Personal Construct Psychology and the Cognitive Revolution

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Abstract

It is now nearly seventy years since George Kelly commenced writing what became his major work defining the theory and practice of personal construct psychology (PCP). In those years much has changed in psychology and in the scientific ethos. The book was completed in the initial stages of what became termed the *cognitive revolution.* If we are to fully appreciate PCP it is important to attempt to place it in the context of Kelly's life and times, and the developments in psychology that preceded and followed it. This article presents relevant aspects of his era, commenting on their significance for understanding PCP and the role that it played, or did not play, in various developments in psychology. In particular, the role that PCP and the repertory grid played in artificial intelligence research on knowledge acquisition for expert systems is discussed in terms of its significance for other aspects of PCP research.

1 Introduction

This article situates personal construct psychology in what has come to be termed the *cognitive revolution*, and situates both in an intellectual history of psychology. The following section analyses the background to, and nature of, the cognitive revolution. The next section analyzes Kelly's accounts of how he came to develop PCP and of the influences upon him. The next section documents the role that PCP played in what has been presented as one of the major achievements of the cognitive revolution, in academic research and industrial applications of knowledge acquisition for *expert systems*. The final section uses the 'lessons learned' and modern critiques of cognitivism to suggest promising directions for PCP research.

We assume familiarity with the main features of PCP and will only present them in as much as the detail is essential to our primary themes.

2 The Cognitive Revolution in the Context of the History of Psychology

2.1 Psychology in the era of Kelly's professional development

By the middle of the twentieth century psychology had become a well-established scientific discipline. The establishment of psychology departments separate from those of philosophy that had commenced at the end of the nineteenth century was largely complete in all universities by the 1940s. Kant's (1786) analysis that psychology could not become a science because mental phenomena could neither be modeled mathematically nor observed had been countered by Herbart's (1877) mathematical analyses and Wundt's (1894) empirical studies, and by the growth of experimental psychology and statistical techniques (Ribot, 1886). One concrete example was research on aptitude testing and analysis stemming from Spearman's (1904) development of correlational statistics in order to analyse Galton's (1870) data on the inheritance of intelligence.

The widespread establishment of psychological laboratories had introduced a different mode of empirical data collection (Morawski, 1988). Boring (1950, p.x) in his influential *History of Experimental Psychology* takes the stance that experimental psychology means "the psychology of the laboratory," although noting that "mental tests are in a way experimental" and "abnormal psychology may be experimental." The last vestiges of religious influence had been removed by the end of the nineteenth century so that the terms 'soul' and 'mind' were no longer used interchangeably (cf McCosh, 1886). Behaviorists such as Kantor (1959b) saw the remnants of the notion of soul in that of mind, and eschewed that term also.

Behaviorism was the dominant intellectual model, although the debates over its ideology continued (King, 1930; Murchison, 1928; Zuriff, 1985). The first generation of behaviorists, Watson, Hull, Guthrie and Tolman, were retiring from their power bases; and Skinner's star was on the ascendant. Behaviorism, however, never completely dominated psychological research, as can be seen by the balanced approaches of: Pratt's (1939) presentation of introspection and behavior as sources of psychological data in her *Logic of Modern Psychology*; Marx's (1951) *Psychological Theory: Contemporary Readings* which gives the behaviorist literature full coverage but also includes papers by Lewin, Snygg, Koffka, Köhler, Gordon Allport, Freud, Rogers and Maslow; and Allport's presidential address to the APA on *The psychologist's frame of reference*:

> *"If we rejoice, for example, that present-day psychology is increasingly empirical, mechanistic, quantitative, nomothetic, analytic, and operational, we should also beware of demanding slavish subservience to these presuppositions. Why not allow psychology as a science to be also rational, teleological, qualitative, idiographic, synoptic, and even non-operational?" (Allport, 1940)*

2.2 Information technology, hypothetical constructs and the cognitive revolution

The era between 1945 and 1965 has come to be termed one of a *cognitive revolution* in psychology (Johnson & Erneling, 1997). The development of complex servomechanisms and related human operator studies, and of digital communications and computer technology, during and after the second world war provided new insights into purposive behavior, new techniques for studying it, and evocative analogies for psychology. In particular, as machines were developed that exhibited complex, goal-seeking behaviors, the analysis of such behavior was abstracted to encompass any system regardless of its form of construction, whether biological or technological. Bertalanffy had developed his *general systems theory* of life as a form of organization before the war (Davidson, 1983), Shannon developed a *mathematical theory of communication* as an outcome of wartime information transmission and encoding studies (Shannon & Weaver, 1949), and Wiener developed his general notion of *cybernetics* as *control and communication in the animal and the machine* as an outcome of his wartime experiences with differential analyzers and servomechanisms (Wiener, 1956).

In parallel with these systemic developments, the neobehaviorists' extension of Watson's strict behaviorism through admission of 'intervening variables' and 'hypothetical constructs' (MacCorquodale & Meehl, 1948) encouraged the study of internal processes of cognition, their properties and relationships, in their own right rather than as simply a means of saving the phenomena of observed behavior. The well-specified phenomena of programs running on digital computers provided both operational analogies for folk psychological notions of 'minds' running

on brains, and a tool that enabled models of complex human cognitive processes to be simulated (Ashby, 1952; NPL, 1959; Shannon & McCarthy, 1956).

Four disciplinary areas developed in this era: *cybernetics* and *systems theory* in which the behavior and structure of living and artificial systems was abstracted to a level where common features were apparent (Ashby, 1956); a revival in America of mainstream research in *cognitive psychology* (Baars, 1986); the advent of *cognitive science* in which computer models were used to account for human behavior (Johnson-Laird & Wason, 1977); and the advent of *artificial intelligence* in which computer programs were developed to emulate human behavior (Fleck, 1982). The strictures of Watsonian behaviorism had not been so influential in Europe and the tradition of research on cognitive psychology originating in the Greek enlightenment had continued through the scholasticism of the middle ages (Kemp, 1996) and the growth of seventeenth century enlightenment science from Newton and Spinoza to Hume, Kant, Hegel, Bentham, Hamilton, John Stuart Mill and Spencer, to the modern studies of Brentano, Meinong, Russell, Selz, Bartlett, Wittgenstein, Lewin, Piaget, Vygotsky, Luria, Turing and Craik that had significant influence on the cognitive revolution in America.

2.3 The cognitive revolution as a return to historic concerns

The nature of the cognitive revolution has been debated particularly by those in science studies who have used it as a case history in tests of Kuhn's theories of scientific revolutions; although there is no consensus as to whether it does satisfy his (changing) criteria (Briskman, 1972; Greenwood, 1999; Palermo, 1971; N. Warren, 1971; Weimer, 1974a, 1974b; Weimer & Palermo, 1973). In the context of American psychology prior to the rise of behaviorism, the resurgence of cognitive studies in the 1950s may be seen as a 'revolution' in the original sense of a return to origins. America had its own long-established cognitive tradition through McCosh, Peirce, Jardine, James, Dewey, Baldwin and Mead from which effort was diverted when Watson acquired his power base by inheriting both the Johns Hopkins department and *The Psychological Review* after Baldwin was disgraced. The American psychologists had strong intellectual links to European cognitive psychologists, notably Hamilton (1859) who introduced the term 'cognition' in psychology (noting that he would use it as alternative for the term 'knowledge' because he needed one with plural and adjectival forms, pp.279-280) and Spencer (1864) whose evolutionary psychology inspired that of Dewey and Baldwin.

