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Known 'Bugs' in cultural historical activity theory

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Abstract

When Cultural-Historical Activity Theory (CHAT) was first propounded by the Vygotskian school of Russian psychologists in the 1920s it offered a robust explanation of how human development is mediated by cultural as well as biological influences. Along the way, CHAT has acquired some "bugs" or usability difficulties by remaining isolated from other theories that have a common heritage. This paper explores how the theory may have evolved if Vygotsky was alive today. Revisions to CHAT are proposed that borrow from complexity theory, innovation theory, group dynamics and Flow theory to explain the evolution of minds, tools and cultures as a series of large-scale discontinuous transformations.

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ABSTRACT

When Cultural-Historical Activity Theory (CHAT) was first propounded by the Vygotskian school of Russian psychologists in the 1920s it offered a robust explanation of how human development is mediated by cultural as well as biological influences. Along the way, CHAT has acquired some "bugs" or usability difficulties by remaining isolated from other theories that have a common heritage. This paper explores how the theory may have evolved if Vygotsky was alive today. Revisions to CHAT are proposed that borrow from complexity theory, innovation theory, group dynamics and Flow theory to explain the evolution of minds, tools and cultures as a series of large-scale discontinuous transformations.

Keywords: Activity Theory, Complexity Theory, transformation, teamwork, tools.

1. INTRODUCTION

CHAT has its origins in a school of psychology led by Lev Vygotsky that flowered in post-revolutionary Russia. CHAT began as a theory of childhood development to explain the link between speech and tool use in young children [1] and differences in the cognition of schooled workers and unschooled peasants in central Asia [2]. CHAT subsequently found wider application in fields such as education, information systems, knowledge management, work design and organisational change.

Vygotsky died in 1934 at the age of 37 before he had time to explore the broader social context of small groups [3] or evolving cultures. There remains today confusion between individual and collective behaviour and the collective use of tools; sometimes the subject is an individual and at other times a group. CHAT has nothing to say about the transformations that occur when teams form, cultures dissolve and reappear in new forms or how tools evolve in partnership with humans.
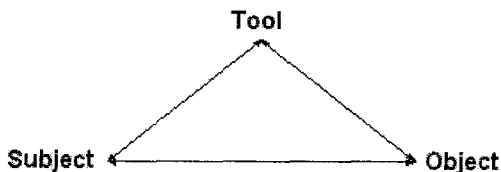

Fig 1. Early model of the concept of
human development mediated by tools

The really big idea in Vygotsky's psychological theory of human activity is that the use of signs or other tools enables humans to evolve both genetically, as other species do and through cultural evolution and which Wertsch [4] describes as a "genetic law of cultural development". Children neither receive knowledge from those who have gone before in the culture, nor simply discover it. Just as DNA shapes cellular development within a biological context [5] the interaction of humans with both tools and others within a cultural context shapes the child's mental development. The culture and the tools within the culture also evolve, and so the historical development of an artifact is built into the artifact itself [6]. Tool use becomes separated from the context and available for wider conceptual application – the decontexualisation of mediational means [7]. Memory, whether it is data, information or knowledge is then accessible in two ways – in external tools and the mind.

Another key concept in CHAT is the zone of proximal development. Vygotsky [8] defined the ZPD as "the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers." In recent times the ZPD has become more broadly defined [9] to deal with collective activity such as the use of a shared object. When something new is created, for example a new work process, new roles or new tools, contradictions are resolved in the preceding activity systems and this leads to an expanded activity, or in the case of failure, leads to contracted activity systems.

Engestrom's [10] main contribution to CHAT has been the triangle that introduces community (See Fig.2) into the schema together with the rules which mediate the relationship between community and subject, and division of labour - or roles - which mediates the relationship between the community and the object. But like other exponents of CHAT, Engestrom switches between the subject as an individual and the subject as a collective, such as a work group participating in a common activity, rather than describe a relationship between the two.
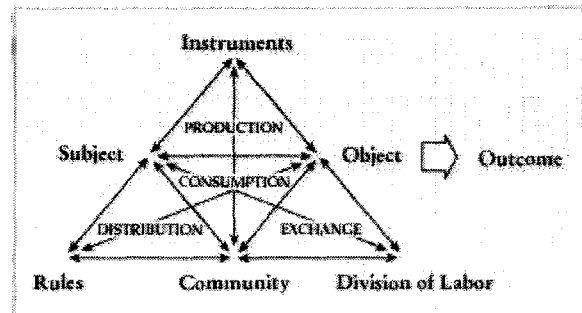

