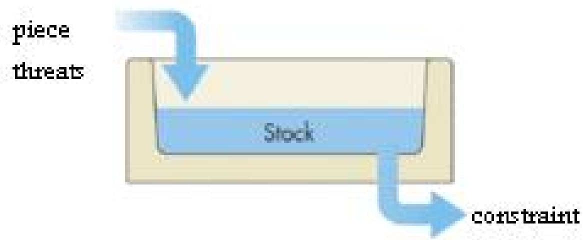

Figure 1: Simplified model (dynamic hypothesis) of positional pressure for each piece

Figure 1 shows a simplification of the proposed model of positional pressure for each piece, based on principles of system dynamics. The future mobility of each piece targets opponent pieces, the trajectories taken by these pieces, and certain other weaknesses such as weak pawns, the opponent's king, or undefended pieces. This threat is mitigated (but not reduced completely) by the *protective factor* of constraints imposed by the lower-valued enemy pieces. The residual "Stock" is the effective stress that can be felt by our opponent, and which we seek to increase. For (Warren, 2008), the management of critical resources is part of an emerging theory of performance: performance depends on resource contribution, resource contribution accumulates and depletes, and this depends on existing resource contribution levels.

Figure 2 shows the plan for managing the perceived stress by incentivizing a coping strategy, such as the placement of constraints, in order to control the effects of the overall cumulative stress. We seek to maintain a resilient position full of adaptive capacity.

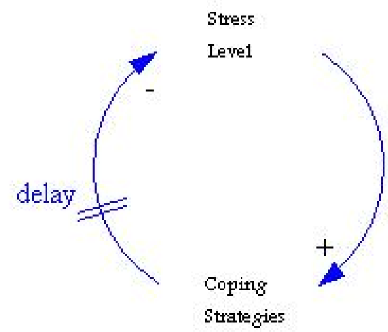

Figure 2: As perceived stress increases, we increase the incentive to cope with the stress

Things start to get complicated when we remove stress (and the associated constraints) from one area of the board and apply it to other areas. The short- and long-term effects of these stress-exchanging maneuvers are examined through oriented and prioritized diagnostic exploration efforts, and in our opinion represent the essence of playing a game such as chess. This conceptual model will form the basis of the machine's perception. We rely on the simplifying principles of system dynamics to predict and anticipate the effects of such stress transformation.

From (Friedl, 2007) we define a *stressor* as any challenge to a player in a game that evokes a response. *Coping* is the set of responses that sustain performance in the presence of stressors. *Resilience* is the relative assessment of coping ability. We desire to create in our opponent's position a condition similar to *fatigue*, defined by Friedl (and modified for game theory) as the state of reduced performance capability due to the inability to continue to cope with stressors. We follow Fontana (Fontana, 1989) and define *stress* as a demand made upon the adaptive capacity of a player in a game by the other. We theorize a correlation between the state of stress-induced reduced performance capability and an "advantage", or favorable chances for the more capable player winning the game.

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we are dealing with a process whose effects take time in revealing themselves

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Strategically, we seek to identify the stress present in the position by 1. examining the demands of each stressor, 2. the capacity of each player to respond to those demands, and 3. the consequences of not responding to the demands.

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we will predict the winning chances at some future point in time, after the present circumstances progress and the structures in place are allowed to unfold

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We carefully define *weakness* so that the stress and tension we create is focused and effective. The information we gather from the interacting pieces should be precise enough to get results - it does not need to be perfectly accurate. Information is power (Bradford et al., 2000), especially in strategic planning. Along the way, we will need to make assumptions about whether or not the stress we are inflicting on our opponent is increasing or decreasing, and whether it is effective or not effective. We might explore promising paths in detail to confirm our assumptions, or we might just rely on our measurements of resilience.

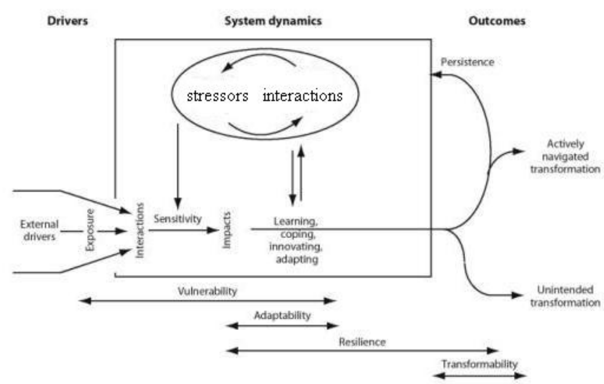

Figure 3: Conceptual Framework, from Chapin, 2009, p.21

Critical is our ability to orient our diagnostic exploration efforts on lines that are promising, with regard to the oriented application of stress and the predicted effects on future lines of play. In our opinion (Schumpeter, 2008), we are dealing with a process whose effects take time in revealing themselves - we will predict the winning chances at some future point in time, after the present circumstances progress and the structures in place are allowed to unfold, including the newly emergent features which we are not currently able to perceive. We establish a portfolio of promising lines, and see where they go. We invest our time and processor resources in the *most* promising, but only after investigating the promising via a swarm of lower-risk experiments (Hamel and Välikangas, 2003). We define a concept of stress which lets us orient our diagnostic exploration efforts on anticipated promising lines. We rely on the promise of adaptive capacity present in resilient positions to sustain our efforts in lines where the perception of weaker cumulative stress, time constraints, and our model of purposeful activity do not permit us to explore.

We theorize that the dynamic forces of change during the playing of a game have an adaptation cost associated with them (Kelly and Hoopes, 2004) (Zeidner and Endler, 1996). This might come from a shift in expectations, or from a required recovery from disruptions. We make "payments" for these adaptation costs from our "bank" of resilience. If we lose our positional resilience, we lose our flexible ability to adapt to the unknown requirements of change. Likewise, we can make "deposits" to our resilience account during quiet periods of maneuver, if we choose, and if we value resilience as an element of our orientation/evaluation methodology. Friedl (Friedl, 2007) refers to this concept as *pre-habilitation*. We seek to attack our opponent's capacity to respond and to strengthen our own, so that the dynamic forces of change that drive the game continuation will cause the unknown positions arriving from beyond our planning horizon to be in our favor.

We seek a resilient mindset. Specifically, we follow Coutu (Coutu, 2003) and aim for three fundamental characteristics: we identify and face the reality of the stresses and constraints present in the positions we evaluate, we identify and reward the values of positional chess, and we develop an ability to improvise solutions based on whatever resources are available to us. We seek to prepare for an unknown future that can be influenced by the strategic placement of resources in the present.

A strategic thinker never allows himself to lose sight of the key factors... he will shape his strategy - a strategy not for total war on all fronts but for a limited war on the fronts defined by the key factors for success... it is this focus on key factors that gives the major direction or orientation to the operation we call strategic thinking -Kenichi Ohmae

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In the generalized exchange of pieces, squares, and opportunities encountered in game playing (Botvinnik, 1970), we seek to establish a pressure that has a realistic chance to resolve in our favor, as determined by heuristic probing and the examination of promising future game sequences. We desire to create and sustain a web of stress which threatens to become real and therefore has the property that (von Neumann and Morgenstern, 1953) have called "virtual" existence. Our opponent must "spend" or dedicate resources to contain or adapt to the threats. Even if a particular threat is contained, it nevertheless has participated in the dynamic shaping and influencing of the events that emerge and unfold in the game.

We will succeed at forming an effective strategic plan when we have identified our values, determined the key drivers to performance, developed a sensor which is effective at measuring them, and have focused on the lines of play that are promising. At all times we wish to maintain a resilient position, which increases our ability to effectively handle the unknown positions which lie beyond the horizon of our explorations.

We will use two key strategies (Maddi and Khoshaba, 2005) to become and remain resilient: we will develop the vision to perceive changes in the promise of a position (as they emerge from our heuristic explorations), and we seek flexibility to act quickly, while remaining focused on our goals of establishing and maintaining a useful structural tension. We seek (Kelly and Hoopes, 2004) a balanced portfolio of resilience skills, where ideally we are focused, flexible, organized, and proactive in any given situation.

We believe that resilient responses (Kelly and Hoopes, 2004) are the result of resilience characteristics operating as a system, as we evaluate and predict the emergent results of change.

Following Jackson (Jackson, 2003), *we avoid placing a complete reliance on specific predictions of the future*, concentrating on relationships, dynamism and unpredictability as much as we do on determinism. In our plan, we will adapt as necessary and seize new opportunities as they emerge from the "mess". We seek to focus on identifying and managing the structures that will drive the behavior of the game, and acknowledge the reality that large portions of the future possibilities will go unsearched and unexplored (until they emerge from beyond our planning horizon and into our perception). As we deepen our exploration and learning, we see new opportunities emerging as much for us as for our opponent, and requiring us to re-direct our diagnostic exploration (and planning) efforts. We see the widest possible spectrum of adaptive responses competing for the fittest solution (Bossel, 1998). Diversity is an important prerequisite for sustainability.

Where possible, we follow the advice of French military strategist Pierre-Joseph Bourcet (Alexander, 2002) and spread out attacking forces over multiple objectives, forcing an adversary to divide his strength and prevent concentration. Such divided forces - a "plan with branches", can be concentrated at will, especially if superior mobility is present, as recommended by French military strategist Guibert. As an end result of all this positional pressure and maneuver, we seek what Napoleon sought, that is (Alexander, 2002), the nature of strategy consists of always having (even with a weaker army) more forces at the point of attack or at the point where one is being attacked than the enemy. Such positions have the possibility of the win of material, and are then approached from a more tactical perspective - one that current heuristics handle well.

From a high level, we visualize the opponent's pieces in the game of chess as a network, and agree with Wilson (Wilson, 2006) that the best way to confront a network is to create a counternetwork, a non-hierarchical organization capable of responding quickly to *actionable intelligence* obtained from diagnostic efforts. Networks are an essential ingredient in any complex adaptive system. Without interactions between agents, there can be no complexity (Beinhocker, 2007). Specifically, we see our pieces on the gameboard less as 'things' and more as 'doings' - intra-twined (Shotter, 2011), entangled with those of our opponent, and as participant parts within and of an indivisible, continually unfolding, stranded in possibility, flowing whole.

We aim for *control* (Wylie and Wylie, 1989) (Kelly and Brennan, 2010), defined by McCormick (McCormick, 2005) as (1) the ability to see everything in one's area of operation that might pose a threat to security and (2) the ability to influence what is seen. Our main efforts must be to establish dynamic control. Once control is established, the opponent becomes an ineffective fighting force - but only in the way a tiger becomes contained within the cage. Direct action does not provide control; control provides the ability to conduct effective direct action (Canonico, 2004). More specifically, we seek to manage the leverage in dislocating the enemy (Wylie and Wylie, 1989) (Palazzo et al., 2010) that leads to control, and to face up to the questions surrounding how influence and the threat of destruction lead (dynamically, now or later) to the control we seek.

Dennett's *intentional strategy* (Dennett, 1981) and *intentional stance* have an obvious application to playing the game of chess, yet are lacking in specific details. Dennett instructs us to treat the object whose behavior is to be predicted as a rational agent; you then figure out what beliefs that agent ought to have, given its place and its purpose. You then figure out what desires it ought to have, on the same considerations, and finally you predict that this rational agent will act to further its goals in the light of its beliefs. A little practical reasoning from the chosen set of beliefs and desires will in many instances, according to Dennett, yield a decision about what the agent ought to do. Even when the intentional strategy fails to distinguish a single move with a highest probability, it can dramatically reduce the number of options - a useful technique especially when considering the unknown effects of joint action. We are told to do what evolution has apparently done when designing humans, simply put together a "bag of tricks" - elegant and appealing to deep principles of organization or not - and hope that nature will be kind enough to let our device "get by" (Dennett, 1998). More on this later.

We strategize with Schoemer (Schoemer, 2009) that our success depends on changing quickly and effectively so that we can do what needs to be done in the future. Change is unpredictable - we can't know which changes will occur, so our most valuable skill is being able to master any changes that do. We need to learn how to master the inevitable, yet unpredictable, change we will face in playing our game. We seek to control the controllables - learning how to focus our time and energy on issues where we can make a difference and learning how not to waste our time and energy on problems we can't solve. We theorize with Schoemer that mismanaged change leaves us worse off than before, and results in even more change. We identify those things that we can control and then get busy controlling them (Schoemer, 2009).

We see the *indirect approach* as the most direct path to victory (Wilson, 2006) (Hart, 1991).

We cannot improve on the centuries-old observation that the secret of all victory lies in the organization of the non-obvious (Marcus Aurelius). To accomplish this, we follow (Maslow, 1987) and critically focus our attention on the unusual, the unfamiliar, the dangerous and the threatening, while seeking (from necessity, and for exploration purposes) to separate the dangerous positions from the safe.

We desire to create, in the words of Vickers (Allison and Zelikow, 1999) (Vickers, 1995), an *appreciative system*, where our value judgments influence what aspects of reality we care to observe, which in turn are influenced by *instrumental calculations*, since what we want is affected by what we think we can get. We seek to establish a readiness to distinguish and respond to some aspects of a system rather than others, and to value certain conditions over others. Central to this concept will be indicators which aim to measure *cause* rather than *effect*, and the gathering of *early knowledge* as the essence of preparation (Beckham, 2007). If our chess playing agent can successfully act as a rational actor, it is through the mechanism of an appreciative system that this is accomplished.

14 Competitive Intelligence Leads to Competitive Advantage

We see one factor above all others as contributing to the success (or failure) of the proposed heuristic: the gathering of useful *competitive intelligence*. Very simply, competitive intelligence is any information that tells us whether our position is still competitive, or how to make it more competitive (Gilad, 1994). The fundamental objectives of competitive intelligence are to avoid surprises and gain competitive advantage (West, 2001). Knowledge has value, but intelligence has power (Rothberg and Erickson, 2005). We follow Fuld and define intelligence as *a time-sensitive assessment that will direct someone to act* (Fuld, 2010). Gilad (Gilad, 1988) offers another useful definition: *processed information of interest to management about the present and future environment in which [a competing entity] is operating.*

For Fuld, *change* will occur and the future will not be the same as today. To prepare ourselves for that future, we look to signs of *early warning* (the ability to see into the future) in the form of *leading indicators*. Early warning consists of four very simple and ”intelligent” steps, which we adapt for our purpose: (1) drawing the road map of possible futures, (2) identifying the signals we need to watch for each of these futures, (3) constructing automated scripts to watch those signals in the course of a machine-played game analysis and exploration, and (4) making sure we create an approach to act quickly once one of the futures we have identified (as promising) begins to emerge (Fuld, 2010). We agree with Fuld that the signals are out there - we just need to construct a diagnostic indicator sensitive enough (but not prone to false alarms) to guide our exploration efforts. We ask not, ”Is this perfectly accurate?” But rather, ”Is this sufficient to make a good decision?” (Hooper and Scott, 1996).

We use competitive intelligence to reduce the risk that our exploration efforts will not be promising. We identify intelligence - not information - as helpful to us and our programmed machine in choosing these paths (Fuld, 1995). By actively seeking intelligence and learning how to use it, we hope to turn information into a powerful weapon that will give us a competitive advantage (Fuld, 1995) - information both valid and timely becomes war's most powerful weapon (Luttwak, 2001). Each competitor playing a game has virtually the same access to information. We envision, with Fuld, that the player that is more effective in converting available information into actionable intelligence will end up winning the game. Without intelligence, you may succeed in winning a battle or two, but you can't expect to win the war (Fuld, 1995).

Gilad (Gilad, 1988) explains how competitive intelligence translates into competitive advantage, which we modify slightly for the purposes of a machine playing a game. The purpose of the data collected is to enable the machine game-player to arrive at an assessment of the current situation on the board (in terms of its position) based on the key success factors. The birth of a strategy follows logically and chronologically the assessment of the situation. This, in turn, is based on the environmental intelligence picture provided by the competitive intelligence program. For Gilad, and for us, the better that input, the better the resulting strategy.

For a business example, one of us (JLJ) recently filled out a multi-question employee satisfaction survey from his current employer - STG Inc. This was necessary, we were told, "to continue to improve processes to help achieve our number 1 Critical Success Factor - to be recognized as one of the best places to work." The survey was actually conducted by another company hired for that purpose, in order to allow employees the ability to respond anonymously. We were told that "Once the survey closes, the data is analyzed, charts and graphs are created and recommendations are made by HR Innovative Solutions." When the period of time allowed for employees to complete the survey passed, we were then told the results - "The overall satisfaction rating (OSR) was X.XX out of 4.06;" (we were asked to keep the results proprietary, but they were very good) "an overall Satisfaction Rating of 3.71 is considered industry standard." One question we were asked was "What would make our company a better place to work?"

We see this example as competitive intelligence in action, supporting the analysis of successful achievement of critical success factors, which drive corrective actions. We can identify with Greene's position (Greene, 1966) that management doesn't care about intelligence sources, nominal costs of collection, or clever filing techniques; they want (reliable) answers to questions, and they want the answers promptly. Intelligence is, in every sense, a control system - the intelligence system keeps the competing entity on track with the external environment - with reality (Page, 1996). STG could have used an inexpensive method for the survey, such as e-mail or instructing managers to pass out forms and collect them. Employees might then be less than honest in their response, fearing that it could somehow be tracked back to them. STG management determined that an accurate (although likely expensive) survey was necessary to make precise changes to company policies in pursuit of achieving good results in chosen critical success factors.

We proceed now with Kahaner's first part of the intelligence cycle - planning and direction (Kahaner, 1997) - which involves a clear understanding of the user's needs (key success factors), and establishing a collection and analysis plan. What is essential here is knowing what needs to be known, at the moment it is needed for use (Rothberg and Erickson, 2005), and turning that knowledge into appropriate diagnostic action. Rockart (Rockart, 1979) defined Critical Success Factors as *the limited number of areas in which satisfactory results will ensure successful competitive performance for the individual, department, or organization.* Continuing, he felt that they are the few key areas where things must go right for the competitor to flourish. If results in these areas are not adequate, the organization's efforts for the period will be less than desired. We agree with Rockart that the critical success factors are areas of activity that should receive constant and careful attention from management. Specifically, the current status of performance in each area should be continually measured.

15 The Glance

Humans playing chess use their eyesight and the cognitive concept of *the glance* to take in the position of the pieces on the gameboard and their relations to each other, except in rare cases when playing blindfold is part of the rules. Even without temporally extended scanning, the eye (in a single glance) provides spatial information which can substitute for trial and error, which can lead to smooth, guided, object-consistent responses (Campbell, 1956). We seek a machine-based implementation of this concept.

The Glance is such a familiar concept that perhaps we ignore it in our day-to-day activity. Looking of all sorts remains one of the indispensable inroads into the surrounding world; we cannot do without it; the only question is how we assess it and, in particular, which forms of looking we choose to adopt (Casey, 2000).

For Casey (Casey, 2000), a glance takes in "a lot" and reveals a layout of surface. It brings us outside of ourselves and into the world we are in, specifically to information about this world. A glance can provide subtle insight and as such can be used as a source of leverage. It is by the glance that what is other than what we expect is allowed to interrupt our activity and become present.

The glance "gets us to the surface of things" (Casey, 2000) by a process much like random groping, from which symbols can be "noticed" or extracted. These symbols can be processed to (heuristically) determine a deeper health, or lack of health.

We will use the concept of the glance to bring to our attention information on the "health" of the position - information processed into transitory understandings and action guiding anticipations - knowledge of "how to go on". We are not seeking to explain anything (Shotter, 2011) - our task is simply to notice what has not been previously noticed before, and in doing so, to understand how it can be transformed.