Jardine's (1885) *Elements of the Psychology of Cognition* commences with the definition:

> *"Cognition is a general name which we may apply to all those mental states in which there is made known in consciousness either some affection or activity of the mind itself, or some external quality or object. The Psychology of Cognition analyses knowledge into its primary elements, and seeks to ascertain the nature and laws of the processes through which all our knowledge passes in progressing from its simplest to its most elaborate condition." (p. 1-2)*

which, except for its use of term *affection* where we would say *emotion*, would not be out of place in a modern cognitive science text on information processing approaches to cognitive psychology.

In his *Psychology: The Cognitive Powers* McCosh (1886), who was President of Princeton and doctoral supervisor of Baldwin, discusses the same limits on the span of attention that Miller (1956) later analysed in a way that is often seen to epitomize the cognitive revolution:

> *"A curious question has been started as to how many things we may have before the mind at one and the same time. Sir William Hamilton maintained that we can have a clear idea, at one time, of six separate objects. It is a matter for experiment. You will find, I think, that if you place before you, in fact or in imagination, a number of objects, say persons, or marbles, or chairs, you will not be able to see or contemplate more than four or five of them; the rest will either look very dim, or, if you think of them, you must do so consecutively." (p.121)*

2.4 The information processing metaphor of the cognitive revolution

It is not surprising that Miller's (1956) *magical number seven, plus or minus two* paper does not reference the Hamilton and McCosh reports of seventy years earlier, particularly since he later notes that he saw the paper at the time as humorous sophistry in an invited address rather than as a scholarly breakthrough (Miller, 1961, pp.400-402). What is interesting is that his presentation of the phenomena is seen as epitomizing the cognitive revolution (Hirst, 1988) because his analysis was based on Shannon and Weaver's (1949) recently developed *information theory* in its application to psychology (Quastler, 1955). Psychology was, and is, still following Kant's prescriptions for being a science by searching for its appropriate mathematics. Lewin (1936) had attempted to do so in his *Principles of Topological Psychology* as had Hull (1940) in his *Mathematico Deductive Theory of Rote Learning*, but the mathematics of their time was inadequate, and the tools to use it effectively did not exist. Unfortunately, information theory and the notion of human *channel capacity* have also failed to realize their apparent early promise (Miller, 2003).

The problem of forming models addressing the ultimate problem of our own (the modeler's) natures has led to the search for metaphors relating human cognition to better-known systems (Leary, 1990). The cognitive revolution may be seen as one in which the *information processing* metaphor of neocognitive psychology rapidly replaced the *black-box* metaphor of behaviorism. The publication of Fogel's (1967) *Human Information Processing* paralleled that of Neisser's (1967) *Cognitive Psychology* and within five years Lindsay and Norman (1972) could publish a mass-market undergraduate textbook called *Human Information Processing: An Introduction to Psychology*.

2.5 Cybernetic models of teleology and anticipation in the cognitive revolution

The information processing metaphor was one outcome of what came to be called *cybernetics* research (Wiener, 1948) that modeled the *teleological* behavior of entities pursuing goals through the negative feedback processes common to servomechanisms and people (Rosenblueth, Wiener, & Bigelow, 1943). At first sight, cybernetics appears to be the ultimate abstract form of behaviorism because it characterizes systems by their input-output behavior, and classifies systems as *cybernetically equivalent* if they exhibit the same input-output behavior under all circumstances. However, the significance of cybernetics applied to living systems is that the equivalent systems might be a human being and a computer program, and that, whereas the person might be regarded by a behaviorist as a *black box* whose *modus operandi* was inaccessible, the program could be treated as a *white box* such that every aspect of its operation

could be investigated. Of course, the *modus operandi* of the computer program, even at the most abstract level, might not correspond to that of the person in any aspect except identical behavior. However, this is an issue for all scientific models of natural phenomena, and the development of systems that were cybernetically equivalent to human behavior was seen as important source of potential insights into the basis of that behavior. This is the pattern of reasoning underlying cognitive science.

Much of what was achieved in the early years of cybernetics was to show that behavior that might seem characteristic of living systems was actually characteristic of any system with certain highly general properties. For example, Ashby (1952) showed that any system with many states of equilibrium would exhibit the phenomena of *habituation* in that its response to repeated stimulation would decline in magnitude. Similarly, the upper bounds on channel capacity analyzed by Shannon and Weaver (1949) are properties of any communication system whether natural or artificial.

Craik (1943) had already gone beyond Wiener's analogy between human tracking behavior and that of servomechanisms in demonstrating that, while the simple servomechanism relied on error-correction to drive its goal-seeking action, people were *anticipatory* in being able to generate appropriate actions that avoided errors. This led him to propose that:

> *"If the organism carries a 'small-scale model' of external reality and of its own possible actions within its head, it is able to try out various alternatives, conclude which is the best of them, react to future situations before they arise, utilize the knowledge of past events in dealing with the present and future, and in every way to react in a much fuller, safer, and more competent manner to the emergencies which face it." (p.61)*

Stroud (1950) presented Craik's research at the first published *Macy Conference on Cybernetics* and Wiener remarked that he was building such a predictive modeler. This he later describes as having the capability to process input-output data from a *black-box* to produce a *white-box* which can regenerate its past behavior and anticipate its future behavior (Wiener, 1961, preface to 2nd edition); the white box is *cybernetically equivalent* to the black box but its mechanism is now open to inspection. The cybernetic model of human goal-seeking and modeling behavior was developed further by Ashby (1952) in his *Design for a Brain*, by Miller, Galanter and Pribram (1960) in their *Plans and the Structure of Behavior*, and by Powers (1973) in his *Behavior: The Control of Perception*.

It is interesting to note that the cybernetic model of purpose had been described by Tolman (1925a; 1925b) eighteen years before the Rosenblueth *et al* paper:

> *"it appears that goal seeking must be defined not only as a tendency to persist in more or less random fashion until food is reached but also as a tendency to select within limits the shorter (and probably also the easier and pleasanter) of two or more alternative ways." (Tolman, 1925a, p.38)*

and quoted with favourable comments by McDougall (1928) in his Powell lecture criticizing Watson's behaviorism. Tolman's formulation of purpose is more insightful than Wiener's because he highlights that random behavior can be goal seeking, and that planning can improve goal seeking. The importance of the random aspect is two-fold: it was later shown that random behavior leading up to the achievement of the goal cannot be modeled better than by a white box containing a zero-memory random source, and an attempt to do so by a deterministic automaton

will lead to one that is indefinitely complex (Gaines, 1976); and that, for some problems, the random solution is near-optimal and can achieve goals that would otherwise require indefinitely large memory (Gaines, 1971). If the referees for the *Philosophy of Science* paper (which has no citations) had been more diligent and drawn attention to Tolman's earlier *Journal of Philosophy* paper, or Hull had applied his mathematical techniques to model Tolman's insights, then a 'cognitive revolution' might have occurred much earlier and been seen as a natural evolution of Hull and Tolman's framework for behaviorism.

