

A cognitive approach and the implementation of a measurement program

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Abstract

The implementation of a measurement program in a large software development organization requires significant teamwork. However, such implementations are a challenging task; indeed, it has been reported that 80% of measurement programs implemented in the USA have a life expectancy of less than two years. The complementary capabilities of team members are often discussed in the various approaches for implementing a measurement program, but these approaches rarely take into account the distinct personalities of individuals within a team or an organization. This paper presents an overview of Ned Herrmann's cognitive approach and discusses how it can contribute to facilitating the implementation of measurement programs in a software organization. Its use is illustrated in the Desharnais-Abran approach to measurement program implementation. Taking this cognitive approach into consideration in the implementation of software measurement programs could contribute to an increase in their success rate.

1. Introduction

The implementation of measurement programs in software engineering is a challenging task. It has been reported [3] that 80% of measurement programs implemented in the USA have a life expectancy of less than two years. Many roadblocks have indeed been recognized along the path to the successful implementation of software measurement programs, such as:

- Lack of organizational commitment;
- Lack of focus;
- Weak start-up of the measurement program, including a weak working group and a weak support program;

To address these issues in the implementation of measurement in software organizations, various measurement programs have been proposed, including the Desharnais-Abran approach which includes a seven-step project management plan [1]:

1. Management commitment build-up;
2. Staff commitment build-up;
3. Selections of the key processes to be improved;
4. Identification of the goals and objectives related to the key process;
5. Design of the measurement program;
6. Description of the Information System to be put in place;
7. Deployment of the measurement program.

Furthermore, for each of these steps, the roles, responsibilities and specific activities of every party to the implementation program are specifically identified in [1]. However, even though the roles may be clearly identified, the interaction between individuals is also an issue, and it is one that is not addressed systematically most of the time.

To address this issue, we present the cognitive approach of Herrmann (1988), and provide examples of how this model can be used in the implementation of a software measurement program. In section 2, an overview of the Herrmann cognitive approach is presented. The Herrmann approach is, of course, simplified in this presentation; further information can be

found in [2]. In section 3, we give examples of its use for analyzing the content of a measurement program implementation plan, and in section 4 present our observations on how the Herrmann cognitive approach could be of use in any environment where multiple individuals interact in making decisions, including, of course, in the implementation of measurement programs.

2. The Herrmann Model

Herrmann built his cognitive approach on the basis of the works of both R. Sperry and P. MacLean [4]. According to Roger Sperry (1981 Nobel Prize winner in medicine), each hemisphere of the brain specializes in one type of thinking. The left side of the brain is logical, analytical and sequential. The right side is spatial, visual and emotional. For example, when buying a stereo, an individual can consider two different types of factors. On the one hand, the left brain will consider the technical performance of the equipment, such as the number of watts per channel, the range of the sound, the guarantee, etc. On the other hand, the right brain will focus on the quality of the sound, the design of the cabinet, the color, and so forth.

Furthermore, the human brain, as modeled by the American physician Dr. Paul MacLean, functions through the interaction of the three cerebral formations illustrated in Figure 1: the reptilian complex, the limbic system and the neocortex. These cerebral functions control instinct, emotions and intellect respectively.

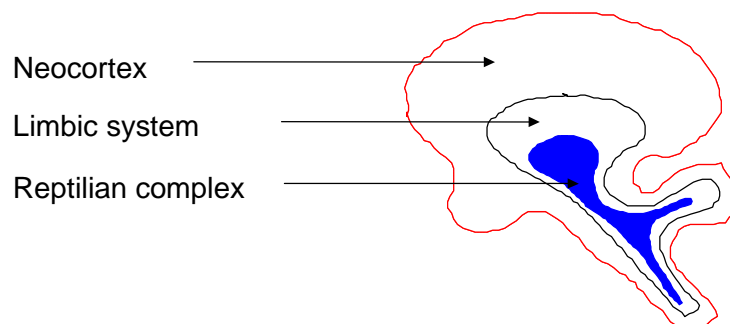


Figure 1: Paul MacLean's Theory [2, p. 62]

The reptilian brain is an ancient primitive brain, so called because it strongly resembles the brain found in prehistoric reptiles, as well as in alligators and lizards today. Driven by instinct, it seems to contain the ancestral lore of the species [2, p. 31]. There are no possibilities for adaptation.