For Shotter (Shotter, 2011), when one is searching for something with an already fixed idea of what that something is like, something can occur in a glimpse, a glance, a striking event, that is surprising, an 'otherness' that can change our behavior. One can use the image of a dog dozing, perhaps eyes half open, suddenly roused to attention, muscles clenched, growling, perhaps barking. We seek a similar concept - a broad-sweeping information-probe, gathering informative symbols which indicate or track sustainability, with triggers set to arouse and change the course of anticipated behavior. We glance out around ourselves in order to anticipate and encounter the sudden before it arrives wholly unbidden and blindsiding (Casey, 2000).

For Casey (Casey, 2000), the primary paradox of the glance is the fact that something so diminutive in extent and bearing can provide such far-reaching and subtle insight. We configure our glance to allow ourselves to be surprised by certain changing events in our environment, a surprise which will allow us to alter our anticipations of the next move in the game.

Additionally for Casey (Casey, 2000), the glance proves to be of inestimable value in coming to know the world as a full phenomenon - our burden can become light if only we accord to the glance a new respect and a new interest. The direction, the intentionality, of the glance is straight into things and and situations - gliding across their proffered surfaces - rendering them striking to the glancer. All of a sudden the glance occurs, an event stands out, something significant happens which we can react to (Casey, 2000).

Specifically, a glance will tell us if our game pieces are "working" and engaged, performing multiple, substitutable roles. The glance will gather the information for our indicators which will suggest the *strategic consequential explorations* which we will use to determine useful estimates of adaptive capacity. Very simply, we glance to determine how to 'go on' in our present position.

We further refine our concept of the glance in specific implementations called orientors.

16 From Orientors and Indicators to a Best Way Forward

The universal response to novelty in animal species is the "orienting response" - an appraisal initiating a chain of cognition aimed at finding the most finely tuned response (Goleman, 2005). One *orients* as an initial step in a strategy for creating coherent action, which Rumelt (Rumelt, 2011) sees as being preceded by diagnosis and the selection of a guiding policy. Once we have decided which issue is preeminent we are prepared to direct and constrain action. A guiding policy creates advantage by anticipating the actions and reactions of others, by reducing the complexity and ambiguity in the situation, by exploiting the leverage inherent in concentrating effort on a pivotal or decisive aspect of the situation, and by creating policies and actions that are coherent, each building on the other rather than canceling one another out (Rumelt, 2011).

For John Shotter (Shotter, 2012a), we must begin our investigations from *noticings*, when a *next step* different from the *usual next step* might be taken. Many of our difficulties in our practical lives are relational or orientational difficulties, to do with discovering how to 'go out' towards initially indeterminate aspects of our surroundings. The relevant anticipations are to do with sensing where we *might* go within our circumstances before actually going there (Shotter, 2012a). Difficulties of this kind cannot be solved by our thinking about them within a rational framework in order to arrive at a plan which we then attempt to put into action (Shotter, 2012a).

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knowledge... comes to be a practical matter of 'knowing one's way about' (where to go, what to do next), instead of being able both to 'picture' a future state of affairs and to argue convincingly in favor of acting to bring it into existence... One's task is, somehow, to offer possibilities to do with how to 'go on' in the present moment, not to lay down rules, principles, or laws stipulating that the future must follow lines drawn from the past. -John Shotter

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With relational or orientational difficulties we face a situation which is, at first, indeterminate for us - we must gradually feel our way forward, guided by the sensing of dis-satisfactions and satisfactions as we grope reflex-wise towards the final actualization of an appropriate action (Shotter, 2012a). The concreteness of the present is still emerging (Shotter, 2010). A *best way forward* ideally develops within our tentative exploratory movements (Shotter, 2012a). We transition from a state of "I don't know my way about" to "Now I know how to go on" (Wittgenstein, 2009). It is only *after* we discover a way of relating ourselves to our surroundings, a way of organizing or orienting ourselves to attend to certain aspects of our surroundings rather than others, that the data relevant to our achieving our goal can be brought to light (Shotter, 2008a). We agree with Shotter that it is the way in which persons look or listen that (in large part) determines what they will hear or see (Shotter, 2010). This is important because everything that we need to witness, if we are to understand the workings of our activities, lies open to view

(Shotter, 2010).

From a high level, if we are to respond appropriately to the unique events occurring around us, we agree with Shotter that we need (and therefore make as our goal) to re-relate ourselves to these unique events in such a way that they arouse in us the uniquely appropriate *transitory understandings* (that give us a sense of where we stand) and *action guiding anticipations* (that give us a sense of 'where we might go next') that can enable us to 'go on' to respond to them appropriately (Shotter, 2005a). Our difficulty is not that of finding the solution, but rather that of recognizing as the solution something that looks as if it were only a preliminary to it (Wittgenstein, 1981). The way to 'go on' can be found here. From within our participatory immersion in the interplay of outgoing and incoming activity (occurring between ourselves and the others and othernesses around us), 'striking,' 'touching,' or 'moving' differences spontaneously emerge. They can provide us with both an evaluative sense of *where* we are placed in relation to our surroundings, as well as an anticipatory sense of *where next* we might move (Shotter, 2005b). We are not seeking the solution to a problem but, so to speak, to find our 'way around' inside something that is (initially) a mystery to us - an unsolvable mystery that might remain so (Shotter, 2005b).

We have found six basic system orientors (existence and subsistence, effectiveness, freedom of action, security, adaptability, coexistence) that apply to all autonomous self-organizing systems - Hartmut Bossel

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With this foundation, and complemented by Stern's *vitality forms* (Stern, 2010), we identify and adapt the framework independently arrived at by Vickers, Bossel and Max-Neef (Vickers, 1959) (Bossel, 1976) (Bossel, 1977) (Bossel, 1994) (Bossel, 1998) (Bossel, 1999) (Bossel, 2007) (Müller and Leupelt, 1998) and (Max-Neef, 1991) to conceptualize the critical success factors which guide diagnostic action, which in our vision share much with that of an ecosystem. We seek indicators which realize Bossel's six basic high-level orienting properties of *existence and subsistence, effectiveness, freedom of action, security, adaptability, and coexistence.*

We theorize with Bossel that these properties are each vital diagnostic indicators of successful system development, and we aim to orient our initial diagnostic exploration efforts along paths which seek to improve the weakest of these properties. Holistic indicators allow us to understand if the system under study is globally following a path that takes the system to a "better" or to a "worse" state (Jorgensen and Fath, 2007). These indicators must give a fairly reliable and complete picture of what really matters (Bossel, 1998).

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the key to well-being lies more in the design of our aspirations than in the devising of means to satisfy them -Geoffrey Vickers

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If a system is to be viable in the long run, a minimum satisfaction of each of these basic orientors must be assured (Bossel, 1994). We theorize with Bossel that the behavioral response of the system is conditional on the chosen indicator set: problems not perceived cannot be attacked and solved (Bossel, 1977). Meaningful non-routine behavior can only occur by reference to orientors, which are therefore key elements of non-routine behavior (Bossel, 1977)

(Bossel, 2007). The possible successes of unoriented non-routine behavior can be only chance successes (Bossel, 1977) (Bossel, 2007). Bossel even goes so far to declare (Bossel, 2007) that orientor-guided decision-making will lead to sustainable development without requiring specification of intermediate or end states. A sustainability indicator should point the way to a course of action (Bell and Morse, 2008). What is lacking is not data but an understanding of what is important and the resolve to act (Lawrence, 1997).

The governors of behaviour are not goals to be attained or dangers to be avoided once for all. They are continuing relationships which can only be maintained by continuous seeking and thresholds beyond which such relationships must not be allowed to stray... I call such governing relationships norms when they are positive and limits when they are negative, to distinguish them from goals which can be attained once for all; and such goals I call objectives... The immediate objective in each instance is only a segment of an activity which has to be infinitely extended in time in order to maintain with our environment some continuing relationship which has become established as a norm... We cannot make sense of any human behaviour unless we identify, behind the objective, the continuing need which it is supposed to serve. -Geoffrey Vickers

We directly follow Lockie (Lockie et al., 2005) in our conceptual foundation of indicators, in which we directly quote due to the importance of the concept. Indicators are instruments to define and monitor those aspects of a system that provide the most reliable clues as to its overall well-being. They are used, in other words, to provide cost and time-effective feedback on the health of a system without necessarily examining all components of that system. According to proponents, the validity of indicators is based on the degree to which the wider network of components and relationships in which they are situated link together in a relatively stable and self-regulating manner, and the degree to which the indicators themselves represent the most salient or critical aspects of the system that can be monitored over time.

We also follow Lawrence (Lawrence, 1997) and declare that indicators are intended to answer the question: "How might I know objectively whether things are getting better or getting worse?". What we are really interested in are *value-based directional indicators*, which are less focused upon numerical representations and are more focused upon action, as in "I should do something about this." We see the strategic benefit of a fusion of sensory and motor elements (Baldwin, 1906) - we perceive so that we might try something to bring our perceptions in line with our expertise-derived values.

For data to be useful to us, it must describe things which actually matter to our future. Objective and relevant data needs to be converted into information if it is to be useful in the development of sustainability indicators (Lawrence, 1997). Information that is measured should evoke *happiness* when the situation improves and *unhappiness* when it gets worse. If the change doesn't matter, we are not monitoring the right data (Lawrence, 1997).

Needs provoke real impulses for

action... when sufficiently gratified cease to exist as active determinants or organizers of behavior

Maslow (Maslow, 1987) notes that needs, along with their partial goals, when sufficiently gratified cease to exist as active determinants or organizers of behavior. Bisogno (Bisogno, 1981) notes that the term *need* means a state of dissatisfaction provoked by the lack of something felt as being necessary. Needs provoke real impulses for action, which for Max-Neef, become (instead of a goal) the motor of development itself (Max-Neef, 1991). Importantly for Bisogno, needs which would appear to be essential in a particular moment, are no longer so when these circumstances - time, place, (or for Maslow a state of satisfaction), change. A need becomes a necessity when its satisfaction is absolutely indispensable to a given state of affairs (Bisogno, 1981).

Needs, however, are theoretical constructs (Tobar-Arbulu, 1987). The "truth" of a need cannot, therefore, be proven in a direct physical way. The existence of a need can be *concluded indirectly* either from postulation or from the respective satisfiers that a person (or entity) uses or strives for, or from symptoms of frustration caused by any kind of nonsatisfaction (Tobar-Arbulu, 1987). We speculate with Tobar-Arbulu that a list of needs could serve as a guideline for monitoring conditions adequate for development, survival, or even moment-by-moment operations. Satisfaction of needs could inspire us to awareness, in addition to serving as a goal of development (Tobar-Arbulu, 1987).

In the absence of a "desire" that picks out one possibility rather than another (Olafson, 1995), our whole active relation to the future, as well to possibilities as such, would become deeply problematic. The conclusion to which all this points (Olafson, 1995) is that if anything can be said to orient us toward the future - any future - and thus to possibility as such, it is surely desire. This is also to say that it is desire that discloses such possibilities to us in a "primordial" way. Olafson develops the concept of perception as the detection of presence. A desire becomes "present" to us by the unique characteristic of an absence (Olafson, 1995), in which case we "need" to do something now so that, in the future, the absence goes away.

This all becomes elevated in importance when we consider the possibility that guidelines for making decisions follow from basic system needs (Bossel, 1981). The "normal" functioning of a given system requires the satisfaction of certain basic needs characteristic of the system and of its function. When deprived of satisfaction of any one of the basic needs, the system will cease to function in the "normal" mode and possibly cease to function altogether. Basic needs are irreducible and one basic need cannot substitute for another (Bossel, 1981).

Health and fitness of a system require adequate satisfaction of each of the system's basic orientors. Planning, decisions, and actions in societal systems must therefore always reflect at least the handful of basic orientors (or derived criteria) simultaneously. Comprehensive assessments of system behavior and development must also be multi-criteria assessments...

We see a value in the two-phased approach of (Bossel, 1976) and (Bossel, 1994): first, a certain minimum qualification must be obtained separately for each of the basic orientors. A deficit in even one of the orientors potentially threatens our long-term survival from our current position. Our computer software will have to focus its attention on this deficit. Only if the required minimum satisfaction of all basic orientors is guaranteed is it permissible to try to raise system satisfaction by improving satisfaction of individual orientors further - if conditions, in particular our opponent, will allow this.

We see *goal functions* as operating to translate the fundamental system needs expressed in the basic orientors into specific objectives linking system response to properties observed on the chess board. We conceptualize that goal functions emerge as general properties in the coevolution of the chess position and dynamic, future development. They can be viewed as specific responses to the need to satisfy the basic orientors. For example, mobility is related to adaptability, constraints relate to coexistence, king safety is related to the orientors of security and existence, virtual existence and stress are related to effectiveness, material is related to existence, security and adaptability, etc. We can creatively come up with new indicators to orient our diagnostic exploration, but we see them fitting within the proposed framework and 'dimension of concern' as outlined previously.

We see the vital orientors, which express our values, as operating together to create a selection method for our immediate goals. The goals we seek are not specific *objects*, but rather changes in our relations or in our opportunities for relating (Vickers, 1995).

...a system's development will be constrained by the orientor that is currently 'in the minimum'. Particular attention will therefore have to focus on those orientors that are currently deficient. -Hartmut Bossel

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We see an interesting similarity with the "ABC" (airway, breathing, circulation) priority system used in emergency room and rescue operations when deciding what to do next with an accident victim. The rescue team performs the set of vital diagnostic tests and then focuses their immediate attention on the critical indicator that scores the lowest. The "health" of the victim (and in fact the direction to take next) would not be based on an average or summation score of the vital indicators, but instead on the vital indicator which scores the lowest. The goal, then would be to do something which improves the score returned by that indicator. If more than one indicator is below a certain critical threshold (such as, the patient is not breathing and there is no circulation), then Cardiopulmonary Resuscitation (CPR) would need to be performed - improvement of the airway, breathing and circulation indicators are all simultaneously attempted.

Our experience in computer chess over the past few years seems to indicate that future chess programs will probably benefit from evaluation functions that alter as the general chess environment changes. -Peter Frey, Chess Skill in Man and Machine, 1977

We also see a similarity to the common yearly *performance evaluation* which is traditionally performed by American management on each company employee, or even a *report card* given to a student. The ritual evaluation will list strengths, weaknesses, and expectations, and it is also common to list improvements necessary to reach the next performance level. The smart worker will examine his vital, multi-criteria diagnostic assessment and *orient* his or her efforts (during the next year) towards improving the weakest scoring of these indicators, while continuing to leverage strengths and meet the listed expectations.

We see similarities to Festinger's principle of *cognitive dissonance* (Festinger, 1957), where a perception of dissonance between an observed indicator and a desired value leads to activity oriented towards reduction of the perceived dissonance. Festinger believes that reduction of dissonance is a basic process in humans, preceded first by perception and identification.

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the set of basic orientors derives from the question: "Given the global features of the system and of its environment, what basic orienting dimensions must the system refer to in its nonroutine behavior, and in particular in fundamental behavioral decisions in order to fulfill the global instruction of the supreme orientor?" - Hartmut Bossel

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We see the chess programs of the future as addressing this conceptual foundation, in creative ways and approaches that cannot yet be envisioned by today's developers. Our conceptualization of stress management and the construction of resilient positions as indicators are, ideally, part of an operational realization of the six orientors. If our concept fails as an orientor of diagnostic exploration efforts, then it needs to be modified or itself re-engineered. Perfectly usable indicators might overlap, or require too much processor time to implement. Perhaps what is required is the art of a talented programmer/chess player to select a set of indicators which also orient with effective insight.

What we are saying is simply that we must pay attention to each of these orientating qualities separately - we should not just roll them up into a grand, universal "number" and expect to effectively and efficiently drive our diagnostic exploration efforts in that fashion. A weakness in one of the six orientors critically impacts sustainable development in the uncertain future and *cannot* be "made up for" with a higher score from the others. A simple mechanism for scoring our diagnostic exploration efforts, such as averaging the lower two indicators (of six total, one for each orientor), or using the lowest if it is far beneath the others, will make sure that the machine pays attention to (and focuses attention on) those orienting parameters that are in need of improvement.

Our present [evaluation function] is blind to the simplest phenomena. The evaluator gladly accepts a position in which the computer is a knight ahead although its king is out in the center of the board surrounded by hostile enemy queens and rooks. -David Slate and Lawrence Atkin, Chess Skill in Man and Machine, 1977

We seek *sustainability itself* as a goal, which makes sense because our opponent can offer us anything else we would otherwise seek (and initially appearing to move us closer to checkmate), but in a way that (for us) might not be sustainable in the long run, due to the hidden effects of dynamic complexity. We can measure sustainability, in its simplest form, by the weakest of our vital diagnostic indicators. A weighted sum of vital indicators would be used for endpoint evaluation purposes, possibly including a limiter on each parameter.

These orienting indicators, which help us to construct a picture of the state of our environment on which we can base intelligent decisions (Bossel, 1998), can all be based on a common foundation, such as cumulative stress, but with a weighting that aims to highlight the particular dimension of concern. Our goal is simply to determine, through appreciative indicators, "What matters most now?" (Vickers, 1995) and then to (initially) focus attention on any move which we perceive to make progress in that area or dimension of concern. We choose to behave like an efficient business manager, besieged by numerous concerns and pressed for time, deciding how to allocate attention in the face of constant demands, both known and unknown, in dynamically creating a response to the important and expensive (if wrong) question "what do I do now?". Curiously, how we allocate the attention of the machine becomes a decision of profound impact on the quality of the move we will later decide to make.

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test the [strategic] principle for its ability to promote and guide action. In particular, assess whether it exhibits the three attributes of an effective strategic principle...

What good is being a piece up if your King is in the center of the board, surrounded by hostile enemy pieces? Better to see if we can return the King to a safe place, even at the price of material, so that we can continue the sustainable development of our position in the future. We therefore orient our attention and future searching in ways to improve King safety.

Our immediate goals, therefore, emerge from the weakest indicators (results) of the vital diagnostic tests, and operate to orient our diagnostic exploration efforts along lines that allow sustainable development in the uncertain future.

The orientors represent our wants or intentions - an intention doesn't exactly require any deep calculation or plan. Gauld and Shotter (Shotter, 1980) (Gauld and Shotter, 1977) declare that intentionality is a fundamental and irreducible feature - a presupposition of all thought, conceptual activity, and action. The intentions are responsible for *forming activity* (Shotter, 1980) - for both the future growth and development of our position and the construction of the diagnostic test of adaptive capacity which we will use to choose our move in the game. We as humans see our world in terms of intentions, and we act in terms of our own (Stern, 2004). One cannot function with other humans without reading or inferring their motives or intentions. For Stern, this reading or attributing of intentions is our primary guide to responding and initiating action. Inferring intentions in human behavior appears to be universal. It is a mental primitive. It is how we parse and interpret our human surroundings (Stern, 2004). It should be no surprise that we find this technique useful in guiding machine-based actions.

...Will it force tradeoffs? Will it serve as a test for the wisdom of a particular business move, especially one that might promote short-term profits at the expense of long-term strategy? ...Does it set boundaries within which people will nonetheless be free to experiment? -Gadiesh, Gilbert, Transforming Corner-Office Strategy into Frontline Action

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We see the intentions as the structured medium or means through which, in interaction with our game-based surroundings, our future position forms, developing itself as the structured means for its own further development or growth (Shotter, 1980). The intentions do not specify the future positions exactly - we see positional growth happening in unpredictable interactions with our game-based surroundings (Shotter, 1980). An intention, then, may be thought of as a specified yet further specifiable means through which one can work towards an end; its already realized aspects limiting and specifying what one may yet do in the attempt to more fully realize it (Shotter, 1980).