2.6 The cognitive revolution as the evolution of behaviorism

The information processing turn in psychology can be interpreted as a logical development of behaviorism in which intervening variables are reified and made observable through the black-box/white-box transformation, and not all psychologists have welcomed it. Bruner was cofounder with Miller in 1960 of the Harvard *Centre for Cognitive Studies* (Miller noting that "To me, even as late as 1960, using 'cognitive' was an act of defiance" 1961, p.411), but later decried the outcome of the cognitive revolution, stating:

> *"let me tell you first what I and my friends thought the revolution was about back there in the late 1950s. It was, we thought, an all-out effort to establish meaning as the central concept of psychology—not stimuli and responses, not overtly observable behavior, not biological drives and their transformation, but meaning. It was not a revolution against behaviorism with aim of transforming behaviorism into a way of pursuing psychology with a little mentalism to it. Edward Tolman had done that, to little avail." (Bruner, 1990, p.2)*

The divergence between Bruner and Miller is apparent in a recent article by Miller (2003) summarizing the 'cognitive revolution' which concludes:-

> *"the original dream of a unified science that would discover the representational and computational capacities of the human mind and their structural and functional realization in the human brain still has an appeal that I cannot resist." (p.144)*

where resolving the Cartesian dualism of a mind-brain relationship is still seen as a major objective. It was this reification of the 'mind' as an assumed causal agent that behaviorism sought to combat, and its reintroduction in cognitive science may be seen as the primary weakness that has undermined potential progress based on the extension of behaviorism to consider internal states (but not to attribute them to some mysterious 'mind').

A definition of a cognitive theory that does make a significant distinction from behaviorist theories, does not introduce the notion of 'mind' and is relevant to Bruner's concerns is provided by Greenwood (1999) in his analysis of the 'cognitive revolution':

> *"a cognitive theory may be reasonably defined (following Fodor, 1991) as any theory that postulates representational states that are semantically evaluable—that can be characterized as true or false, or accurate or inaccurate—and rules, heuristics, or schemata governing the operation of such representational states, as they are held to be involved in receiving, processing, and storing information. By this measure, most of the states that have been postulated by cognitive psychologists since the 1950s have been unproblematically and unambiguously cognitive: perceptions, concepts, beliefs, memories, and even images can be characterized as having contents evaluable as true or*

false (or accurate or inaccurate), and are held to be processed according to transformation rules, representative and availability heuristics, disjunctive and conditional rules, and so forth. Most of the internal variables postulated by neobehaviorists— such as "drive," "habit strength," "divergent habit family hierarchy," "pure stimulus act," and the like—were not cognitive in this sense, with one obvious exception. Tolman's "cognitive maps" are semantically evaluable. For this reason, Tolman's system was often justly treated as a precursor of contemporary cognitive psychology." (p.9)

A focus on semantically evaluable representational states echoes some philosophical approaches to the question of meaning, but this would probably not satisfy Bruner (1990) who sees 'meaning' as a socio-cultural construct:

"This method of negotiating and renegotiating meanings by the mediation of narrative interpretation is, it seems to me, one of the crowning achievements of human development in the ontogenetic, cultural and phylogenetic senses of that expression." (p.67)

The semantic focus of cognitive theories reintroduces notions that bridge between psychology and philosophy including those of metaphysics (which was the part of Hebart's program that led Wundt and later psychologists to reject him as the father of psychology). In the present era the criticisms leveled at behaviorism are paralleled by strikingly similar criticisms of cognitivism (Costall & Still, 1987; Descombes, 2001; Gergen, 1994; Johnson & Erneling, 1997; Shotter, 1993). The approach to psychology resulting from the cognitive revolution is seen as *"instrumental, individualistic, systematic, unitary, ahistorical and representational"* (Shotter, 1993, p.7).

3 Personal Construct Psychology

3.1 Kelly's professional development

George Kelly was a clinical psychologist and educator with experience and publications in experimental, perceptual and military psychology and statistics (Fransella, 1995). His professional training and career spanned 45 years from 1922 to 1967 culminating in his appointment as Riklis Chair of Behavioral Science, Brandeis University (Adams-Webber, 1980). His major work, *The Psychology of Personal Constructs* (Kelly, 1955), was published while he was Professor and Director of Clinical Psychology at Ohio State University (1946-1965) and reflects experience gained in running traveling psychology clinics at Fort Hays Kansas State College (1931-1943), his military experience as a Navy aviation psychologist (1943-1945), and his clinical and educational experience at Ohio State University.

He provides an intellectual biography of how he came to develop PCP both in the book itself and in chapters prepared for an intended second book (Maher, 1969). He notes how he first read one of Freud's works in 1930 as he became a graduate student and remembers the *"mounting feeling of incredulity that anyone could write such nonsense, much less publish it."* (Kelly, 1969a, p.47). However, a decade or so later in his clinical work he notes that he *"went back to Freud for a second look,"* and *"now I had listened to the language of distress, Freud's writings made some kind of sense"* (p.50). He notes:

"Through my Freudian interpretations, judiciously offered at those moments when clients seemed ready for them, a good many unfortunate persons seemed to be profoundly helped." (p.51)

However, he went on to become *"uncomfortable with my Freudian 'insights'"* (p.52) and commenced his own interpretations:

"So I began fabricating 'insights.' I deliberately offered 'preposterous interpretations' to my clients. Some of them were about as un-Freudian as I could make them—first proposed somewhat cautiously, of course, and then, as I began to see what was happening, more boldly. My only criteria were that the explanation account for the crucial facts as the client saw them and that it carry implications for approaching the future in a different way.

What happened? Well, many of my preposterous explanations worked, some of them surprisingly well. To be sure, the wilder ones fell flat, but a reexamination of the interviews often suggested where the client's difficulty with them lay. Now I would not want to say that as a general rule, my fabricated 'insights' worked as well as my Freudian ones. But I can say that some of them out-performed normal expectations." (p.52)

Kelly's insight that many of a wide variety of interpretations that made sense to a client might help them cope with their problems was important to his development of a psychology that is constructivist, individualistic and pluralistic, and emphasizes *constructive alternativism*—there are always other interpretations that may make a problematic situation more tractable.

3.2 From a clinical handbook to a new system of psychology

In 1936 Kelly published a *Handbook of Clinical Practice* that was the first draft of his major work (Kelly, 1955, p.ix). It included tests based on bipolar rating scales which were later described in a paper on *diagnosing personality* (Kelly, 1938b) Another paper that year on *the assumption of an originally homogeneous universe and some of its statistical implications* discusses evolutionary processes in scientific reasoning:

"Spencer's definition of evolution as 'a change from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity' describes a natural course of development which might well be taken as a basis in scientific reasoning." (Kelly, 1938a, p.201)

and formulates its main results as a *"postulate"*, an *"axiom"* and two *"correlates"* (p.207). These two papers may again be seen as prefiguring what became important features of PCP: its formulation in terms of a *fundamental postulate* and *corollaries;* the *creativity cycle* cycling between loose and tight construing*;* the analogy of *man-the-scientist*; and the *bipolar construct* (which is instantiated both in the tests and in Spencer's definition).

Kelly tells how his theory arose from three attempts to develop the handbook into a major book:

"From this beginning the handbook was supposed to develop gradually into something which might have wider use. But, time after time, the writing bogged down in a morass of tedious little maxims. It was no good—this business of trying to tell the reader merely how to deal with clinical problems; the why kept insistently rearing its puzzling head.