The main functions are:

- to look after basic needs (hunger, thirst, sleep)
- to manage danger
- to house territorial instinct

The next oldest brain is the limbic, or mammalian, brain, which encircles the more primitive brain, and which consists of the limbic system. The limbic brain registers rewards and punishments, is the seat of emotion, and controls the body's autonomous nervous system.

The neocortex, or "thinking cap", produced *homo sapiens*. The neocortex is large in relation to both the brain and the body. It is the neocortex that seems to enable us to think, perceive, speak and act as civilized beings. It is also the source of language.

From both these works, Herrmann developed his own metaphoric model divided in which the brain is into four quadrants. His model, illustrated in Figure 2, shows the left side of the neocortex as A, the right side of the neocortex as D, the left side of the limbic system as B and the right side of the limbic system as C. Herrmann did not consider the reptilian part of the brain in his model.

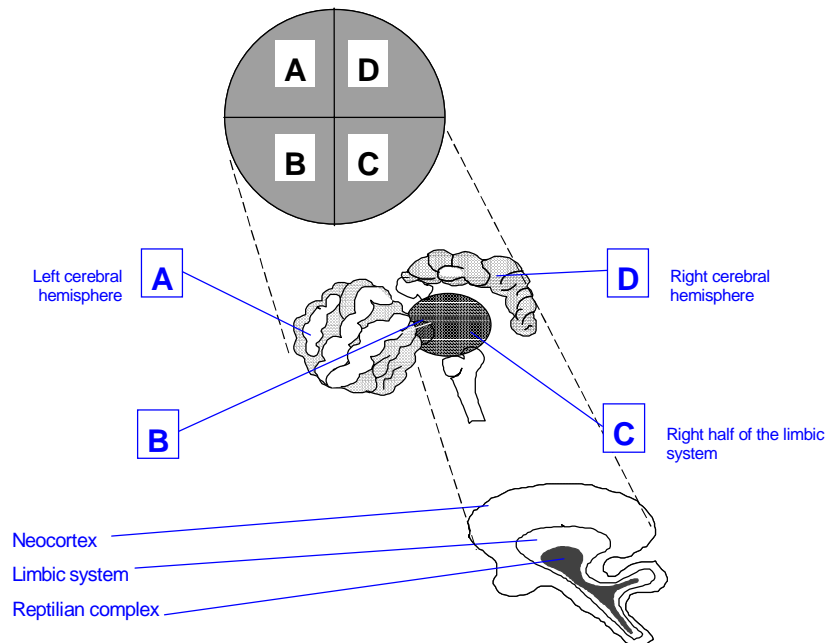


Figure 2 Herrmann's Metaphoric Model [2, p. 64]

The whole brain model is represented in Figure 3. The cerebral mode thinking process can be analytical/logical and/or imaginative/conceptual. The limbic mode thinking process can be organized/detailed and/or interpersonal/expressive. If we add to that the distinction between the left and right sides of the brain, there are four modes of thinking, defined as follows [2, p. 424):

- A) Analytical/logical: gather facts, analyze issues, solve problems logically, argue rationally, measure precisely, understand technical elements, consider financial aspects.
- B) Organized/detailed: find overlooked flaws, approach problems practically, stand firm on issues, maintain a standard of consistency, provide stable leadership and supervision, read fine print in documents and/or contracts, organize and keep track of essential data, develop detailed plans and procedures, implement projects in a timely manner, articulate plans in a orderly way, keep financial records straight.
- C) Interpersonal/expressive: recognize interpersonal difficulties, anticipate how others will feel, intuitively understand how others feel, pick up nonverbal cues of interpersonal stress, relate to others in empathetic ways, engender enthusiasm, persuade, teach, conciliate, understand emotional elements, consider values.
- D) Creative/innovative: read signs of coming change, see the "big picture", recognize new possibilities, tolerate ambiguity, integrate ideas and concepts, bend or challenge established policies, synthesize unlike elements into a new whole, problem-solve in intuitive ways.

The behavior of an individual using each of these quadrants would be respectively:

- a) I analyze: This person prefers facing situations from their logical angle and in a rational and analytical way.
- b) I use: This person prefers facing things in a practical and concrete manner.
- c) I feel: This person prefers human aspects and communication that contribute to harmony. Preoccupied with the past, this person will preserve tradition.
- d) I explore - I discover: This person is very much attracted by strategic thinking (future).

