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Augmentative Communication Systems:

Human development as a metaphor for computer development - Part II

Abstract

A model of the developmental interdependence of the individual and collective mankind is used as a metaphor for the development of the computer and telecommunications. This model of computer development, which incorporates models of metaphor and Gordon Thompson's "shared space" concept of communication, is used to evaluate the development of computer-aided augmentative communication systems - past, present, and future - which are used by non-vocal severely physically handicapped people.

The computer is an excellent machine to aid the non-vocal severely physically handicapped (NVSPH) because it can simulate and augment those areas which require assistance. Computer-aided augmentative communication systems (CA-ACS) would be an example.

Research in this area is slow to utilize advances in computer technologies. Industrial robots may have impressive perceptual-motor abilities (Weber, 1985; Ballard and Brown, 1985), but they are totally beyond the resources of the handicapped. Nevertheless, some research is directed towards small general purpose robots, e.g., for residential use (Weber, 1984; Higgins, 1985), which have marvelous potential use in aiding NVSPH people. Despite the fast pace of technological advances, one should expect sophisticated CA-ACS and other technical aids for the handicapped to be relatively slow in coming.

A non-electrical, low technological solution is the preferred solution whenever possible. A matrix of symbols on a piece of paper is cheap, easily reproduced, and doesn't break down. If this is insufficient, a high technological solution should be chosen with some sort of low technology back-up (Shein, 1984).

Computers, especially the microcomputers used by the handicapped, are so new historically, and the pace of technological change so rapid, it is necessary to formulate some understanding of the nature of the computer as it affects the development of both the individual and society. This calls for models of development of both the individual and society, and the application of the electronic medium itself. With such a perspective on the user and the computer, it is possible to evaluate computer-aided communication systems (CA-ACS) as an evolving technology.

The essential needs of NVSPH people are, in a practical sense, a question of time, resources, and money. More fundamentally it is a question of the degree to which society recognizes in handicapped people the same innate human spirit which is common to all humanity. Implicit in any assistance for handicapped people is the moral imperative that, by virtue of their being human, their nobility and dignity demand that these essential functional needs be met and that services be made available to allow them to participate fully in society.

The individual and society are developmentally interdependent. These interdependent relationships, both between the components that make up an individual and amongst members of society, are due to the fact that any well-developed organism vitally requires a diversity of interdependently functioning parts (Danesh, 1979). This collection of diverse parts can reach its fullest capacity only if the parts are fully participating and harmoniously united. The degree to which they achieve this level of integration is the degree to which they will reach their individual and collective potentials. This developmental movement towards increasing integration and unity applies to both the individual and the body of mankind as a whole. When society provides these services for the handicapped, the dignity and nobility of collective humanity are raised as a result.

The five dimensions of human development

There are five dimensions to individual development: perceptual-motor, language, cognition, social, and psycho-spiritual/moral (see model III on p.183). Silverman, McNaughton, and Kates (1978) state that the physical, mental, and social aspects of the whole child are linked together and influence each other. All five dimensions are developmentally

interdependent. Language and cognition skills have a mutually beneficial effect upon each other (Carrier, 1974). Language and culture are both semiotic systems which reinforce each other's development, and are inextricably bound (Hymes, 1974; Halliday, 1973). Effective language is a system which achieves the desired social effect in the quickest and most efficient manner (Rice, 1978). The goal of communication is only achieved when the listener indicates whether the communication has had the desired effect.

Hymes (1974) and Halliday (1973) also suggest that language also is the means by which a child organizes and encodes his or her experiences, perceptions, and observations. The converse is also true. The child's use of various means of interacting motorically, perceptually, and socially stimulates the development of symbolic representational skills (Harris and Vanderheiden, 1980) and, of course, cognition.

Finally, implicit in the social component of communication and the model as a whole, as well as reflecting the developmental interdependence between the individual and society, is the moral principle that our actions are the implementation of our perceptions of another person's nobility and dignity. As a result, these perceptions and attitudes affect the degree of motivation of an individual to communicate and interact with other people. Society's health, dependent upon the performance of individuals for its collective well-being, is profoundly affected by these perceptions and attitudes.

Metaphor, communication, and development

The concepts of metaphor, communication, and development are fundamental features of the use of a computer.