So we started to write about the whys. It was encouraging to find words trickling out behind the typewriter keys again. Yet no sooner had we started than something strange began to happen; or rather, we discovered that something unsuspected had already happened. It turned out to be this: in the years of relatively isolated clinical practice we had wandered far off the beaten paths of psychology, much farther than we had ever suspected.

We backed off and started again, this time at the level of system building. It was a half-and-half job; half invention of coherent assumptions which would sustain a broad field of inquiry, and half articulation of convictions we had already been taking for granted." (Kelly, 1955, p.ix)

The clinical handbook became the second volume of his major work, and what emerged as the first volume was a highly original theoretical psychology with examples of applications, of practical tools operationalizing the psychology, and of their applications. A further twelve years of research until his death in 1967 generated a number of publications including invited presentations at major conferences and other universities and some twenty three dissertations and theses by his students, that elaborated the theory and its applications.

3.3 Kelly's intellectual development

Kelly's publications show his wide-ranging erudition in matters of: the philosophy of science and mathematics in works of Hegel, Spinoza, Comte, Stumpf, Husserl, Dewey, Russell, and others; foundational psychology in the works of Locke, Spencer, James, Meyer, Freud and Bergson and others; and methodological issues in psychology such as those raised by Gilbreth's *therbligs*, Bridgman's *operationalism*, Lecky's *self-consistency*, Windelband and Allport's *idiographic-nomethetic* distinction, Snygg and Combs' *neophenomenology*, Hull's *mathematico-deductive theory,* and MacCorquodale and Meehl's analysis of *hypothetical constructs* based on Reichenbach's (1938) notion of s*urplus meaning*. His formulation of his own theory exhibits exceptional care in the definition of terms, and attention to clarity in presentation.

He was acutely aware of the issues relating to a scientific psychology outlined in the previous section, and attempted to present his theory in a way that circumvented them. In particular, he saw many of the notions that were taken for granted in psychology, such as cognition, learning and motivation as inherently misleading, and deliberately avoided their use. This is also true of other notions such as that of mind which he avoids completely, never finding it appropriate to discuss where the psychological processes he models are located:

"Persons anticipate both public events and private events. Some writers have considered it advisable to try to distinguish between 'external' events and 'internal' events. In our system there is no particular need for making this kind of distinction. Nor do we have to distinguish so sharply between stimulus and response, between the organism and his environment, or between the self and the not-self." (p.55)

Kelly goes so far as to reject the three-fold classification of psychological phenomena that is presented a priori in the standard works of all his predecessors:

"The classical threefold division of psychology into cognition, affection and conation has been completely abandoned in the psychology of personal constructs." (p.130)

This is an unconditional rejection of a misleading distinction that had fettered psychology for some two centuries, and an indicator of the truly revolutionary nature of his proposal for a personal construct psychology. His own, and later, research justified the rejection by showing how cognitive, emotional and motivational processes could be generated from the same principles.

The overall outcome is a systemic psychology, well-founded in both theory and practice, that is minimal in its basic principles and powerful in accounting for, and providing the means to change, human behavior. In reading Kelly's presentation of PCP it is important to respect the minimalism, and to note that the notions he leaves out are often just as telling as those he includes; it is very easy to import familiar notions that are unnecessary and inappropriate to the foundations of PCP.

3.4 A psychology founded on the notion of anticipation

Kelly's generative principle for PCP is expressed in his one, and only, postulate:

> *"Fundamental postulate: a person's processes are psychologically channelized by the ways in which he anticipates events" (Kelly, 1955, p.46)*

which is followed by careful definitions of each of its major terms, and by eleven corollaries which:

> *"amplify the system by stating certain propositions which, in part, follow from the postulate and, in part, elaborate it in greater detail." (p.50)*

This formal style of logical presentation is one that, as already noted, Kelly (1938a) had adopted in an earlier paper. It is the argument form of Aristotelean scholasticism deriving from that of Euclid's *Elements*. Three of those cited by Kelly use it in their presentations of psychology: Spinoza (1876) in his *Ethics* including his analysis of human emotions; Spencer (1864) in his volumes on psychology in his *Synthetic Philosophy*; and Hull (1940) in his *Mathematico Deductive Theory of Rote Learning*. Its use may have been a personal preference, but it may also have been an attempt to show that a non-behaviorist psychology could be couched in formal terms (Kelly notes that he has "no serious quarrel…with Hullian learning" (pp.xiii-xv)).

The notion that *anticipation* is the fundamental generator of psychological processes comes, as Kelly notes (pp.129, 154, 157), from Dewey (1910):

> *"Every biological function, every motor attitude, every vital impulse as the carrying vehicle of experience is thus apriorily regulative in prospective reference; what we call apperception, expectation, anticipation, desire, demand, choice, are pregnant with this constitutive and organizing power. In so far as 'thought' does exercise such reorganizing power, it is because thought is itself still a vital function." (p.212)*

Kelly was the first to formalize Dewey's analysis of the role of anticipation in psychology. Its role in general biological functions was later modeled by Rosen (1985; 1991) in his works on *Anticipatory Systems* and *Life Itself*. Rosen framed his models in terms of *category theory* which Eilenberg and MacLane (1945) originated prior to Kelly's book but which only became widely accessible in the 1970s (MacLane, 1971). It has more recently been used to model general cognitive processes (Magnan & Reyes, 1994) and Piaget's *genetic epistemology* (Piaget,

Henriques, Ascher, & Brown, 1992), and it provides an appropriate mathematics for constructivism that was not available to Kelly.

Kelly states that the term *anticipation* subsumes both *prediction* and *control* (which he also presents as the primary objectives of science), and hence his postulate encompasses action. We may 'predict' that an event will happen by acting to make it happen, again a notion from Dewey in his discussion of how people cope with the world:

> *"This is the method of changing the world through action, as the other is the method of changing the self in emotion and idea." (Dewey, 1930, ch.1)*

Kelly's exemplars of 'prediction' show that he gives it broader connotations than usual, of *being prepared* for possible eventualities, rather than of necessarily expecting that they are likely to occur, and of imagining and creating new eventualities that had not previously been instantiated.

3.5 The logical foundations of anticipation

Reasoning about possible and anticipated events was an important topic for early Greek logicians. Aristotle discusses the logic of possibility in depth in his *Analytics*, and he also emphasizes the significance of oppositionality in reasoning. Kelly cites Aristotle but somewhat negatively, perhaps because he was influenced by Korzybski's (1948) attribution to Aristotle of many defects in Western thought, but also because he saw Aristotle's 'categories' as pre-existing rather than constructed (p.305). This is unfortunate because there is a richness to Aristotle's thought, and a grounding in human experience, that parallels Kelly's own approach. Modern logic in Kelly's time, founded on the work of Frege (Demopoulos, 1995) and Russell (Rodríguez-Consuegra, 1991) to support mathematics, had moved far from practical reasoning and relevance to psychology (Mohanty, 1982).