We can explore the moves that (partially) satisfy our wants, and by simple focused learning, examine the consequences of what emerges as we slide forward a few promising moves into the future. We need both the readings and the norms. For only if we know both where we are and where we want to go can we act purposefully in seeing about getting there (Laszlo, 1996). A need is seen as a process, with no beginning and no end, of satisfaction and dissatisfaction, undulating through time with sometimes slow, sometimes quick rhythms, with no resting point (Galtung, 1980). Life is seen as an effort to extinguish lamps in the console signaling "need unsatisfied/unattended" (Galtung, 1980). Very simply, we look at what has conferred "coping capacity" to our position in times of trouble, what worked in the past. We ask, if there were past failures, could they be attributed to any of the features conferring general resilience? (Walker and Salt, 2012)

Adaptability (adaptive capacity): The capacity of actors in a system (people) to manage resilience. This might be to avoid crossing into an undesirable system regime or to succeed in crossing into a desirable one... "nonadaptive" governance of a dynamic system with changing thresholds is bound to fail... Governance is adaptive when it changes in anticipation of or in response to new circumstances, problems, or opportunities. - Brian Walker, David Salt, Resilience Practice

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We tentatively envision the following chess-based *dynamic leading indicators* as *orientors and strategic guides to action*, based on Bossel's collection:

- *existence and subsistence* (low-ply exploration of promising moves indicates that position is sustainable and good moves are available, possibly quick mate check, all captures explored)
- *effectiveness* (material, adjusted by positional engagement of each piece - level of stress created by pieces makes sufficient short- and long-range threats to reduce resilience of opponent while sufficiently avoiding opponent's threats, pieces threaten in multiple directions)
- *freedom of action* (mobility - including 2nd and 3rd order, penalty if pieces are trapped or pinned, multiple good moves available from position)
- *security* (dynamic King safety - opponent's projected piece power in direction of King is neutralized by friendly pieces and piece constraints, small bonus for King at corner or 1 square from corner)
- *adaptability* (positional score is not decreasing with increased diagnostic exploration depth)

- *coexistence* (effective use of constraints to weaken effect of enemy pieces, while avoiding enemy constraints, pieces are not constrained by other friendly pieces, enemy pieces are not able to concentrate force on a weak spot or "pin" without dynamic prospects for undoing pin)

We simply ask, "What areas of competitor activity do we feel need close attention?" (Fuld, 1995). With regard to the indicated direction for exploration, we ask not, "Is this perfectly accurate?" But rather, "Is this sufficient to make a good initial decision?"

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when one is modeling some situation... it is reasonable to use any assumptions that work, but it is not reasonable to make these assumptions into "laws," or to forget that these are assumptions that people made in the first place. -William Byers

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Hubert points out (Hubert, 2007) that what is generally missing in sustainability programs is a set of *leading indicators* (such as those proposed above) that provide signals of system changes that will ultimately affect the system's output, and are timely enough to allow intervention that can change the outcomes. When properly done, these leading indicators provide insight into the state of a system's health. For Hubert, an unbalanced dependence on lagging indicators (such as rewarding pieces for sitting on good squares) is to be fooled by early successes, or what is sometimes called the "getting better before it gets worse" - focusing on an outcome (maximum yield) rather than on leading indicators of health.

Without leading indicators, we cannot easily distinguish early successes from the early stages of looming failure. Additionally, Hubert feels that the common cause behind many resource management failures is this focus on managing for a single outcome, which first improves performance, but later leads to system collapse. Finally, Hubert declares his opinion that *we can sustain systems that are evolving when we understand that all we need to do is think in terms of sustaining a system's health and functionality* rather than its specific form or condition (Hubert, 2007).

In all of these noticings, due to their just happening *nature, their spontaneity, there is at work, as Steiner puts it, an "'otherness' which enters us [and] makes us other". And it is in this way that we can overcome the trap of simply returning again and again to what is already familiar to us. -John Shotter*

A *frame* provides an official main focus for attention, in accord with the business at hand (Goleman, 2005). The frame is highly selective; it directs attention away from all the simultaneous activities that are out of frame. What is out of frame can easily go unperceived - any frame at all, in fact, defines a narrow focus where the relevant schemas direct attention, and a broad, ignored area of irrelevance (Goleman, 2005). The dominant track, however, has to be picked out of the entire assemblage of activity (Goleman, 2005).

It is within such ongoing, open, unfinished, spontaneously adjustive and responsive activities as these, in the course of which we orient ourselves to the others and othernesses around us, that we speak of ourselves *as perceiving our surroundings, of us as being in a perceptual rather than a cognitive relation to them. Rather than having to 'think out' how to relate ourselves to our surroundings, as the solution to a puzzle, we find ourselves in such circumstances bodily responding to them spontaneously in a certain manner - we behave in such moments in distinctive ways which can serve as a beginning for a way of thinking (a prototype) rather than in ways which are the result of thought. -John Shotter*

Our orientors create parallel tracks - in frame and out of frame - creating a structure in social awareness that duplicates the division within the mind between conscious and unconscious (Goleman, 2005). What is out of frame is also out of consensual awareness - indeed, the social world is filled with frames that guide our awareness toward one aspect of experience and away from others. But we are so accustomed to their channeling our awareness that we rarely notice that they do so (Goleman, 2005).

Perhaps Pfaff's method of determining arousal (Pfaff, 2006) is appropriate here:

A = F(KgAg + Ks1As1 + Ks2As2 + Ks3As3... + KsnAsn)

where A = arousal, as a function (F) of generalized arousal (Ag) - such as captures, checks and large changes in other critical indicators - and specific forms of arousal (As) - the orientors discussed previously. For Pfaff, the plus signs are not meant to imply simple linearity, but rather to indicate that A is an increasing function of the variables Ag and As(1 to n).

17 Shannon's Evaluation Function

Shannon proposed (Shannon, 1950) a simple evaluation to be performed in relatively quiescent positions. We wonder out loud if Hegel's observation is more correct - that the health of a "state" shows itself not in the quietness of peace but in the commotion of war (Friedrich, 1954). In war, the strength of the cohesion of the parts with the whole is demonstrated (Friedrich, 1954). Quiescent evaluations do not (and cannot) measure how far a position will bend before it breaks. We suggest that a more accurate evaluation might roughly simulate the interactions of war via diagnostics such as probing to determine multiple-move constrained mobility of the pieces, and the identification of the lowest-scoring of the sustainability indicators.

Networks are comprised of a set of objects with direct transaction (couplings) between these objects... these transactions viewed in total link direct and indirect parts together in an interconnected web, giving rise to the network structure...

While recent tournaments have shown that Shannon-style evaluations (combined with *alpha-beta pruning* and the *null-move* heuristic) can be used to produce world-class chess programs, we seek an alternate approach with the capability of even better performance. Programs that use Shannon's evaluation often have trouble figuring out what to do when there is no direct sequence of moves leading to the placement of pieces on better squares (such as the center), or the acquisition of a "material" gain.

We see a general correlation between the placement of a piece on a "good square" and the ability of that piece to inflict stress on the opponent, and to mitigate the effects of stress caused by well-placed opponent's pieces. We even see that the concept of mobility has value in a general sense. However, we see problems with this technique being used to build positional pressure, such as the kind needed to play an effective game of correspondence chess. The long and deep analysis produced by the machine is often focused in the wrong areas, as determined by the actual course of the game. We do not attempt here to declare that we are experts in the reasons that it "works". It is a diagnostic test of adaptive capacity - a stress test of sorts - which is remarkably effective in performing a social action - choosing a move in a game.

...The connectivity of nature has important impacts on both the objects within the network and our attempts to understand it. If we ignore the web and look at individual unconnected organisms... we miss the system-level effects. -Jorgensen, Fath, et al., A New Ecology

The adaptive stress produced by the Shannon method is not of the type that reduces the coping capacity of the opponent, or increases our own resilience, in certain game situations where positional play is required. For example, in positions that are empty of tactical opportunities, the machine can be effectively challenged by opponents who know how to play a good positional game of chess (Nickel, 2005). The terms of the Shannon evaluation function do not seem suitable metrics for guiding diagnostic exploration and planning efforts, in these cases.

Fontana (Fontana, 1989) advises us to ask: what are the stressors, what needs to be done about them, and what is stopping us from doing it? There is little to be gained from generalizing, if our goal is to identify the stressors, accurately assess the levels of stress present, and mobilize according to the results.

18 The Positional Evaluation Methodology

So we need something like a map of the future. A map does not tell us where we will be going, or where we should be going - it merely informs us about the possibilities we have... We therefore need a description of the possibilities ahead of us...

We propose that an approach which attempts to increase the *oriented positional pressure* or cumulative stress on the opponent, even if unresolved at the terminal positions in our diagnostic exploration efforts, is a viable strategy and has the potential to play a world-class game of chess. Our strategic intent is to form targeted positional pressure (aimed at weakpoints defined by chess theory and at constraining the movement of the enemy pieces) that will resolve *at some future point in time* into better positions, as events unfold and gameplay proceeds. At minimum, this pressure will allow for sustainable evolutionary development as one component of a resilient position. We will not judge pieces primarily by the "squares" they occupy, but instead, by our heuristic estimates of the level of flexibly persistent and oriented stress they can contribute (or mitigate) in the game positions which lie beyond our planning horizon.

We construct an orientation/evaluation methodology with the goal of making our machine more knowledgeable with regard to the positional concepts discussed earlier. In designing our methodology, we heed the advice of (Dombroski, 2000) that this methodology is our test of effects and consequences and is our guiding light in our search for the consequences of our choices.

...Such a map would not have to give us very detailed information... But it should give us a useful image of what may be ahead, and allow us to compare the relative merits of different routes... before we embark on our journey. -Hartmut Bossel

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Our orientation/evaluation centers on a heuristic appraisal of the stress we inflict on the opponent's position, and our mitigation of the stress created by the opponent. We aim to reduce our opponent's coping ability through careful targeting of stress. The dynamic forces of change, acting over time and in a future we often cannot initially see, transform the reduced coping ability of our opponent, our carefully targeted stress, and our resilient position full of adaptive capacity, to future positions of advantage for us.

Perhaps this concept is what inspired Bobby Allison to race most of the 1982 Daytona 500 without a back bumper - it fell off after contacting another car early in the event (NASCAR, 2009). Some drivers accused Allison's crew chief of rigging the bumper to intentionally fall off on impact. Allison's car without the bumper had improved aerodynamics, and the forces of dynamic change operating over the 500 mile race supplied the driver with an advantage he used to win. This odd example is used to suggest that "evaluations" of winning chances should take into account the dynamic effects of interacting forces over time, rather than just static observations. Other examples (the winged keel of the Australia II yacht and the new loop-keel design, hinged ice skates and performance enhancing swimsuits come to mind) show how small changes, combined with other critical abilities and *interacting with a dynamic environment over time*, can create a performance advantage.

Sustainability... means, as said before, that only the riverbed, not the exact location of the river in it, can and should be specified -Hartmut Bossel

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We seek, in similar fashion, to favor certain interacting arrangements of pieces, such that the dynamic forces of change (operating during the playing of a game) cause favorable positions to emerge over time, from beyond our initial planning horizon. We seek to re-conceptualize the "horizon effect" to our advantage. We cannot arrange for a bumper to fall off during a chess game, but we can do the equivalent - we can actively manage the dynamics of change to improve the chances for persistence or transformation (Chapin et al., 2009). This would include the general approaches of reducing vulnerability, enhancing adaptive capacity, increasing resilience, and enhancing transformability (Chapin et al., 2009). We manage the *exposure* to stress, in addition to the *sensitivity* to stress (Chapin et al., 2009).

We adopt the vision of (Katsenelinboigen, 1992), that we define a "potential" which measures a structure aimed at forcing events in our favor. Ideally, one which also absorbs or reduces the effects of unexpected events.

We follow the suggestion in (Pearl, 1984) to use as a strategy an orientation/evaluation based on a *relaxed constraint* model, one that ideally provides (like human intuition), a stream of tentative, informative advice for managing the steps that make up a problem-solving process, and use the insight from (Fritz, 1989) and (Sterman, 2000) that structure influences behavior.

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in order to understand what power relations are about, perhaps we should investigate the forms of resistance and attempts made to dissociate these relations... The exercise of power... is a way in which certain actions modify others... Power exists only when it is put into action, even if, of course, it is integrated into a disparate field of possibilities -Foucault

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In order to more accurately estimate the distant positional pressure produced by the chess pieces, as well as to predict the future capability of the pieces in a basic form of planning (Lakein, 1974) (Shoemaker, 2007) we create the software equivalent of a *diagnostic probe* which performs a heuristic estimate of the ability of each piece to cause and mitigate stress. The objectives we select for this stress will be attacking enemy pieces, constraining enemy pieces, and supporting friendly pieces (especially those pieces that are weak). To support this strategy, we calculate and maintain this database of potential mobility for each chess piece 3 moves into the future, for each position we evaluate.

We update this piece mobility database dynamically as we evaluate each new leaf position in our diagnostic exploration efforts. This database helps us determine the pieces that can be attacked or supported in the future (such as 2 moves away from defending a piece or 3 moves away from attacking a square next to the enemy king), as well as *constrained* from accomplishing this same activity. Note that the piece mobility we calculate is the means through which we determine the pressure the piece can exert on a distant objective. We can therefore see how mobility (as a general concept) can become a vital holistic indicator of system health and one predictor of sustainable development.

We reduce our bonus for each move that it takes the piece to accomplish the desired objective. We then consider *restrictions* which are *likely* to constrain the piece as it attempts to make moves on the board.

For example, let's consider the pieces in the starting position (Figure 4).

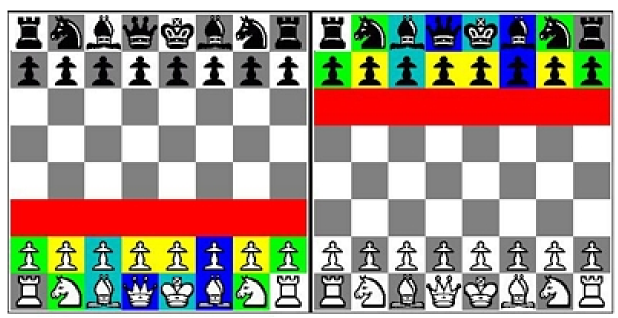

Figure 4: White and Black *constraint map*, pieces at the starting position Legend: Red: pawn constraints, Yellow: Minor piece constraints, Green: rook constraints, Blue-green: Queen constraints, Blue: King constraints

What squares can our knight on g1 influence in 3 moves, and which squares from this set are likely off-limits due to potential constraints from the enemy pieces?

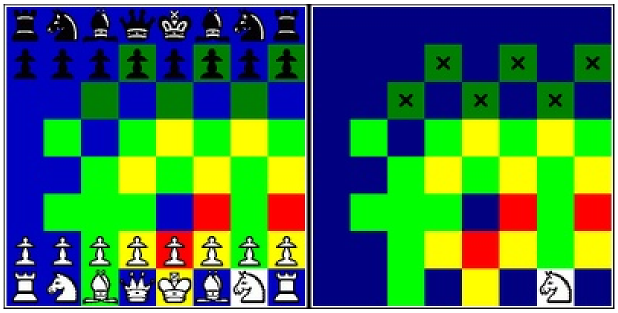

Figure 5: Influence Diagram and Simulation Diagram, Ng1 at starting position *Legend:* Red - 1 move influence, Yellow - 2 move influence, Green - 3 move influence, Dark Red - 1 move influence possibly constrained by opponent piece, Dark Yellow - 2 move influence possibly constrained by opponent piece, Dark Green - 3 move influence possibly constrained by opponent piece, Blue - no influence possible within 3 moves, X - presence of potential constraint "Power... is diagrammatic... it passes not so much through forms as through particular points which on each occasion mark the application of a force, the action or reaction of a force in relation to others" -Deleuze

forces are in a perpetual state of evolution; there is an emergence of forces... the diagram... exposes a set of relations between forces... it is the place only of mutation. -Deleuze

We now construct the *influence diagram* (Shoemaker, 2007) and the *simulation diagram* (Bossel, 1994) (Figure 5), which are interpreted in the following way. If a piece is on our influence diagram for the knight, then it is possible to attack it or defend it in 3 moves (this includes waiting moves or moves which move a piece out of the way). We label this kind of map an *influence diagram* because it shows the squares that the piece can influence in 3 moves, provided that it is unconstrained in movement by the enemy.

The influence diagram captures the behaviorally relevant structure of the system. It is therefore the basis for any simulation model. Because of its importance for the success of model development, the influence diagram has to be developed with care and precision... To capture their dynamics correctly, real systems cannot usually be represented by linear approximations -Hartmut Bossel

Keep in mind that we need to take into account the location of the other pieces on the chessboard when we generate these diagrams for each piece. If we trace mobility through a friendly piece, we must consider whether or not we can move this piece out of the way before we can continue to trace mobility in that particular direction. If we trace mobility through an enemy piece, we must first be able to spend 1 move capturing that piece. For Campbell (Campbell, 1956), perception can provide information and behavioral guides equivalent to those obtainable through trial-and-error exploration.

The world is really a dynamic operation; only by means of symbols can the mind deal with it "as if" it were a static structure... [for one thing to be meaningful] you must have three: a thing, a relation, and another thing. The meaning of one of them is determined by your momentary awareness of the other two. -Albert Upton

Understanding how power works is the first prerequisite for action, because action is the exercise of power (Flyvbjerg, 1998). A strong understanding of situations where conflict exists must therefore be based on thought that places conflict and power at its center (Flyvbjerg, 1998). Foucault (Foucault, 1982) defines a *relationship of power* as a mode of action that does not act directly and immediately on others. Instead, it acts upon their actions: an action upon an action, on possible or actual future or present actions. A *relationship of violence*, in comparison, acts upon a body or upon things; it forces, it destroys, or it closes off possibilities. We can threaten the knight itself, or the potential actions of the knight. The knight makes threats of its own on the board - its power is exercised rather than possessed (Foucault, 1995). An exercise of power shows up as an affect, since force defines itself by its very power to affect other forces (and in turn to be affected by them)(Deleuze and Hand, 2006). Foucault's theory of power is about using tools of analysis to understand power, its relations with rationality and knowledge, and aims to use the resulting insights precisely to bring about change (Flyvbjerg and Richardson, 2002).

the 'objects' of our inquiries do not pre-exist out in the world awaiting discovery of them; they emerge through and within intra-actions. They exist in terms of... the guiding expectations with which we go out to meet whatever is happening within our surroundings. -John Shotter

We focus on power relations because *power produces knowledge* (Foucault, 1995). Power and knowledge directly imply one another - there is no power relation without the correlative constitution of a field of knowledge, nor any knowledge that does not presuppose and constitute at the same time power relations (Foucault, 1995). For Bertrand Russell (Russell, 2004), the laws of social dynamics are only capable of being stated in terms of power in its various forms. Power must be met by power. The only way to contain aggression and cope with hostility is to build up and intelligently manipulate consequential constraints, threats and force (Jervis, 1976). The issue is not whether we confront power; the only question is how we do so: how well we use its force and evade its traps (Flyvbjerg et al., 2012). We see the position on the board as evolving in a world of perpetual strategic relations (Flyvbjerg et al., 2012) among the pieces.

We see the intra-action of the game pieces as a phenomena that is real and (importantly) that we can use to intervene in the world (of our game) to affect something else (Barad, 2007). For Barad, reality is composed of things-in-phenomenon, and from which we derive objective knowledge. We are therefore concerned with the practices which articulate and account for the phenomena in our world, specifically, Barad's dynamic topological reconfigurings/entanglements/relationalities/ (re)articulations (Barad, 2007). We seek to learn the consequences of these phenomena in our diagnostic explorations, which we will then use to re-guide the explorations that follow. We ultimately seek to establish heuristics and cues which indicate "I need to learn the consequences of this move" and complementarily, "I am done with my learning, for now."