As outlined above, a common innate human spirit, which is shared by all humanity and is the basis for the developmental independence of the individual and society, is the central metaphor of this paper. The other central metaphor is the model of the five dimensions of personal development.

A metaphor is one of several analogical forms of rhetoric which compares two essentially dissimilar things but which have, in common, an implicit or explicit statement of similarity. A metaphor has three parts: the thing being described (the tenor), the thing being used to do the describing (the vehicle), and the statement of implicit or explicit similarity (the meaning) (Hatcher, 1977). Metaphor, the bearer of meaning between communicating individuals, is, thus, a basic tool of communication.

Fundamental to metaphor, communication, and the use of

symbols, in general, is pattern recognition on both perceptual and abstract levels. Hofstadter (1979) writes that pattern recognition ". . . lies very close to the core of 'pure' intelligence" (p.662) and that this ". . . elusive sense for patterns . . . involves all the mechanisms of representing knowledge" (p.674). This ability to recognize a pattern of meaning which two dissimilar things have in common (i.e., to think in metaphors) is perhaps the most important tool or process of intelligence (Hatcher, 1977). We are able to reduce the complexity of the countless impressions reaching the brain by the process which not only finds similarity but even identity in diverse structures (Kay, 1984).

Metaphor has five dimensions: the vehicle, the tenor, the meaning, the social implementation, and the psycho-spiritual/moral (see model II on p.183). Metaphor ". . . explain(s) the unfamiliar in terms of the familiar, the abstract in terms of the concrete . . .(,) has the capacity to encompass a great deal of meaning into a few words, and because it offers a variety of meanings, it can be an expansive description rather than a limiting or restrictive one" (Hatcher, 1977, p.9). Metaphor is infinitely diverse in its application for there is no final or complete perception of a concept; ". . . it can always be more acutely perceived or more exquisitely dramatized in the phenomenal world" (Hatcher, 1977, p.10-11).

The act of communicating, sharing, a metaphor is not to present a pattern or road-map solution, but to present the metaphorical problem itself. Since the listener or receiver is merely presented with the tenor and the vehicle, the receiver is forced to figure out, to discover, the meaningful similarity himself. As a result, he experiences it for himself.

Kay (1984) states that this experiencing of other people's ideas amplifies our ability to learn from others and so becomes a springboard for personal and societal growth, the developmental role which metaphor plays between the individual and society. The interdependent development of the individual and collective mankind ". . . is almost completely contingent on our utilization of this analogical process" (Hatcher, 1977, p.26). Thus, metaphor also has a psycho-spiritual/moral dimension.

But beyond the understanding and dramatization of the abstract notion and its social implementation, there is one other facet to the developmental role of metaphor. To use Hatcher's words, by the ". . . habitual utilization (or rather implementation of the abstract notion, the individual and society can) . . . assimilate that quality as part of his essential nature" (p.11). To use Kay's (1984) words, one so interacts with the concept that it becomes more fully one's own. By the "habitual utilization" and "repetitious aggregations of concrete instances", metaphor, at the heart of communication is an essential tool-like medium for the developmental interdependence of personal and societal growth.

Human metamorphosis: The five stages of development

All living organisms change in a developmental process which is the transformation, or rather metamorphosis, of one stage into another. For mankind, this means the dynamic movement of individuals, societies, and the body of mankind as a whole in the direction of increasing complexity and integration (Saiedi, 1984). Furthermore, our perceptions and understanding of reality, including our developmental stage, is relative to our particular stage of personal and societal development. People can resist almost anything, except the requirements of their stage and the movement towards increasing complexity and integration (Saiedi, 1984).

There are five stages of human metamorphosis. Each stage is sub-divided into the five dimensions of development (perceptual-motor, language, cognition, social, and psycho-spiritual/moral) since each stage encompasses all five dimensions of development. Each stage is developmentally interdependent with the other stages because people, at each stage, are dependent upon people at all the other stages for their well-being.

The five stages of metamorphosis are: (1) perceptual-motor stage: infancy, 0-2 years; (2) language stage: pre-school childhood, 3-5 years; (3) cognition stage: childhood, 6-11 years; (4) adolescence stage; (5) maturity stage (see model Va on p.183).

Because of the interdependent relationships, both within the individual and amongst people, the basic motivation of the personality is the ego's search for identity and integrity (Erikson, 1963). Therefore the model is essentially the developmental movement from infancy to the realization of intro- and inter-individual relativity, fundamental unity, and limitless diversity.