Kelly uses geometry rather than logic to explicate his system (ch.6), and in so doing he models an *intensional* logic, one in which predicates are defined in terms of their properties rather than extensionally in terms of those entities that fall under them (Shaw & Gaines, 1992). The intensional logic of the human imagination which can conceive objects and situations that do not exist and may never exist has been studied through the ages: in the psychologies of Reid (1813) and Meinong (1983); in the "fictions" of Bentham (Ogden, 1959) and Vaihinger (1924); and, in modern times, in Routley's (1980) voluminous exposition of logical foundations for Meinong's work; in Zalta's (1988) formal exposition of intensional logics; and in Boër's (2003) logic of *thought-contents* based upon it. Kelly (1964) only became aware of Vaihinger's developments of Kant's constructivism when he was invited to address the American Society of Adlerian Psychology in 1964 and the Ansbachers, who had edited a collection of Adler's writings, drew his attention to Vaihinger's influence on Adler. In particular, this was the source of Adler's *fictional final goal*, a notion that resonated with Kelly's own notion of anticipating the intersection of constructs that might never be instantiated by an element.

In Kelly's time there were no adequate formal foundations for an intensional logic of such fictions. It was not until 1963 that Hintikka (1963) and Kripke (1963) published the model sets formulation that gave intensional logic its *possible worlds* formal foundations, and not until 1983 that projective geometry was found to provide a formal model for intensional implication (Urquhart, 1983). It was only in the 1980s that artificial intelligence research developed *description logics* (Baader, Calvanese, McGuinness, Nardi, & Patel-Schneider, 2003) for

knowledge representation and inference that provided rigorous, practical tools for reasoning with intensional logics. There are now solid foundations for formalizing much of Kelly's psychology, and computational tools for operationalizing it.

3.6 Kelly's constructivism

The first corollary introduces Kelly's constructivist position:

> *"Construction corollary: a person anticipates events by construing their replications"*
>
> *"By construing we mean 'placing an interpretation': a person places an interpretation upon what is construed. He erects a structure, within the framework of which the substance takes shape or assumes meaning. The substance which he construes does not produce the structure; the person does." (p.50)*

He goes on to note that construing is individual and involves a hierarchic organization of dichotomous constructs that each have a limited range of convenience and may be inferentially incompatible.

Kelly's constructivism is a corollary, not an additional postulate, because it derives from his fundamental postulate through the same line of reasoning that led Craik to propose that human anticipatory capabilities are based on mental models. Indeed, if one substitutes Kelly's verb "to construe" with the alternative, "to model," then one finds parallels with much of the later literature on mental and scientific models (Gentner & Stevens, 1983; Hesse, 1967). Research on the role of models in practical reasoning raises strikingly similar issues to those that Kelly discusses (Gaines, 1993b). However, it is a major strength of Kelly's approach that he does not find the need to situate his construct systems "in the head" as Craik does his models. Kelly's exposition is phenomenological, presupposing only that anticipation occurs, and deriving the consequences of this postulate in terms of psychological phenomena, not unnecessarily specific mechanisms that might underlie those phenomena.

In the cybernetics literature, Conant and Ashby (1970) gave a systemic derivation of Craik's conjecture in their paper "*Every good regulator of a system must be a model of that system.*" The generality of this result may be seen by noting that a perfectly anticipatory system, given access to the inputs of another system, will be able to predict the outputs of that system. An observer of the two systems will see identical input-output behavior from both, and hence whatever model it forms of one system it must also, for consistency, impute to the other. If it sees one system as a 'world' and the other as an 'agent', it will infer that the agent has developed a model of the world. This result shows the generative power of Kelly's fundamental postulate in determining what models an observer, such as another person or a psychologist will make of an anticipatory system. It also provides a formal basis for Jenkins' (1981, p.216) insight that:-

> *"When one looks at the models that the psychologist builds, one discovers, in fact, that they are not models of the mind, but rather models of the task being performed by the subjects"*

However, it is important to note that the notion of a 'model' in all these discussions is not necessarily, and not generally, that of a scientific theory based on the application of general principles. An undigested store of past experience that was used to guide action and provide adequate anticipation in situations considered by Craik, Conant and Ashby would satisfy their notions of a 'model.' Anticipation is a phenomenon that can be supported by an indefinite range

of processes, and Kelly's corollaries about construing should be treated as a conceptual framework for analyzing various aspects of anticipatory phenomena, not a sketch of how anticipation is carried out.

For those who have met constructs largely through the repertory grid, it is important to note that Kelly's notion of constructs is not just based on that of logical opposition, but also encompasses structures reminiscent of Bartlett's (1932) *schemata*:

> *"Man looks at his world through transparent patterns or templets which he creates and then attempts to fit over the realities of which the world is composed." (Kelly, 1955, p.8-9)*

> *"we consider a construct to be a representation of the universe, a representation erected by a living creature and then tested against the reality of that universe." (p.12)*

Kelly's notions of the nature of constructs as involving a similarity and a difference, and of being defined through their relations to a network of constructs, probably originated from his reading of Spencer's works:

> *"As we find by analyzing it, and as we see it objectively displayed in every proposition, a thought involves* relation, difference, likeness. *Whatever does not present each of these does not admit of cognition." (Spencer, 1862, p.68)*

> *"Every thought involves a whole system of thoughts and ceases to exist if severed from its various correlatives." (Spencer, 1862, p.121)*

Kelly takes care to note that his notion that constructs are validated through their predictions does not necessarily lead to the constructivist problem of self-fulfilling prophecies because different constructs may be involved in the validation:

> *"Just as constructs are used to forecast events, so they must also be used to assess the accuracy of the forecast, after the events have occurred. Man would be hopelessly bogged down in his biases if it were not for the fact that he can usually assess the outcomes of his predictions at a different level of construction from that at which he originally makes them. A man bets that a horse will win a certain race because it is black and he has recently won with a black hand at poker. When the race results are in, however, he is likely to construe the announced decision of the judges as being more palpable evidence of the horse's performance in the race than is the horse's color." (p.13)*

3.7 Reflexivity and pluralism

Kelly repeatedly emphasizes that his psychology is fully reflexive and applies to psychologists, other scientists, and to himself and his theories:

> *"It is customary to say that the scientist's ultimate aim is to predict and control. This is a summary statement that psychologists frequently like to quote in characterizing their own aspirations. Yet, curiously enough, psychologists rarely credit the human subjects in their experiments with having similar aspirations" (p.5).*

He applies PCP to itself and to other psychological theories, noting that it has a limited range of convenience *"to human personality"* (p.11). However, his wide-ranging applications of PCP, for

example to fundamental issues of science, show that, for Kelly, 'human personality' had a much greater scope than normally envisioned. Like Hegel, he also emphasizes that his theory encompasses the possibility of its own invalidation:

> *"Our own theory, particularly if it proves to be practical, will also have to be considered expendable in the light of tomorrow's outlooks and discoveries. At best it is an ad interim theory." (p.14)*

Pluralism is a natural consequence of Kelly's reflexive constructivism which allows him to model not only co-existing personal construct systems but also co-existing public construct systems:

> *"One does not have to disprove one proposition before entertaining one of its alternatives." (Kelly, 1969a, p.55)*

This pluralism is expressed through his notion of *constructive alternativism*, the title of the first chapter of his book and one of his major contributions to both therapeutic techniques and the philosophy of science:-

> *"what any scientist can hope to discover is not an absolute categorical truth, nor even a relative fraction of truth, but a categorical truth applied in the context of relationships" (Kelly, 1955, p.189)*

In this broader application of his theory, Kelly prefigures the notions of Kuhn (1962) in the sociology of science and Derrida (1967) in the hermeneutics of literature, and provides psychological foundations for the phenomena they describe; however, he did not develop this aspect of his work in greater depth.