[Foucault] insists that the principal characteristic of power is always to manifest itself in a discourse about something other; power can only be effective - and tolerated - when some part of it is hidden... it can only be... analyzed in the places it both inhabits and vacates simultaneously, and hence viewed only indirectly. -Hayden White

In applying Foucault's conception of power relations to the pieces on the gameboard: we see the maneuvers in terms of the network of relations, constantly in tension, and as a perpetual battle rather than a simplistic conquest of territory (Foucault, 1995). The knowledge we acquire is meaningless if it is not derived from these maneuvers and the corresponding power relations. For Foucault (and in our interpretation, the situation involving the pieces on the gameboard), power is a machine in which the players' pieces are caught, those who exercise power just as much as those over whom it is exercised - it becomes a machinery that no one owns (Foucault, 1980). This is not necessarily a bad thing, as Foucault declares, but rather that it is *dangerous* (Flyvbjerg et al., 2012). Since it is dangerous, we always have something to do: to determine the main danger, and to explore/plan for ways to mitigate or take advantage.

An understanding of planning that is practical, committed and ready for conflict provides a superior paradigm to planning theory - planning is inescapably about conflict: exploring conflicts in planning, and learning to work effectively with conflict can be the basis for a strong planning paradigm (Flyvbjerg and Richardson, 2002).

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when we say total environment we... mean... that which is in such immediate relation to the individual that its forces can be reckoned with both as cause of and effect of his activity, that is, that much of environment which comes within the appreciable range of circular behavior. - Mary Parker Follett

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Returning to Figure 5, we can determine that the white knight on g1 can potentially attack 3 enemy pieces in 3 moves (black pawns on d7, f7 and h7). We can defend 8 of our own pieces in 3 moves (the knight cannot defend itself). One way to interpret Figure 5 is as *an organized puzzle-solving gestalt* which is itself a 'picture' of something, A, which is then to be applied, non-obviously, to provide a new 'way of seeing' something else, B. This is what (Masterman, 1970) calls a *Kuhnian paradigm.*

We decide to reward pieces for their potential ability to accomplish certain types of worthwhile positional objectives: attacking or constraining enemy pieces, defending friendly pieces, attacking squares near our opponents king (especially involving collaboration), minimizing our opponent's ability to attack squares near our own king, attacking pieces that are not defended or pawns that cannot be defended by neighboring pawns, restricting the mobility of enemy pieces (specifically, their ability to accomplish objectives), etc. In this way, we are getting real about what the piece can do. The bonus we give the piece is 1. a more precise estimate of the piece's ability to become strategically engaged with respect to causing or mitigating stress and 2. operationally based on real things present on the chessboard. In this way, our positional orientation/evaluation methodology will obtain insight not usually obtained by a computer chess program, and allow our machine to take positive, constructive action (Browne, 2002). It is still an estimate, but the goal here is to orient our diagnostic exploration efforts on likely moves in a positional style of play, and to evaluate positions from a more positional point of view.

Any analysis of behavior which does not take into account that response is to a relating, will be inadequate. -Mary Parker Follett

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What does the orientation/evaluation methodology look like for the proposed heuristic? We model (and therefore estimate) the positional pressure of our pieces, by following a two-step process:

1. We determine the *unrestricted future mobility* of each chess piece 3 moves into the future, then

2. We estimate the *operating range* or level of *engagement* of the pieces by determining the limiting factors or constraints that bound the unrestricted mobility.

The concept of using limiting factors is briefly mentioned (Blanchard and Fabrycky, 2006) in the context of Systems Engineering. (Lukey and Tepe, 2008) argue that an important aspect of cognitive appraisal is the extent to which stress-causing agents are perceived as controlled. Balancing processes such as constraints (Anderson and Johnson, 1997) seek to counter the reinforcing loops created by a piece creating stress, which, if unconstrained, can potentially create even more stress (perhaps in combination with other pieces). Once we have identified the limiting factors, we can more easily examine them to discover which ones can be altered to make progress possible - these then become *strategic factors*.

Power begins... with the organization of reflex arcs. Then these are organized into a system... the organization of these systems comprise the organism... Power is the legitimate, the inevitable, outcome of the essential life-process -Mary Parker Follett

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The consideration of constraints is a part of the *decision protocol of Orasanu and Connolly* (Orasanu and Connolly, 1993) and (Plessner et al., 2008) which also includes the identification of resources and goals facing the decision maker. We therefore reduce the bonus for accomplishing objectives (such as, attacking an enemy piece or defending a friendly piece) if the required moves can only be traced through squares that are *likely* to result in the piece being captured before it can accomplish its objective. We also reduce the engagement bonus for mobility traced through squares where the piece is attacked but not defended. We may use another scheme (such as probability) for determining stress-application reduction for piece movement through squares attacked both by friendly and enemy pieces where we cannot easily resolve whether or not a piece can trace mobility through the square in question (and therefore create stress). We think in terms of rewarding a self-organizing capacity to create stress out of the varied locations of the pieces and the constraints they face (Costanza and Jorgensen, 2002).

We reward each piece for its predicted ability to accomplish strategic objectives, exert positional pressure, and restrict the mobility of enemy pieces, based on the current set of pieces on the chess board at the time we are calling our orientation/evaluation methodology. Using anticipation as a strategy (van Wezel et al., 2006) can be costly and is limited by time constraints. It can hurt our performance if it is not done with competence. An efficient compromise between anticipative and reactive strategies would seem to maximize performance.

We give a piece an offensive score based on the number and type of enemy pieces we can attack in 3 moves - more so if unconstrained. We give a piece a defensive score based on (1) how many of our own pieces it can move to defend in 3 moves and (2) the ability to mitigate or constrain the attacking potential of enemy pieces. Again, this bonus is reduced for each move it takes to accomplish the objective. This information is derived from the influence diagram and simulation diagram we just calculated. Extra points can be given for weak or undefended pieces that we can threaten.

The proposed heuristic also determines king safety from these future mobility move maps. We penalize our king if our opponent can move pieces into the 9-square template around our king within a 3 move window. The penalty is larger if the piece can make it there in 1 or 2 moves, or if the piece is a queen or rook. We penalize our king if multiple enemy pieces can attack the same square near our king. Our king is free to move to the center of the board - as long as the enemy cannot mount an attack. The incentive to castle our king will not be a fixed value, such as a quarter pawn for castling, but rather the reduction obtained in the enemy's ability to move pieces near our king (the rook involved in the castling maneuver will likely see increased mobility after castling is performed).

The king will come out of hiding naturally when the number of pieces on the board is reduced and the enemy does not have the potential to move these reduced number of pieces near our king. We are likewise free to advance the pawns protecting our king, again as long as the enemy cannot mount an attack on the monarch. The potential ability of our opponent to mount an attack on our king is the heuristic we use as the basis for king safety. Optionally, we will consider realistic restrictions that our own pieces can make to our opponent's ability to move pieces near our king.

Pawns are rewarded based on their chance to reach the last rank, and what they can do (pieces attacked and defended in 3 moves, whether or not they are blocked or movable). The piece mobility tables we generate should help us identify pawns that cannot be defended by other pawns, or other pieces - it is this weakness that we should penalize. Doubled or isolated pawns that cannot be potentially attacked blockaded or constrained by our opponent should not be penalized. Pawns can be awarded a bonus based on the future mobility and offensive/ defensive potential of a queen that would result if it made it to the back rank, and of course this bonus is reduced by each move it would take the pawn to get there.

The packets that organize information and make sense of experience are "schemas," the building blocks of cognition. Schemas embody the rules and categories that order raw experience into coherent meaning. All knowledge and experience is packaged in schemas. Schemas are the ghost in the machine, the intelligence that guides information as it flows through the mind. -Daniel Goleman

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The information present in the future mobility maps (and the constraints that exist on the board for the movement of these pieces) allow us to better estimate the positional pressure produced by the chess pieces. From these calculations we can make a reasonably accurate estimate of the winning potential of a position, or estimate the presence of positional compensation from a piece sacrifice. This orientation/evaluation score also helps orient the diagnostic exploration process, as the positional score is also a measure of how sustainable the position is and helps us determine the positions we would like to explore first.

In summary, we have created an initial model of positional pressure which can be used in the orientation/evaluation methodology of a computer chess program, which can be refined in diagnostic tournaments of many short games. (Michalewicz and Fogel, 2004) remind us that models leave something out, otherwise they would be as complicated as the real world. Our models ideally provide insight and identify promising paths through existing complexity.

(Starfield et al., 1994) emphasize that problem solving and thinking revolve around the model we have created of the process under study. We can use the proposed model of positional pressure to direct the machine to orient the diagnostic exploration efforts on moves which create the most stress in the position as a whole. For our diagnostic exploration efforts, we desire a proper balance between an anticipatory and a reactive planning strategy. We desire our forecast of each piece's abilities to help us anticipate its effectiveness in the game (van Wezel et al., 2006), instead of just reacting to the consequences of the moves.

By identifying the elements and processes in our system (Voinov, 2008), identifying the limiting factors from the interactions of the elements, and by answering basic questions about space, time and structure, we describe and define the conceptual model of our system.

19 Observations from Cognitive Science

We make the following observations about our approach, from (Wood, 2009), which in our vision also apply to the concept of a machine playing a game.

Our motives and needs, for whatever we choose to do, affect what we see and don't see. After carefully selecting what we choose to notice, we need somehow to make sense of these perceptions and form strategic guides for our behavior. Wood declares that the most useful theory for explaining how we organize perceptions is *constructivism*, which is the theory that we organize and interpret experience by applying cognitive structures called *schemata*.

We use four types of *cognitive schemata* to make sense of perceptions: prototypes, personal constructs, stereotypes, and *scripts*. Scripts are *guides to action* based on experiences and observations. A script consists of a sequence of activities that identify what we and others are expected to do in certain specific situations. Many of our daily activities are governed by scripts, although we're often unaware of them. We theorize, based on the interpretation of (Honeycutt and Cantrill, 2001) that scripts are a kind of *autopilot*, that much subconscious activity which takes place in playing a game consists of following scripts, triggered by perceptions. In most of these activities, we use scripts to organize perceptions into lines of action. The script tells us what to do, in our case - how to gather and organize information, when we find ourselves in a general or even a particular situation.

Scripts represent *generalized knowledge* (Lightfoot et al., 2009) and as such, can be used to command a machine to take actions (or figure out what is likely to happen next) in a generalized situation - such as addressing or determining the needs of a position in a board game.

For (de Wit and Mayer, 2010), Knowledge that people have is stored in their minds in the form of 'cognitive maps'. These cognitive maps are representations in a person's mind of how the world works. A cognitive map of a certain situation reflects a person's belief about the importance of the issues and about the cause and effect relationships between them. A person's cognitive map will *focus attention* on particular phenomena, while *blocking out other data* as noise, and quickly make clear how a situation should be perceived. Cognitive maps help to direct behavior, by providing an existing repertoire of 'problem-solving' responses (also referred to as 'scripts') from which as appropriate action can be derived.

Our machine will use scripts to, among other things, construct a map showing how fully engaged a piece is in the game. Maps are *guides to action* (Hahlweg and Hooker, 1989) because they depict genuine invariant relationships that exist, in this case, among the pieces on the game board. We will also use scripts to manage the stress in a position, along particular dimensions of concern, and to manage diagnostic exploration efforts.

For Markman (Markman, 2012), it is *habits* rather than scripts which explain certain cognitive processes. The key signature of a habit is that it is an action you can perform automatically without having to think about it consciously. For Markman, whenever there is a routine that you do in the same way all the time, you develop a habit for it so that you don't have to think about it explicitly any more. We apply this concept to the simple tasks of gathering information about the relationships among the pieces when considering what move to play in a game - we might have thought about this explicitly when learning to play the game, but after years of experience we won't think about the process of doing the behavior any more.

Markman explains that the mind is constantly looking to create habits (Markman, 2012), and implies that the repetitive tasks of gathering and analyzing information in playing a game might become automated, so that we are not even consciously aware of what we are doing. For Markman, smart thinking requires developing smart habits to acquire high-quality knowledge and to apply this knowledge to achieve your goals (Markman, 2012).

A script codifies the schemas for a particular event; it directs attention selectively, pointing to what is relevant and ignoring the rest - a crucial factor for programming computers (Goleman, 2005). A computer program has the capacity to make endless inferences about and responses to a situation - a script allows those inferences to be channeled along paths that make sense for a given event (Goleman, 2005).

20 Serious Play Can Lead to Serious Strategy

We follow (Brown, 2009) and (Sutton-Smith, 2001) in a conceptualization of *play* that will form one foundation of our automated diagnostic exploration efforts.

Humans adopt *play* as a foundational behavior that guides exploratory activity and in some cases becomes a basis for acquiring knowledge. Play is the basis of all art, games, books, sports, movies, fashion, fun, and wonder (Brown, 2009). Play is the vital essence of life - it is what makes life lively (Brown, 2009). However, a machine does not know how to play. It simply does what we tell it to do, so we must tell it how to play with the pieces on the board and the relationships among these pieces. Why must our machine play? Because, *Play is the answer to the question, How does anything new ever come about? (Jean Piaget).*

We further conceptualize play (Sutton-

Smith, 2001) as the extrusion of internal mental fantasy into the web of external constraints. Additionally, we adopt the practical aspect that play seems to be driven by the novelties, excitements, or anxieties that are most *urgent to the perceptions* of the players (Sutton-Smith, 2001). Finally, we note that the imagination makes unique models of the world, some of which lead us to anticipate useful changes - the strategic flexibility of the imagination, of play, and of the playful is the ultimate guarantor of our game-based survival (Sutton-Smith, 2001). Play lies at the core of creativity and innovation (Brown, 2009).

We desire our machine to always be busy making up its own work assignments (Paley, 1991). Specifically, the "work assignments" involve choosing our courses of action and adjusting those courses based on the internal satisfactions we receive (Henricks, 2006). We desire from our machine a behavior similar to "playfulness", and a set of creative, inquisitive, exploratory orientations centered on an object-based model of the game-world (Henricks, 2006). We desire an activity of directed exploration, object manipulation and precise appraisal. We seek to manage the exploration of the new. This conceptually involves the creation of small-scale experiments that can be run outside the mainstream management systems and learned from (Välikangas, 2010). Whatever we do, we do not perform as immutable policy, but as an experiment. We use the action to learn. Learning means the willingness to go slowly, to try things out, and to collect information about the effects of actions, including information that the action is not working (Meadows et al., 2005). We resort to strategic experiments because more is unknown rather than known - the winner is often the one who learns and adapts the quickest (Govindarajan and Trimble, 2005).

We agree with (Brown, 2009) that *movement* is primal and accompanies all the elements of play we are examining. Through movement play, *we think in motion* - movement structures our knowledge of the world, space, time, and our relationship to others (Brown, 2009).

The creative person can be seen as embodying or acting as two characters, a muse and an editor... the muse proposes, the editor disposes. The editor criticizes, shapes, and organizes the raw material that the free play of the muse has generated. -Stephen Nachmanovitch

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Our exploration of future game positions therefore must take into account piece movement that is likely, critical, interesting, stress inducing/relieving, or otherwise "lively". Children at play engage other children or contemplate ways to engage their playmates. We therefore desire to create a heuristic which playfully examines the future consequences of the transformation of stress on the board, as the pieces move about or are *constrained* by objects on the board, such as blocked pawns or lower-valued enemy pieces.

Our efforts roughly follow Baldwin's concept of a *voluntary process*, which involves three elements: desire, deliberation, and effort (Baldwin, 1906). *Desire* implies a lack of satisfaction with one or more of our expert-derived sustainability needs - suggesting a move as a *reflex response* in an initial attempt at exploring the future. In *deliberation*, we acknowledge the complexity actually present on the game board, which requires additional investigation beyond our initial perceptions and explorations. Uncertainty and resistance require that we pursue a strategy of scenario construction to interpret how the power relationships among the game pieces might change, allowing us to stress-test the position to determine the suitableness of a move for execution. Finally, *effort* arises just after deliberation, and either selectively continues the deliberation process or puts an end to it. For Baldwin, every original co-ordination of perceived stimulation involving desire, deliberation, and effort is an act of *attention*. For Marcus (Marcus, 2008), a reflexive system excels in handling the routine, while the deliberative system helps us to think outside the box. Wisdom will come ultimately from recognizing and harmonizing the strengths and weaknesses of the two.

We begin our efforts by conceptualizing the building of a *principal variation* two moves into the future, by first examining the single move that creates the most oriented stress for our opponent (or mitigates the perceived stress caused by his pieces). Again using our orientors as discussed earlier, we then look at the most likely response. For Roos and Victor, the first thing we do with play is to actively construct what we see in our imagination. This *construction phase* allows us to bring our intuition from all our experience and our analyses into something concrete, something we can play with (Roos and Victor, 1998). For de Geus (de Geus, 2002), we do not navigate to a predefined destination. We take steps, one at a time, into an unknowable future. Follett (Follett, 1924) has discussed this simple approach conceptually as a "reflex-reaction" which attempts to alter the perception of the reflex stimulus - we are using an *effector* to respond to what our *receptor* has detected. The task we face here (Shotter, 2008b) cannot be planned ahead of time, for the relevant features influencing each step only become present to us as we take each step, as we move pieces around within our surroundings. Thus, we must always create the relevant, sequentially unfolding ways of relating ourselves to events in our circumstances for another next first time from within what Shotter has called "the interactive moment."

Why do we act this way? In the world of practical human affairs, men must often *interlace* their actions in with those of others (Shotter, 1980), hence, what they as individuals *desire* and what *actually happens* are often two quite different things. Our action of interest is *joint action* (Ginsburg, 1980) - the results of which cannot be traced back to the intentions or desires of particular individuals, such as (in our interpretation) the players in a game or contest. Such joint action points to multiple other possible actions, to a world of meaning or reference which seems to make its appearance even as this joint action occurs (Shotter, 1980). The essence of adaptive management (Walker and Salt, 2012) is treating management as an experiment, or to be more precise, treating it as a hypothesis coupled to a management experiment to test it. Hypotheses about the nature of a situation help to narrow the range of possibilities (Kramer, 2007).

The dynamic of the [Weick, 1979] model can be described as follows. A system deals with the dynamic complexities of its environment (ecological change) by acting to meet the demands of the environment (enactment) and by developing insight into the nature of the environment on the basis of these actions (selection, retention)... dynamic complexity is *dealt with by using hypotheses... and it is therefore considered to be a model that describes how hypotheses are developed - Eric-Hans Kramer, Organizing Doubt, p.81*

In such joint activity (Shotter, 2008b), entities must, in their spontaneously responsive reactions to those around them, interlace what they do in with the activities of others. In such circumstances we remain ignorant of quite what we are doing, not because the plans or scripts in us informing our conduct are too deeply buried to bring out easily into the light of day, but because they are not the major influences on our conduct. *The actions of others determine our conduct just as much as anything within ourselves.* For Shotter (Shotter, 2008b), and as a result, the overall outcome of the exchange is simply not up to us. In fact, it cannot be traced back to the intentions of any individual - man or machine. If we can become familiar with the nature and character of joint action, we can learn both to attend knowledgeably - and to interact meaningfully - with an event of joint action *even though we cannot mechanically predict the details of its actual unfolding* (Shotter, 2008b).

After "sliding forward" (or specifically, making a *strategic consequential exploratory hypothesis*) to discover or learn the unintended and unpredictable effects of joint action (Shotter, 2010), we then work backwards in our principal variation, examining the consequences of the *next most likely move*, and so on. A system should have the ability to discredit its current insights (Kramer, 2007) - dynamic complexity is necessarily dealt with by using hypotheses - doubt reminds the system of the inherent risks of hypotheses. A joint action always has to undergo a process of formation - each instance of players fitting their lines of action to one another has to be formed anew (Blumer, 1986). Joint action is temporally linked with previous joint action (Blumer, 1986). Our behavior becomes an activity where our orientor-derived "wishes" confront the activity of the environment (Follett, 1924), each altered continuously not only by the other but by the activity between them. We interpret the multiple-stimulus "mess" as a whole and watch the response to that, as the interknit factors develop (Follett, 1924). We might follow Follett's conception of behavior and conceive of a *reflex arc* as the path of our perception as stimulus and response interweave in a self-creating coherence (Follett, 1924). Our actions are determined by what is in fact anticipated by those who will respond to what we do - they have no meaning in and of themselves - only within an ongoing confluence of joint- or co-action can they begin to have a practical meaning (Shotter, 2012b).

