

CHAPTER 2. Activity Theory

The concept of activity arising from human [actors] making use of consciously chosen artefacts is of particular importance, and therefore especially valuable when exploring human use of technology, as a conscious, purposeful activity (Nardi, 1995b, p. 7; Vygotsky, 1978).

My entrance into activity theory has been through activity theoretical HCI, introduced by Kaptelinin & Nardi (1995b), and Bødker (1991), working backwards through Leontiev (1978) to Vygotsky (1978) and back again, briefly including Engeström (1987), here presenting it historically chronological.

There are several varieties of activity theory.⁴ The discussion in this thesis leans mainly on the approach that was developed by A. N. Leontiev (1975),⁵ based on the cultural-historical psychology of L. S. Vygotsky (Vygotsky, 1978), and the body of literature, related to activity theory and HCI, initiated by Bødker (1991) and Bannon (1991), with Kuutti's work on activity theory as a framework for HCI research (Kuutti, 1995), and underlining of object dependent transformative activity structure (Kuutti, 1999), in addition to Kaptelinin and Nardi's foundational activity the-

4. 57, according to Rogers (2008).

5. English version. Russian version published 1959.

oretical HCI approach (Kaptelinin and Nardi, 2012a; Kaptelinin and Nardi, 2006; Nardi, 1995b).

The activity theoretical perspective of interactive action *extended* the cognitive science approach, where a user of software would be regarded merely as a cognitive information processing unit, which was rather usual within cognitive psychology at the time. In his much cited paper 'From human factors to human actors: The role of psychology and human computer interaction studies in system design', Liam Bannon presented a set of possible solutions to these issues. 'Within the HF (human factors) approach, the human is often reduced to being another system component with certain characteristics, such as limited attention span, faulty memory, that need to be factored into the design equation for the overall human-machine system. This form of piecemeal analysis of the person as a set of components de-emphasises important issues in work design. Individual motivation, membership in a community of workers, and the importance of the setting in determining human action are just some of the issues that are neglected' [...] 'By using the term human actors emphasis is placed on the person as an autonomous agent that has the capacity to regulate and coordinate his or her behaviour, rather than being a passive element in a human-machine system' (Bannon, 1991, pp. 27-29).

During the last two decades, activity theory has become a growing and central post-cognitivist approach and concept in HCI research (Bannon, 1991; Bødker, 1991; Kaptelinin et al., 2003; Kaptelinin and Nardi, 2006; Kuutti, 1995; Nardi, 1995b), questioning the previous information processing approach, introducing human needs, agency, thoughts and practice as aspects of human-computer interactivity.

Together with findings from previous research in the field of intuitive action, the theoretical foundation for the main discussion in this thesis, is situated at the junction of recent research of intuitive interaction in user interfaces (Blackler et al., 2011; Blackler and Popovic, 2015; Blackler and Hurtienne, 2007; Blackler et al., 2005; Bærentsen, 2000; Mohs et al., 2006b; Naumann et al., 2008; Mohs et al.,

2006b; Blackler et al., 2011; Hurtienne and Blessing, 2007), and what has come to be termed as activity theoretical HCI, where activity theory was established as a theoretical framework from which HCI would benefit Bødker (1991), Bannon (1991), and continued by e.g. Nardi and Kaptelinin (Kaptelinin and Nardi, 2012a; Kaptelinin and Nardi, 2006; Kaptelinin et al., 2003; Nardi, 1995b). As such, the discussion of one of the most used terms or concepts related to human users of technology—intuitive interaction—leans on concepts from the activity theory framework in the analysis of the empirical material.

This chapter is structured as follows: first, a short introduction to activity theory as a framework for understanding the relation between consciousness and activity is presented. The introduction is followed by a historical overview, presenting its origin in Soviet cultural-historical psychology and development into a set of principles for an understanding of how human cognition and activity are related to context, and the diffusion from a primarily Russian field of research into the western realm, and subsequent adoption by other fields of research, in this case, human-computer interaction. The chapter continues by presenting the basic concepts and central elements found in the activity theory literature and concludes with presenting the central body of literature related to activity theory as an approach human-computer interaction research and practice.

2.1 Activity theory - a short introduction

The cultural-historical theory of activity, CHAT, or simply activity theory, is in the literature described mainly as a theoretical framework rather than a unified theory. As such, activity theory has surfaced as a philosophical framework for the study of human thought and agency, both as individuals and as members of a group (Leon-

tiev, 1978, pp. 119-120; Engeström, 1999a, p. 19). Kuutti presents, briefly, activity theory as:

"Activity theory is a philosophical and cross-disciplinary framework for studying different forms of human practices as developmental processes, with both individual and social levels interlinked at the same time" (Kuutti, 1995, p. 25).

The central tenet of activity theory is to understand the unity of consciousness and activity—in a complex context of motives and activities, goals and actions, tasks and operations, in a hierarchical structure that guides the way we mediate our interaction with the world (Leontiev, 1978), in an approach that acknowledges and includes the cultural and contextual aspects of human activity and development (Vygotsky, 1978).

An important element of activity theory is to understand the concept that activity emerges from human actors utilising consciously chosen artefacts (Leontiev, 1978; Vygotsky, 1978). It is, therefore, especially valuable or useful when exploring human use of technology, i.e. human activity mediated by a computer, as a conscious, purposeful activity (Kuutti, 1995; Nardi, 1995a, p. 7).

The activity theoretical framework is an integrated system of conceptual tools and theoretical approaches, and provides thus a conceptual model for analysing the relationship between humans as subjects, and the external world.

Activity theory focuses on practice, which obviates the need to distinguish 'applied' from 'pure' science—understanding everyday practice in the real world is the very objective of scientific practice (Nardi, 1995b, p. 7).

Within the HCI research community, Activity Theory gained increased attention in the early to mid 90s (Bannon, 1991; Bødker, 1991; Kuutti, 1995; Nardi, 1995b), and

has been adopted, not as a fully developed, predictive theory, but as a framework for comprising the many elements of human activity, i.e. personality, thought processes, actions, goals and needs in the study of human practice and behaviour, both as individuals and as members of a collective. Through a set of principles, activity theory affords exploring human use of technology, as a conscious, purposeful activity, through an abstracted or metaphorical tool like i.e. the screen-based graphical user interface, which constitutes key areas for what is regarded as the fundamental unit of analysis in activity theory: human activity and its three main characteristics in being goal- or object-directed, mediated by artefacts, and contextual within societal practice. In this thesis, activity theory affords the analysis of the elements of a purposeful, *computer mediated human activity*, as its unit of analysis.

2.2 Historical overview

The term "activity theory" can, historically, trace its roots to the ideas of human thought and agency in Activity Theory originate from the cultural historical school of Soviet psychology in 1920-30s, founded by Lev Vygotsky (1978), and further developed by A. N. Leontiev (Leontiev, 1978), and A. R. Luria (Luria and Cole, 1978; Luria et al., 1979) as the founding group of researchers, pioneering the concept of mediation of human activity. Succeedingly developed further by some of their students (Davydov, 1999b; Zinchenko and Gordon, 1981), and subsequently introduced to and developed in western psychology, and education and learning by e.g. Engeström (1987), Cole (1996) and Wertsch (1998) in addition to the, already mentioned works of Bødker, Kuutti, Bannon, and Kaptelinin and Nardi in the field of human-computer interaction.

Vygotsky introduced the central concept that human activity originates from having an objective and being mediated through tools. Mediation is a dominant theme

in Vygotsky's work, and he states that human consciousness is characterised by the use of psychological tools, like symbols and languages - of cultural-historically conditioned representations, and that our interaction with the real world is indirect and mediated through societal and culturally constructed tools.

The communication of consciousness can be accomplished only indirectly, through a mediated path. This path consists in the internal mediation of thought first by meanings and then by words. Therefore, thought is never the direct equivalent of word meanings. Meaning mediates thought in its path to verbal expression. The path from thought to word is indirect and internally mediated (Vygotsky, 1987, p. 282).

Also, a central element in Vygotsky's mediation concept, is the reciprocity with which we relate to tools, e.g. technology, where we are being shaped, and develop as human beings, by employing what he coined 'higher psychological functions' - by our use of cultural artefacts. This notion of culturally mediated actions would lean on the principle of internalisation, where external mediation develops into actions based on internally mediated psychological tools (Kaptelinin and Nardi, 2012a; Leontiev, 1978; Vygotsky, 1978).

