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Cognitive Complexity

1.1 Introduction

Cognitive complexity characterizes cognition on a scale of simplicity to complexity. It is the focus of academic research in areas such as personal construct psychology, organizational theory, and human-computer interaction (Bell :2010).

Cognitive Complexity was initially defined as a measure of the "testability and maintainability" of a module's control flow. While it excels at measuring the former, its underlying mathematical model produces an inferior value when measuring the latter. This white paper describes a new metric that departs from the use of mathematical models to evaluate code in order to address the shortcomings of Cognitive Complexity and produce a measurement that more accurately reflects the relative difficulty of understanding, and thus of maintaining methods, classes, and applications (Thomas :1976).

James Bieri first introduced it in 1955 in The Journal of Abnormal and Social Psychology with Cognitive complexity-simplicity and predictive behavior. He tests two hypotheses in the article:

- There should be a positive relationship between degree of cognitive complexity and predictive accuracy.

- There should be a negative relationship between cognitive complexity and assimilative projection.

Bieri (1955) proposed the idea of cognitive complexity, which is concerned with the arrangement of constructs and their similarities. If the elements in a grid are all constructed in the same way, the structure of the constructs is straightforward, and they all lead to the same prediction. Monolithic construing refers to the tendency for constructs to be deeply interconnected. If the elements are construed in less related ways for all constructions, the organization becomes more complex, resulting in different predictions. Of fact, if the constituents for all constructs are construed in completely unrelated ways, we get chaos in prediction, a completely fractured set of constructs (ibid).

1.2 What is Cognitive Complexity

The notion of cognitive complexity is how capable humans perceive things in their environment. It also specifies how many cognitive processes are necessary to execute a task. Things that are difficult to execute involve more processes than easy activities. Making a sandwich is a far easier process than writing a term paper. Writing the paper requires many additional cognitive processes, such as using web resources, conducting effective research, and writing in a specific style and tone (Crockett:1965).

Cognitive complexity can also help people analyze events more effectively by helping them to recognize subtle differences in nuance and meaning (Vannoy:1965) . Life experience and education are the primary determinants of an individual's cognition complexity. Individuals can build mental constructions as a result of exposure to complicated events, whether through life experience or education and training (Landfield and Cannell:1988).

The personal construct theory, which claims that individuals understand the world through mental constructions, expands on this view of what is cognitive complexity (Crockett:1965).These constructions act as shortcuts, allowing people to analyze circumstances and tasks more rapidly. Instead of searching through multiples of the same color notebook, someone might color-code their notebooks to make it easy to determine which notebooks are for particular subjects. Mental constructs make it easier to solve complicated problems by automating aspects of the problem-solving process (Daniel, Robert and Robert E. :1993, See: 1992).

1.3 Cognitive Complexity in Different Fields

According to Thomas and Richards (2008), Cognitive Complexity can be defined in different fields:

In artificial intelligence: Cognitive complexity is defined as an extension of the concept of Kolmogorov complexity in an attempt to explain how humans sense significance. It is equal to the length of the observer's shortest description. Identifying a specific Inuit woman among a hundred people, for example, is easier in a Congolese community than in an Inuit village (Thomas and Richards :2008).

Cognitive complexity and probability are related; situations are cognitively unlikely if they are easier to define than to generate. Humans assign two levels of complexity to events: description complexity and generation complexity. To 'produce' an event, such as seeing an Inuit woman in Congo, the intricacy of each event in the causal chain that got her there must be added up. The significant disparity between these complexities (difficult to construct, easy to explain) renders the meeting unlikely and so narrable (ibid).

In computer science: Cognitive (or psychological) complexity distinguishes human variables (related to psychology and human cognition) from, for example, computational complexity in human-computer interaction (Thomas and Richards :2008).

In psychology: Cognitive complexity is a psychological trait or variable that reveals how complicated or simple a person's frame and perceptual competence are (Thomas and Richards :2008).

A person with a high cognitive complexity score is more likely to notice subtleties and minor differences than someone with a low score, which indicates a less complicated cognitive framework for the task or activity (ibid).

1.4 Bloom’s Revised Taxonomy and Cognitive Complexity

There are six levels of cognitive learning according to the revised version of Bloom's Taxonomy. Each level is conceptually different. The six levels are remembering, understanding, applying, analyzing, evaluating, and creating (Anderson and David : 2001).

These levels can be helpful in developing learning outcomes because certain verbs are particularly appropriate at each level and not appropriate at other levels (though some verbs are useful at multiple levels). A student might list presidents or proteins or participles to demonstrate that they remember something they learned, but generating a list does not demonstrate (for example) that the student is capable of evaluating the contribution of multiple presidents to American politics or explaining protein folding or distinguishing between active and passive participles (ibid).

Remembering

Definition: retrieve, recall, or recognize relevant knowledge from long-term memory (e.g., recall dates of important events in U.S. history, remember the components of a bacterial cell). Appropriate learning outcome verbs for this level include: cite, define, describe, identify, label, list, match, name, outline, quote, recall, report, reproduce, retrieve, show, state, tabulate, and tell.