By using the dynamic structures of these interdependent relationships, the ego's identity is developed by means of identifications with other parts in the social milieu - parents, peers, and other cultural entities. The ego achieves this by developing skills of reality testing. This, Erikson says, is done by keeping ". . . tuned to the reality of the historical day, testing perceptions, selecting memories, governing action, and otherwise integrating the individual's capacities of orientation and planning" (p.192).

Reality testing is not only a means by which to come to terms with social reality but with the self as well. Theoretically then, the ego, torn between the id and superego, ultimately achieves a balance between the two with the formation of an ego-ideal. The ego-ideal is the kind of self which the ego strives to emulate. The personality structurally manipulates the symbols and metaphors of its internal and external milieu on both

emotional and cognitive structural levels in an interactively complex weave of cause and effect.

The vital need of any well-developed organism for an harmonious diversity of functioning parts is also reflected in Erikson's stages, beginning with the egocentricity of infancy in which the infant considers itself to be the totality of the universe. From childhood to adolescence, the ego achieves liberation from attachments to infant love-objects and other metaphors. In maturity, the personality, coming to an awareness of the totality of one's life cycle, perceives itself as one part of the whole body of mankind.

The individual's stage of transition from adolescence to maturity is a metaphor of the metamorphosis which collective mankind is presently experiencing (Danesh, 1979). The computer and international telecommunications, for example, are not historical accidents, but natural outgrowths of mankind's present stage which, like individuals and societies, is moving towards increasing complexity and integration. An understanding of human metamorphosis, then, helps to explain the developing personal use of a computer and its role in society, now and into the future.

The nature of the computer

Despite the sophistication of packing a million characters of information on a chip the size of a large postage stamp, the computer is internally like a series of wheels with only two cogs or on/off switches. On the other hand, what is essentially abstract (i.e., arithmetic operations) has been manifested in a mechanical form. Furthermore, if a number can represent a letter; letters, words; words, concepts; then numbers, when effectively coded and manipulated, can represent language and illustrations. But unlike pictures or text on paper, this communication medium fluidly changes, like magic, to allow a dynamic interaction which responds instantly to the user.

The computer is a marvelous metaphor machine for human communication. It is the latest in a long history of invented media, going back to ancient times, for storing, retrieving, and sending information. Unlike traditional media which are static (e.g., symbols on paper), the computer is a dynamically interactive form of communication - like conversation (Kay, 1977).

Much of the confusion and controversy surrounding the computer is due to its protean nature.

> . . . it can act like a machine or like a language to be shaped and exploited. It is a medium that can dynamically simulate the details of any other medium, including media that cannot exist physically. It is not

> a tool, although it can act like many tools. It is the first metamedium, and as such it has degrees of freedom for representation and expression never before encountered and as yet barely investigated. Even more important, it is fun and therefore intrinsically worth doing. (Kay, 1984, p.59)

A computer can be described as a dynamically interactive, protean, metaphorical metamedium which is an intelligent medium for, and simulation of, the world around and within us. The computer, potentially, has a role in every instance of metaphor and communication, mentioned in this paper, for both the individual (internally and externally) and collective mankind. And, because of the central role of metaphor and communication in the developmental interdependence of the individual and collective mankind, the computer, potentially, is the central or main technology for that developmental relationship.

Nevertheless, one should be very careful not to lose sight of the fact that it is only a medium of communication. It is not the real thing any more than a novel or movie can fully capture and express human experience.

Initially though, new technologies are magical in their attractiveness. The television and the automobile, after decades of use, culturally still have a fascination for us.

Once we have incorporated new intellectual structures and ideas, we really cannot un-learn them. They not only stay with us for the rest of our lives, but we unconsciously pass them on to the next generation in the way we rear our children. Once our attitudes and perspectives on life have been extended, not only does our internal psychological world become transformed, but, as a result, the society around us is also transformed. Technology, even the computer, does not bring about major change as much as technology, invented as a response to cultural forces, releases new found resources and potentials nascent within humanity and its cultures. It is in this sense that technology, especially electronic communication technology, becomes a means for the metamorphosis of the individual and society into new levels of development. This is because metaphor, that limitless educational tool for human development, is at the heart of the communication process itself. And the computer is a metaphor machine **par excellence.**