Fig 2: Engestrom model of mediated activity
incorporating community
Image Source: Uni of Helsinki

Another key concept in CHAT is the triarchic structure of activity [11], sometimes called the CHAT hierarchy which describes the transformations that continually take place – activity <> action <>operation and motive <> goal <> conditions (tasks) to which they are related. What starts out as a conscious action may become an automatic action or operation [12] as occurs when people learn to use new computers or software. What was initially a conscious struggle becomes routine and below the level of conscious awareness – an operation. Leont'ev, like Vygotsky, regarded transitions in

socio-cultural history as quite different to the laws of evolution, and in particular Darwin's laws of natural selection [13] Leont'ev [14] recognised that operations become exapted or crystallised into tools. He said "it is generally the fate of operations that, sooner or later, they become the function of a machine." Tools remain conceptually classified – placing like with like - rather than developmentally. Since Vygotsky's day the concept of tools has expanded from signs and language to include physical and systemic entities. Under the present conceptual classification, primary tools are physical and include machines and artifacts, secondary tools are symbolic and include language, signs, concepts and mental models and tertiary tools are memetic and include cultures and systems [15].

2. THEORIES THAT COULD INFORM CHAT

There are four broad groups of theories of development that could inform CHAT. Complexity Theory provides an overarching explanation of the evolution and transformation of the kinds of systems that are considered by CHAT, especially human cultures, groups, tools and minds. Kuhn's theory of scientific revolutions describes the evolution of knowledge. Innovation theories explain how tools evolve within and across cultures. Theories of group dynamics explain how groups evolve and group and individual behaviour intersect.

Evolution of evolutionary theory
The new science known as Complexity Theory [17][18] explains how any kind of system - physical, chemical, symbolic, human or biological - evolves. Complexity Theory holds that new order is autocatalytic and emerges spontaneously on its own as a consequence of the structure and stage of the development of a system. This concept is similar to Leont'ev's concept of self-developing systems. Autocatalysis occurs when a system becomes sufficiently dense and connected [19]. At this point a self-sustaining network arises (See Fig 3). The separate components become an integrated new whole with a "life of its' own" at a higher level of order or organisation.
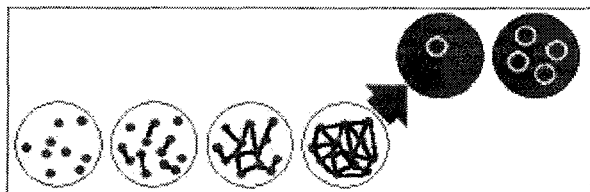

Fig 3. Complexity theory: as a system becomes more interconnected, new more complex order emerges.

The process is analogous to the change in state [20] that occurs when gases cool, become liquid and then cool further to become solids. Kauffman draws a parallel between the Permian Age species extinctions of 245 million years ago and the emergence of new technologies. Some 96 percent of the planet's species disappeared from the face of the earth, but on the rebound, there was an explosion of new species. When a new technology emerges [21] there is a huge explosion in variants, with later evolution being "limited to modest improvements of increasingly optimised designs. From a CHAT perspective, while humans have evolved culturally, in a process different from biological evolution our tools appear to have evolved somewhat genetically instead.

Evolution of cultures
Transformations of human culture can also be described by complexity theory [23]. Each stage of human civilisation [24] is marked by large scale technological and social "internal