Figure 3 Specialized brain processes

From these specialized brain processes, Herrmann identified the next corresponding sets of thinking styles, as illustrated in Figure 4 [2, p. 425]:

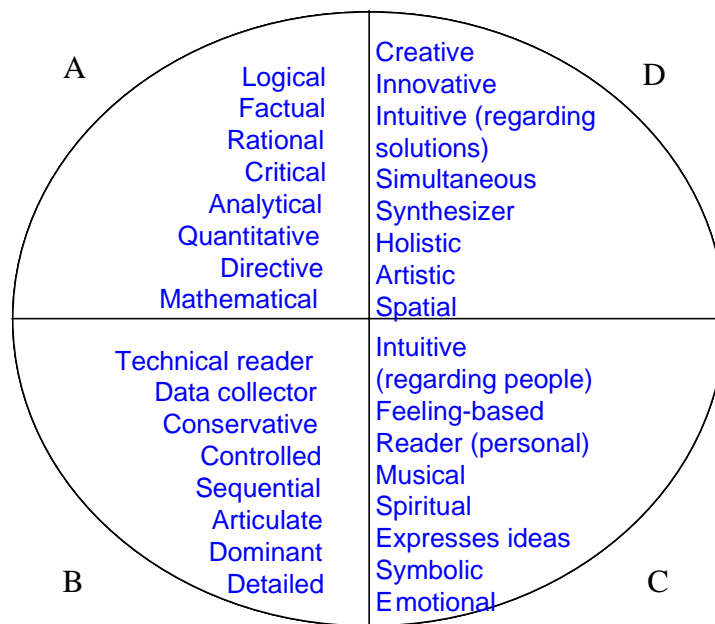


Figure 4 Herrmann thinking styles

Each of these quadrants corresponds to a cognitive style which can be found to be dominant in any single individual.

It should be pointed out that, even though this model identifies styles or preferences of individual cognitive approaches, it does not equate with competence. It is necessary to distinguish between preference, interest, motivation and competence. An individual could have a great interest in music and be really motivated to learn music, but this might not mean he or she is competent to conduct an orchestra. This individual could similarly have a preference for the role of orchestra conductor, but not the orchestra conductor's competence. Figure 5 presents a model which clarifies these differences.

Figure 5 Preference versus competence

It should also be noted that an individual does not necessarily have only one dominant preference. Research in this field has found that 7% of people are single dominant, 60% double dominant, 30% triple dominant and only 3% quadruple dominant. Therefore, the majority of people have two dominant preferences.

Dominant preferences in cognitive modes will, of course, have a significant impact on the decision-making process of an individual who would naturally be giving greater emphasis to

his or her cognitive dominance, and neglecting simultaneously other cognitive dimensions, as shown in Figure 6. For example, in quadrant 1 the analytical dominance might verify whether or not the individual has all the facts, but could easily overlook feelings of other participants and might fail to discover opportunities for synergies.

Figure 6 Dominant preferences and decision-making

3. Usefulness in the implementation of a measurement program

Herrmann's cognitive approach could be of use in any environment where multiple individuals interact in making decisions, including, of course, in the implementation of measurement programs. It can be used in two types of context: one at the design level, and the other at the individual level. For example, at the individual level the approach makes it possible to take into account the individuals receiving the message, that is, the individuals who will have to review, approve, commit and/or implement. It is therefore important to know how these individuals perceive the message, how they analyze it, and why they act upon the message, based on their perceptions and understanding (cognitive styles).

In this section, we show how the use of this cognitive approach can add value and can help increase the chances of a successful implementation when taken into consideration. This can be done from two points of view:

- A) in an actual instantiation of a specific measurement program with real project participants;
- B) in a generic situation, for understanding from a cognitive viewpoint the elements to be taken into account at the time of a specific instantiation.

This latter view increases readiness and the chances of a better cognitive understanding of the content of a measurement program in contexts where the individual participants vary from organization to organization, and, of course, across groups within the same organization.

The examples below are illustrations of the latter perspective.

Since the Desharnais-Abram approach [1], specifies for each step of the implementation plan, the roles, responsibilities and specific activities of every party to the implementation program, it is easy to illustrate how the Herrmann approach can be used.