3.8 Learning and motivation in a PCP framework

The explication of *learning* does not need additional postulates within PCP because it is inherent to Kelly's fundamental postulate—anticipation of a changing world requires a changing construct system:-

> *"Constructs are used for predictions of things to come, and the world keeps rolling along and revealing these predictor to be either correct or misleading. This fact provides the basis for revision of constructs and, eventually, of whole construction systems. If it were a static world that we lived in, our thinking about it might be static too. (Kelly, 1955, p.14)*

Kelly also subsumes the notion of *motivation* through his *choice corollary*, slightly revised in his later work to:

> *"a person chooses for himself that alternative in a dichotomous construct through which he anticipates the greater possibility for the elaboration of his systems" (Kelly, 1970, p.15).*

Again, the strength of this explication of motivation can only be realized if one thinks in terms of the total hierarchical structure that will be have to be fitted as a templet through either choice, and the actions that may be necessary to do so.

Kelly's use of the term 'choice' evokes connotations of rational choice that have misled some commentators to construe his psychology as excessively rational (Fransella, 1995, p.114).

However, his use of that term was deliberately provocative to both his students and his clients, emphasizing that there was always the possibility of constructing alternative interpretations of events even if doing so might be extremely difficult.

3.9 Limited recognition of PCP by cognitive psychologists

In examining the role of PCP in the cognitive revolution, we do not think it fruitful to enter the debate about whether or not PCP is a 'cognitive psychology' (Adams-Webber, 1990; W. G. Warren, 1990). The definition of a cognitive theory in section 2.6 can readily be fitted to PCP if one takes construct systems as 'representational states that are semantically evaluable' (as validated or invalidated). Thompson (1968) references PCP as "a cognitive personality theory" in Kelly's obituary, and that classification is propagated in Zusne's (1975, item 514) biographies of eminent psychologists.

However, Kelly's relevance to cognitive psychology was not recognized by the central figures of the cognitive revolution, and his work has only recently begun to be cited in this context by proponents of a 'second cognitive revolution' (Harré & Gillett, 1994, p.133-140). Adams-Webber (1990) notes that Kelly and Neisser were colleagues at Brandeis as the latter was writing his book on *Cognitive Psychology* (Neisser, 1967), and that Kelly and his students read the book in manuscript form. However, although Neisser adopts a constructivist stance to perception noting that *"the central assertion is that seeing, hearing and remembering are all acts of construction"* and *"all perceiving is a constructive process"* (p.95), he nowhere cites Kelly's book that preceded his by some twelve years. It is interesting that Neisser (1976) in his next book repudiates his earlier constructivism, stating that Gibson's (1979) *Ecological Approach* (which Neisser had read in draft form) now provides his preferred explanation of the same phenomena. If he had assimilated Kelly's work, particularly his rejection of the *internal-external* and *organism-environment* distinctions, he might have noticed that Gibson's *affordances* may be modeled as Kellyan *constructs* embodied in the environment that support human interaction with that environment, and are consistent with a wider interpretation of constructivism.

Most studies in the information processing paradigm of the cognitive revolution were not constructivist, but, although Kelly's theoretical psychology can be interpreted within that paradigm (as will be shown in the next sub-section), it again went unnoticed. Festinger's (1957) work on *cognitive dissonance* and Berlyne's (1960) on a *curiosity drive* have natural interpretations within a PCP framework but these links appear never to have been developed. Kelly was invited to conferences that could have provided links to cognitive psychology research. He gave a paper at Lindzey's conference on the *Assessment of Human Motives* in 1957 where Gordon Allport and Raymond Cattell also gave papers (Kelly, 1958), and where Allport's (1958) paper makes positive references to PCP. He was a commentator at the first conference on the *Computer Simulation of Personality* in 1962 (Kelly, 1963). He also gave an invited paper in 1961 to the Moscow Psychological Society (Kelly, 1969b), where Luria who, apart from his own studies of cognition, was at that time the chief expositor of Vygotsky's work in the West, but there appears to have been no further outcome. However, all these activities largely involved the old guard of cognitive psychology, not the new constituency emerging in the cognitive revolution.

4 Knowledge Acquisition for Expert Systems

This section documents the role that PCP played in what has been presented as one of the major achievements of the cognitive revolution, in academic research and industrial applications of knowledge acquisition for *expert systems* (E. Feigenbaum, McCorduck, & Nii, 1988).

4.1 The expert systems breakthrough in artificial intelligence research

In the 1970s significant successes in artificial intelligence research were reported when so-called *expert systems* were developed that successfully emulated human reasoning in mass spectrometry for molecular identification (E. A. Feigenbaum, Buchanan, & Lederberg, 1971) and in medical diagnosis for microbial infections (Shortliffe, 1976). Some positive results were urgently needed as a result of the negative consequences of a dispute in Britain in 1972 on whether the Mathematics Laboratory at the University of Cambridge or the Department of Machine Intelligence and Perception at the University of Edinburgh should be funded to acquire an American DEC PDP10 computer. At that time government policy was to support the primary British computer company ICT by funding British universities to purchase its 1900-series. Sir James Lighthill, Lucasian Professor of Applied Mathematics at Cambridge, was commissioned by the Science Research Council to make a survey of the state-of-the-art in artificial intelligence research. He had been a friend of Turing and an advocate of undergraduate education in computing when he was Professor of Applied Mathematics at Manchester, but his own research was in fluid dynamics unconnected to artificial intelligence. The so-called *Lighthill Report* was damning as to the lack of achievement of twenty five years of artificial intelligence research (Lighthill, 1973), and had an adverse effect on funding not only in Britain but also in America.

Thus, the expert system 'breakthrough' was an important opportunity for artificial intelligence researchers to claim the high ground, forming the *American Association for Artificial Intelligence* (AAAI) and holding its first conference in 1980. A number of commercial organizations were formed to commercialize expert systems and support their development through programming and inference tools called *expert system shells*. Interest grew to such an extent that in 1982 the Japanese government was persuaded to launch its *Fifth Generation Computer Systems* research program in which artificial intelligence and expert systems research was to play a major part (Gaines, 1984; Moto-oka, 1982). The Japanese program was used by artificial intelligence researchers to encourage their own governments to fund their research, resulting in the: DARPA *Strategic Computing* program and *Microelectronics and Computing Technology Corporation* (MCC) in the USA (Roland & Shiman, 2002); ESPRIT program in the EEC (Roukens & Renuart, 1985); Alvey program in Britain (Oakley & Owen, 1989); and many other national initiatives world-wide (Gaines, 1990).