Understanding

Definition: demonstrate comprehension through one or more forms of explanation (e.g., classify a mental illness, compare ritual practices in two different religions). Appropriate learning outcome verbs for this level include: abstract, arrange, articulate, associate, categorize, clarify, classify, compare, compute, conclude, contrast, defend, diagram, differentiate, discuss, distinguish, estimate, exemplify, explain, extend, extrapolate, generalize, give examples of, illustrate, infer, interpolate, interpret, match, outline, paraphrase, predict, rearrange, reorder, rephrase, represent, restate, summarize, transform, and translate.

Applying

Definition: use information or a skill in a new situation (e.g., use Newton's second law to solve a problem for which it is appropriate, carry out a multivariate statistical analysis using a data set not previously encountered). Appropriate learning outcome verbs for this level include: apply, calculate, carry out, classify, complete, compute, demonstrate, dramatize, employ, examine, execute, experiment, generalize, illustrate, implement, infer, interpret, manipulate, modify, operate, organize, outline, predict, solve, transfer, translate, and use.

Analyzing

Definition: break material into its constituent parts and determine how the parts relate to one another and/or to an overall structure or purpose (e.g., analyze the relationship between different flora and fauna in an ecological setting; analyze the relationship between different characters in a play; analyze the relationship between different institutions in a society). Appropriate learning outcome verbs for this level include: analyze, arrange, break down, categorize, classify, compare, connect, contrast, deconstruct, detect, diagram, differentiate, discriminate, distinguish, divide, explain, identify, integrate, inventory, order, organize, relate, separate, and structure.

Evaluating

Definition: make judgments based on criteria and standards (e.g., detect inconsistencies or fallacies within a process or product, determine whether a scientist's conclusions follow from observed data, judge which of two methods is the way to solve a given problem, determine the quality of a product based on disciplinary criteria). Appropriate learning outcome verbs for this level include: appraise, apprise, argue, assess, compare, conclude, consider, contrast, convince, criticize, critique, decide, determine, discriminate, evaluate, grade, judge, justify, measure, rank, rate, recommend, review, score, select, standardize, support, test, and validate.

Creating

Definitions: put elements together to form a new coherent or functional whole; reorganize elements into a new pattern or structure (design a new set for a theater production, write a thesis, develop an alternative hypothesis based on criteria, invent a product, compose a piece of music, write a play). Appropriate learning outcome verbs for this level include: arrange, assemble, build, collect, combine, compile, compose, constitute, construct, create, design, develop, devise, formulate, generate, hypothesize, integrate, invent, make, manage, modify, organize, perform, plan, prepare, produce, propose, rearrange, reconstruct, reorganize, revise, rewrite, specify, synthesize, and write.

1.5 Cognitive Complexity Communication

The number of psychological constructs that an individual may employ to characterize someone is referred to as cognitive complexity in communication. These psychological notions are commonly used to describe personality traits such as "energetic" or "caring." Those who are more perceptive of others tend to characterize others using more psychological terms. These individuals have greater interpersonal cognitive complexity, allowing them to notice more information about a person than others with less talent. An average person may describe someone as "friendly," but someone with higher interpersonal cognitive complexity will observe that they are also giving and self-confident (O'Keefe : 1988).

Cognitive complexity has significant and profound effects on communication in relationships. Communication and cognitive complexity have been identified as important in affecting the quality of marital interactions (Denton and Sprenkle :1995).

In a research of 60 couples, Denton and Sprenkle (1995) revealed that more intellectually complex partners were better able to predict the intended effect of a message and that communication and cognitive complexity were more closely associated in disturbed marriages. They discovered, in particular, that there was greater agreement between what one member of the dyad reported as his/her intent and the intent

perceived by his/her partner, and that these partners were better able to predict the actual results of what was said on each other in distressed marriages. According to the researchers' findings, disturbed marriages may necessitate that partners communicate at their best levels of ability.

Martin (1992) hypothesized that individuals with lower degrees of cognitive complexity may be somewhat limited in both their own patterns of communication activities and their responses to their partners' communication. His findings partially supported the findings of Denton, Burleson, and Sprenkle (1995), in that he discovered that in interactions involving issues of importance to the relationship, more cognitively complex male partners tended to use a style of communication he refers to as "transitional redundancy."

That is, certain spouses exhibit more consistent patterns of interaction than others, which may contribute to a family system's specific style. These patterns can be symmetrical, in which partners replicate each other's conduct, or complementary, in which one person of the couple demonstrates a relationally oriented behavior and the other member accepts that move. Less cognitively complex male partners revealed no variations in communication style regardless of the importance of the topic in identical concerns important to their relationships. That is, the less cognitively sophisticated partners did not display the ability to change their communication style in response to varied challenges. Denton and Burleson (1995) investigated marital couples, cognitive complexity, and marital distress in a later study and discovered that while individuals in distressed marriages may be able to detect their spouses' negative intentions, they like them better when they are less able to detect these intentions.