Implementation of the computer as a metaphor machine - artificial intelligence, automation, and fluidity

The computer is an anthropomorphic device. We expect it to act like us, to be as fluid as our own thoughts and actions, to be automated to the degree that it becomes transparent in our

milieu, and have artificial intelligence (AI) with human-like senses of sight, touch, and hearing. In its interaction with us, we expect AI, automation, and fluidity to ever increasing degrees. Furthermore, this anthropomorphic device can itself be described in terms of the five dimensions of human development previously discussed. A computer has perceptual-motor properties, artificial language (AL), AI, a social context and implementation, and a role in the emerging global telecommunications networks. Finally, all five of these areas are metaphorically portrayed and manipulated by a computer because the computer is an excellent metaphor machine.

Artificial intelligence: While Hofstadter (1979) would describe "pure" intelligence as pattern recognition; Hatcher (1977) would refer to metaphor, if not as a definition of basic intelligence, at least as one of its most important tools.

When a computer simulates, for example in robotics, the human perceptual-motor system, and, for example in "expert systems", human use of knowledge, it demonstrates artificial intelligence. In essence, AI is the attempt to simulate, in some fashion, those behaviours or processes which are associated with human intelligence (Barr and Feigenbaum, 1981). But, because human intelligence, by nature, involves all five dimensions of development, AI inevitably encompasses a wide range of abilities. In other words, any human pattern can be mechanically replicable to the degree that: (1) the pattern has been recognized; (2) its processes have been sufficiently understood to be constructed, and (3) sufficient time and resources are available.

The potential power of a computer to simulate is more than just the illusion of spreadsheets and desktops on a monitor. Firstly, like live theatre, it is the ability to evoke this suspension of reality in people's interaction with a technology which can portray, reprocess, and manipulate phenomena in the real world and in worlds which cannot realistically exist (Kay, 1984). Secondly, it is the potential ability to communicate these real and imagined phenomena instantaneously between any two or more persons (or machines) on the planet. The potential power of a computer lies in its ability to both simulate and communicate, or rather, to "consimulate". AI has yet to master adequately the simulation of people and has hardly begun to exploit its potential role when combined with communication. Ultimately, since the manipulation of metaphors is at the heart of communication, a genuinely anthropomorphic computer should be able to both manipulate and communicate metaphors. It should be able to "commetaphor".

Automation: A machine is most helpful if it requires the least amount of intervention on our part. The ultimate degree of automation is the machine which independently functions to the degree that it becomes transparent to our daily activities.

It is in the context of a discussion of illusions and system transparency that Kay (1984) describes two approaches to user interface as two types of "agents". In both agents, there is a computer-generated theatrical illusion of a task or activity which is simulated by the computer. The direct agent displays, for example, an image of the activity on a computer monitor. By means of this theatrical illusion, the user **directly** manipulates tasks, such as a spreadsheet or materials on a desk top. It does not act without the user but passively awaits the user's next command. Thus, the direct agent's intelligence is also an illusion since all intelligent choices are made by the user.

Compared to the direct agent, the indirect agent is a smarter, more independent fellow. In essence, he will automatically go ahead to finish a job without supervision ". . . and could ask for and receive advice, offered in human terms, when it was stuck" (Kay, 1984, p.58). The indirect agent would independently move about global computer networks of banks of information and would telecommunicate, or rather, commetaphor with other software robots and people.

Fluidity: This term refers to our perceptions of what we expect to perceive from the machine. Like AI, fluidity is grounded in the notion that if we have perceptions, intellectual and sensorial, then so should the computer. People experience reality within and outside of themselves perceptually (i.e., the senses of sight, time, etc.) and intellectually; and, based upon these perceptions, impose this view of reality upon the world by their actions.

Through our senses, we perceive reality as fluid as a river, not in discrete steps. Our sense of space is a fluid sensation in which our place in relation to everything else is perceptually in a constant flux. Our sense of motion is a fluid sensation of the changes within space, both within and outside of ourselves. Our sense of time is a fluid sensation of the duration of the relationships between space, motion, and the other five senses. The three senses of time, space, and motion are higher-order senses in that they are functionally dependent upon the five standard ones: sight, hearing, taste, smell, and touch.