4.2 Adoption of PCP in knowledge acquisition research and practice

From the perspective of system development expert systems could be seen as paradigm shift such that when one was developing a system for an ill-defined task that could be performed by a person then one modeled the person rather than the task (Gaines & Shaw, 1985). However, the difficulties of eliciting knowledge from skilled people were well-documented in the psychological literature (Bainbridge, 1979; Nisbett & Wilson, 1977), and these were soon encountered by expert system developers. The problem was described in one of the first texts on *Building Expert Systems* (Hayes-Roth, Waterman, & Lenat, 1983):

> *"Knowledge acquisition is a bottleneck in the construction of expert systems. The knowledge engineer's job is to act as a go-between to help an expert build a system. Since the knowledge engineer has far less knowledge of the domain than the expert, however, communication problems impede the process of transferring expertise into a program. The vocabulary initially used by the expert to talk about the domain with a novice is often inadequate for problem-solving; thus the knowledge engineer and expert must work together to extend and refine it. One of the most difficult aspects of the knowledge engineer's task is helping the expert to structure the domain knowledge, to identify and formalize the domain concepts." (p.129)*

In the same era Shaw and Gaines (1979) had developed techniques using fuzzy logic to provide an *entailment analysis* of repertory grid data that generated rules relating the rating of an element on one construct to that on others, and suggested that this might provide a method for expert system development (Gaines & Shaw, 1980). They conducted an experimental study to evaluate the use of the grid to elicit expert knowledge using as a 'gold standard' the seven distinctions underlying the BIAIT methodology for setting up business accounting systems (Carlson, 1979). They elicited grids from a range of individuals having varying degrees of accounting expertise, added a grid representing the BIAIT constructs, and used a SOCIOGRIDS analysis (Shaw, 1980) of the grids to show that the BIAIT constructs were being elicited from experts (who had no explicit knowledge of the methodology), and that the socionets produced modeled the varying expertise of the subjects (Shaw, 1984; Shaw & Gaines, 1983).

In the spring of 1983, John Boose joined the Boeing Artificial Intelligence Center to help run an Associate's Program to train those in Boeing who might make effective use of expert systems technology. Boose (1989) notes that he first explored repertory grid techniques in 1976 while a student at the University of Maryland School of Architecture, trying to build a software system that would help people design their own homes. At Boeing he thought that repertory grids might be effective in helping Associates identify variables for rules. He began to build a grid elicitation system and:

> *"At this point, an interesting collection of articles was found describing tools and methods for extending repertory grid analysis (Shaw, 1981). Boose began applying ideas from some of the tools, notably ENTAIL (Gaines & Shaw, 1981) and DYAD (Keen & Bell, 1981)." (p.504)*

Boose called his system the Expertise Transfer System (ETS, Boose, 1986) and described it at the 1984 AAAI conference (Boose, 1984). Shaw invited him to York University to exchange information on their mutual interests. That resulted in agreement to cooperate, an exchange of research materials over the next twelve years, and the joint founding and management of three series of international conferences on knowledge acquisition: a North American series held in Banff commencing in 1986; a European series circulating around the UK, Germany, France, Holland and Spain, commencing in 1987; and a South-East Asian series alternating between Japan and Australia commencing in 1990.

Artificial intelligence research was booming in this era. The *International Joint Conference on Artificial Intelligence* in Los Angeles in 1985 attracted over 7,500 participants, and had the atmosphere of a rock concert with thousands of participants avid to attend presentations in theatres that could seat 500 or less. The exhibition was like a major technology trade show with

lavish stands demonstrating artificial intelligence tools from a range of start-up companies, and tables sagging under the weight of a burgeoning artificial intelligence literature. The 1986 knowledge acquisition meeting was intended to be a workshop for some 40 specialists, but some 120 papers were submitted and we had over 400 requests to attend.

The repertory grid became widely accepted as a powerful knowledge acquisition tool and each knowledge acquisition conference had a number of papers not only from the Boeing and Calgary teams but also from an increasing number of other groups worldwide with whom they were collaborating or who were working with grids independently. The workshops also attracted cognitive science researchers such as Bill Clancey who were addressing the issues of eliciting human knowledge from perspectives such as that of situated cognition (Clancey, 1997). They also attracted industry partners such as Alain Rappaport of Neuron Data, developer of the expert system shell *NEXPERT*, and led to the repertory grid tool *KSS0* (*RepGrid)* being integrated with NEXPERT and marketed by Neuron Data as *NEXTRA*.

As we noted in the abstract, this was a remarkable time for PCP research because it was being developed and applied in different ways by well-funded research groups in industry and universities. It rapidly became apparent that to do this required further elaborations of PCP that had not been particularly relevant to Kelly's interests or to the clinical and educational applications that had ensued. The following sub-section summarizes some of the lessons learned (Gaines & Shaw, 1993a), as has also been done by others (Bradshaw, Ford, Adams-Webber, & Boose, 1993; Ford, Bradshaw, Adams-Webber, & Agnew, 1993).

4.3 Relevance of the expert system studies for PCP

The extraction of rules from a repertory grid was at first the only way in which anticipation could be modeled because expert systems shells needed such rules in order to support inference. Our early work focused on integrating our repertory grid tools with the shells of our colleagues at Neuron Data (Gaines, Rappaport, & Shaw, 1992; Gaines & Shaw, 1993b) and at the German *National Research Center for Information Technology* (GMD) (Gaines & Linster, 1990; Shaw, Gaines, & Linster, 1994). Hypermedia systems were used to collect relevant information from a variety of sources; grids were elicited from experts and developed from the hypermedia data; rules were derived by entailment analysis; frames were derived from the grids; the rules and frames were loaded into the expert system shell; inference was run on cases and assessed by experts; if the inference was incorrect the expert corrected it and posted it back to the grids; and the cycle repeated. This cyclic process of knowledge acquisition and testing through application was an attempt to replicate an essential feature of expertise, that the expert is not just a repository of knowledge but someone who uses that knowledge to be *"open to experience"* (Gadamer, 1972). This openness is naturally modeled from a PCP perspective of a person as *"a process," "a form of motion"* (Kelly, 1955, p.47-48), whose *"construction system varies as he successively construes the replication of events"* (p.72).

However, while Kelly is clear as to what is happening he does not consider in depth the question of how it happens and what will affect it. Our computer programs provided a 'white-box' anticipatory system emulating human expertise that could be used as a 'test subject' for some interesting experiments. It had been found that grid techniques could be used to build complex expert systems with surprisingly little effort; in particular, with surprisingly little data. We conjectured that this was because the interactive elicitation process led to the expert entering

only stereotypical elements characterized by relevant constructs and correct outcomes. This hypothesis was tested by taking an existing dataset in the literature (Cendrowska, 1987), and creating degraded versions of it by introducing random errors and irrelevant constructs with random ratings. We then determined how many elements were needed on average in a grid to achieve correct performance with various levels and types of degradation. It was found that to achieve perfect performance one need enter: 6 stereotypical elements; or 18 carefully selected elements; or 90 randomly selected elements; or 326 elements with 25% errors; or 641 elements with 5 irrelevant constructs; or 1970 elements with 10% errors and 1 irrelevant construct (Gaines, 1989).

The results with just errors or just irrelevant constructs were as expected; any constructivist educator knows the importance of students having access to valid learning experiences and having their attention drawn to their significant features. The strong interaction between even a small error rate and a single irrelevant construct was surprising, but it did model the problems of the initial stages of the development of a new science when the quality of data and its relevant features are unknown. Civilization under those conditions addresses the problem through the parallel anticipatory processes of many scientists, sharing their results, and gradually focusing in on elements and constructs that allow the anticipatory process to become fast, correct, encoded, and widely assimilable. Both the Boeing (Boose & Bradshaw, 1987) and our experience (Gaines & Shaw, 1989) had led to us working with groups of experts rather than individuals, and using a wide variety of sources of expert knowledge. We realized that PCP could provide a model for collective endeavors possibly involving artifacts if we treated the collective as an individual (as McDougall (1920) had suggested) with distributed psychological processes (Gaines, 1994b).