Mutual social coordination requires that there be a continuous unfolding of individual action that is susceptible to being continuously modified by the continuously changing actions of the partner. I call this continuous mutual adaptation process co-regulation. -Alan Fogel

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For Fogel (Fogel, 1993) (Fogel et al., 1997), *co-regulation* is a social process by which individuals dynamically alter their actions with respect to the ongoing and anticipated actions of their partner/opponent. During co-regulated discourse the individual's actions are emergent from the constraints on individual action. Co-regulation refers to the dynamic balancing act by which a smooth (social) performance is created out of the continuous mutual adjustments of action between partners/opponents. This continuous process of co-regulated interaction is, effectively, the way we explore the future consequences of our candidate move, and becomes the diagnostic test of adaptive capacity.

Co-regulation is the mutual creation of action by a negotiated process of exerting and ceding control in which self and other are relational poles of a dialog. -Alan Fogel

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Influenced by Bakhtin, we see every candidate move as directed towards an *answer* and profoundly influenced by the answering move that it anticipates. The candidate move formed by an agent playing a game is directly, blatantly, oriented toward a future answer-move; it provokes an answer, anticipates it and structures itself in the answer's direction (Bakhtin, 1981). The words of Brenner (in an unrelated matter) are now appropriate: it is a characteristic of this *discovery phase* that various lines of promise will perhaps prove to be transient; others will stand up to the various empirical tests to which they will be put and prove fruitful. The winners in the 'race of ideas' cannot be decided at this point (Brenner, 1980).

We see parallels to the approach of Daniel Stern in the field of psychology (Stern, 2004). *Moving Along* is the term the Boston Change Process Study Group uses for the everyday dialog that moves a therapy session forward - at least in time. It is what the therapist and patient do together. Moving along captures the often ambling, loosely directed process of searching for and finding a path to take, of losing the way and then finding it (or a new one) again, and of choosing goals to orient to - goals that are often discovered only as you go along (Stern, 2004). This is the view of the process at the local level as it is unfolding.

For Stern, the moving along process is by its nature improvised - sloppiness is not to be avoided or regretted but rather is necessary to understand the almost unlimited co-creativity of the moving along process. If one accepts that sloppiness is not only necessary but potentially creative, and not necessarily psychodynamically determined [i.e., the dynamic interplay of conscious and unconscious factors] but inherent in the moving along process, one treats it differently (Stern, 2004). We can apply Stern's ideas to playing a game such as chess - each relational move and present moment is designed to express an intention relative to the inferred intentions of the other. The two end up seeking, chasing, missing, finding, and shaping each other's intentionality. In this sense also, the moving along process is co-created.

Importantly, Stern also speaks of *vitality dynamics* (Stern, 2010) - we proceed in the way described in order to notice changes or shifts in the vital sustainability forces felt to be active during an event in motion or in our case, an event under development. We can then apply techniques suggested by Pfaff (Pfaff, 2006) to generate arousal - the most fundamental force in the human nervous system - to direct our explorations in ways to restore sustainability perceptions and to generate a better fit into the environment of our position. Very simply, we explore moves and the consequences of moves where we are the most uncertain about the sustainability of our position or our opponent's position.

We must conduct our inquiries from within the midst of turbulent, flowing processes, within which the only stabilities available to us are -

like the eddies and vortices that form in confluences in which two or more flowing processes meet together - dynamic stabilities dependent for their very existence upon their embedding within the continuous flow of relational activity in their surroundings. -John Shotter

In this "serious play" we have described we seek serious strategy (Roos and Victor, 1998) - we strive to retain control over the course of the imagined interaction by constantly reacting to its emerging results - what can and cannot be done must depend on what the enemy can or cannot do (Luttwak, 2001). The success of any strategic move always depends upon the current initiatives of and potential reactions available to competitors (Fahey, 1998). The ambiguity we face as we look into the future generates its own possible resolution (Byers, 2011). Any specific understanding of ambiguity must necessarily be tentative - ambiguity is real but cannot be made precise. It is ambiguity and not certainty that best describes the way things are (Byers, 2011).

Play is experimenting with a toy that the player accepts as representing his or her reality. This makes the toy a representation of the real world with which the learner can experiment without having to fear the consequences... Underneath all the fun there is a very serious purpose: playing with one's reality allows one to understand more of the world we live in. To play is to learn. -Arie de Geus

Byers declares that the clarity of science has room within it for the ambiguous and goes seriously astray when this ambiguity is unacknowledged (Byers, 2011). Further for Byers, the statement of the fundamental ambiguity (such as the principal variation we develop in attempting to "play" a game such as chess) gives us an insight into what is going on; at every level, the same fundamental dynamic of ambiguity plays itself out (Byers, 2011). The results of science and the critical problems that we face demand that we face up to uncertainty and ambiguity, no matter how stressful this is (Byers, 2011).

We establish a few simple rules for our serious play: we orient our diagnostic exploration efforts (initially) along the lines of improving the score of the weakest, vital diagnostic test - the *strategic principle* which enables us to do something now by guiding our action and helping to allocate scarce resources (Gadiesh and Gilbert, 2001). We perform a exploration "cut-off" only after we confirm that the position in question is *resilient* and the moves left unexamined are not the most promising (and remain so), after performing a shallower exploration.

man is in his actions and practice, as well as in his fictions, essentially a story-telling animal. He is not essentially, but becomes through his history, a teller of stories that aspire to truth... I can only answer the question 'What am I to do?' if I can answer the prior question 'Of what story or stories do I find myself a part?' - Alasdair MacIntyre

We seek to tell stories - narratives - which reflect our values and which paint different futures of how the driving forces might behave. We pay attention only to what we think we need to know (Schwartz, 1996). The events are made into a story by the suppression or subordination of certain of them and the highlighting of others (White, 1978). Meaning, then rests not within the individual symbolic acts which possess "interestingness", but within the episode itself (Johnson-Cartee, 2005). Experimentation may seem incongruent with sustainability. But in a world whose only certainty is change, adapting - at the proper scale and speed - is the only means to sustain what we value (Thiele, 2011).

We must confront ourselves with at least a crude and basic version of what ultimately might transpire, in order for decisions made now to become effective later. What seemed like a good idea initially might not seem so when one looks at the consequences of the consequences. Using a range of different scenarios you greatly reduce the likelihood of unintended consequences (Ogilvy, 2002). In order to interpret present meaning, we need to spin out alternative scenarios of future use. As only a snapshot of the present, current-position data is ambiguous. Many scenarios are necessary to interpret the several possible meanings of these signs (Ogilvy, 2002).

Unexpected discoveries in the principal variation will cause the machine to re-focus its efforts on the next most promising lines. We then begin to deepen our diagnostic exploration efforts and spend more time exploring alternate moves in our principal variation. We do things in order to discover what to do - our actions, which amount to little "bets" on which moves are promising, produce insights which can be analyzed (Sims, 2011).

This is nothing more than *Ashby's model for adaptiveness* (Bertalanffy, 1968), where the system tries different ways and means, and eventually settles down in a field where it no longer comes into conflict with critical dynamic values of the environment. Our leverage for dealing with "driving forces" comes from recognizing them, and understanding their effects. Little by little, our actions contribute to new driving forces which in turn will change the world of the gameboard once more (Schwartz, 1996). On some level, all three layers of intelligence - action, strategy, and prediction - need to occur simultaneously to create a seamless sustaining of competitive advantage (Rothberg and Erickson, 2005).

Intelligence for a system with limited processing resources consists in making wise choices of what to do next (Simon and Newell, 1976) or how to go on (Wittgenstein, 2009). There is no easy *solution* for complex problems. What there is instead is an obvious *direction* (for exploration). The reason is that often there are too many (interacting) variables in a situation (Trout, 2008). This directed and flexibly persistent "evolution" creates designs, or more appropriately, discovers designs, through a process of trial and error (Beinhocker, 2007).

Evolution is a general-purpose and highly powerful recipe for finding innovative solutions to complex problems. It is a learning algorithm that adapts to changing environments and accumulates knowledge over time. - Eric Beinhocker

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Evolution is a possibility generator (Beckham, 1998). A variety of candidate designs are created and tried out in the environment; designs that are successful are retained, replicated and built upon, while those that are unsuccessful are discarded (Beinhocker, 2007). Evolution is a method for searching enormous, almost infinitely large spaces of possible designs for the almost infinitesimally small fraction of designs that are "fit" according to their particular purpose and environment (Beinhocker, 2007).

Evolution is a general-purpose and highly powerful recipe for finding innovative solutions to complex problems (Beinhocker, 2007). It is a learning algorithm that adapts to changing environments and accumulates knowledge over time (Beinhocker, 2007). The limits to this approach are seen to be the ability to manage complexity, and knowledge (Beinhocker, 2007). Beckham agrees (Beckham, 2006), declaring that smart organizations subject their most important decisions to a Darwinian environment in which the strongest ideas survive and evolve to higher levels of fitness. The strategist looks at evolution not so much in terms of the survival of actual organisms, but the survival of ideas (van der Heijden, 2005).

Stephen Gould (Gould, 1996), speaking of biological evolution, notes that a species can evolve further only by using what physical properties it has in new and interesting ways. Any biological adaptation also produces a host of structural by-products, initially irrelevant to the organism's functioning but available for later cooptation in fashioning novel evolutionary directions. Evolution continually recycles, in different and creative ways, many structures built for radically different initial reasons (Gould, 2002). For Gould, much of biological evolution's creative power lies in the flexibility provided by this storehouse of latent functional potential. It is quirky shifts and latent potential, redundancy, and selected flexibility - three basic principles which define and permit the creativity of evolution, the capacity to originate novel structures and functions.

For Mitchell (Mitchell, 2009), the result of evolution by natural selection, in our case simulated, is the appearance of "design" but with no designer. We hypothesize with Mitchell that the appearance of computer-produced design comes from chance, the selection for exploration of the promising moves which are fit for the game environment, and long periods of simulated time in order to validate this fitness.

We see the diagnostic exploration "tree" formed in this fashion as an extended diagnostic test of how *resilient* and *adaptively controlling* our position is - the predisposed capacity to respond effectively to future situations that are beyond our ability to predict. We see resilience as the basic strength and adaptive control (with the *flexible persistence* of Beckham (Beckham, 2002) as a foundation) as the primary objective. These properties are more measurable and meaningful than estimates of winnability, especially in the case where we are deciding what to do next (and ignorant of what the future holds). The "tree" is more a tool which is useful to plan what we want to learn, rather than an expectation of where we will be in the end (Cohn, 2006). We fully expect that our opponent will (eventually) play a move which will take us outside of our current learning tree, and we fully expect, through the mechanisms of resilience and adaptive control, to be able to meet the challenges of the positions which newly emerge.

After "evolving" a plan through a mechanism that "proposes" and then "disposes", we can test it using the principles of *war gaming* developed by Gilad (Gilad, 2009). More specifically, we develop basic scenarios that illustrate the full range of potential strategic shifts (threats or opportunities) (Page, 1996). A wargame develops scenarios (through the mechanism of simulated competition) that otherwise might not occur to us (Herman et al., 2009). The basic aim of a war game, which ideally captures the complexity of competitive dynamics, is to turn information into actionable intelligence (Fleisher and Bensoussan, 2007). Gilad would have us envision any and all plans that we develop as *bets* that come with *risk*, a risk originating from the competitive dynamics in our environment. We now test our plan and its assumption that the competitive response we will receive from our opponent is *containable*. War gaming is nothing more than role-playing in order to understand a third party, with the goal of answering: What will the opponent do? What then is my best option? Gilad cautions that war gaming will not guarantee success - nothing will - but states that *it will increase the odds in our favor*. Ideally, *an effective war game produces a list of improvements for the existing plan, or a list of options for a new plan.*

Scenario-based planning attempts to make sense of the situation by looking at multiple futures, which are treated as equally plausible, reflecting not only the inherent uncertainty in the situation, but also what is considered predictable (van der Heijden, 2005). The purpose of scenarios, wrote Pierre Wack, is to gather and transform information of strategic significance into fresh perceptions. When this works, it leads to strategic insights beyond the mind's previous reach (Schwartz, 1996). For Schwartz, it is driving forces, predetermined elements, and critical uncertainties which give structure to our exploration of the future (Schwartz, 1996). The process of building scenarios starts with looking for driving forces, the forces that influence the outcome of events. Driving forces are the elements that move the plot of a scenario, that determine the story's outcome. Without driving forces, there is no way to begin thinking through a scenario. For Schwartz, they are a device for honing an initial judgment, for helping to decide which factors will be significant and which factors will not (Schwartz, 1996).

For Michael Howard, it is essential that we constantly try to adapt ourselves to the unpredictable, and to the unknown. Our plans, whatever they are, are likely wrong. This fact is, for Howard, amazingly irrelevant. What matters is that we get them right when the critical moment arrives (Howard, 1974). We affirmatively answer Herman's central question (Herman et al., 2009): if we had the opportunity to probe the future, make strategic choices, and view the consequences of those choices in a risk-free environment before making irrevocable decisions, that we would in fact take advantage of such an opportunity. For (Oriesek and Schwarz, 2008), wargaming is a form of accelerated learning.

This process is termed "path analysis" by Bossel (Bossel, 2007), who suggests that our first task consists of quickly finding the most relevant development paths despite a multitude of uncertain, time-dependent, or adjustable parameters. The efficiency of this task, in his and our opinion, depends on how cleverly possible parameter constellations are combined in consistent and plausible scenarios.

The second task of path analysis is the comparative evaluation and assessment of different development paths to clarify which path (or which group of paths) should be preferred. For Bossel, in this phase of the work, *evaluation criteria* have to be introduced that reflect the existence and development interests of the system. We must make sure that the necessary minimum level of orientor fulfillment is achieved for each individual orientor, then we must determine the total quality of orientor satisfaction (for individual orientors and some aggregated quality measure).

We additionally note positions where imbalances are created (using our vital diagnostic indicators) and investigate the consequences, especially when efforts to return to a resilient position require extra efforts.

For software testing and configuration purposes, we envision the use of *automated tournaments of hundreds of games*, each lasting perhaps three minutes long, to assess and fix the parameters of these orientation/evaluation efforts so that we might succeed in the widest number of situations. We envision a tool which identifies and stores positions where faulty analysis was generated. We see the programmer/developer examining these saved positions and identifying the reason for the failure to orient/evaluate the indicated position.

We recognize certain positions as "tactical" in nature when responses become forced or when imbalances in vital indicators create few branches in our principal variation. We defer in these cases to a methodology designed for a more tactical situation.

We critically examine the trade-offs between examining principal variations that are many moves long, versus the exploration of the secondary and tertiary lines that do not go as deep. We conceptualize our machine behaving like a child at play, creating novel combinations, and finding or discovering what works and does not work in an evolutionary fashion. We strive to enter into dialog-structured relations with our opponent, and to allow these relations to call out spontaneous reactions from us. We aim for an engaged, responsive understanding from within the unfolding dynamics of such relationships. This kind of understanding is utterly unavailable to us if we adopt exclusively a non dialog-based approach (Shotter, 2008b).

We can base our efforts on the observed behavior of large groups of Internet-connected humans examining a common chess position, such as the daily chess puzzle featured at http://www.chessgames.com/index.html (we have no connection to the owners of this site - one of us (JLJ) pays a yearly fee to access certain advanced site features).

21 John Boyd's OODA Loop

The *OODA Loop* (Observe, Orient, Decide, Act) is a strategic methodology which was originally applied by USAF Colonel John Richard Boyd to the combat operation process http://en.wikipedia.org/wiki/OODA_loop. Boyd was of the opinion that without OODA loops, we will find it impossible to comprehend, shape, adapt to, and in turn be shaped by an unfolding, evolving reality that is uncertain, ever-changing, and unpredictable (Boyd, 1996). Boyd advocates an approach of pulling things apart and putting them back together until something new and different is created (Boyd, 1987). Further, Boyd suggests we present our opponents with ambiguous or novel situations in which they are not capable of orienting their behavior or coping with what's going on (Boyd, 1987), while we maintain our *fingerspitzengefühl*. For Boyd, orientation shapes the way we interact with the environment, and therefore the way we observe, decide, and act (Boyd, 2005). Boyd suggests that effective orientation demands that we create mental images, views, or impressions, hence patterns that match with the activity of our world (Boyd, 2005).

For Boyd, in a competitive encounter against a talented opponent, our limited perceptions cause novelty to be produced continuously, and in an unpredictable manner. In order to maintain a competitive position we must match our thinking and doing, hence our orientation, with that emerging novelty. Yet, any orientation we assume prior to this emerging novelty is perhaps mismatched after the fact, possibly causing confusion and disorientation. However, Boyd points out, the analytical/synthetic process permits us to address these mismatches so that we can competitively *rematch* ourselves and thereby reorient our thinking and action with that novelty (Boyd, 1992).

We therefore envision our *diagnostic exploration process* as an operational realization of this concept. We *observe* information, unfolding circumstances and interactions, *orient* our behavior according to Bossel's concepts discussed earlier, *decide* which path to explore, and then *act* by "sliding forward" one move. We then repeat the process, periodically "backtracking" to examine moves which were initially determined to be the next best.

(Boyd, 1976) attempts to philosophically arrive at a theory useful for conducting warfare or other forms of competition, such as playing a game. Boyd concluded that to maintain a competitively effective grasp of reality one must operationally follow a continuous cycle of interaction with the environment oriented to assessing its constant changes. Boyd states that the OODA decision cycle is the central mechanism of such adaptation, and that increasing one's own rate and accuracy of assessment (compared to that of one's opponent) provides a strategic foundation for acquiring an operational advantage in a dynamically changing environment.

Conceptually, we are exploring the present and future consequences of the transformation of positional stress, with an emphasis on the sustainability of the intermediate positions, the satisfaction of our operational needs, and (ultimately) the perceived winnability of the final position. We are faced with a dynamic, novel, unstable world that we must constantly adapt to even as we try to shape it for our own ends (Hammond, 2001).

22 Adaptive Campaigning model of Grisogono and Ryan

Grisogono and Ryan (Grisogono and Ryan, 2007) propose the model of *Adaptive Campaigning* as a modified form of Boyd's OODA loop that presents a more relevant form for the challenges of operating in an environment with high operational uncertainty. Here we 'adapt' their approach for game theory.

Adaptive Campaigning proposes a repeating cycle of Act Sense Decide Adapt (ASDA). By placing 'Act' first this model stresses the need to act (make exploratory trial moves) with whatever information is present, and by immediately following that with a 'Sense' of what has changed in our environment. The 'Decide' function follows to determine what is learned from the sensed feedback that results from the action, and what to do next - including possible re-orientation based on results from the vital diagnostic tests.

These first three elements of Adaptive Campaigning correspond closely to the four elements of Boyd's OODA loop, but with a different emphasis on where the cycle starts, and with the

'Orient' function of OODA incorporated into the 'Decide' functions of ASDA. The object of the 'decision' is to choose the next trial move in our forward exploration, or to begin backtracking by exploring alternative moves in our principal variation. So 'Adapt', the fourth element of ASDA, explicitly adds the need to invoke adaptation and consider what, if anything, should be changed on every cycle, before continuing to the next cycle with another external 'Act'.