This means that for each main activity the specific cognitive requirements can be identified. Such a mapping has been done for each step in the approach, whereas for each main activity of each step it was established to which dominant preference(s) a particular activity pertains. For example, an activity that needs to focus on the logical thinking process of an individual was classified as a quadrant A activity, whereas one that required a global vision was classified as quadrant D, and so forth. Of course, a specific activity could pertain to more than one dominant preference.

This can bring value to the implementation process when the cognitive requirements of each activity within the measurement program, as well as the cognitive styles of the various participants can be identified and taken into account. From there, it is possible to structure and balance a working group, and both the content and the delivery format of project presentations.

To illustrate in greater detail how the Herrmann approach can be applied, the following two of the seven steps of the measurement approach described in [1] are presented as examples of the

applications of this cognitive model (Appendix A contains the mapping for the full set of seven steps):

1. Management commitment build-up;
2. Staff commitment build-up;

For each of these two steps, the various activities are listed and their corresponding dominant preference is identified and indicated within parentheses in the text (A: analytical/logical; B: organized/detailed; C: interpersonal/expressive; D: creative/innovative). As mentioned previously, it is possible that a single activity could refer to more than one dominant preference.

Example 1: Management commitment build-up – Step 1.

For this step, the following two sub-steps, based on activities that require mostly cognitive styles A and B are performed (the other sub-steps are presented in the Appendix):

- Sub-step 1: Identification of the information that will help the manager taking the decision on implementing a measurement program
This involves collection and quantification of facts (styles A and B), analysis of the problems (style A) and expression of those problems and their solutions with precision (style B).
- Sub-step 4: Demonstration of the benefits
This involves a rational demonstration (style A), but also a global vision, new ideas and long-term perspectives (style D) to demonstrate the conformity of the alignments with the organizational strategy.

The next figure presents the relative distribution of the activities by cognitive style for the management commitment build-up step (and all sub-steps – not only for the two sub-steps described above). It should be noted that the following convention was applied for the assignment of weights to determine the relative distribution of the cognitive style: a weight of 5 was assigned to the first dominant cognitive style, a weight of 3 to the second dominant style (if present) and a weight of 1 to the third dominant style (if present). Then, for each cognitive style type, the weights are added and the relative distribution calculated across the full step.

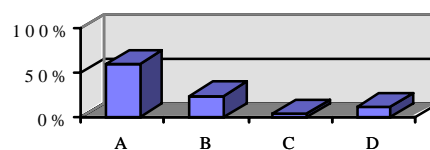


Figure 7: Cognitive style distribution – Step 1 Management commitment build-up

Example 2: Staff commitment build-up – Step 2

For the staff commitment build-up step, the following sub-steps, based on activities that require mostly cognitive styles A and B and a significant amount of style C, are performed:

- Sub-step 1: Find the arguments
Presentation of facts – data- problems (style A)
Note: Logical solutions could be inefficient because of human factors (inertia or fear of losing power) (style C must then be taken into consideration).
Person with good credibility (we can rely on this person) (style C)
Anticipation of reactions, empathy,

- Taking the culture into account,
 - Knowing optimal way to present the project.
- Sub-step 2: Provide tools for data collection
 - Practical aspect – applicable and efficient (style B)
 - Demands great deal of oneself and others. (Needs style C perspective).
 - Plan training related to peoples needs (style C).
- Sub-step 3: Help manager control the data collection process
 - Plan - organize – establish process – efficiency (style B).
 - Verification and validation.
- Sub-step 4: Development of analytical skills
 - Examine each document thoroughly (style A)
 - Dissection of the information.

The activities in the set by style, have been placed in their respective quadrants in Figure 8. Their relative distributions are presented in Figure 9.

Figure 8: Thinking style quadrants – Step 2

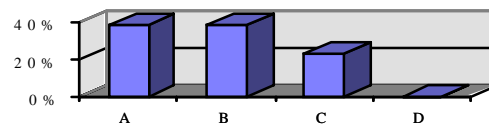


Figure 9: Cognitive styles distribution – Step 2 Staff commitment build-up

4. Conclusions

In the first section, Herrmann’s cognitive model was presented, and the cognitive styles of this model were mapped to the activities of a measurement program. Two examples were presented, listing various activities within each step, and each activity was mapped to its corresponding cognitive style. From these two examples and from the distribution charts summarizing each example, it becomes obvious that each step calls on one of a number of cognitive styles, and each has a distinct distribution. This information can be quite useful to measurement program designers (and their managers) in that it can help them to properly tailor their messages to the cognitive styles of both their own team members and the audiences targeted at each step. This might imply, for example, that if an audience is known beforehand and can be positioned on the Herrmann cognitive model, then the message format and delivery style can be tailored to this specific audience, be they visionary managers or finance-oriented managers.