The tool's function is to serve as the conductor of human influence on the object of activity; it is externally oriented; it must lead to changes in objects. It is a means by which human external activity is aimed at mastering, and triumphing over, nature. The sign, on the other hand, changes nothing in the object of a psychological operation. It is a means of internal activity aimed at mastering oneself; the sign is internally oriented (Vygotsky, 1978, p. 55)

In his universal law of development within the cultural-historical tradition, he states that we reflect on the employment of technical (physical), functional, and culturally founded psychological tools, such as e.g. patterns of notation or tutorial schemas. This mediational triangle structure of behaviour, where the relation between stimulus and response is mediated by tools, is shown in figure 1.

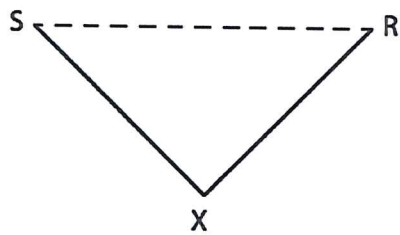


Figure 1. Vygotsky's depiction of mediated action, where he introduces 'sign operations' and the requirement for an 'intermediate link between stimulus and response', establishing the conception of a 'complex mediated act' (Vygotsky, 1978, p. 40).

In its most simple original version, the starting point is the activity; an action undertaken by a human, the subject, towards an object in order to achieve an outcome, and where the action is mediated by a tool. (figure 2).

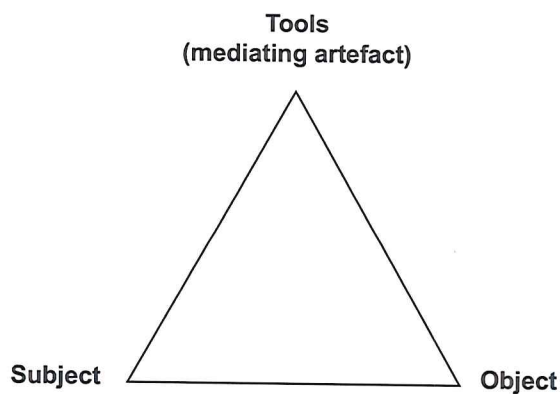


Figure 2. Revised version of Vygotsky's mediational model of human interaction with the environment. There exist a number of depictions of this version of the mediational model, with the tool on top.

The foundational concept of activity theory is the dialectical and developmental unity of consciousness and activity, which must be perceived as an interaction between a conscious, enacting subject, and an object, that must be recognised as an object positively existing in the real world (Vygotsky, 1978).

In addition to this primary concept, there are the following basic principles; object-orientedness, hierarchical structure of human activities, internalisation-externalisation, and mediation, on which activity theory is based (Kaptelinin and Nardi,

2006; Leontyev, 2009; Wertsch, 1981).⁶ Vygotsky did not present his work as activity theory, but the cultural historical school and activity theory share the views on consciousness and mediation, with the slight difference in cultural historical direction focus on mediation by mental artefacts such as language, while activity theory has emphasised mediation by tools, without being incompatible (Zinchenko, 1995).

Leontiev extended Vygotsky's individual focus into situating human activities in a collective context - an activity system, showing the differentiation of individual action and collective activities through the division of labour (Engeström, 1999c, p. 5).

For an extended period of time it was largely a Soviet 'phenomenon', until Vygotsky's and Leontiev's work was translated into English and introduced to an international psychology audience (Luria and Cole, 1978; Luria et al., 1979; Cole, 1990) and Wertsch (Wertsch, 1981). During the last two decades — the post-cognitivist period (Kaptelinin and Nardi, 2012a) activity theory has been described and adopted as a useful analytic framework for HCI and interaction design, and human agency in a human-computer interaction context (Bannon, 1991; Bannon and Bødker, 1989; Bødker, 1991; Kaptelinin, 1996a; Kaptelinin et al., 2003; Kaptelinin and Nardi, 2006; Kuutti, 1995; Nardi, 1995b).

Vygotsky's concept of tool and sign mediation (Vygotsky, 1978), and Leontiev's concept of activity (Leont'ev, 1974; Leontyev, 2009) was extended by Engeström (1987), in his development of the Scandinavian direction of activity theory, thus, bringing it, alongside Cole (1988; Cole and Griffin, 1980), and also Wertsch (1981), into the western realm, primarily in the context of organisational learning. Engeström (1987) uses the core ideas from Vygotsky (1978), and further develops

6. A. N. Leontyev, *The Development of Mind*, 2009 published by Marxists Internet Archive Publications. This is a reproduction of the Progress Publishers 1981 edition, plus "Activity and Consciousness," originally published in "Problems of Dialectical Materialism. Philosophy in the U.S.S.R." by Progress Publishers, 1977.

Leontiev's activity theory framework (Leontyev, 2009), by re-conceptualising our view on activity - as a system of collective processes, and thereby expanding its mediational model as an activity system, a model that considers both the cooperative and shared character of human activity, by utilising concepts such as division of labour, community and rules, in addition to subject, object and mediating artefacts.

The historical presentations of when and how activity theory originated and evolved is usually explained as a linear process (Engestrøm 1987 in Kapelinin 2012), developed by Vygotsky, Rubinshtein, Leontiev, Luria and other Russian researchers (Kaptelinin et al., 1995), before the theory is brought to the West by Engestrøm into other areas, such as organisational learning and pedagogy, and subsequently moved on with Bødker and Bannon (Bannon and Bødker, 1989; Bannon, 1991; Bødker, 1991) to the field of human-computer interaction where researchers in the late 80s had acknowledged the need for a new theoretical framework that not only discussed human-computer interaction in an information processing approach, but a theoretical foundation for how to include human needs and activity related to the context of HCI research and development. This linear presentation, which makes traversing the activity-theoretical literary landscape slightly less difficult (but still not easy) is, according to Kaptelinin (Kaptelinin and Nardi, 2012a), a bit too simplistic regarding the actual development-historical process associated with AT. I have still chosen this simplistic genealogy since it would make the historical presentation somewhat easier to follow while not having any decisive impact on the discussion.

2.3 What is activity?

Davydov categorises activities as e.g. productive, developmental, playful, object-manipulating, and comprise a hierarchy in order of 'importance' which he presents as: work, artistic activity, activity linked moral issues, followed by activities of law,

with religious activities near the bottom of the list, and lastly: sport (Davydov, 1999a, p. 44).

An activity will arise from something being done by someone for the purpose of achieving a result of one kind or the other which means that activities differ from each other by being targeted at various goals, based on different needs and their accompanying motivation. The successful achievement following the transforming of an object into a result is the foundation for the entire activity. The principle of objectiveness is essential in Leontiev's theory of activity, as he states that an activity cannot exist without a purpose (Leontyev, 1977, p. 182), and that an activity is characterised by its duality, that an objective exists, initially, independent of the activity, subsequently transforming the activity by giving it a specific direction, reciprocally also transforming the subject in the subject's process of reflecting on the idea or notion of the object, but also that the object of an activity may be recognised by the subject's motive (Leontiev, 1978). Therefore, human activity is characterised both by its objectiveness, and its subjectiveness in that the activity of the subject must consistently be directed towards the transformation of an objective which is capable of meeting a specific need. (Leontiev, 1978, p. 12).

The process of transforming an object into an achievement is characterised by being a dynamic process that forms an 'ebb and tide' kind of motion between the subject and the object. Leontiev describes this as a circular process,

The subject-activity-object transitions develop a kind of circular movement, so it may seem unimportant which of its elements or moments is taken as the initial one. But this is by no means movement in a closed circle. The circle opens, and opens specifically in sensuous practical activity itself. Entering into direct contact with objective reality and submitting to it, activity is modified and enriched; and it is in this enriched form that it is crystallised in the product. (Leontiev, 1978, pp. 10-11)

Leontiev (1978), expanded Vygotsky's work by conceptualising the 'theory of activity', and structuring activity as comprised by a need-motive, goals and conditions, in a hierarchical structure, with the 'main' activity and the actions and operations at three different hierarchical levels that constitute the activity. These three hierarchical levels consist of 1. motivated activity, 2. goal-directed actions focused on fulfilling the individual goals of the actions and which will together fulfil the need for the activity, and 3. the single operations comprising the actions, and which are linked to the prerequisites for the undertaking of the operations (see chapter 2.4.2).