rearrangements, new associations and configurations" known as a phase shift or phase condensation. The shift from Hunter-Gatherer *food-collecting* societies to Agricultural *food-producing* societies resulted in changes in the structure of the system, particularly the frequency and kind of interactions between people (Fig.4). Iberall makes an analogy between roaming and a gaseous state and village life and a liquid state. A third wave or phase shift was postulated by Toffler [25] to explain the shift from the Industrial Age (circa 1700-early 2000) to the Information Age (1950 onwards). The current stage of human cultural evolution is now thought to be a shift from the Information Age to the Knowledge Age [26]. Each stage of cultural transformation is associated with the automation of the dominant mode of work in the previous epoch [27].
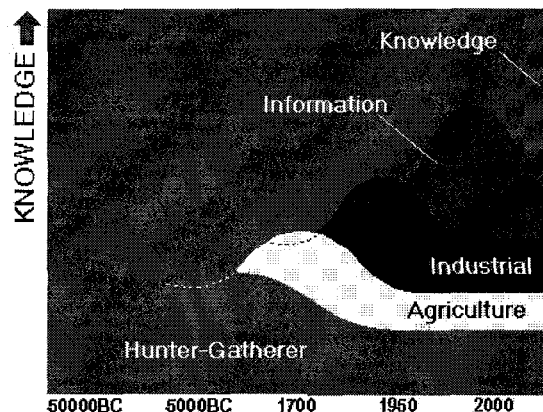

Fig 4. Cultures emerge spontaneously from previous cultures, mature, then decline but remnants remain.

Evolution of Knowledge
The evolution of knowledge as described by Kuhn [28] whose Theory of Scientific Revolutions has close parallels with complexity theory. Kuhn argued that as contradictions in a current theory accumulate a new and better explanation emerges that is so different from the past theories it should be considered a revolution rather than evolution. Each new concept does not fully displace the old, but rather the new and old theories often live side-by-side. Scientists quite happily move between Newton's laws of motion, quantum dynamics and string theory as the basis for explaining how the physical world works.

As human society works it way through a new culture associated with a new scientific revolution there are some who quickly adopt and make use of the new knowledge and others who are slow to do so. Rogers [29], the father of innovation theory showed that the adoption of any new tool or technology follows a cycle in which the curious, well-connected visionary risk takers begin the process followed by the progressively more conservative and risk averse. The innovation process is equivalent to Engestrom's [30] introduction of a culturally advanced artifact to a cycle of expansive learning whereby contradictions occur which may result either a possible expanded activity or a contracted activity.

Drawing on Kuhn concept Foster [31] proposed the S-curve theory of technology adoption to explain the conversion of knowledge into tools and to explain successive waves of the emergence and extinction of technologies and products during the 21st century. The time lapse between knowledge discovery and implementation is becoming shorter as the rate of cultural change accelerates with each successive epoch. For example, the newly emergent photonics, biotechnology and nanotechnology industries owe their existence to Einstein's theory of relativity,

formulated at the start of the 19th Century and Crick and Watson's discovery of DNA in the 1930s [32]. A problem for defenders committed to old technologies is that the emergent technologies reshape the marketplace or the cultural niche so that old technologies have nowhere to live.

Major cultural differences between people living within a single culture but born at different times, or raised in different cultures are becoming major barriers to societal learning and evolution. In the world of business and government, most large organisations are split into specialist functions such as marketing, finance, production, research and development and each function has its' own culture and tools – language specialisation, methods, decision making processes. Differences between these cultures and accelerating change is becoming a barrier to organisation transformation [33]. In the education system, traditional pedagogical methods of chalk and talk or knowledge telling instruction [34] compete with the new media for mind space. Children today live in a world of rich and information-intensive experiences provided by multimedia tools - television, film, video games, computers and the internet [35]. As learners, they arrive "Knowledge age" ready, able to use whatever is available" and have little or no difficulty using the tools if they are allowed access to them. They see computers as both tools and an active form of leisure [36]. But their teachers – average age 47 in Australia and similar in other countries – [37] are unable or unwilling to use the increasingly clever tools [38] On average, students use a computer for more than five hours a week at home and for less than half an hour at school. [39]. In a sense, the teachers are culturally retarded, having been raised in an Industrial Age or Information Age culture, one or two epochs removed from the present day. Todays teachers and students are more culturally apart (See Fig 5) than Luria and Vygotsky's central Asian unschooled and schooled subjects separated by one cultural epoch. Their literate subjects were capable of deductive reasoning and conceptual categorisation [40]with only a brief experience of school whereas illiterate subjects were not.

Fig. 5. Cultural gap between today's learners and their teachers or parents compared with Luria's study.