Psychologically, we also have intellectual perceptions in the metaphorical sense that we feel, touch, smell, and even taste ideas. For example, we can perceive, even feel, music, both sensorially and intellectually, at the same time. Cognition, then, is also a fluid sensation that works sometimes as a free-form stream of consciousness, with a river of associations. Sensorial perceptions (all eight of them) are used as metaphors for ideas. Ideas, in turn, are used as metaphors to explain our perceptions. This metaphorical use of ideas is the way we order perceptions into a framework which will allow them to be more consistently processed, or rather, understood. We give them structure.

In our perceptions and intellectual view of the world, we expect a certain measure of both patternicity and randomness. We expect a balance (P/R) between the two. This P/R setting is like the setting on a thermostat. Across a possible range of proportions, there is a second P/R setting. At one time, we anticipate considerable novelty (randomness) and, proportionally, less regularity (patternicity). At other times, we require a different P/R setting. So there is also a P/R setting for the degree to which we anticipate regularity or irregularity in a P/R setting. This is expressed by P/R2(P/R1). This P/R2 setting changes, along with P/R1 as we go through life. Thus the degree of expected patternicity and randomness (P/R3) also varies with different persons, places, things, and actions. Thus, our expectation of P/R in life is expressed by P/R3(P/R2(P/R1)). These P/R settings, though, are all "in the eye of the beholder."

We do not conveniently divide the world into discrete degrees of patternicity and randomness. The two may be opposites, but both influence each other as they often describe the same phenomena, e.g., a river is both regular and unpredictable.

The five dimensions of the development of computer technology

Potentially, as a commetaphor machine, the computer has a role in all five dimensions of individual development: perceptual-motor, language, cognition, social, and even the psycho-spiritual (see model I on p.183). At present, computers are, at best, consimulation machines. But, if they are to master their anthropomorphic role, they must increasingly imitate, or at least appear to imitate, aspects of these five dimensions of human development.

Perceptual-motor dimension: The computer should, to an ever-increasing degree, imitate in a human manner the collection, process, and communication of information involving all eight senses. Furthermore, this information should be presented in as fluid and automatic manner as people would naturally expect. The computer should be able to perceive space, time, and motion as well as the other five senses.

Artificial language (AL): The computer initially does not have to think in linguistic terms, but only to understand when spoken to and respond in a natural language. The computer should eventually be sufficiently adept at the recognition of patterns and common isomorphic structures in language that it should begin to deal with metaphor in a human manner. As well as script and oral language, there are cultural symbols of a visual and auditory nature, as well as symbol systems such as body language. When the computer becomes sensitive to a greater amount of sensorial information than merely words keyed into a

keyboard, it will proportionally develop language and cognitive skills. The development of perceptual-motor and language skills in the computer are interdependent, just as they are in human beings.

Artificial intelligence: Despite major advances in the performance of mathematics and in pattern recognition, the family pet has a wider range and sophistication of pattern-recognition skills than computers. Computers must be able not only to integrate all of the perceptual-motor and linguistic information at its disposal and not only recognize patterns in that information, but they must be able to recognize common isomorphic structures within those patterns. In other words, like people, the computer should be able to, for example, detect P/R settings (e.g., the P/R3(P/R2(P/R1)) formula described previously) in people and things, and respond appropriately with its own P/R settings.

Social dimension: As previously mentioned, society and cultures also manifest abstract notions and their concrete metaphorical forms as a means of collectively learning and adapting to changing conditions. Language and metaphor are only meaningful as a communication medium when understood in their pragmatic context. People developmentally and effectively need to commetaphor. The computer, an electronic medium which can consimulate and potentially can commetaphor, has a potential role in the interdependent development of the individual and collective mankind since this developmental interdependence ". . . is almost completely contingent on our utilization of this analogical process" (Hatcher, 1977, p.26). Computers will not decrease or limit group interaction and activity, but will increase group activity in a manner which is, like language, communication, both personally individualized and social.

Psycho-spiritual/moral dimension: Communication and metaphor together provide the relationship between the computer and the psycho-spiritual/moral dimension. Metaphor is used by the ego in reality testing and defense mechanisms. The arts (visual, auditory, and textual) are means by which many social and psychological issues are sublimated and so relatively dealt with in a socially appropriate and healthy manner. The computer could be such an artistic tool, especially given its potential as a consimulator, with the user in either an active or passive involvement. Since much of psychology involves the professional reflecting back on the client of problematic areas, a computer could not only be a personal monitor of one's environmental and internal biologial status, but of one's psychological status as well. A computer could function, to a limited extent, in the introspective role of a diary, except the computer could dialogue. The computer, as an intimate diary, could become a tool to assist emotional development - a kind of "ego-ideal".