Human activity consists of actions or a group of actions in sequence, in a conscious process of achieving or fulfilling the object of the activity. The goal of an activity encourages the activity itself. Leontiev argues that actions comprising an activity are connected to the notions of needs and motives (1978). This is also discussed by Davydov (1983, 1999a), who claims that actions are only connected to needs, and that this need is based on a desire to fulfil a task:

Actions as integral formations can be connected with nothing but needs based on desires, and the actions aimed at fulfilling certain tasks stem from motives. Motives in their turn are specific forms of needs in the case when a person has set himself a task and is undertaking certain actions to fulfil it. Thus motives are consistent with actions. Actions are based on motives, and acting is possible if certain materials or sign and symbol means are available. (Davydov, 1999a, pp. 42-43)

According to Davydov, an object is not an independent, physical, thing in itself, but something that a subject acts towards, as a goal or purpose regardless of the activity being internal as a reflection, or external, following the character of the motive, that can be both material or conceptual, and as such will facilitate an activity being able to encompass several approaches in ensuring an object's ability to guide the direction of an activity. This may be affective elements i.e. emotions, needs, will, tasks, plans, means, motives. In a structure with several possible

approaches, according to Davydov, it will be the need that will be the most important (Davydov et al., 1983).

In recognition of the importance of the collective aspect of human activity, Leontiev argues that,

'This first description now, after a quarter century, appears in many ways unsatisfactory and too abstract. But it is exactly owing to its abstractness that it can be taken as an initial departure point for further investigations. Up to this point we were talking about activity in the general collective meaning of that concept. Actually, however, we always must deal with specific activities...' (Leontiev, 1978, p. 62).

Leontiev argues that activity is a system of hierarchical levels where he distinguishes between collective activity and individual action, structuring human activity as a 'division of labour', as an important aspect in the process of the development of mental functions (Leontyev, 2009). Davydov discusses this as communicative action, arguing that communication reveals the cultural and interpersonal relations in an activity system, and inseparably linked to the activity itself (Davydov, 1999b, pp. 46-47).

2.4 Basic principles

In this chapter I will present and describe the basic elements of activity theory. I will present the concepts of object orientation, and point towards the underlying motivation for the activity, and how the process of human activity is divided and distributed in a hierarchy of levels, showing how an activity comprises consciously chosen sub-tasks, which in turn are undertaken by a string of single operations. These operations are internalised and externalised in a back and forth dialectical

pattern, mediated by mental and physical tools towards the achievement of a primary goal.

Activity theory is, rather than an established theory, composed of a collection of principles that, together, constitutes a conceptual system. An activity is, broadly speaking, any instance of a subject's interaction with the world. In activity theory, this act of interaction is characterised by the subject's purpose and contextual motive, and is oriented towards an objective.

Activity theory separates between processes at different levels in a hierarchical order. An activity consists of a set of actions which are guided at an intended result which, in turn, are realised through operations (Leontiev, 1978; Kaptelinin and Nardi, 2012a; Kaptelinin, 1996a; Kaptelinin and Nardi, 1997), see figure 3, 'Leontiev's hierarchical structure of activity', page 35.

Activity theory differentiates between activities in the mind and external activities, but that the two cannot exist separately. This dual character of activities, i.e. they have both an internal and external side that are connected, is a crucial aspect of 'activity' within activity theory, and central to the principle that actions in the mind and actions towards the world - internal and external actions - mutually affect us.

The notion of humans making and using tools in order to mediate their interaction with the world is one of the key principles within activity theory (Vygotsky, 1978). According to Vygotsky, there are two categories of tools: technical ones and psychological ones. The purpose of technical tools is to manipulate physical objects, for instance, a pencil, while psychological tools are used by a person to influence another person or, reciprocally towards themselves, for example, a note containing a symbolic or linguistic help of some sort. (Vygotsky, 1987)

In an HCI research context, *activity* is a primary theoretical construct (Kaptelinin and Nardi, 2012a), and represents a relational context in which a [human] subject (Leontiev, 1978), interacts, physically or cognitively, with an object, positively existing in the world. This relationship is characterised by the subject's needs being met through the subject's interaction with the world, where the subject's activity towards an objective, and world and mutually influence each other (Kaptelinin and Nardi, 2012a).

Also, the relational aspect of the unity of consciousness and activity is a foundational principle of activity theory, where this relation is characterised as being asymmetrical, where [conscious] subjects possess *agency*, and have needs, unto which performing activities are necessary in order for the needs to be fulfilled. It is through this interaction that consciousness, the human mind, becomes an element in the activity 'matrix'.

Building on Wertsch (1981), Kaptelinin and Nardi (2006), identified the main principles in activity theory. They are here described in the order presented by Kaptelinin and Nardi.

2.4.1 Object-orientation

As the object of activity, represents one of the most basic concepts in activity theory, it plays a vital role in research that is utilising activity theory as the analytical framework. According to Leontiev, the main characteristic of activity is that it has a purpose - an object, and that all activity is object-oriented:

The expression "objectless activity" has no meaning at all. Activity may appear to be objectless, but the scientific investigation of activity necessarily demands the discovery of its object. Moreover, the object of activity appears in two forms: first, in its independent existence, commanding the activity of the subject, and second, as the mental image of the object, as the product of

the subject's "detection" of its properties, which is effected by the activity of the subject and cannot be effected otherwise (Leontyev, 1977, p. 182).

One initial problem of the object-oriented character of activity in activity theory is its somewhat linguistic lack of a distinct direction - in that the English word *activity* does not, in itself, contain or provide any connotation or guidance as to whether an activity has a certain direction or goal. Also, as stated by e.g. Kuutti (1995) and Kaptelin (2005), the typical English use of the term activity is too encompassing for the term to have any direction in itself, and that activity, as in object-oriented activity, is invariably connected to *agency* and associated with a transformation process. The notion of purposeful activity may be better expressed in German by the terms *tätigkeit* and *handlung*, which are closer to the original Russian term *deyatel'nost*. Likewise, the term object, as the foundation for purposeful activity, can be translated from the two Russian words *objekt* and *predmet*, which have almost the same and, often interchangeable, meaning. Leontiev (78,81)⁷ in Kaptelinin (Kaptelinin, 2005, p. 6) describes this difference with the meaning of *object* relating to physical things existing independently of the mind, while the meaning of the word *predmet* would relate to a target or purpose in the mind, in the character of a thought or an action. Subsequently, Leontiev stated that the object of an activity should be understood as primarily related to "something at which an action is directed", i.e. the *predmet* approach to the term object (Leontiev, 1978; Leontyev, 2009, p. 29), where activity would be object-related, as in purposeful - *predmetnaja deyatel'nost* (Kaptelinin, 2005, p. 7).

Human activity is characterised by transforming the object of an activity into a planned or wanted outcome. The main characteristic of an activity is that it has a purpose - an object, and that all activity is object-oriented. An 'object' in activity

7. This book was reproduced in 2009, as *The Development of Mind* (Leontyev, 2009). Available from Marxist Internet Archive, Pacifica, CA. (<https://www.marxists.org/archive/leontev/works/development-mind.pdf>)

theory relates to the objective of an activity, as a source of motivation and guide in the process of transforming the object into an outcome (Kuutti, 1995).

According to Leontiev (Leontyev, 1977), the principle of object-orientation is:

The expression “objectless activity” has no meaning at all. Activity may appear to be objectless, but the scientific investigation of activity necessarily demands the discovery of its object. Moreover, the object of activity appears in two forms: first, in its independent existence, commanding the activity of the subject, and second, as the mental image of the object, as the product of the subject’s “detection” of its properties, which is effected by the activity of the subject and cannot be effected otherwise (Leontyev, 1977, p. 182).