Ideally, successful application of the 'Adapt' element results in the machine improving its ability to focus/orient its efforts on the right objectives at the right time and in the right place. Modern combat, including game playing, can therefore be characterized as *competitive learning* in which all sides are constantly in a process of creating, testing and refining hypotheses about the nature of the reality of which they are a part (Kelly and Brennan, 2009).

Recent criticism of Adapting Campaigning (Thomas, 2010) claims that Boyd's work adequately addresses the issues in question, and should be revisited. Time will tell whether OODA or ASDA loops will prevail.

23 Bent Flyvbjerg's "OODA Loop"

Flyvbjerg (Flyvbjerg, 2001) has arrived at a OODA-type loop by asking the following questions: 1. Where are we going? 2. Who gains, and who loses, by which mechanisms of power? 3. Is it desirable? 4. What should be done? - which perhaps allows a more incremental or contemplative action than that suggested by Boyd. A sensitive perception of the power relations (and how they change) might allow one to "feel" how the situation might evolve. What Bourdieu (Bourdieu, 1990) calls the "feel for the game" is central to all human action of any complexity, including planning, and it enables an infinite number of 'moves' to be made, adapted to the infinite number of possible situations, which no rule maker, however complex the rule, can foresee (Flyvbjerg, 2004).

When combined with a move-suggestion heuristic which is reasonably effective (such as the satisfaction of sustainability needs), perhaps all that needs be done is to sit and execute. Flyvbjerg (Flyvbjerg, 2004) would have us ask "What possibilities are available to change existing power relations?" There can be no adequate understanding of planning without placing the analysis of planning within the context of power. Rationality without power spells irrelevance (Flyvbjerg, 1998b) (Flyvbjerg, 2004).

24 Endpoint Evaluation

Much as an employee receiving a yearly evaluation from his or her employer, we must come up with a method to decide how desirable a game position is, at the point we voluntarily stop diagnostic exploration and probing efforts. But the future is unknown, and unknowable. Worse, selecting a point at which we can evaluate, once and for all, the consequences of an action is a convenient fiction. In reality, the game positions we address as outcomes are never really endpoints - they are artificially imposed milestones (Watts, 2011). Something always happens afterward, and what happens afterward is liable to change our perception of the current outcome (Watts, 2011). We seek therefore to establish dynamic potential through a sum of lagging and leading indicators - the orientors discussed earlier, except that we are no longer interested in *guiding diagnostic action* but instead in *establishing value* via vicarious or substitute trial and error, much as a *Consumer Reports* magazine evaluates, then ranks automobiles via a score relating to their perceived value. The score is a prediction of your satisfaction level, possibly years after you make the purchase, relative to other possible purchases.

What do we choose to value? In our view, no term offers more promise than *health* (Newton and Freyfogle, 2005), which connotes a kind of vigorous prospering. Health is an attribute, not of an entity in isolation, but of an entity integrated into an environment. Health needs to include healthy relationships, cycles, and functions. Properly grounded, health can serve as our overall goal. In an interlocked system at a given time, it is possible to maximize only one variable (Newton and Freyfogle, 2005). We cannot, as David Ehrenfeld has observed, make everything "best" simultaneously. Health is plainly a goal (an end) rather than a means (Newton and Freyfogle, 2005). The yardstick of success for Hart (Hart, 1991) is the degree of *freedom of action* one enjoys at the end of the maneuver process. To this end one seeks all possible means of keeping the enemy guessing - the advantage goes to the side which can most quickly adjust itself to the new and unfamiliar environment and learn from its mistakes (Howard, 1974).

What specifically do we choose to value? Whatever indicates or hints at how the present interlocking forces will resolve in the unknowable future. We value the *signs* of a healthy position, in the hope that this *appearance of health* reflects (and is part of) a true health underneath (Foucault, 1994). These signs are both objects of knowledge and that which they signify (Foucault, 1994). But why value a sign of health? We have to stop analysis somewhere - each sign is just a surface phenomena and in itself not the thing that presents itself to interpretation, but instead the interpretation of yet other signs (Foucault, 1964). Semiotics is the theory of signs, of how they signify and mean what they mean. We value signs because in playing a game we are - and become - the results of our dedication to our chosen symbols (Ogilvy, 2011). We cannot know what reality is in any absolute or objectivist fashion; instead, all we can know is our symbolic constructions, the symbolic realities that are defined by our particular paradigms or frames of vision (Ogilvy, 2011).

Where possible, our numerical health score is based on chances of winning. In certain cases, opening book databases can be consulted to establish a winning percentage, based on the number of high-level games played and the win-loss-draw results. We speculate that two computer chess programs, each developed independently, might consistently arrive at nearly the same *numerical endpoint evaluation*, in the opening stage of the game, if calibrated to the winning percentage expected from databases of recent high-level games, and where an identical strategy has been selected of obtaining a resilient position and adaptive control in the face of uncertainty and resistance. Evidence for independent development might only be proven with longer time controls, such as in correspondence chess, or in positions obtained in middlegame or endgame, where the different diagnostic exploration mechanisms are uniquely influenced and differentiated by finding sustainable paths to advantage.

Alternatively, distance (in moves) from checkmate can be used, where we can directly perceive the checkmate in our diagnostic exploration efforts.

We suspect (backed by a review of positions from competitive events) that most positions faced by our machine will not fall into either category. We propose for these positions a method which seeks a perception of *substitute or vicarious trial and error* - a source of information in approximate equivalence to what we would arrive at if we actually explored further (Campbell, 1956) - that will serve us (functionally) as an important *behavioral guide*.

Conceptually, we can use *oriented stress* to estimate the size of the advantage, measured as *the size of the mistake which could be made by the player with the advantage, which would then lead to a sustainable, even game*. To have an advantage is to have the ability to make a mistake - a greater advantage means we can make a greater mistake. This concept is more directly measurable than winning chances, which are often shrouded in dynamic complexity, and can be used in a game strategy which seeks to accumulate small positional advantages over time. What we are saying is simply that it is easier (in most cases) to measure and favor "increasing distance from draw" than "decreasing distance from checkmate" - this aligns with Lawrence (Lawrence, 1997), who declares that it may be more important to know whether we are making progress towards the goal than it is to know the size of the gap between the current situation and the (ultimate) goal we have set. We hypothesize that this conceptual foundation is equivalent, in most cases.

This measurement philosophy will need to be adjusted in certain well-known cases, such as Rook and pawn endings, or Bishop of opposite color endings, where an additional pawn might not have direct leverage into winning potential. Such cases would need to be programmed in on a case by case basis, starting with the most likely endgames, and consulting a reference such as Fine (Fine and Benko, 2003).

The purpose of the endpoint evaluation (for the principal variation) should be to establish a *marker* against which we compare competing moves and branch moves. We construct *strategic challenge lines* (with perhaps less effort in time) and see how close we come to the marker score. Those challenge lines which come close in score to the marker will become strategic fallback positions, and will become elevated to the new principal variation - or a replacement branch of the principal variation - if emergent discoveries are made which force us to change our mind on which move (or move branch) is the most promising. We are organizing our sustainability perceptions into a narrative format, and, subsequently, integrating newly acquired narratives into available, already internalized "tales" (Thiele, 2006).

Very simply, Karl Weick informs us that judgments of accuracy lie in *the path of the action* (Weick, 1995). Our endpoint "evaluation" is deemed "usefully accurate for game playing purposes" if and only if it steers our exploration efforts down the diagnostically important paths, and away from the diagnostically unimportant sequences. Errors in this characteristic alone make or break our scoring methods.

Our endpoint evaluation (for the principal variation) will represent 1) a vicarious estimate of what we would obtain if we continued further our trial and error explorations and 2) the fact that no strategic challenge line *that we investigated* resulted in a more promising score for either white or black. It represents a strategic estimate of the adaptive capacity of the system, after performing intelligently-constructed (but limited by time constraints) stress-test investigations. As the output of a diagnostic test it is neither right nor wrong - it is a strategic guide for further investigation and also a (curiously) useful technique for selecting a move in a time-limited social game. When our orientors of behavior are properly established and our challenge lines properly determined and investigated (from a sustainability perspective), endpoint evaluation can be used as an effective estimate of the chances of winning the game. Otherwise it is just one path of many - long analysis which is likely wrong analysis.

It should be no surprise if we never actually reach these endpoint positions in the actual game - we are executing a diagnostic test of the ability to configure and reconfigure in order to persist in time (Bejin and Zane, 2012). An adaptive position will possess the capability of reconfiguration - the system will be free to morph - and in fact will exercise this capacity at some point down our projected diagnostic path. The scenario planning approach does not claim to be able to "see" the future - but rather to better prepare us for whatever future does emerge - in effect, helping us to construct our own diagnostic test of adaptiveness. Endpoint evaluation is a necessary part of that process, directing attention down the diagnostically important paths (and away from those paths which will likely provide us no diagnostic information) to efficiently "stress test" the system as a way of measuring resilience. The machine is gathering information which is useful as a diagnostic test of adaptive capacity. We use the results of this test to have the machine dwell on or attend to the lines that deserve our attention in estimating resilience - some might say to "play" the game of chess.

Taking a *performative*, rather than a representational attitude, to the aims of our inquiries, leads us to the realization that their outcomes are not to be measured in terms of their end points, the results they arrive at, but in terms of what we learn, what we can come to embody, along the way in making them (Shotter, 2011).

The procedural details and critical tradeoffs at a deeper conceptual level (such as exploration depth versus exploration width, or the cues which direct us to abandon unpromising lines) might not be derivable from theory alone - procedures are ideally developed and refined in diagnostic tournaments of hundreds of 3-minute (duration) games. Obviously, we do not want to spend time (or attention) looking at unpromising moves which hold little chance of becoming the principal variation. These unpromising and unlikely moves tell us little about our adaptive capacity - we can postpone or spend less time attending to them when we can generate diagnostic evidence of sustainability and an advantage margin which indicates that such paths are unlikely. Zukier cites Aristotle (Zukier, 1986) in declaring that human happiness (or misery) takes the form of action, that the end for which we live is a certain kind of activity. We are "happy" when our diagnostic test of adaptive capacity - our intelligently constructed stress test of our position - shows evidence of stretching and adapting activity, in well-crafted scenarios of future development.

In comparing different paths of system development, we hypothesize with Bossel that the most favorable path will be the one for which (1) the minimum conditions are always satisfied for all orientors, and (2) the overall orientor satisfaction is better (Bossel, 2007).

25 Complexity

We insist that it is *complexity itself* which demands an approach much like the *proposed heuristic* in order to play a game like chess at a high level in a tactically empty position. Complex systems are controlled by countless individual interactions that occur inside the system (Benyus, 2002). The complexity present when playing in the positional style is due to connections - the more connected something is, the more complex it is (Beckham, 2001). A change in one connected thing gives rise to changes in the various things to which it is connected. More connections mean more change (Beckham, 2001).

In a complex environment, the changes that one action will generate are often *beyond prediction* because of all the other interactions they set off (Beckham, 2001) (Byers, 2011). Small changes often amplify to become very large changes - all we can do is watch for warning signs (Benyus, 2002). Complex conditions demand continuous adaptation. In a complex, highly connected system, things happen fast - or in a way that involves a quick emergence into our perception. Maintaining a steady state of dynamic balance requires continuous adjustment and accommodation. These shifts occur naturally as one change sets off another (Beckham, 2001).

In Beckham's "zone of complexity" much different approaches are needed to succeed. These approaches involve making short predictions, enabling self-organization, using simple materials as building blocks, being continuously flexible and adaptive, all while looking for lessons and metaphors in other complex systems, particularly biological systems. Out there in the zone of complexity, things are different. We agree with Beckham that management that succeeds will be catalytic, facilitative, enabling, adaptive, incremental, and patient (Beckham, 2001).

Systems expert Russell Ackoff once emphasized that success with a true system demands the effective management of *interactions*, not the management of *actions*. *Interaction* is what happens continuously at the various connections between things. It follows then that successful management in a densely connected system involves managing effectively in an environment of complexity (Beckham, 2001).

Every piece on the game board, in its power relations to the other pieces, contributes to the complexity present. In response, we strategically form the principal variation, choose to explore (or not explore) the diagnostic paths, establish a resilient position with adaptive capacity, and ultimately, determine a "marker" score we use for comparison purposes with other possible moves to choose a move in the game. Our stress test of adaptive capacity is used to unravel complexity and strategically best-position ourselves for what will later emerge.

26 Uncertainty

van der Heijden's insightful observations of organizations facing their future can be applied to game theory. In playing a game, complexity and uncertainty are unavoidable, and are perhaps the main challenges faced by the players (van der Heijden, 2002). To deal with complexity and uncertainty, game players develop thinking approaches that are often flawed (van der Heijden, 2002). What is essential to long-term survival is the ability to recognize and react to change before your opponent (van der Heijden, 2002).

All strategic decisions are affected by uncertainty and the further one peers into the future, the greater the uncertainty impacting decisions (van der Heijden, 2002). Uncertainty is not, according to Pierre Wack, 'just an occasional, temporary deviation from a reasonable predictability; it is a basic structural feature of the... environment'. There can be no competitive advantage or strategy without uncertainty (van der Heijden, 2002). The only solution according to Wack, is to: 'accept uncertainty, try to understand it and make it part of your reasoning', which is essentially what scenario planning attempts to do (van der Heijden, 2002).

The scenario planner observes from a point in the future, from where the present is considered and explained - as a historian would explain historical facts (van der Heijden, 2002). Because of inherent uncertainty, multiple future vantage points are required. From each position, a different story is told that makes sense of the current 'blur' (van der Heijden, 2002). Uncertainty ensures that we will always end up with multiple scenarios: each one will be a logical story that interprets and explains what is happening and why (van der Heijden, 2002).

Complex systems carry a degree of intrinsic unpredictability that cannot be reduced by any amount of analysis (van der Heijden, 2002). Managers need to embrace uncertainty, to think creatively yet systemically about possible future events (van der Heijden, 2002). In doing so, scenario planners focus not on predicting single future outcomes, but rather on managing uncertainty in a number of scenarios projecting a range of plausible future outcomes (van der Heijden, 2002).

We embrace van der Heijden's ideas, which we have liberally applied and directly quoted in this section, in order to support our opinion that other approaches to playing the game of chess are faced with a 'horizon effect' that exists in part due to a failure to address the full effects of complexity and uncertainty.

27 Narrative Rationality

It is generally impossible to decide, at the time of perception, whether perceptions will prove accurate or inaccurate, correct or incorrect, because perceptions are partly predictions that may change reality, because different perceptions may lead to similar actions, and because similar perceptions may lead to different actions (Starbuck and Milliken, 1988). Many perceptual errors, perhaps the great majority, become erroneous only in retrospect (Starbuck and Milliken, 1988). Partly for this reason, we seek a narrative version of rationality.

To the extent that a story can be told about the world around us, sense can be made of its complex relationships, and judgments can be levied upon them. The mental acts of understanding and judging, cognitive psychologists suggest, is achieved through the organization of perceptions into narrative format, and, subsequently, the integration of newly acquired narratives into available, already internalized tales...

Narrative rationality (Fisher, 1985) is an attempt to recapture Aristotle's concept of *phronesis*, or "practical wisdom." Practical wisdom prompts us to address the question, "And then what?" before taking action (Thiele, 2011). We designate this concept as the meta-paradigm which explains how a machine can follow our human-written instructions to "play" a game such as chess. For Schank, storytelling and understanding are functionally the same thing (Schank, 1995). What is essential to narration is not that it is a *verbal* act of telling, as such, but that it embodies a certain point (or points) of view on a sequence of events (Carr, 1991).

Louis Mink has called narrative a primary "mode of comprehension" and a "cognitive instrument" (Carr, 2001). Very simply, narrative is the form in which we make comprehensible the many successive interrelationships that are comprised by a path or progress through life or history (Mink, 2001). Narrative is a primary and irreducible form of human comprehension, an article in the constitution of common sense (Mink, 2001). The cognitive function of narrative form is not just to relate a succession of events, but to mentally give form or shape to an ensemble of interrelationships (of many different kinds) as a single whole (Mink, 2001).

...This capacity arises because narrative, and narrative alone, allows us to forge a coherent temporal/historical context for existence while making sense, and justifying, actions in terms of plans and goals. -Leslie Paul Thiele

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The narrative paradigm offers a reliable, trustworthy, and desirable guide to belief and action (Fisher, 1985). When narration is taken as the master metaphor (Fisher, 1984), it subsumes the others. The other metaphors are then considered conceptions that inform various ways of recounting or accounting for choice and action. In short, *good reasons* (i.e., for playing one move over another) are the stuff of *good stories*, the means by which humans realize their nature as reasoning-valuing animals (Fisher, 1984).

There is no genre that is not an episode in a story (Fisher, 1985), which we stretch to include the conflict-situation faced by players in a game. Good reasons (for making a move) are an expression of practical wisdom; they are, in their highest expression, an encompassment of what is relative and objective in situations. They function to resolve exigencies by *locating and activating values* that go beyond the moment, making it possible that principles of decision or action can be generalized (Fisher, 1985).

No guarantee exists that one who uses narrative rationality will not adopt "bad" stories, but it does mitigate this tendency (Fisher, 1985). The absence of narrative capacity or a refusal of narrative indicates an absence or refusal of meaning itself (Fisher, 1984). When placed in the context of an episode (Frentz and Farrell, 1976), symbolic acts (such as sequential moves in a game) acquire *episodic force*, which completes the explanation by specifying the communicative function of the acts within the overall sequential structure of an episode. As stated earlier, the events are made into a story by the suppression or subordination of certain of them and the highlighting of others (White, 1978).

The *consequential force* of any symbolic act occurring in an episode follows logically from the *episodic force* of that act (Frentz and Farrell, 1976) - in our case, the narrative-inspired principal variation sets a "marker" score which determines the threshold of our attention when considering other moves.

During the encounter, actors (in our case, the players in the game) will survey the probable rules of propriety and - in principle - exclude the least likely candidates (Frentz and Farrell, 1976). For (Frentz and Farrell, 1976), it is *context* (meaningfulness criteria and encounters), *episodes* (strategically generated sequences of action whose goals and form are conjointly created by two or more actors) and *symbolic acts* (such as imagined moves in a game) which together form a language-action paradigm of rationality.

We aim for *narrative coherence* (Carr, 1991), an essential structural feature in performing an action, as we intend to shape and form future events. When plans go awry, when things fall apart, (Carr, 1991) it is by reference to or by contrast with story-like projections, "scenarios," that they do so. What occurs "one thing after another," is, in terms of reality (Carr, 1991), the result of narrative coherence. Narrative coherence (Carr, 1991) is what we find or effect in much of our experience and action, and to the extent that we do not, we aim for it, try to produce it, and try to restore it when it goes missing for whatever reason.

David Carr further informs us (Carr, 1991) that if we think of narrative as "organizing," "making sense of," and rendering "coherent" our action and experience, narrative organization of action may be considered cognitive in the sense that the action's implicit "story" is nothing but our knowledge of what we are about or what we are doing. Such narratives (Carr, 1991) may serve to organize and make sense of the experience and action of their authors and their readers, *focusing their attention in certain directions and orienting their actions toward certain goals.* A good story - necessary in sensemaking - holds disparate elements together long enough to energize and guide action (Weick, 1995).

In the end, our machine-code (when executed) accomplishes what rational people seek in any generalized situation (Frentz and Farrell, 1976): we consider various alternative actions and examine their consequences by an imaginative rehearsal of episodes. In light of this rehearsal and their intuitions about the propriety of each form the episode might take, a particular social action (here, a move in a game) is chosen. We aim for (Fisher, 1984) an inherent awareness of narrative probability, what constitutes a coherent story, and a constant habit of testing narrative fidelity, whether the stories we experience ring true with the value-inspired stories we know to be successful in diagnostic tournaments of many games.