Electronic communication - five types of shared space

The computer is a communication medium which allows people, groups, organizations, and systems to "commune" with each other in a "shared space". This concept, originated by Thompson (1979), delineates three measures of communication effectiveness:

> The ease with which stored human experience can be accessed.
> The size of the common information space shared by the communicants.
> The ease with which the society using the system can discover and develop a plurality of new and fresh consensus. (p.60)

The concept of shared space is interpreted as consisting of five types of space: perceptual-motor, information space, technological space, geographical space, psycho-spiritual/moral space (see model IV on p.183).

Perceptual-motor space: The perceptual-motor component of the individual is the medium through which the language, cognition, social, and psycho-spiritual components work. Pattern recognition also utilizes the perceptual-motor system. And, of course, metaphor is the meaningful comparison of perceptual-motor information. Since it is the functional medium through which all information is processed (even abstract thoughts are abstractions of sensori-motor and concrete operations), the five senses in relation to the senses of space, time, and motion, can affect our perception of shared communication space.

In a communication network the perceptual-motor information is coded and then simulated at the other end. The telephone and computers, in general, operate in real time (i.e., instantly respond by people's sense of time), allow interruptions equally instantaneously, and the quality of the simulations are acceptable enough for the users to suspend their normal expectations of reality.

Included in this disucssion of perceptual-motor space is environmental control of things and actions - internally and externally to the user, as well as immediate to, and remote from, the user. If one can monitor the internal workings of the body, it is a natural step to controlling our internal operations. Externally, we could monitor and control things and actions in our presence or remote from us.

Information space: Unlike traditional media for text which are static, text and pictures on a computer monitor are fluid. Words appear and disappear, move back and forth on command. Aside from being obviously related to technological space it (i.e., the structure of the system itself), is much influenced by the

metaphors that are used to communicate the information. Specifically, it relates to the type of symbols being used and the quality of leverage which the system allows.

There are several factors which bear on the type of information which the computer system allows. Obviously, the wider the diversity and quality of information, the larger the information space shared by the communicants. If this text were also intelligible to a wider range of people or were capable of expression to subgroups with special needs, such as the handicapped, information space would increase. Illustrations also increase the information space of a text.

The range of expressive ability of the symbol systems used and the comprehensibility of the information expressed is the degree to which the information is mutually useful (semantically, syntactically, and pragmatically) and socially appropriate to the widest range of peoples, places, and special interest groups. A variety of symbol systems may be necessary to meet all of these needs.

There are seven factors which affect the ease of information access:

1. Cognitive level required: In any symbol system, the greater the ambiguity of the symbol system, the greater the information or interpretive load and the level of cognition demanded.

2. Interpretation style: This refers to the style of metaphor which the information uses. The demands (i.e., level of difficulty) of finding the meaning common to both tenor and vehicle relate to the richness of the expressive ability, which increases the information space shared by the communicants. It also relates to the way the information can be quickly read.

3. Structure (syntax range): The organization of the symbol system itself is the syntax range. If the symbol system has a myriad of rules, exceptions to rules, and strategies that only a linguist would appreciate, its virtue of flexibility will be lost on the average person. However, if a common metaphor is used consistently throughout the system, a child may be able to use very sophisticated systems.

4. Vocabulary range: The larger the expressive range, the greater and the more useful will be the information expressed.

5. Semantic range: The range of subjects and metaphors which the symbol system can express is the semantic range. A system may have the vocabulary but lack the structure to express the required nuances.

6. Pragmatic range: This involves the flexibility of the system

to adapt to requirements of a wide variety of social settings and the rules that govern those settings. Various communication networks demand different technical and social protocols. Three examples are love letters, business telephone calls, and a computer club's electronic mail system.

7. Ease of training: There is the matter of the length of time and degree of difficulty it takes to learn to use the system. With the skillful use of metaphors, training could take minutes by using a person's previous experience as a metaphor to accessing the system.

The ease of information access is also a factor of the degree of leverage which the system demonstrates. Leverage refers to: (1) how fluid and natural is the symbol system; (2) the use of direct and indirect agents; and (3) the degree and number of interrupts which the system allows.