An activity occurs to satisfy a motive or a human being’s *objective* with the subsequent need to engage in activity. Therefore, the objective of an activity can be identified through the motive. However, even as the objective of an activity stimulates the activity, it is not given that it leads the direction of the subsequent activities that may exist within that activity. Therefore, the motive, coming from need, represents the necessary precondition for an activity to occur. A motive could be explicit or implicit (material or ideal), it can be perceived or imagined. This explanation highlights the view that there is no such thing as a motiveless activity. Therefore, “an activity does not exist without a motive; ‘non-motivated’ activity is not activity without a motive but activity with a subjectively and objectively hidden motive,” (Leontiev, 1978, pp. 62-63). An activity is therefore driven towards the satisfaction of the motive or need. However, Kaptelinin (2005), claims that this object relatedness is not without “uncertainties and inconsistencies”, pointing to the characteristics of a lack of separation between the objective of an activity and the motive of an activity as problematic.

Within activity theory, the relationship between a *subject* and an *object* is mediated by tools. A *subject* is a living entity with intentions and agency to act upon things

and objectives, to fulfil its needs or goals, as opposed to other elements within a particular context, that are, however useful, graspable - physical or cognitively, without agency. Within this context, the concept of agency points to the capability of an individual *subject* to, independently, act upon an object in the world, and change the context within which the objective is situated. Leontiev describes this reciprocal process:

In activity an object is transformed into its subjective form or image while at the same time activity passes into its objective results and products. In this regard activity emerges as a process that effects a reciprocal transformation between the subject-object poles. [...] Activity that is internal in form, having arisen out of external practical activity, is thus not separated from it and does not rise above it, but retains its basic, two-way connection with it. (Leont'ev, 1974, pp. 9, 22).

Collectively, the unity of subject and object is part of the framework of activity, as e.g. defined by Davydov et al. in their analysis of Leontiev's activity approach:

"[...] human activity is characterized not only by its objectiveness but also by its subjectiveness: the activity of the subject is always directed toward the transformation of an object that is able to satisfy some specific need. Activity brings together in a unity such opposing principles as object and subject." (Davydov et al., 1983, p. 32).

Kuutti, focusing on the structure of activity states:

"An activity is a form of doing directed to an object, and activities are distinguished from each other according to their objects. Transforming the object into an outcome motivates the existence of an activity. An object can be a material thing, but it can also be less tangible (such as a plan) or totally intangible (such as a common idea) as long as it can be shared for manipulation and transformation by the participants of the activity." (Kuutti, 1995, p. 27).

Object orientation is a term that has a different meaning within applied computer science than within the activity theoretical framework. Since [activity theoretical] human-computer interaction is situated within the computer science discourse, it would possibly facilitate a good reading experience to clarify that the meaning of the *object* in activity theory relates to the objective of an activity, as a source of motivation and guide in the process of transforming an object into a *wanted outcome* - as the purpose of an activity, and not necessarily a physical thing that exists in itself, as described by e.g. Leontiev (2009), and Davydov (1999a).

In a human approach, most of the objects we are surrounded by, and use, when working towards achieving a goal, are culturally mediated, either as a thing or its abstraction - a symbol or, as in an HCI context - a screen element in a user interface with which humans interact. Also, the character of objectiveness could be an established or a priori fact, which means that not only tangible artefacts but also social and cultural properties can be as real as physical ones, or other kinds of non-disputable entities, which means that the character of an object, its colour, temperature or surface, is both a measurable or perceived quality (Davydov, 1999a; Leontyev, 2009; Kapteinin and Nardi, 2012a).

2.4.2 Hierarchical structure of use

Activity is defined by the contextual motive and necessitated by the objective, in the subject-object interaction, and can be represented as a hierarchical structure (Leontiev, 1978). Activity consists of consciously directed sub-tasks, actions, with goals representing the result of the action, which is put together by single operations that are not characterised by conscious direction, or even reflected upon, but are related to the conditions for the operations. (Leontiev, 1978; Zinchenko and Gordon, 1981; Kuutti, 1995, p. 30)

In Leontiev's three-levelled hierarchical structure, the mid-level is relating to goals being the objective of actions that, together with other actions, can form a group of actions, each with their own goals connected to each action in the group. While actions are the result of conscious doings, they are consisting of single *operations*, a part of human activity which may be undertaken in a kind of automatic approach, due to being situated in context, or dependent on what in activity theory is defined as a condition. For instance, when reading a book, I don't have to consciously think of turning the pages in order to continue to read. Unless I have a physical handicap, the turning of the page is not a goal in itself. Also, I read the book without thinking that I am technically reading the words on the page. As a literate adult, reading as a single technical operation in itself is without a goal, but dependent on the conditions in which it occurs. Can I sit down while reading? Is there a sufficient amount of light, so I can see the printed words on the page? On top of the hierarchy, we find the primary task and base for human activity, and that is motivated by an objective [of achieving an outcome]. The objective of an activity stimulates the activity, but it is not given that it leads the direction of the subsequent activities that may exist within that activity. The motive therefore, represents the necessary precondition for an activity to occur.

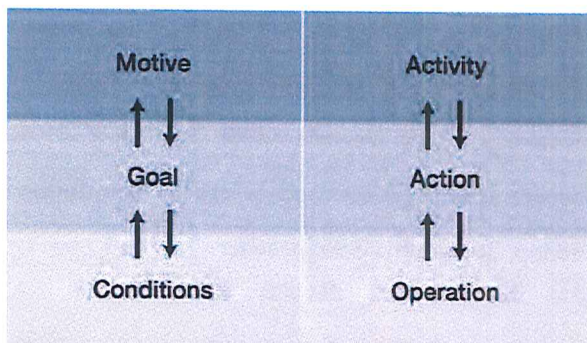


Figure 3. Leontiev's hierarchical structure of activity as continuous reciprocal transformation between the parts of activity (Davydov et al., 1983, p. 36; Leontiev, 1978; Leontyev, 2009). Depiction derived from Davydov et al. (Davydov et al., 1983, p. 36), and visually based on fig. 2.3 in Kuutti (Kuutti, 1995, p. 30). We see that an activity is initiated by a motive, and is comprised by a set of actions based on a conscious direction for each specific action, for which undertaking in turn is dependent on a sequence of operations that is not goal-directed, but related to the conditions for the operations.

As an activity occurs to satisfy a motive or a human being's objective need to engage in activity, the objective can be identified through the motive. A motive could be explicit or inexplicit (material or ideal), it can be perceived or imagined. This explanation highlights the view that there is no such thing as a motiveless activity. Therefore, "an activity does not exist without a motive; 'nonmotivated' activity is not activity without a motive but an activity with a subjectively and objectively hidden motive," (Leontiev, 1978, pp. 62-63).

Human **activity** exists only as actions or a sequence of actions, and is undertaken as a consequence of a purpose or a need - an objective towards which all human activities are directed (Leontiev, 1978). It is the contextual foundation for understanding the actions, or group of conscious actions that point towards the goals that together with other actions comprise the activity that leads to the fulfilment of the objective. However, this structure can change. An activity may lose the motive that generated the objective (Leontiev, 1978). This may lead to the object of an activity instead becomes the goal of an action, thus transforming the activity into an action, leading to the borders between activity and actions becoming fuzzy (Davydov et al., 1983). This is a bidirectional process; a mutual pattern of transformation, making the different parts of a use activity structure flexible and mobile, and in a continuous state of change and development, as a constant, reciprocal relationship between subject and object, where the subject reflects over, and transforms, the object, and is equally transformed (Leont'ev, 1974; Davydov et al., 1983, p. 36; Kuutti, 1995, p. 27).

Also, an action may evolve into a separate objective, thus turning into an activity. An action may also become a resource for reaching a goal, or as a result of skill acquisition, thus transforming into an operation (Leontiev, 1978, p. 104). This bidirectionality is further explained by Davydov, Zinchenko, and Talyzina:

Thus an activity can lose its motive and become an action, and an action can become an operation when the goal changes, or as a result of user practice. The motive of some activity may become the goal of an activity, as a result of which the latter is transformed into some integral activity. Hence, mutual transformations are constantly taking place: activity \rightleftharpoons action \rightleftharpoons operation and motive \rightleftharpoons goal \rightleftharpoons conditions. The mobility of the constituents of activity is also manifested in the fact that each of them may become a part of a unit or, conversely, come to embrace previously relatively independent units (for example, some acts may be broken down into a series of successive acts, and, correspondingly, a goal may be broken down into subgoals) (Davydov et al., 1983, p. 36).