A narrative which can bind the facts of our experience together leads to the full intelligibility and expression of our abstracted rules, principles and notions (Fisher, 1984) (Goldberg, 1982). Viewing events and actions in light of what follows them, and of what follows from them, is our way of viewing the present - more generally, it is our way of viewing time and living and acting in it (Carr, 1991).

The story schema can be applied to almost all events in our social life (Polkinghorne, 1988). Mink wrote of the configurational mode of comprehension, where things are understood as elements in a single and concrete complex of relationships (Mink, 1974). Configurational comprehension emphasizes the relations that may hold between particular elements, and perhaps is critical for any attempt to hold together a number of elements in nice balance (Mink, 1987).

We truly approach an "artificial" intelligence when we can tell coherent stories about our present position and effectively determine a useful-for-future-maneuver adaptive capacity. A machine which executes diagnostic tests written by a programmer - the results of which are later used to guide coherent action via complexity-reducing, human-developed tricks - can appear "intelligent" to those who are unaware of the actual heuristics used. This "intelligence", however, is limited in two ways (Ashby, 1962): it will be an adaptation to (and a specialization towards) a particular environment, and will be directed towards keeping essential variables within limits. It might be fair to say that our diagnostic tests were intelligently constructed by a programmer, and efficiently executed by a machine.

28 Results

We have created software to demonstrate certain basic features of the proposed heuristic and now examine four positions to see if we can obtain a better positional understanding of how well the pieces are performing. John Emms (Emms, 2001), reached Figure 6 as white (black to move) with the idea of *restricting the mobility* of black's knight on b7.

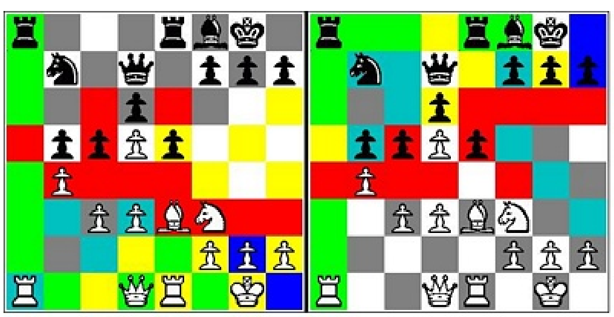

Figure 6: Emms-Miralles (Andorra, 1998) Constraint maps Legend: The left diagram identifies the possible constraints imposed by the white pieces, with red representing pawn constraints, yellow minor piece constraints, green rook constraints, blue-green queen constraints, and blue king constraints. The right diagram identifies possible constraints imposed by the black pieces. The white and grey squares represent the standard chessboard squares without constraints.

How fully engaged is this piece in the game? Let's see what the *influence diagram* and *simulation diagram* from the proposed heuristic show us:

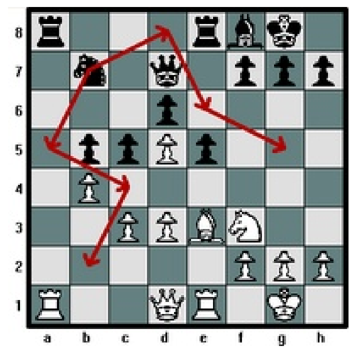

Figure 7: Emms-Miralles Tracing knight mobility from b7-a5-c4-b2 and b7-d8-e6-g5

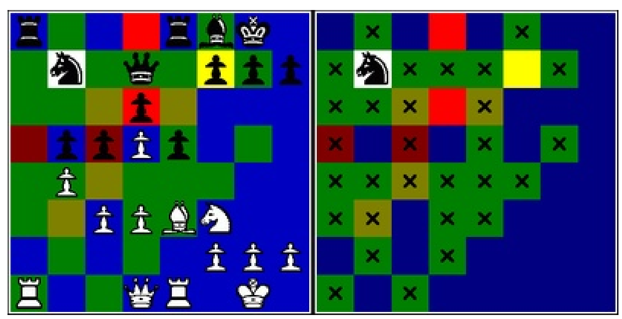

Figure 8: Emms-Miralles Influence Diagram and Simulation Diagram for Nb7

We generate the *constraint maps* as in Figure 6 in order to estimate the squares that the knight on b7 is likely to be denied access. We then apply the constraint maps to the individual vectors which make up the influence diagram as in Figure 7 to create the simulation diagram. When a movement vector hits a constraint, future mobility through that square is constrained, and we use an "X" to indicate *constrained* mobility. We can see from the X's (denied potential mobility) of Figure 8 that the movement of the piece on b7 has been constrained. It is Emms' view that positional details like this one can be vitally important when assessing positions.

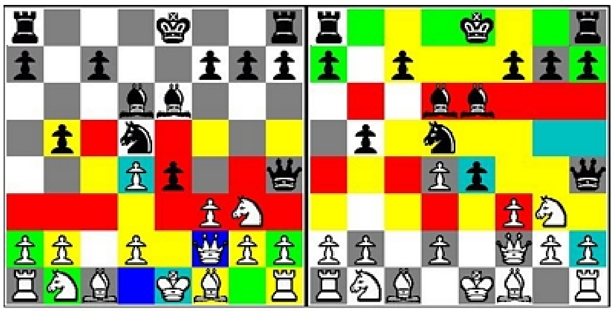

Figure 9: Constraint maps, white (left), black (right), Estrin-Berliner variation analysis (1965-68 corr.) after 12.Qe2 Be6 13.Qf2, Black to move

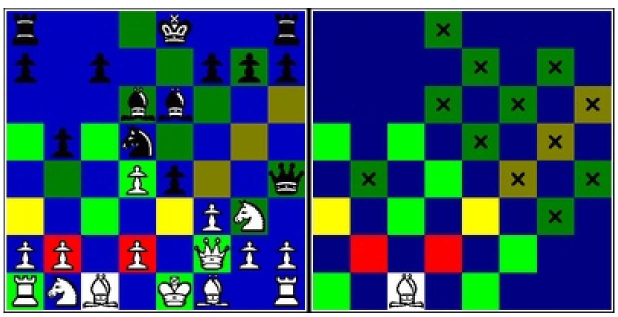

Figure 10: Influence Diagram and Simulation Diagram for Bc1

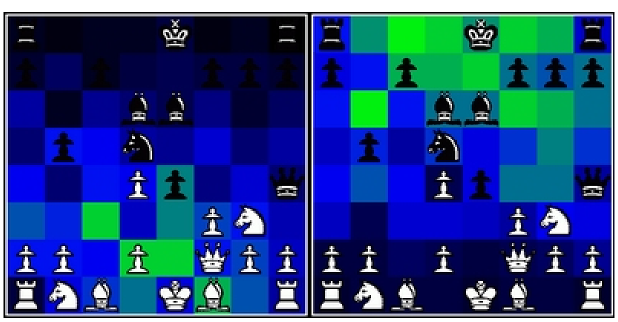

Figure 11: King safety heuristic maps: left - black king safety, right - white king safety. In the left diagram, darker squares are safer squares for the black king, while lighter colored squares are more dangerous.

The organization and its environment impinge on each other in many ways. Strategy succeeds or fails by interacting with this environment. It succeeds by avoiding, making use of, or overcoming, the impingements. - Geoffrey Chamberlain

Figure 9 examines a sideline from Estrin-Berliner (1965-68 corr.) after the proposed improvement 12.Qe2 Be6 13.*Qf2*. How fully engaged is the white Bishop on c1? We generate the constraint maps and influence diagram as before in order to construct the simulation diagram. We see that the bishop on c1 can enter the game after moving a pawn out of the way, and become useful for creating and mitigating stress in future positions.

Figure 11 displays an experimental king safety heuristic which is generated from all the piece influence diagrams and a rule which awards points based on number of pieces which can attack a square and the distance/constrained effort required to do so.

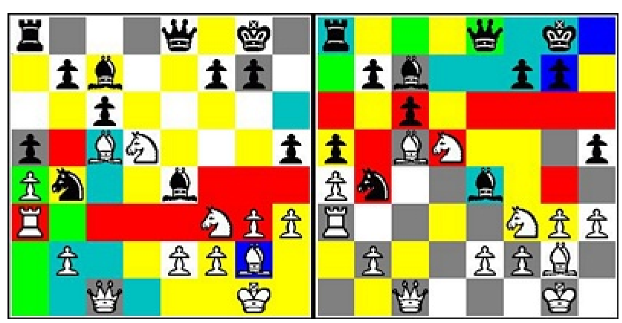

Figure 12: Constraint maps, white (left), black (right), Umansky-World correspondence game (2009)

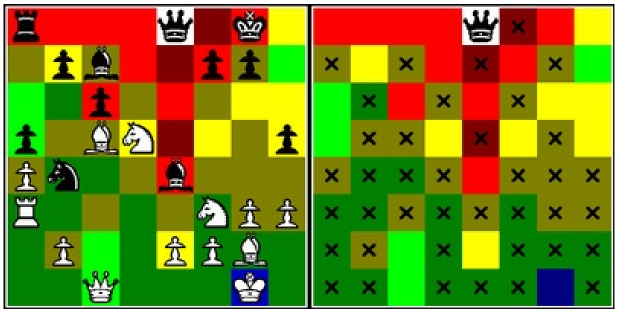

Figure 13: Influence Diagram and Simulation Diagram for Qe8

Figures 12 and 13 examine a position from the recent Umansky-World correspondence game. The constraint map gives insight to the controlling influences present on the squares, and the influence diagram/ simulation diagram for the Queen on e8 gives insight to what this piece can threaten in 3 moves. Note that this piece can influence square c1 via the difficult to find move sequence e8 to e6-h6-c1.

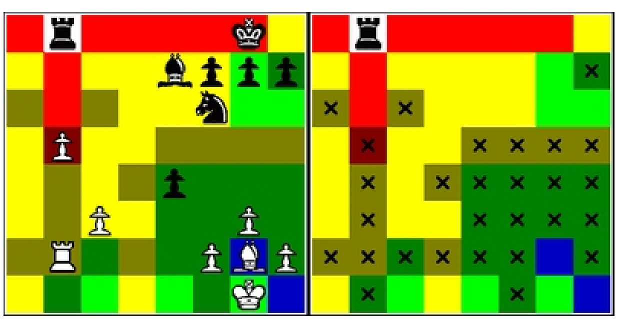

Figure 14: Influence Diagram and Simulation Diagram for Rb8, Levy-Chess 4.4, simultaneous exhibition, 1975, after 27.axb5

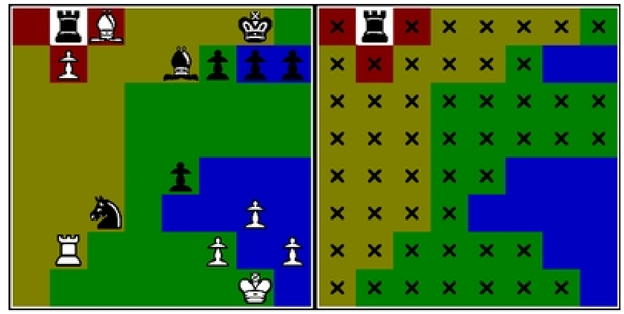

Figure 15: Influence Diagram and Simulation Diagram for Rb8, Levy-Chess 4.4, simultaneous exhibition, 1975, after 31.Bc8

Figures 14 and 15 show how a machine can potentially recognize a trapped piece, with an example first identified and discussed by (Levy, 1976).

The computer can use the heuristic knowledge present in the influence diagram and simulation diagram to estimate the strategic potential or how *fully engaged* each piece is in the game. The maps are a useful holistic measurement of a capacity to produce stress in a position, and can be used as part of an oriented, vital system-level indicator to predict and manage the sustainable development of a position in a chess game. Perhaps sensemaking and noticing interact as complements in effective problem solving: sensemaking focuses on subtleties and interdependencies, whereas noticing picks up major events and gross trends (Starbuck and Milliken, 1988). *Noticing* determines whether social actors even consider responding to environmental events. If events are noticed, actors make sense of them; and if events are not noticed, they are not available for sensemaking (Starbuck and Milliken, 1988).

A system that is to control its environment successfully must adapt by constructing models that allow it to decide what information to get, and how to act on it (Lloyd, 1995). To solve problems of control and stability, one needs a picture of the qualitative behavior of the system. That is, for nonlinear systems, control requires insight into the nature of the system's dynamics (Lloyd, 1995). To characterize and control our surroundings, we must identify the parts of the system where order can be increased at the expense of disorder (Lloyd, 1995).

29 Conclusions

The elements of a system and their interactions define the system structure...

Alternative conceptual frameworks are important not only for further insights into neglected dimensions of the underlying phenomenon. They are essential as a reminder of the distortions and limitations of whatever conceptual framework one employs (Allison and Zelikow, 1999). Only by analyzing a phenomenon from an alternative perspective (preferably multiple alternative perspectives) can all the intricacies of a situation be understood (Canonico, 2004). Our alternative conceptual framework for machine-based chess can, at minimum, allow us deeper insight and better understanding of current methods. Particularly in explaining and predicting actions, when one family of simplifications becomes convenient and compelling, it is even more essential to have at hand one or more simple but competitive conceptual frameworks to help remind us of what was omitted (Allison and Zelikow, 1999). To solve problems that blind spots have made unsolvable, people need new perceptual frameworks that portray the problematic situations differently (Starbuck and Milliken, 1988). Allison and Zelikow believe this is a general methodological truth applicable in all areas of life, including, in our opinion, a strategy for playing a game.

...By answering the basic questions about space, time and structure, we describe the conceptual model of the system... Creating a conceptual model... very much resembles that of perception -Alexey Voinov

Where meaning is concerned, it is not a matter of converging on closer and closer measurements - alternative contexts can determine widely divergent significances for the same physical entity (Ogilvy, 2011). Rival interpretations will continue to contest the proper reading of whatever evidence is brought to bear (Ogilvy, 2011). One source suggests that we should look at between four and six alternate concepts for our design (Kossiakoff and Sweet, 2003).

We agree with strategist Bernard Brodie that strategy is a field where truth is sought in the pursuit of viable solutions, not at all like pure science, where the function of theory is to describe, organize, and explain and not to prescribe. The question that matters in strategy is: Will the idea work? (Steiner, 1991). Brodie believed that strategy was associated with problems involving economy of means, i.e., the most efficient utilization of potential and available resources (Steiner, 1991).

A systemic (rather than analytic) approach, focusing on interactions and feedback mechanisms rather than concentrating on agents, will offer insights on where to apply leverage so as to contribute to the development of security and stability. The targeting derived from such an approach will focus on building and fostering identified sources of resilience and adaptive capacity, while mitigating or disrupting sources of stress.

Complexity theory highlights the non-linearity of feedback mechanisms, implying a requirement for the continuous monitoring of measures of effectiveness in order to adapt effects-seeking operations (Calhoun and Hayward, 2010).

The properties of the parts can be understood only from the dynamics of the whole. In fact, ultimately there are no parts at all. What we call a part is merely a pattern in an inseparable web of relationships. -Fritjof Capra, The Role of Physics in the Current Change in Paradigms

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Ecosystems are working models of sustainable complex systems, and it is reasonable to study them for clues to the sustainable management of the human enterprise (Jorgensen and Muller, 2000), including 'conflict ecosystems' mentioned by Kilcullen (Kilcullen, 2006). We identify *systems thinking* and the *systems approach* as the theoretical basis for an orientation/evaluation methodology, shifting our focus from the parts to the whole. The use of approximate knowledge and the conceptualization of a network of interacting components is realized through a system dynamics model of stress, or positional pressure.

The reality of the position on the chessboard is seen as an interconnected, dynamic web of power relationships, with *oriented, cumulative stress* one driving force of change. *You can avoid reality, but you cannot avoid the consequences of avoiding reality (Ayn Rand).* We seek resilient positions and flexible, adaptive capacity (with the promise of sustainable development) to counter the effects of unknown positions that lurk just beyond our planning horizon. The concepts of *orientors and indicators*, *cumulative stress*, *constraints* and *virtual existence* allow us to effectively simplify the dynamic reality of each game piece interacting with every other game piece on the board - to the point where we can predict promising directions of exploration (via the mechanism of stress transformation) and identify the *accessibility space* (Bossel, 1998) of future sustainable development.

In the final analysis, perception seems to be the key to skill in chess... The difference between two players [when one defeats the other in a game] is usually that one looks at the promising moves, and the other spends his time going down blind alleys. -Neil Charness, Chess Skill in Man and Machine, 1977

A model can be considered as a synthesis of elements of knowledge about a system (Jorgensen and Muller, 2000). Our model of dynamic interaction presented in this paper ideally captures the dominant variables that control the transformation of stress (Kossiakoff and Sweet, 2003), omitting the higher order effects that have a cost/benefit deemed to be overall not effective. No models are valid or verifiable in the sense of establishing their correctness (Sterman, 2000) (Voinov, 2008). The question facing clients, academics, and modelers is not whether a model is true but whether it is useful as a basis for some action, which in our case, is orienting diagnostic exploration efforts (through the critical lines) in an exponentially growing tree of possibilities, in a way that obtains actionable intelligence and therefore allows a strong positional game of chess to be played.

(Miller and Page, 2007) advise, with regard to computational modeling, that we judge the quality and simplicity of the model, the cleverness of the experimental design, and examine any new insights gained by the effort. We should also ask ourselves if our model has just enough of the right elements, and no more. To be a good model, Miller is of the opinion that we have stripped phenomena down to their essentials, yet have retained enough of the details to produce the insights we require.

Learning to handle a complex system means learning to recognize a specific set of indicators, and to assess what their current state means for the 'health', or viability, of the system. Often this learning of indicators is intuitive, informal, subconscious... - Hartmut Bossel

For Nijhout et al., (Nijhout et al., 1997), the most important thing that should be required of a model is that, with small quantitative changes in parameter values, it can produce the evolutionary diversity present in that pattern, and the effects of perturbation experiments and mutations on the pattern. It must also reproduce in its dynamics reasonable portions of the ontogenetic transformation that the real pattern undergoes (Nijhout et al., 1997). We conceptualize an equivalence with the game position, and the exploratory moves suggested by our model.

Ideally, our responsibility would be to use the best model available for the purpose at hand (Sterman, 2000) despite its limitations. We view modeling (Sterman, 2000) as a process of communication and persuasion among modelers, clients, and other stakeholders. Each party will judge the quality and appropriateness of any model using criteria which reflect on their role and perceived future benefits. This includes the time and effort involved in the unending struggle to improve the model to the point where its performance reflects what theory would expect of the particular approach. Modeling team A might not want to use a particular model due to significant time, money, belief, performance, and familiarity with their current approach. Team A might not even be interested in discussing new approaches. However, modeling team B might be looking for a new challenge, perhaps due to dissatisfaction with the current model, a belief in predicted performance, or perhaps due to a willingness to spend long hours and to engage with the types of problems suggested by the new approach. Team A might now become interested, seeing the preliminary success of team B.

Our attempts to reengineer the way machines play chess are, in the true spirit of reengineering (Hammer and Stanton, 1995), throwing away current methods and starting over, but placing at the forefront of our design efforts the values and concepts of positional chess and Systems thinking. We acknowledge the dynamic and static elements of a chess position, and construct a sensor array which responds to a perception of stress in the position in order to orient our efforts to effectively navigate in an exponentially growing diagnostic exploration effort. We adopt a Soft Systems Methodology - that is, we see the game position as complex and confusing, and we seek to organize the exploration of future consequences through the means of a learning system (Checkland and Poulter, 2006).

The proposed heuristic offers insight on the ability of the chess pieces to create and mitigate stress and aims for a rich awareness of discriminatory detail (Weick and Sutcliffe, 2007) between promising and less promising positions. We agree with Donohew, et al., (Donohew et al., 1978), that *information seeking* must be a primary method for coping with our environment. Key components include the monitoring of structural tension created by the pieces as they mutually constrain each other and seek to satisfy vital system-level needs, and the attempt to create positions which serve as a platform for future success, in a future that is uncertain. All sustainable activities have to accept the natural system of constraints in which the investigated entity operates (Jorgensen and Muller, 2000).