Evolution of Communities
The relationship between collective or community and individual activity is one of the missing links in CHAT, as Davydov [41] points out. However, researchers in the field of group dynamics have been able to provide such a link. The conditions under which disconnected groups to highly performing teams – that share newly created and agreed knowledge [42] - include clear goals, feedback, creativity, trust, distributed leadership and focus on the task [43], goal directedness and enthusiasm [44] and a sense of time transformation [45][46]. These conditions have much in common with a state of "optimal experience" known as Flow [47] which is proposed by Chen et al [48] as an explanation for

the driving force of cultural evolution. Senge [49]was one of the first to draw parallels between systems theory, a forerunner of complexity theory, and "autocatalytic" transformation from a chaotic group state to an organised team state. Losada [50]used the Complexity theory concept that growing connectivity within a system leads to its transformation to explore the dynamics of effective and ineffective teams. He found that high team performance was highly correlated to connectivity within a group as measured by the number and strength of speech acts between the participants.

The process of group development identified by Tuckman [51] has all the features of a phase transition as described by complexity theory. As participants in a meeting proceed through the five stages of development - forming, storming, norming, performing and adjourning – they move from a chaotic state to an aligned state and return to a chaotic state in a quantum jump when disturbed or they adjourn permanently (See Fig 6).
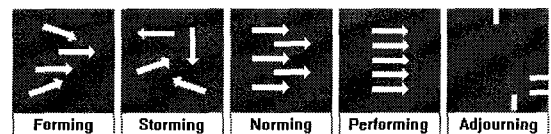

Fig 6. Teams form through alignment of their interests; they change from a chaotic to an organised state

Each stage of the process is related to the degree of interconnectedness, alignment between the interests, and co-ordination between the members of a group. Thus, when numerous individuals engage with a shared tool such as a group decision support system, a dinner table or a freeway the collective individual objects are transformed into a common object, which transcends the previous objects – a kind of advanced more complex object. This is quite different to the unstable or chaotic group dynamics when an object is mandated by one subject such as a manager or when the subjects speak simultaneously with many voices as occurs with anarchy, or when separate coalitions form within a group antagonistic towards each other.

3. DISCUSSION

Complexity theory shows that all human systems – technological, social and cultural – are transformed both incrementally within an epoch and via large-scale discontinuous transitions between cultural epochs. Many new forms emerge, and their antecedents disappear, but not in a continuous genetic line. Features are exapted – borrowed and made use of in new ways - from other "ways of thinking or behaving and tool species" that are a better fit with the emergent cultural ecology that is co-created during the transition.

A new style of culture begins to form around subjects who break away from the current scientific orthodoxy or cultural frame and begin to create new and richer symbolic tools. The subjects also incorporate existing knowledge into new kinds of physical tools – new ways to make tools, new ways to live and work, new ways to think either on your own or collectively as they pursue new advanced objects. The objects for these rapidly evolving subjects do not fit the ecology of the existing dominant culture. The process begins when one or more subjects imagine a tool that through use allows activity to be directed at a more complex shared object, that integrates the previously separate objects of individual subjects. The new imagined tool is "concretised" in not just one direct continuous pathway but a kind of "intelligent groping" or bootstrap which Penrose [52] showed was similar to the formation of a five-fold symmetry quasi-periodic crystal.

This crystal, which should not exist in a three-dimensional world, comes into existence, not via a serial assembly, but as a simultaneous integration, as if the pieces knew where they had to fit, and locate themselves where they are needed.

Major cultural transformations now occur on a time-scale of less than a human lifetime. Between 1950 and 2003 the western world has experienced the tail of the Industrial Age (-1950), the full swathe of the Information Age (1950-1990) and the onset of the Knowledge Age (1990-). In any cultural epoch, "pockets of resistance" to the emergent culture remain committed to the tools, roles and rules of earlier times. The laggards remain locked in place through their affinity with the groups with which they share cultural rules, roles and tools.

There is a clear pattern emerging that suggests that this process of transformation of the collective, planetary-wide, human culture and tools is co-evolving through an ascending hierarchy from action > data > information > knowledge > wisdom in ever shorter epochs.