Actions are conscious goal-directed processes that must be undertaken to fulfil the objective of an activity, made up of a series of singular *operations*, related to condition and context, that users, in its sequential character of processing the operations, and thus influence on the conditions for attaining the goals. (Kaptelinin and Nardi, 2012a; Kuutti, 1995; Leont'ev, 1974). Initially, however, an operation would be the result of a conscious act: an action, until the subject has gained sufficiently experience, having internalised it, and no longer needs to reflect on it; thus it would subsequently be transformed into an operation, undertaken unconsciously and automatically, and placed into the sequence of other automated operations. This “action-operation dynamic” and the increase of sense of utilisation by actions resulting from this reciprocal internalisation-externalisation is a typical aspect of human development (Kuutti, 1995, p. 31). A typical example of this process is, learning to play an instrument. In order to produce an audible tone, one must concentrate on putting the fingers in the right place. To produce not only an audible tone, but also a tone of a certain quality that others would, presumably, enjoy listening to, one would also have to put the finger in the right place, in the correct way, depending on the instrument. When playing on a string instrument, e.g. the guitar, a correctly placed finger, would, in addition, have to press the string with a sufficient amount of power against the fretboard, and simultaneously, pluck the string with the other

hand in order to produce a good sounding guitar tone. At a novice level, every one of these individual operations would be an action. The first goal would be to place one's finger in the right place, i.e. play the correct tone. The goal of the next action could be that the tone should sound good or with a certain amount of sustain. For an inexperienced novice, all these single operations would be quite complex actions, that would include intricate coordination involving both arms and hands, and mental functions. While, assuming all the conditions were set and stable, an experienced musician would, automatically and unconsciously, combine them into a single smooth operation.

Likewise, changing conditions could alter the foundation for an automated undertaking of operations, and lead the subject into conscious reflection, transforming the operation into a conscious action (Kuutti, 1995). In the instrument example above, a changed condition could be an unplanned change from an electric to an acoustic setting, forcing the musician, here: a guitar player, to be more aware of using an increased force in the plucking of strings, and reflect on how much the plucking style has to be changed in order to reach the goal that everybody should be able to hear the music. In this example, the automated operation of plucking a string was transformed into a conscious action, until this new way of plucking strings would be internalised and fully adapted to the new condition, when it would transform back into an operation.

2.4.3 Mediation

The principle of mediation is a central concept that human activity originates from having an objective that is fulfilled by being mediated by the conscious use of tools as an intermediate link between the subject and object. Mediation is a dominant theme in Vygotsky's work, and he states that human consciousness is characterised by the use of psychological tools, like symbols and languages - of cultural-historic-

ally conditioned representations, and that our interaction with the real world is indirect and mediated through societal and culturally constructed tools.

The communication of consciousness can be accomplished only indirectly, through a mediated path. This path consists in the internal mediation of thought first by meanings and then by words. Therefore, thought is never the direct equivalent of word meanings. Meaning mediates thought in its path to a verbal expression. The path from a thought to a word is indirect and internally mediated. (Vygotsky, 1987, p. 282).

Also, a central element in Vygotsky's mediation concept, is the reciprocity with which we relate to tools, e.g. technology, where we are being shaped, and develop as human beings, by employing what he coined as 'higher psychological functions' - by our use of socially and culturally mediated artefacts. This notion of socially and culturally mediated actions would lean on the principle of internalisation, where external mediation develops into actions based on internally mediated psychological tools (Vygotsky, 1978; Leontiev, 1978; Kaptelinin and Nardi, 2012a).

The tool's function is to serve as the conductor of human influence on the object of activity; it is externally oriented; it must lead to changes in objects. It is a means by which human external activity is aimed at mastering, and triumphing over, nature. The sign, on the other hand, changes nothing in the object of a psychological operation. It is a means of internal activity aimed at mastering oneself; the sign is internally oriented (Vygotsky, 1978, p. 55)

Kaptelinin et al. argues that activity theory in itself is "built upon the concept of mediation", which makes it particularly suitable for HCI "exploration" (Kaptelinin et al., 1995, p. 190).

Both in societal and organisational life, at work or socially, an increasing part of human activities is performed through an interface, as a unique and, seemingly, ubiquitous tool in mediating human interaction with the world. Kaptelinin dis-

cusses the theoretical implications this would have for the field of HCI, and argues that it is not the interaction with computers that is the primary goal in itself, leading it to become what Kaptelinin terms as Computer-Mediated Activity (Kaptelinin, 1995b). Thus, the notion of mediation is an important concept within the cultural-historical psychology (Vygotsky, 1978; Leontiev, 1978), as it represents not only the foundation for all human praxis but also what makes us uniquely human, also including the comprehension of 'similarity' within the process of transforming objects, that would be central in transforming existing knowledge into new knowledge.

Every aspect of what might be called the successful by the human species - nearly all human interactivity with the world and everyone and everything in it is culturally and technically mediated in some form, either by physical objects or signs, or in the internal plane as language or other symbolic artefacts (Kaptelinin and Nardi, 2012a; Leontiev, 1978). We can build cities and live in them. We can communicate without being physically or simultaneously present. We may work towards a target, by acting indirectly, using either abstract symbols, or by combining actions, that separately do not lead to the achievement of a goal, but combined, constitute an activity of a logical and sequential string of actions that lead to the achievement of a desired goal. The construction and use of tools and language are described as defining properties of higher mental functions and, therefore uniquely human (Vygotsky, 1978; Wertsch, 1991). The distinction of human interacting agency as it unfolds in all its complexity, societal and technological, the physical and the intangible is powered by mediation. Leontiev describes this relationship of humans and the enabling tools that extend human abilities into higher achievements that would not have been possible without functional organs (Leontyev, 2009).

Zinchenko (1995), discusses the mediation of a human-tool relationship and specifically the relationship that arises out of extensive and longitudinal interaction to such an extent that the activity, the interaction, becomes dissolved into an intuitive singularity; i.e. that the human and the tool melt together through a “master’s introspection”, and presenting the conception that all elements that comprise the modern socio-technical contexts and materiality, are contributing to the experiential pattern repository, consisting of both previous actions and their representative metaphors which we can access and recognise in similar or related artefacts and their related contexts and recollecting previous praxis.

The special character of the user interface, mediating human interaction with the world, is versatile in the sense of being able to mediate a multitude of activities, thus encompassing several relations (Kaptelinin, 1995b; Kaptelinin, 2015), as a tool into which the user, in the internalisation process, can externalise and distribute simulation capacity, forming a functional organ, subsequently influencing learning and development.

2.4.4 Internalisation and externalisation

Internalisation was introduced by Vygotsky as “the internal reconstruction of an external operation” (Vygotsky, 1978, p. 56), as an intermediate approach to the conceptualisation of the relation between internal and external activity, which previously had been approached either from a Cartesian point of view, focusing on the internal mental activity as the sole domain of psychological study, or the contrasting behaviouristic approach focusing on external behaviour as the only point of departure in psychological study (Wertsch and Stone, 1985).

Internalisation describes how external elements or activities in the real world *becomes* an internal plane, “hosting” the internalised processes (Leontiev, 1978). By transforming external activities into internal ones, this process provides a possibility

to simulate potential interaction with the world in the mind, in the form of considering various strategies, by mentally, and initially, testing possible actions and operations - in the mind, making reflections that had not previously been present. Leontiev states:

Internalization is thus not a process by which external activity is *transferred* onto a pre-existing inner "plane of consciousness": it is the process by which the inner plane is *formed* for the first time. (Leont'ev, 1974, p. 20)

Internal activity, originating from external, physical activity cannot, however, be separated from this external activity, but is expressed as a constant *reciprocal* relation with external activity, where human mental processes develop and redevelop. These continuous reciprocal processes are possible because both the internal (mental, in the mind), and the external (practical, physical) activities have fundamentally the same structure, as there are no boundaries between the internalisation and externalisation processes (Leont'ev, 1974, pp. 21-22).

This dual character of human activity is also expressed by Cole (1996, pp. 136-137) who, in his discussion of human activity and the relationship between internal and external activity, states that human activity cannot be separated from each other, since the physical aspect of activity is the externalised form of the person's activity in the mind.