Tailoring the message to a specific audience type can contribute to increasing the chances that a specific message be properly received by its audience, and acted upon, rather than being discarded because of difficulty generated by the mode of delivery of a message that is not mapped to the cognitive profile of the audience. Taking this cognitive approach into consideration in the implementation of software measurement programs could contribute to an increase in their success rate.

5. References:

- [1] Desharnais, Jean-Marc, Abran, Alain, ‘How to Successfully Implement a Measurement Program: from Theory to Practice’, in Metrics in Software Evolution, GMD, 1995, pp. 11-26.

- [2] Herrmann, Ned, 'The Creative Brain', Brain Books, 1988
- [3] Rubin, Howard A., 'Software Engineering in the 1990s: Business Oriented Measurement', IFPUG Spring Conf. Proceedings, Lake Buena Vista, Florida, April 1990.
- [4] Sperry, R.W. "Bridging Science and Values – A Unifying View of Mind and Brain", American Psychologist, 32, no 4, April 1977, pp 237-245.

Appendix A: Measurement Program (Desharnais-Abran)

Analysis of Cognitive Dominance for each activity within each step.

For each step, the various activities are listed and their corresponding dominant preference is identified and indicated within parentheses in the text (A: analytical/logical; B: organized/detailed; C: interpersonal/expressive; D: creative/innovative). As mentioned previously, it is possible that a single activity could refer to more than one dominant preference.

The following convention was applied for the assignment of weights to determine the relative distribution of the cognitive style: a weight of 5 was assigned to the first dominant cognitive style, a weight of 3 to the second dominant style (if present) and a weight of 1 to the third dominant style (if present). Then, for each cognitive style type, the weights are added and the relative distribution calculated across the full step.

Steps	Sub-steps (details)	Sequence of dominance			
1. Management commitment build-up	Finding the necessary information that will help the manager make a decision on the relevance of implementing a measurement program	a	b	d	c
	Demonstrate of the benefits	a			
	Align with organizational strategy	a			
	Manage the measurement program as a project	b			

Steps	Sub-steps (details)	Sequence of dominance			
2. Staff commitment build-up	Find the necessary arguments that will lead the staff involved in the data collection process to accept the measurement program	a	c		
	Offer useful tools to automate the data collection process to favor the acceptance of the measurement program	b	c		
	Help project managers control the data collection process	b			
	Develop analytical skills to extract information from the data and measures	a			

Steps	Sub-steps (details)	Sequence of dominance			
3. Selection of the key processes to be improved	Evaluate the maturity level of the software development organization	a	b		
	Use SEI model and assessment results to identify candidates for process improvement	b	c	a	
	Select the priorities for the key processes targeted for improvement programs	a			
	Determine the main strengths and weaknesses for quality and productivity	a	d		

Steps	Sub-steps (details)	Sequence of dominance			
4. Identification of the goals and objectives related to the key process	Determine the goals and objective of the measurement program. The goal describes the intention of what should to be achieved.	a			
	Goal should be reached (with or without specifying the achievement conditions) through measurable behavior over time.	b	a		

	Evaluate the capability to achieve the goals and objectives	d	a		
	Help the organization to establish the priorities	b			
	Sensibilize organization to achieve long term results	d	b	c	
	Link the measurement program to the IT	a	d	b	
	Use GQM approach at the organization level	b	a		

Steps	Sub-steps (details)	Sequence of dominance			
5. Design of the measurement program	Allow management not only to see if the objectives have been reached, but also to understand why they have not been reached	a	b	c	
	Present and sustain tools, standards, definitions and choice of measures		b		

Steps	Sub-steps (details)	Sequence of dominance			
6. Deployment of the measurement program	Selection of a pilot site	d	c	a	
	Train personnel	c	b		
	Assign responsibilities and tasks	b	c		
	Set up the measurement group	b	c		

Steps	Sub-steps (details)	Sequence of dominance			
7. Description of the Information System to be put in place	Model all the measures to be collected to meet the objectives	b	a		
	Define the validation process and the control reports	b	c	a	