The invariance of basic orientors... as well as the change in attention focus resulting from changes in orientor satisfaction, provide the system with the ability to cope flexibly and adaptively with a widely and quickly changing state of system and environment. -Hartmut Bossel

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Our orientation/evaluation centers on an array of vital diagnostic appraisals of the cumulative stress each side inflicts on the opponent's position, and the perceived mitigation of such stress. (Selye, 1978) considers stress to be an essential element of all our actions, and the common denominator of all adaptive reactions. We aim to reduce our opponent's coping ability and adaptive capacity through oriented targeting of stress. The dynamic forces of change, acting over time and in a future we often cannot initially see, ideally transform the reduced coping ability of our opponent, our carefully targeted stress, and our resilient position full of adaptive capacity, to future positions of advantage for us. The entire purpose of modeling stress is to aid the orientation of diagnostic exploration efforts - that is, we orient exploration efforts in priorities based on the changing amounts of stress in the position (and the results of vital diagnostic tests). We additionally monitor the stress that threatens to become real, having the property that (von Neumann and Morgenstern, 1953) have called "virtual" existence. Even if the threat does not materialize, it nevertheless has the capability to shape and influence the events that do become real.

It is the possibility of letting a great many relationships influence each other under precisely stated assumptions and of determining the consequences, which gives the computer model its enormous power and advantage over conventional planning methods...

(Jorgensen, 2009) and (Bossel, 2007) discuss the application of Bossel's orientor ideas to simulated animals (animats) roaming in simulated environments, where orientation rules are developed over time to direct and control the behavior of the simulated animal and optimize the acquisition of food and energy resources. These simulations involve the 'perception' by the simulated animal of clues in the environment to the presence of food as well as danger. We ask ourselves what orientation rules would develop if the simulated environment were instead the board game of interest. Might we then develop optimal rules (or minimally, a good set of rules) for orienting our diagnostic exploration behavior critical in playing a board game?

We acknowledge that resilience is a distinguishing characteristic of any successful system (Sanderson, 2009) (Gunderson et al., 2010). The creation of resilient positions full of adaptive capacity allows us to sharply and effectively postpone diagnostic exploration efforts in less-promising lines with the low-risk promise of sufficient resources to 'MacGyver' the unknown future that lies beyond. We determine the level of resilience present in a position using a set of (heuristic) vital diagnostic tests, such as the ones proposed by Bossel. We desire a methodology which emulates a productive thinking process, such as one envisioned by (Hurson, 2008), but where we playfully consider responses that reflect the changing, urgent stress in the position, and the resilience of the less urgent positions and analysis lines left unexamined.

...The speed with which the great number of calculations are accomplished enables one to experiment repeatedly with different assumptions for the future in different parts of the model, i.e. with different "scenarios". - Michael G. Strobel and Hartmut Bossel

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We configure our scripts for diagnostic exploration activity using the results from automated tournaments of 3-minute-duration games.

From the highest level, we desire to model the cumulative dynamic stress present in the position so that we can effectively explore the possible directions of promising development. Our estimate of winning chances critically depends upon 1. exploring the promising and risk-mitigating paths and 2. correctly identifying those paths whose exploration of future consequences can justifiably wait until later. Inaccuracies in these two areas of classification will create a limit to overall performance, as we strategically attempt to compete against other agents with different and refined approaches to this same problem. We seek, as a strategy, to gain a sustainable edge over our opponent, and see the careful formation and execution of the strategic plan as the best and most productive way to accomplish this.

The concepts of *competitive intelligence*, *critical success factors*, *serious play*, *evolution*, *wargaming*, *Boyd's OODA Loop*, *Grisogono and Ryan's Adaptive Campaigning Model*, and *endpoint evaluation* critically complete the conceptualization. We seek to "play" the game of chess through a strategic orientation and exploration that is guided by a playful-but-serious examination of the future consequences of stress transformation, the tentative separation of positions into categories of *uninteresting, not worthy of attention, probably sustainable* (allowing a strategic pause in further explorations) and *interesting, worthy of attention, possibly unsustainable* (requiring additional time/diagnostic exploration), and vital diagnostic tests which orient, summarize and simplify the complexity present on the game board. We gather competitive intelligence to measure our successful attainment of critical success factors - our success or failure will serve as our guide to diagnostic action.

We establish value through an endpoint evaluation which substitutes for further trial-and-error exploration by summing critical parameters in order to 1) critically perceive the size of the mistake which would need to be made to reach a sustainable, even game, 2) accumulate small, sustainable positional advantages and 3) establish a marker to develop challenge lines with strategic potential if or when problems develop with branches in our principal variation, or with the indicated move itself.

Instead of [a] world of externally related parts only in mechanical motion, i.e., in motion from one place to another, we have moved into a world in a very different kind of motion. Instead of a world of things... we find ourselves as having our be-

ing within a... world of internally related, dialogically structured events, events with their own unfolding, inner movement. Within the unfolding of such dialogically-structured events, other events (events which are other to each other), play into each other in a complexly 'orchestrated' movement to create further, such new and unique events. And, in the inner movement within such events, rather than the mere locomotion of a set of constant, externally related parts into a new configuration, we have - at least for a moment - a metamorphosis of a wholistic event into new whole, i.e., there is a complex movement in which, in the intertwining of events, a new dynamic form is created. -John Shotter

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Serious play can leverage the accumulated strategic information and judgment gained over the years. It can help develop original strategies (Roos and Victor, 1998). Serious play can enable us to explore, challenge, disagree, and come to agreement on how we will meet the future (Roos and Victor, 1998). We intelligently answer the question 'What am I to do?' by using our knowledge of the power relations and basic needs to create stories - narratives - which aspire to best play, helping to create sustainable positions with a sustainability margin useful in progressing towards our ultimate goal of winning the game.

The presented results demonstrate the possibilities of the proposed building blocks for four test positions. Perhaps chess is more than just calculation (Aagaard, 2004), but the day may come sooner than we think when computers use heuristics to play a positional game of chess at skill levels equal to their current strong tactical play. Correspondence chess would provide the ideal testing ground for a positional heuristic.

The proposed heuristic offers promise as a way to play the game of chess, precisely because 1) it follows a strategy which addresses the complexity of the reality on the chessboard, 2) it develops scenarios which address uncertainty, resistance and sustainability, 3) actions taken by the machine use competitive intelligence, power relations and leverage in diagnostic explorations which ultimately measure freedom of action and "mistake margin" from an even game, 4) it follows Rumelt's strategic approach of diagnosis, guiding policy and coherent action, and 5) it addresses Stern's fundamental dynamic pentad of movement, time, force, space, and intention. Creatively, we propose promising moves and then dispose of the lines which fail to grab our attention, proceeding in an evolutionary way to explore a consequential space otherwise inaccessible by brute force methods. We ultimately choose a move which is diagnostically fit for the environment, which is understood to be dominated by the consequences of the consequences of the consequences of the power relations of the game pieces.

We might borrow the words of economist Joseph Schumpeter (1883-1950) and theorize that chess is a game of Creative Destruction.

Future work will involve the construction of a prototype software application which implements the concepts discussed in this paper.

We close with a modified verse - rewriting the words, if you will - delivered (initially) by Alexander Meiklejohn to Edward Chase Tolman:

To my ponderings I hope you will be

kind As you follow up the wanderings
Of my amazed mind.

Note: colored diagrams were produced by a computer program in HTML format and rendered in a Firefox web browser in a method similar to that used by the software program *ChessDiagrams* by Ambar Chatterjee.

Special thanks to all my friends at chessgames.com, through whom I continue to learn about chess.

30 Appendix A: Selective Search and Simulation

We recognize that the concept of *selective search* is a critical concept in playing the game of chess, but we suggest an alternative way of thinking about the method where we choose to explore certain future lines, and choose not to explore others.

The phrase *dynamic simulation with strategic scenarios* has certain advantages. First, we recognize that we are using a *dynamic* model. Second, the concept of a *simulation* permits us to think about or explore the uncertain future where we encounter resistance. Third, we are *strategic* in our selection and rejection of lines. Last, we follow certain *scenarios* in our war gaming of the future - this allows us to learn what might lie ahead.

We suggest that this approach is more precise and allows us to answer the question "So, how are you doing selective search?" with the answer, "What we are doing is more than just searching - it is more like conducting a complicated diagnostic test of how 'ready' we are for the uncertain future. As part of a strategy, we explore the critical emerging results of stress interactions. We construct a dynamic model and create strategic scenarios. The process resembles biological evolution, as we first propose moves which satisfy orientors aimed at sustainability, and then dispose of lines judged by our competitive intelligence to be not worth our attention.

We aim for resilience, adaptive control and flexible persistence in the face of complexity and the uncertain plans of our opponent. We develop and expand scenarios which have strategic potential to become a replacement principal variation (or replacement branches) when unexpected discoveries are made.

Through endpoint evaluation we establish a marker which is used to set the threshold of our attention when constructing challenge lines. Specifically, our attention is diverted away from exploring those (unlikely) challenge lines where we have demonstrated sustainability and where we believe we have a margin which allows for fallback positions, if necessary. We aim to create results normally produced by a productive thinking process."

We note that *of course* we are doing selective search (correctly termed *selective retention*) - but curiously - that *it is the environment itself that is doing the selection.* A careful analysis will show that we are in fact proposing a Campbell-esque blind variation - the environment determines which variations show sustainability and which specific line becomes the principal variation via the proxy of our vicarious "knowledge". We don't as much cut off exploration efforts as (strategically) postpone, do a less thorough job, or slow them - the minute the initially less promising begin to show promise as a replacement branch of our primary line, we again renew our interest (and efforts) in continuing them.

This concept can be compared to the idea presented in (Ward and Schriefer, 1998) of a *dynamic scenario generator*. The authors note Peter Senge's observation that "Perhaps the single greatest liability of management teams is that they confront complex dynamic realities with a language designed for simple static problems". Senge proposes that the basic purpose of a learning organization is to continually expand and create its future. We concur, and agree with Ward and Schriefer that both profound and rapid learning occur when scenario planning and systems thinking are employed. The dynamic scenarios methodology combines the two approaches. Today's decisions and events take on different meanings depending on the different tomorrows that are their possible consequences (Ogilvy, 2011).

Simply put, we agree with Flyvbjerg (Flyvbjerg, 2001) that rationality and power are interrelated, that in "playing" a game our time is best spent pursuing answers to the following questions (Flyvbjerg, 2001): What are the most immediate and the most local power relations operating, and how do they operate? How has the active exercise of power in the relations being investigated affected the possibilities for the further exercise of power, with the resulting reinforcement of certain power relations and the attenuation of others? How are power relations linked together, according to what logic and strategy? How have these relations made certain rationalities possible and others impossible, and how do the rationalities support or oppose the power relations? How can the games of power be played differently? Power is the process, which via struggles and confrontations transforms, supports, or reverses these force relations (Flyvbjerg, 2001).

31 Appendix B: The Importance of Sustainability

We have placed much emphasis on the concept of sustainability, and feel the need to explain why this concept is such a critical strategy when playing a game in the positional style.

Whatever diagnostic test we use for exploring the future cannot prepare us for all possibilities. We instead must be "ready" for whatever emerges from the "mess" of interactions, some of which are foreseeable and are representative of the types of situations we will later face. Sustainability allows us to continuously generate responses - future positions which in turn are likewise sustainable. Anyone who has played competitive sports learns to develop quick tests to determine, on the fly, whether the current team position is sustainable, and if not, what needs to be done (personally, or calling instructions to others) to correct it.

When facing a tactically empty position, we feel that a strategy that develops, then selectively expands a portfolio of likely scenarios is a good way to determine how ready we are to face an uncertain future. We prepare ourselves to respond to the mistake of our opponent, or for the situation where a scenario initially judged to be not worth our attention, had unexpected side effects which resulted a more favorable position for our opponent. We seek to uncover unexpected situations "down the road" which impact the "health" and sustainability of the position and cause us to shift our move played to one with a more favorable outlook. We are now ready in general, and will handle the specifics as they come.

In short, we feel that the nature of the complexity which exists on the game board, of dynamic and evolving systems in general and of 'conflict ecosystems' and the peculiarities of systems in particular, must all be reflected in the search for general principles of sustainable development (Bossel, 2007).

32 Appendix C: Reflex and Automatic Action

Baldwin (Baldwin, 1891) offers a unique perspective on the *reflex action* which is a useful concept for game playing.

A nervous circuit is *reflex* when its reaction upon a particular kind of stimulus is single, definite, constant, and does not involve thinking for its execution. In more general terms, a reaction is reflex whenever we are certain beforehand that it will take the form of a particular well-defined action, and will do its work without any interference or mandate from ourselves.

This kind of "automatic action" is useful for generating candidate moves in a game. We can generate candidate moves by reflex, relying on higher levels of cognition to assemble the narratives and construct the challenge lines. In fact, a chess player might only be conscious of assembling the narrative - the candidate moves might just appear in consciousness from a subconscious reflex process.

Strategically, our reflex-reaction seeks to alter the perception of the reflex-stimulus: in other words, it must very specifically alter the power relations towards that specific stimulus, it must 'respond' to that stimulus (Follett, 1924). In our implementation, this is the orientor which is in the minimum.

When writing software to play chess, we seek to specify the activity (normally) done by the subconscious, and what better concept than a reflex action, based on the sustainability orientors and power relations. We seek Baldwin's concept of *contractility* (Baldwin, 1906), where instead of a response involving a *movement* to a stimulus, we have a response instead as a *strategic consequential exploration* on the game board. We use higher level cognitive efforts to arrange the sequences of moves, determine sustainability and health, the alternate challenge lines and "safe cut offs" or postponements, on our way to constructing a useful diagnostic stress-test of adaptive capacity.

33 Appendix D: Related Quotations

The analysis of general system principles shows that many concepts which have often been considered as anthropomorphic, metaphysical, or vitalistic are accessible to exact formulation. They are consequences of the definition of systems or of certain system conditions. - Ludwig von Bertalanffy

a good model enables prediction of the future course of a dynamic system. - Bruce Hannon and Matthias Ruth

Perception, motivation, and values combine to create choice. - Joe Vitale

It's your decisions about what to focus on, what things mean to you, and what you're going to do about them that will determine your ultimate destiny. - Anthony Robbins

We are successful because we use the right level of abstraction. - Avi Wigderson

We can influence the future but not see it. - Stewart Brand

The mind will not focus until it has clear objectives. But the purpose of goals is to focus your at-

tention and give you direction, not to identify a final destination. - John C. Maxwell

Of all the factors that contribute to adapting to change, the single most important factor is the degree to which individuals demonstrate resilience - the capacity to absorb high levels of change and maintain their levels of performance. - Mark Kelly and Linda Hoopes

Every piece of business strategy acquires its true significance only against the background of that process and within the situation created by it. It must be seen in its role in the perennial gale of creative destruction; it cannot be understood irrespective of it or, in fact, on the hypothesis that there is a perennial lull. - Joseph Schumpeter

It is not the strongest of the species that survive, not the most intelligent, but the one most responsive to change. - Charles Darwin

Resilience or some variation of this idea is a concept that is explicitly if not tacitly implicit in almost all explanatory models of behavior ranging from the biological to the social. It may be an inextricable part of the ways in which we define and explain not only human behavior but virtually all phenomena with variable outcomes. - Meyer Glantz and Zili Sloboda

any approach able to deal with the changing complexity of real life will have to be flexible... It needs to be flexible enough to cope with the fact that every situation involving human beings is unique. The human world is one in which nothing ever happens twice, not in exactly the same way. This means that an approach to problematical human situations has to be a methodology rather than a method, or technique... [Soft Systems Methodology] provides a set of principles which can be both adopted and adapted for use in any real situation in which people are intent on taking action to improve it. - Peter Checkland and John Poulter

I think that resilience is manifest competence despite exposure to significant stressors. It seems to me that you can't talk about resilience in the absence of stress. The point I would make about stress is the critical significance of cumulative stressors. I think this is the most important element. - Norman Garmezy

No plan survives contact with the enemy. - Field Marshal Helmuth von Moltke

In many ways, coping is like breathing, an automatic process requiring no apparent effort... Is coping always a conscious process? ...we so often may repeatedly respond to a recurring stressor that we lose our awareness of doing so. - Charles Richard Snyder

What business strategy is all about; what distinguishes it from all other kinds of business planning - is, in a word, competitive advantage. Without competitors there would be no need for strategy, for the sole purpose of strategic planning is to enable the company to gain, as effectively as possible, a sustainable edge over its competitors - Keniche Ohnae

Rykiel (1996) defines model credibility as "a sufficient degree of belief in the validity of a model to justify its use for research and decision-making."... there is no use talking about some overall universal model validity; the model is valid only with respect to the goals that it is pursuing - Alexey Voinov

A principal deficiency in our mental models is our tendency to think of cause and effect as local and immediate. But in dynamically complex systems, cause and effect are distant in time and space. Most of the unintended effects of decisions leading to policy resistance involve feedbacks with long delays, far removed from the point of decision or the problem symptom. - John Sterman

everything in nature, everything in the universe, is composed of networks of two elements, or two parts in functional relationship to each other... The most fundamental phenomenon in the universe is relationship. - Jonas Salk, Anatomy of Reality

What is the core of the matter? Why should a machine not be an excellent chess player? Is the task insoluble in principle? ... No. The problem seems to be soluble... The machine may play chess badly, like a beginning amateur, but the machine is not guilty. Man is guilty. He has not yet succeeded in teaching the machine, in transferring his experience to it. What is involved in teaching a machine to play chess? - Mikhail Botvinnik *once you become aware of what means the most to you, you're less likely to put off something that's really valuable for something that matters much less... it's knowing the difference between what's important and what isn't that allows us to solve problems effectively. - Joy Browne*

Intelligence is the ability to acquire knowledge, and not the knowledge itself. - George F. Luger

Where sustainability is not even a goal, it is unlikely that sustainability will be achieved by accident. And even if it is a declared goal, sustainability cannot be achieved where money, time, resources, and the creative energies of individuals are wasted. - Hartmut Bossel

While a self-organizing system's openness to new forms and new environments might seem to make it too fluid, spineless, and hard to define, this is not the case. Though flexible, a self-organizing structure is no mere passive reactor to external fluctuations. As it matures and stabilizes, it becomes more efficient in the use of its resources and better able to exist within its environment. It establishes a basic structure that supports the development of the system. This structure then facilitates an insulation from the environment that protects the system from constant, reactive changes. - Margaret Wheatley, Leadership and the New Science

If system behavior is guided by balanced reference to basic orientors it will have the best chance for success in the long run... Systems which have evolved under evolutionary forces to be sustainable... can be viewed as having been designed in a way to achieve balanced satisfaction of basic orientors... To be efficient and effective, path analysis, policy synthesis, and system design for sustainable development have to take the orientor satisfaction of affected systems into account. - Hartmut Bossel

It should be obvious that in your workplace there are some things you can control and some things that you can't. The trick is being able to identify those things you can control and then to get busy controlling them... My goal is to make you see that you have more control over things than you think you do... You can regain a sense of control if you start to focus on issues where you can make a difference and stop wasting time on those where you can't. - Karl Schoemer

Those who have to make the decisions should also be those who create the scenarios... We also recognize... that issues of power and influence are central in determining how situations will unfold... power is a key determinant of... organizational... thinking... The key aim in writing scenarios is to grab the attention of the intended audience in order to convey clear, concise and plausible stories about what types of futures might unfold as a direct outcome of decisions made in the present and over time in relation to the focal issue. - George Wright and George Cairns

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