Internalisation is presented as a simulation process that takes place in the *internal plane of action*, without actually performing them in reality. This internalisation process - the planning of *what* is going to be done, *why* it is needed, the simulation of *how* it is going to be done, and the consideration of the potential outcome of the activity, prior to actually performing an action in the real world (Leont'ev, 1974).

Leontiev, describing the transition process as going from something physical or sense-able to a thought or idea, stated that

“Internalization is that transition by which external processes with external material objects are transformed into processes carried out on the intellectual plane, the plane of consciousness. When this happens, the processes are subjected to a specific transformation: they are generalized, verbalized, abbreviated, and, most importantly, become susceptible of further development that exceeds the possibility of external activity.” (Leont'ev, 1974, p. 18).

Davydov et al. (1983, pp. 34-35), and Kuutti (1995), states that human activities are not fixed or constant as they are included in processes in which skill acquisition takes place as a consequence of previous actions and operations, and in a constant reciprocal relation of patterns of internalisation and externalisation, forming new actions and operations (Leontiev, 1978). This is achievable since both internalisation and externalisation, according to Davydov et al. essentially have a corresponding structure (Davydov et al., 1983, pp. 34-35).

”A person's internal activity ‘assimilates the experience of humanity’ in the form in which it manifests itself in the corresponding external activity (Kuutti, 1995, p. 33) [...] It means that a person's mental processes acquire a structure necessarily linked to socio-historically formed means and modes, which are transmitted to him by other people through teamwork and social intercourse” (Kuutti, 1995, p. 33; Leont'ev, 1974, p. 19).

The relational aspect of the unity of consciousness and activity is a crucial principle within activity theory, and reflected in being asymmetrical, where [conscious] subjects possess *agency*, and having needs, unto which performing activities are necessary in order for the needs to be fulfilled. It is through this interaction that consciousness, the human mind, becomes one with activity, forming meaning.

Externalisation is the typical unique human ability, transforming activities in the internal plane into external activities by the help of tools. It could be the sketching of an idea, jotting down procedures and possibilities, that earlier have been merely a thought, and employing a mediating artefact, in order to manifest or materialise a reflection in the internal plane into something visible or physical. Externalisation could also be a necessary action when conditions change and mental processes in the internal plane need adjustments, or in need of being communicated to others. This, resulting in what, in turn, would provide a transformative feedback, as a result of the operations or actions, is in line with Kuutti's statement about externalisation being the mediated fulfilment of an objective, and a process that reciprocally, transform the individual (Kuutti, 1995). This is also reiterated by Kaptelinin and Nardi, in presenting the internalisation procedure as "a process during which phenomena external to the subject, both physical and social, become both individual and internal", and describe this procedure as a dynamically, bidirectional redistribution of functional elements with the likely transformation of both the internal and the external processes, as the individual learns and develops (Kaptelinin and Nardi, 2012a, pp. 16-17).

As the internalisation process relies on the use of cognitive tools such as signs and language, to comprehend contextual information about a particular activity, the externalisation process employs both physical and psychological tools. In an example of the case study, presented in ch. 5, an expert user or super-user externalised his previously internalised knowledge about a particular activity, like stowing a ship, by initiating or deciding on how the new software (psychological tool) should handle the stowage activity, thus influencing an alteration in the way other employees carry out that activity.

2.4.5 Development

The significant increase in human use of digital technologies, renders human activity increasingly, and exclusively, 'mediated'. The development of skills which is essential in mediated operations is central to the notion of familiarity, and the perception of intuitiveness based on previous experience, stems from learning in a culture where everything is mediated, in an approach related to a computer-mediated communication discourse.

Leaning on Vygotsky (1978), the cultural aspect of human actions, that is, the knowledge that accumulates from being a member of a culture and the human use of cultural artefacts that naturally follows; wherein an almost ubiquitous socio-technical context would include that simple interaction with a computer, utilising a user interface, could be regarded as basic knowledge.

Also, Leontiev links experience and development by situating the source of internal activities by practical activity: "inner mental activity derives from practical activity historically shaped as a result of the formation of human society based on labour and that these processes are formed anew during ontogenetic development in the separate individuals of each new generation." (Leont'ev, 1974, p. 19).

Vygotsky emphasised the importance of using a developmental method to understand human mental functioning, and this applied to mediation in all its forms no less than any other topic. In this connection, he argued that a hallmark of the relationship between sign and behaviour, as well as between word and thought, is that it undergoes a fundamental change (Daniels et al., 2007, p. 186).

Dialectical development

As human use-activities are parts in an overall interacting context, where related activities might change the conditions in such a way that users, during a working

process, may experience problems that may cause downtime or a stop in ongoing activities. Within activity theory this is labelled as contradictions i.e. events that manifest themselves as complications and mismatches - breakdowns. This kind of misalignment could be represented by, e.g. not sufficiently trained users or inadequate design of interfaces that fail to support the processes of skilled workers intuitive use. As opposed to the traditional (Western) logic that regards contradictions as indications of problems that have to be solved, activity theory regards contradictions as options for learning; as problems that have to be overcome in a process that is dynamically and dialectically developing; transforming use-activities and tools related to the hierarchical structure, and reciprocally changing cognitive actions on the internal plane, over time (Vygotsky, 1993, pp. 159-160; Leontiev, 1978; Kaptelinin and Nardi, 2006; Ilyenkov, 2009). Davydov, referencing on Ilyenkov, states,

Ilyenkov showed that the ideal is revealed in the human capacity to reproduce or re-create a material object resting on a word, a draft, or a model. The ideal exists in constant intertransitions of the activity elements according to the following scheme: object—action-word-action—object. The ideal is the existence of an object in the phase of its formation, in the subject's activity manifesting itself as a need and a goal. (Davydov, 1999b, p. 50)

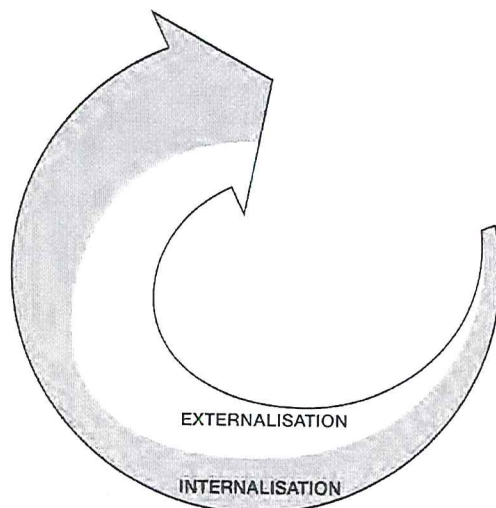


Figure 4. Engeström's expansive cycle of learning, and the relation between internalisation and externalisation during the development process. Engeström (1999a, p. 34).

Engeström (1987, 1999a), introduced the dialectical relation between internalisation and externalisation as a long-term perspective on learning as an expansive cycle of the development of the activity (Engeström, 1999b, p. 64), starting with an emphasis on internalisation, exercising for new skills, or changing to new work methods, e.g. in a context of introducing new software in an organisation, gradually, through experiencing breakdowns, by reflecting on this character of the actions comprising an activity, users would become competent and experts while the activity, with its inherent operations and actions increasingly externalised in the user interface. This form of learning by expanding, by experiencing breaks in a planned sequence of actions and overcoming them, leads to an evolutionary kind of development that through contradictions, breakdowns and workarounds in a context where the borders between action and operations are dynamic and flexible, and the border between actions and activity is blurred (Davydov et al., 1983; Kuutti, 1995), will contribute to the development of both subject and object. Engeström states: “In activity-theoretical terms, activity systems travel through zones of proximal development, [...] a terrain of constant ambivalence, struggle, and surprise” (Engeström, 1999b, p. 90).

Engeström (1987) uses the core ideas from Vygotsky (1978), and Leontiev (1978), by re-conceptualising our view on activity - as a collective process, and thereby expanding its mediational model as an activity system, a model that considers both the cooperative and shared character of human activity, by utilising concepts such as division of labour, community and rules, in addition to subject, object and mediating artefacts.

2.5 Functional organ

”The hope is that, in not too many years, human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today”.