4.4 Meta-ratings, rules and case-based anticipation

Another lesson learned was that the rules generated can best be regarded as stereotypical elements from which irrelevant constructs have been discarded, with inference being based on matching with these elements not taking into account the irrelevant constructs. We made provision for this by introducing a set of meta-ratings into the grid, encoding *unknown*, *possible*, *irrelevant*, and *inapplicable*, and adjusting our matching algorithms to take account of such meta-ratings appropriately. The availability of the meta-rating *unknown* enabled us to represent epistemic lack of knowledge or uncertainty; that of *possible* enabled us to represent inferential inconclusiveness, of being prepared for events that might not occur in an open universe; that of *irrelevant* to represent the non-significant constructs in stereotypical elements; and that of *inapplicable* to represent ordination structures in a single grid—our later inference system could reconstruct subsumption relationships from such information.

However, existing expert system shells could not make proper use of the meta-ratings in inference, and so we eventually developed our own knowledge representation and inference program that could represent bipolar constructs and the meta-ratings, and use them properly in inference (Gaines, 1991, 1993a). We showed that the frames, schemata and inference schema of description logics could be fully represented, formalized and implemented through a repertory grid with meta-ratings (Gaines, 1994a). This research also involved extending the ratings to encompass numeric, categorical and relational data, and it was interesting that it was simple to do this without distorting the nature of the grid or the normal approaches to its analysis. This gave some insights into the way in which precise, quantitative measures were introduced in the

evolution of science in order to refine the qualitative constructs of informal, everyday reasoning and communication.

One outcome of these developments was that the wheel went a complete circle and we came to realize that the technique that had interested those developing expert systems in PCP, the extraction of rules from expert experience elicited in repertory grids, was unnecessary and a less powerful approach than anticipation based on matching new cases directly against those in the grid. It was fortuitous that the earliest successful expert systems such as MYCIN had used rules to represent knowledge and that this had been incorporated in the initial expert system 'shells.' Later developments in *case-based reasoning* (Leake, 1996) had been shown to support more rapid development of expert systems, and the technique involved was a simple extension of the FOCUS (Shaw, 1980) clustering algorithm. In PCP terms this was further evidence that effective anticipation could be based directly upon experience without the restructuring of that experience into more overt 'knowledge.' Human anticipatory activity based on experience may show patterns that an observer might construe as 'rules,' but it is inappropriate to infer that such activity is based-on rules. A PCP-based model of human actions as anticipation based on experience may provide a model of Bourdieus' (1990) *habitus* that addresses Wittgenstein's (1953) arguments concerning the impossibility of human behavior being regulated by rules.

5 Conclusions

As Adams-Webber (1990) has noted, the success of PCP in providing methodologies for expert system development based on the information processing metaphor for human cognition shows that it can provide foundations for cognitive psychology. However, this by no means implies that PCP can be subsumed within psychologies based on the information processing metaphor. To do so would be to constrain the intellectual framework of PCP unnecessarily, detracting from the generality and power of Kelly's formulation.

One aspect of the cognitive revolution that we regard as negative is that it has tended to resurrect the concept of mind and a focus on internal psychological processes. While construct systems can be treated as internal to the person, or the person's 'mind,' we believe Kelly's explicit rejection of the *internal—external*, *stimulus—response*, *organism—environment*, *self—not-self, cognition—emotion, emotion—volition,* and *volition—cognition* distinctions as part of his psychology is one of his most important contributions. All of these can be modeled as constructs of psychological theories, but none of them is foundational to psychology.

In particular, the lack of these distinctions at the core of PCP enables them to be added to encompass other psychological systems, and alternative distinctions to be added to model some of the newer, or neglected psychological systems. We have already noted that Gibson's (1979) ecological psychology can be modeled as a significant elaboration of PCP by taking some constructs to be embodied in the environment and to become active through facilitating certain human anticipations.

A similar approach may be taken to modeling Kantor's (1959a) unjustly neglected *interbehaviorism* which emphasizes that psychological processes arise through the close coupling of person and environment. In particular, Kantor's (1953) studies of the evolution of the construct systems of various sciences provide important data for PCP research, and the PCP framework provides the means to elaborate his rich theories. Kelly was on the Board of, and

published in, Kantor's journal, the *Psychological Record*, but Kantor only cites Kelly's work prior to PCP and Kelly does not mention Kantor's research.

There has been a debate about the role of PCP in social constructionist research (Mancuso, 1998; Stam, 1998), with an attempt at synthesis from a PCP proponent (Mancuso, 1996) being rejected typically because it *"suggests that individual's construals must be central to any explanation"* (Burkitt, 1996; Wortham, 1996). It could be insightful to develop a synthesis of the two approaches in which constructs are modeled as affordances embodied in the social milieu, by no means universally accessible, but not completely individual either. Kelly discusses *"widely shared or public construction systems"* (p.9), and eschewed the *internal-external* and *self—not-self* distinctions. His emphasis on the term *personal* was to redress a balance heavily tilted towards uniform rationalism in which individuality was modeled as a deviation from an assumed norm rather than as the natural process of an individual interpreting her or his experience. It is a rhetorical rather than ideological emphasis.

We will conclude by mentioning briefly some other areas of major advance in the past fifty years that stand apart from the cognitive revolution and PCP, but are highly relevant to both, notably sociocultural and neurological studies. Shortly after Kelly's major publication, Hall (1959) published his anthropological analysis of the propagation of human culture, distinguishing three major mechanisms: *informal* through mimicry; *formal* through reward-punishment; and *technical* through language. More recently, Bourdieu (1977) has provided an exhaustive analysis of what he terms *habitus*, the operation and reproduction of informal culture, and Lave and Wenger (1991) have analyzed the way in which individual human action arises out of sociocultural situations modeled as *communities of practice* (Wenger, 1998). This research may be seen from a PCP perspective as investigating the processes whereby construct systems are generated and reproduced in a community, and the relevance of PCP has been noted by sociological system theorists such as Luhmann (1995).

In parallel with sociocultural studies of the transmission of construct systems, there have been major advances in neurological studies of the underlying processes, commencing with the Olds and Milner (1954) discovery of a reinforcement center in the hypothalamus. This provided neurological foundations for Skinner's model of learning based on contingencies of reinforcement, and hence also of Hall's model of the reproduction of formal culture. More recently, the discovery of 'mirror neurons' (Stamenov & Gallese, 2002) that support imitative activity in motor and language learning. This has provided neurological foundations for Tarde's (1903) *Laws of Imitation* and Hall's model of the reproduction of informal culture. From a PCP perspective, reinforcement and mirror neurons provide neurological mechanisms for two of the most important ways in which construct systems are transmitted non-verbally between people.

In conclusion, the role of PCP in the cognitive revolution is not subject to precise delineation, but its consideration provides a range of perspectives on what Kelly achieved through the development of a theoretical psychology to motivate his clinical maxims. He clearly went far beyond that objective, largely because he ruthlessly excluded many significant psychological constructs from the core of his psychology, modeling them as part of other construct systems. In the cognitive revolution PCP extended the range of disciplines in which it has proved to be a powerful tool by encompassing the development of expert systems based on information technology. More recently it is beginning to play a similar role in the wider context of *knowledge*

management research, where social and organizational issues come into play (Gaines, 2003; Jankowicz, 2001).

We hope this article will be useful in situating PCP in the context of the cognitive revolution, and both of them in the wider history of psychology, and in stimulating further PCP research, particularly that concerned with the interaction of psychology, sociology and anthropology.

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