Technological space: Technology is required to support the kinds of shared information space which were just described. Technological space is increased in relation to the ability of the technology's infrastructure to carry out the various aspects and leverage of symbol systems.

Geographical space: The greater the number and diversity of peoples and cultures electronically connected, the greater the pool of accessible information. The converse is also true.

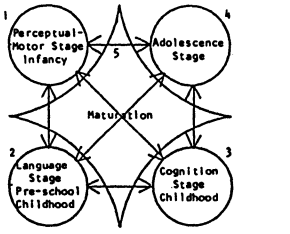
Psycho-spiritual/moral space: This concept refers to the degree the developmental interdependence of the individual and society is encouraged and facilitated by group decision making (or consensus), as this relates to common psyche, moral values, and goals.

Computer metamorphosis: The five stages of development

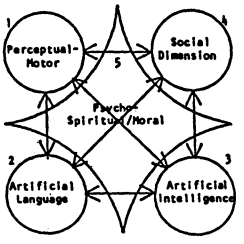
The five stages of human development are a metaphor for the five stages of the development of the use of the computer (see model Vb on p.183). If the computer is an anthropomorphic machine, then it should appear to develop in a similar manner. The technological advances which are speculatively outlined in this paper are dependent not only on those advances being technically feasible, but also on the degree of cooperation among the various companies and governments who are involved in these developments. Finally, each stage should be sub-divided into areas of the five dimensions of computer development, but, due to space limitations, there shall only be a summary of each stage. CA-ACS will also be reviewed at each stage.

1. Perceptual-motor stage - Infancy: A stage one computer has some primitive vision and other sensor skills, and can mimic some movements of the arm and wrist. It can only receive input from

Va HUMAN METAMORPHOSIS: 5 STAGES OF DEVELOPMENT



I 5 DIMENSIONS OF COMPUTER DEVELOPMENT



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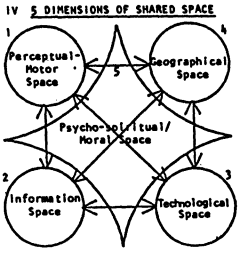
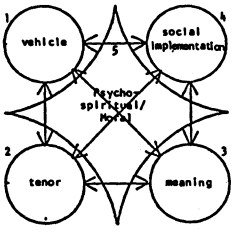
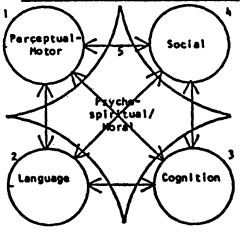


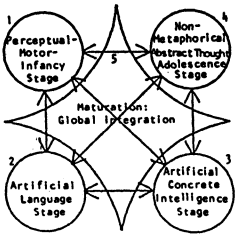
II 5 DIMENSIONS OF METAPHOR



III 5 DIMENSIONS OF HUMAN DEVELOPMENT



Vb COMPUTER METAMORPHOSIS: 5 STAGES OF DEVELOPMENT



K. MADDI

a keyboard or similar device. It is electronically isolated as it lacks networking capabilities.

The electronic symbol display boards, with rows of lights, perhaps with some memory and a voice synthesizer, would be a stage one device. The same applies to the display of pages of symbols in a matrix pattern on a computer monitor. Both systems are essentially primitive messaging machines.

2. Artificial language stage: A stage two computer can integrate sight, hearing, and touch information and, as a result, make a decisive move. It can perform a primitive type of direct agents, like the desktop metaphor on the Macintosh computer. It can, when questioned, provide information from a database. It has expressive and receptive language skills of a few hundred words, but there is little system integration. At best, only files are transferred between programs in memory or between similar computers.

Since 1979, microcomputers, like the Apple II, have been used by the handicapped for the display, messaging, teaching, and practice of graphic symbols, as well as the diagnosis and training of perceptual-motor skills.

More recently, commercially available, small portable, battery-powered computers, like the Epson HX-20, have been used for messaging and as an intelligent interface to another computer. An intelligent interface computer can interpret a limited input (e.g., a single switch) and amplify, or rather, translate it for use by a conventional computer like the Apple II or the IBM PC (Shein, 1984).