J. C. R. Licklider, 1960⁸

The processes of internalisation and externalisation exist simultaneously and continuously during human activities, and connected by a mediating tool, forming a functional organ intended at achieving or fulfilling an objective (Leontyev, 2009; Kaptelinin, 1995b, p. 51).

The idea of functional organs is a key concept in the context of human-computer mediated activity, since the computer, within activity theory, is considered, as a mediating and converging tool capable of incorporating the representation of a multitude of aspects and elements of the real world, a “special kind of tool” (Kaptelinin, 1995b, p. 49). The capabilities of the computer as a mediating tool allow for the distribution of cognition, and through its thus an ability to represent and simulate other mediating tools. This might also pose a challenge as to how it would allow a user to internalise real world elements using both physical and mental tools such as the computer itself, and representational symbols and language. This context would also constitute the foundation for how humans transform mental representation of an activity into an external activity. Thus, in an HCI-related context a human-computer functional organ would require tool-related competencies, knowing about the tool’s functionality and operating procedures, but also task-related knowledge about the functional limits, i.e. recognising what would be pos-

8. Man-Computer Symbiosis. IRE Transactions on Human Factors in Electronics, HFE-1 4-11. (Licklider, 1960)

sible to achieve, i.e. being dependent on goal and ability to situate the various possibilities that the functional organ provides into the structure of activity, which would indicate that internal processes guide functional organs. According to Kaptelinin, this internal guidance might also be mediated, necessitating the development of new internal skills to master the new tool (Kaptelinin, 1996b, pp. 21-22; Kaptelinin and Nardi, 2006, pp. 64-65).

The activity theoretical concept of *internal plane of action* is defined by Kaptelinin as "[...] a concept developed in activity theory that refers to the human ability to perform manipulations with an internal representation of external objects before starting actions with these objects in reality" (Kaptelinin, 1995b, p. 51), a process termed the *orientation* phase (Leontyev, 2009; Kuutti, 1995). Kaptelinin views the user interface as an extension of the internal plane of action, and by letting the user interface become an extension of the internal plane of actions, it becomes a part of what activity theory describes as a functional organ, introduced by Leontiev (2009), and described as the necessary combination of human capabilities and external artefacts facilitating the accomplishment of goals (Kaptelinin, 1995b). Kaptelinin defines functional organs as "functionally integrated, goal-oriented configurations of internal and external resources. External tools support and complement natural human abilities in building up a more efficient system that can lead to higher accomplishments" (Kaptelinin, 1995b, p. 50).

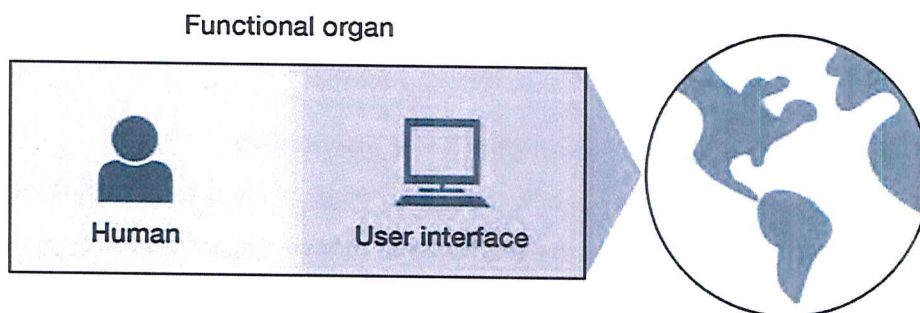


Figure 5. Functional organ. The user interface as an extension of the internal plane of action, forming a human-computer functional organ (Kaptelinin, 1995b, p. 50).

Another dialectical approach to the relation between subject and tool, as a framework for designers building the mediating tools is presented as The Human-Artifact model by Bødker and Klokmoose (2011). This model calls for a ‘theoretical framework to address the gap between culture, experience, and the practical role of artefacts in embodiment and mediation’ (p. 318). The model’s notion of reciprocity describes how human operations are inscribed into artefacts that gradually transform both humans and artefacts in a dialectical development process, where skills are acquired, and goals are transformed according to the accumulation of agency, and provides a framework for theorising around “the dialectics between the whole of the use of an artifact in relation to activity, and its parts” (Bødker and Klokmoose, 2012, p. 101), focusing on action possibilities related to levels in the activity hierarchy, grounding the analysis from the three perspectives of human activity. The model is might help designers to inform their work, and shorten the distance to theory, by focusing on the questions: *Why?* - as related to the motivation for the activity, *What?* - as related to the goal of an action, and *How?* - as related to the single operations within a use-activity (Bødker and Klokmoose, 2012, p. 100). For designers occupied by designing “good UX”, the model's focus on the relation between the user's expectations of interaction possibilities, and what the designers' intended possibilities of use, i.e. the expectations among tool-competent users versus the planned use pattern inscribed in the artefact (Bødker and Klokmoose, 2012, p. 101).

2.6 Activity theory and human-computer interaction

The ‘human factor’ in HCI analysis was previously process- and task-oriented (Card et al., 1983), by focusing on people’s interaction with computers, achieving goals without considering typical human aspects such as an underlying *purpose* to act, what the task would *mean*, or *reflections* over the potential achievement, i.e. *why* and *how*

they interact, and the context within which they act (Kaptelinin, 2015; Kaptelinin, 1992). The cognitive science approach to human-computer interaction, viewing humans as *information processing units* had been the foundation of HCI research. Within the approach of information processing psychology, it would prove difficult to guide the design of usefulness, usability and recently, user experience. The activity theoretical perspective of interactive action extended the cognitive science approach with its quantitative view of humans, as just a set of attributes, and its opposition to the vision of humans as thinking, reflecting and participating actors with needs, and objectives, was discussed by Bannon (1991, pp. 27-29).

The considerations of an activity theoretical approach to HCI grew out of the notion of a need for analytical tools in the direction of a human activity discourse. During the last couple of decades the number of computing devices that affect human activity, whether being in contact with the public through a website, paying bills in an online bank, operating the alarm-setting panel in their home, or being at work doing vocation-specific tasks, has increased considerably. The number of contexts in which humans use screen-based computing devices to mediate both tasks at work and during leisure, show that the number of functional elements in screen-based user interfaces acting as mediating tools that represent possibilities for operations and actions, and in turn activities, has, to a large extent become ubiquitous, in what Kaptelinin refers to as the age of computer-mediated activity (Kaptelinin, 1995b).

Activity theory was, initially, brought into the human-computer interaction discourse by Bødker (1991), and Bannon (1991; Bannon and Bødker, 1989). During the last two decades, activity theory has become a growing and central post-cognitivist approach and concept in HCI research. The main body of activity theoretical literature, related to HCI, has continued with important contributions from e.g. Kuutti (1995), Kaptelinin and Nardi (Kaptelinin, 1995b; Kaptelinin, 1995a; Kaptelinin et al., 2003; Kaptelinin and Nardi, 2012a; Kaptelinin and Nardi, 2006; Kaptelinin and Nardi, 2018), and Bertelsen (Bertelsen and Bødker, 2003) to name but a few.

Bødker states that “a computer application, from the user's perspective, is not something that the user operates on but something that the user operates through on objects or subjects of interest in the work activity. In other words, human beings operate through computer applications, as well as other tools, on materials that they are turning into products with the help of others” (Bødker, 1989, p. 173).