Epoch	Work automated	Dominant Tool
Hunter gatherer	-	
Agriculture-action	Food finding	Structure
Industrial-data	Farming	Machines
Information	Clerical-factory	Computer
Knowledge	Lecturer, lawyer	Networks
Wisdom	Gurus, leaders	Meta-tools

As tools become smarter and incorporate more complex knowledge, then they become accessible to people with little or no education. This creates a new raft of issues that need to be considered, particularly how a culturally advanced tool is used, adapted or adopted by neophytes to a culture by those stuck in a past culture, or creators of the emergent culture and how the interaction of these different sub-cultures proceeds. Two kinds of subject emerge in the same activity system. Some subjects are able to engage with the tool with little or no conscious effort, at the level of operations. The subjects either *use* it without consciously being aware of the knowledge it contains, or through use and familiarity discern the knowledge within. Other subjects engage with the same tool at a higher cognitive level as they *create* new and improved versions of the tool, at the level somewhat higher than actions, tentatively called the ideal. Many of the new tools that place high level cognitive expertise in the hands of ordinary mortals also permit the user to co-create new knowledge – or new symbolic tools. The knowledge is then incorporated into the tool itself thereby transforming the tool.

New tools are also emerging which scaffold what it means to be human, for example, a team learning system provides the "trainer wheels" that helps ordinary people step up to a high functioning expert role as a team leader or facilitator. When a person uses such a tool, they are constrained in how they use it by the tool's design, and as a result develop the skills of the expert by simply following the tools "guidepath". A neophyte can, with minimal instruction, assist a group to make sense of complex data or information and create and reach agreement about their own new knowledge So where does the role of the more capable peer and the tool begin and end?

The collective ZPD has more work to do than ever before. It has to also explain collective transformation, co-evolutionary transformation with tools and discontinuous transformation. *Collective transformation* occurs when multiple subjects each with different objects, bring their objects into alignment to create a new shared object, such as when a team forms and creates new knowledge or recreates or discovers "old"

knowledge, at least for themselves. *Co-evolutionary transformation with tools* occurs when the subject uses a new complex tool to create new tools that evolve the tool and the subject such as occurs in software programming. *Discontinuous transformation* occurs when subjects collectively change their object and create a new cultural context in which roles, tools, minds and rules are all transformed.
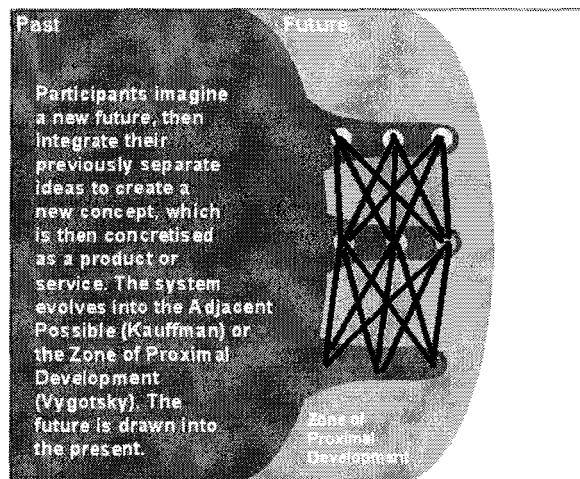

Fig. 6 Integration of the objects of separate subjects into a common object on the far side of a discontinuity.

The collective ZPD needs to show how multiple antecedent activity systems give birth to new activity systems on both small (groups) scales and large (community) scales which in turn give birth to new activity systems each with different objects. In the transition from one cultural state to another more advanced state, collective subjects are faced with many choices of objects, each related to a variant of the underlying mix of tools at the individual or group's disposal. A new set of interrelated activity systems form on the far side of a cultural discontinuity and then coalesces - through competition or standardisation between the emergent and more complex tools – via a kind of Schumpterian deluge of creative destruction into a single activity system with a single object where the use value of the tools largely defines the nature of the activity.

4. CONCLUSION

In one sense, the main game of human evolution has been temporarily diverted for the past hundred thousand years to the evolution of prostheses for brains - tools. If Vygotsky lived today he would have asked why, as our tools become smarter, some humans become less so. A new theory of activity needs to recognize that minds, tools, roles, rules and cultures also evolve, not in a serial manner, but in a discontinuous way. The theory must also recognize there is a battle for mediational power underway between between humans and our tools, which are also evolving and becoming more complex and clever. Perhaps the future genetic history of humans is no longer in partnership with our tools but combined in a new genetic line.

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