Thompson (1984) states that there are two modes to this intelligent input device. The first mode is to act as a tool for communicating symbols in visual form, or via a speech synthesizer, like the stage one computer software. It could also control devices in the environment, which would be an example of a stage two capability. The second mode of an intelligent input device allows one to use a conventional microcomputer with standard software via the symbol system which the user is accustomed to using.

3. Artificial concrete intelligence stage: A stage three computer has greater integration of perceptual-motor information and so can respond to, and remember, environmental conditions within pre-determined boundaries. It has expressive and receptive language skills of a few thousand words. It can understand most formal language forms, except metaphor. Its programs are functionally integrated. In other words, it would be able to conduct a dialogue with the user and to recognize isomorphic structures within a knowledge-base.

A stage three computer has well developed direct agents and some primitive examples of indirect agents which would be limited to specific program applications and their networks. Computers of different types and capabilities would be networked together, share information, and learn from each other as a result of their interaction together.

CA-ACS, with stage three language capabilities, should be able to predict the next selection of a symbol, and correct syntax errors. It would have full editing, windows, integrated software, and multi-tasking for a variety of tasks like note-taking, "expert system" type of databases, electronic mail, and other computer networks. These, combined with well-developed direct agents, primitive indirect agents, robots (stationary or attached to an electric wheelchair), and internal and external environmental controls, would transform the intelligent interface computer into the beginnings of an "ego-ideal" or "electronic buddy" both to serve the user's needs and act as an extension or amplification of all five dimensions of their personal development.

4. Adolescence stage - the essential skills of non-metaphorical abstract thought: All motor skills and eight senses of a stage four computer are integrated in a pattern recognition system with a well developed hierarchy of isomorphic structures. It can mimic human movement in conventional, but unpredictable circumstances. It can manipulate concrete and abstract metaphors when they are limited to a specific goal or task. It is able to understand the content and social context of conventional (i.e., predictable) cultural systems. It is able to think about thinking (within pre-determined boundaries), to learn from other machines and people, to make hypotheses, test them out, draw conclusions, and make recommendations. Therefore, it has genuine indirect agents which embody an exteriorized ego-ideal. There is a universal network within a group of nations which is the standard carrier for all types of electronic media. It has sophisticated applications of P/R settings, fluidity, and leverage.

Finally, the typical display monitor will be replaced by holograms. Holograms, in turn, will be replaced by the presentation of information by means of induced hallucinations, which may be controlled directly by thought and minature devices implanted in the body (Cartwright, 1983). In such a system, all eight senses will be used. Effectively, the handicapped person would neither feel nor appear to be anymore handicapped than the person today who wears eye-glasses.

5. Maturation stage- the global integration of personal and collective artificial metaphorical intelligence: All motor and sensorial skills of a stage five computer are integrated into an ethic and an esthetic of physical, emotional, intellectual, social, and spiritual well-being for all humanity, and for all living things. It may well be an extension of consciousness for both the

individual and collective humanity.

It has genuine metaphorical intelligence which will imitate and enhance human intelligence. It can reflect the unique ways and constantly evolving changes of each individual and group it serves. It incorporates the relativity, fundamental unity, and infinite diversity of reality. It has meta-cognition. It not only learns from others and its own experiences, but is able to design new ways of thinking, especially in its symbionic relationship with people. With direct brain connections and induced hallucinations, every human being will be incorporated into the global network.

At this stage of human and technological maturity, there probably wouldn't be any sensorial, physical, or intellectual handicaps, since this stage calls for a degree of sophistication that would be able to remedy such handicaps.

Conclusion

Before one can adequately evaluate computer-aided augmentative communication systems, it is necessary to formulate some idea of the nature of computers and the users themselves. A computer is, unlike former media, a meta-medium with degrees of expression we have barely begun to exploit. Nevertheless, it is clear that the computer is an anthropomorphic device. Furthermore, a model of the developmental interdependence of the individual and society is a metaphor for the developmental interdependence of computers and telecommunications. The basic five elements of this model are also a metaphor for other related models: stages of metamorphosis for individuals and computers, the five components of metaphor, and the five types of shared communication space. In essence, by understanding how people function, one can gain some understanding of how computers function.

CA-ACS are more than an electronic symbol board. They are an electronic medium for the manipulation, storage, and transmission of information. Communicatin is, after all, more than just saying words. And, because communication is at the heart of the development of the individual and society, CA-ACS are part of the very essence of what human development is all about. Similarly, computers are at the heart of human development at this point in history.

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