However, there are situated contexts where the user interface ceases to be transparent, e.g. during moments of breakdowns, when the mediating tool becomes visible during our reflections over the character of the breakdown, and adjustments of the user interface. Bødker discusses three possible, basic instances of human-interface relations (Bødker, 1991, p. 38): first, when the objective only resides within the computer artefact. Bødker mentions a spread sheet as an example, that in itself has no direct relation to objects outside the computer, with the argument that a print-out of the spread sheet would not have the same functionality as the spread sheet in the computer. Another example could be a 3D object, that in itself would not have a direct relation to physical objects in the real world other than the visual representation. A print out would, similar to the spread sheet, not have the same capabilities as the computer version. Second, when the objective exists in the real world, but is present exclusively as an activity in the software. Bødker discusses the use of a word processor as an example, where the object is a letter which, at least prior to print out, exists only within the use activity, mediated by the computer, where it can be edited. Another example, closer to this thesis, would be ORCA, the software that has been part of the research. Here the object, a successfully stowed chemical tanker is a physical object, while the use-activity of stowage planning is only present ‘on the screen’. The user interface is the mediator between the object of the use-activity and the object in the real world, and that it is *how* the user interface relates to the process of coupling the final object and screen object, i.e. between the object-oriented use-activity on the screen and the physical object which determines the qual-

ity of the user interface in this specific constellation. This relation is elaborated in ch. 7.8 (Mediation in ORCA). According to Bødker, the third type of situation, occurs when the object exists, physically, outside the artefact but is controlled by operating the artefact, such as e.g. a control panel (Bødker, 1991, p. 38). An example of this type of situation is the physical stowage process of a chemical tanker as it happens when the ship is at the quay. This is done by the maritime staff on board by manoeuvring physical pumps and pipes. This is done by operating physical artefacts such as control panels with knobs and levers. However, this part of the stowage process is outside the scope of analysis in this thesis, and will not be elaborated further.

Within the discourse of information systems and human-computer interaction research, activity theory is described as a framework that acknowledges several perspectives regarding flexibility and contextual awareness. A theoretical framework that considers whole systems of organisations, work practices, technology and artefacts, but also the cognitive capacity of individuals, with all of their culture, history, experience, understanding and contextual complexity that goes into the tasks we, as human agents, undertake or must relate to, in our quest to fulfil our needs or reach our objectives. Thus, it is well suited as a theoretical lens for analysing the character of activity in a human-computer context as it provides a methodological approach and the tools for understanding patterns in the context of goal-oriented human use of technology (Kaptelinin and Nardi, 2012a). It is a framework that recognises the transformational processes of internalisation and externalisation, and the related concept of mediation (Vygotsky, 1978; Leontiev, 1978), including the character of development that is related to internalisation and externalisation connected to human activity, and in increasing numbers, the process of internalisation and externalisation that is computer mediated (Kaptelinin, 1995b). Activity theory is especially suitable as an analytical tool in a human-artefact interaction context since this

relation is, by definition, always mediated, and therefore is particularly suitable for HCI “exploration” (Kaptelinin et al., 1995, p. 190).

Wertsch claimed that human-machine systems appear as primarily an extreme version of the human-environment interaction term, and that HCI is no more than one kind of human-environment interaction, where humans interact with mediated tools rather than other people (Wertsch, 1981, p. ix). However, these reflections were made ahead of the period where activity theory was brought in as a potential theoretical framework for HCI (Bødker, 1991; Kuutti, 1995; Nardi, 1995b; Bannon, 1991; Kaptelinin, 1995b). Nardi, says: “We have recognized that technology use is not a mechanical input-output relation between a person and a machine; a much richer depiction of the user's situation is needed for design and evaluation” (Nardi, 1995a, p. 8). Kaptelinin would argue that due to the special character of the user interface as a mediating tool, humans, rather than interacting with the computer, would interact with the world - and other humans, *through* it, thus describing human-computer interaction as being primarily computer-mediated activity (Kaptelinin, 1995b, pp. 49-50).

In an activity theoretical approach to HCI research, *activity* is the primary theoretical construct, and represents a relational context in which a [human] subject interacts, physically or mentally, with an object, positively existing in the world (Leontiev, 1978). The notion of context in activity theory provides a room for discussing human use of user interfaces based on human activity in a specific context that includes connected aspects, such as a motive, goals, needs and conditions, and also previous experience and the user's ability to undertake situated actions. This relationship is characterised by the subject's needs being met through the subject's interaction with the world, where the subject's activity towards an objective, and world and mutually influence each other (Kaptelinin and Nardi, 2012a).

Focusing of the structure of activity itself, Kuutti explains, “An activity is a form of doing directed to an object, and activities are distinguished from each other according to their objects. Transforming the object into an outcome motivates the existence of an activity. An object can be a material thing, but it can also be less tangible” (Kuutti, 1999), and describes activity theory in a wider perspective as a philosophical framework endowing a multitude of perspectives in studying human agency, whether this agency, both procedural or developmental, as individuals or as members of an organisation or society, underlining the tool approach of mediation (Kuutti, 1995, p. 25).

These are key elements in the discussion about the activity theoretical structure, since the theory's ability to absorb various aspects of human agency in a socio-technical context is formalised through a conceptual framework that must be made strong enough to encompass both humans and technology within the same conceptual models (Kaptelinin, 1995b). The different levels of the hierarchical structure of activity in activity theory allows for evaluating single elements, or categories of elements in the structure based on context or perspective, related to the varying goals of actions, differing associated conditions (Zinchenko, 1981). According to Kaptelinin, this could affect design choices and strategies for skill acquisition, and facilitates an understanding of the computer as a mediating tool strongly influenced by both social and cultural elements, and hence an awareness for technological and contextual differences, both socially and culturally (Kaptelinin, 1992).

Within an activity theoretical HCI/computer-mediated activity framework, the unit of analysis regarding intuitive interaction in user interfaces would be focusing on actions and operations in the interaction context with the user interface, and how skills and expertise are utilised. All human-computer interactions are mediated

by the user interface, thus user interface mediation revolves primarily around the contextual relations between human and computer, on operations and actions level.

As a conceptual framework, activity theory is a valued lens in qualitative approaches (Ejeld et al., 2002), as it provides a method for finding and analysing patterns of operations, actions and activities, by its inherent and integrated repository and system of terms and language. Activity theory facilitates an understanding of an activity as a subject's purposeful interaction with an object through the use of a mediated tool, *and*, the subsequent transformation and development that emerges on the various levels of activity, action and operations, from the interaction (Leontiev, 1978).

2.7 Affordances in activity theory

Mediated affordances in the user interface explain how the user interface artefacts are to be used or operated. This proposes the concept of a, per-element, 'user guide' as an inherent part of the user interface, and not solely as possibilities for action that lie in every object.

Kaptelinin and Nardi's concept of handling affordances and effector affordances, where they split the affordance concept into affordances that facilitate possibilities for handling *with* the technology—namely *handling affordances*, and *effector* affordances that specifies possibilities for acting *on* the technology, which combined will facilitate the possibility of acting *through*, (Kaptelinin and Nardi, 2012a) shows that functional user interface artefacts ought to be regarded as more than just 'symbolic communication', i.e. as mediated affordances. Mediated affordances are artefacts that afford, not only motivated [inter]action. According to Kaptelinin and Nardi's discussion of handling affordances, mediated affordances also encompass a how-to func-

tionality, through mediated abstractions in a user interface, following their concept of learning affordances (Kaptelinin and Nardi, 2012b), which creates an immediate understanding in performing tasks through ‘abstracted tools’ in the user interface.

While Bærentsen and Trettvig (2002) focus on a general activity theoretical approach to affordances, the approach of Nardi (1995a), Kaptelinin and Nardi (Kaptelinin and Nardi, 2012b), and Kuutti (Kuutti, 1995) is centred around the various diversities and incompatibilities regarding the use of the affordance concept within the HCI discourse. They do this by pinpointing the main limitation in Gibson’s framework in an HCI context, stating that ‘it lacks an appropriate conceptual apparatus for understanding technologies as a special type of object, that is, tools mediating human interaction with the environment’.

Affordances are not objects in themselves, but represent, through the visual character of the objects, instructions on how the objects are to be used. Again, a central aspect of user interface elements is *use*. If an affordance represents an instruction for use, it must also be an element in facilitating intuitive use of user interfaces. This must be situated in a goal directed, human activity centred, vocational context. This is also supported by Bødker who states that, ‘The user interface cannot be seen independently of the goal or object, or of the other conditions of the use activity’ (Bødker, 1991, p. 141). This supports the argument of a task- or activity-based understanding of what constitutes intuitive use of user interface elements.

We might regard all interfaces, analogue and physical as well as digital, as some kind of mediating tool through which people might perform work or communicative activity. A screen-based user interface can, then, be regarded as a framework for mediation; a mediated whole, in which to situate functional elements and the

adhering affordances that might be linked to them in order to give the user the possibility, or sense, of immediate understanding.

Leontiev describes this inscription of behaviour as crystallisation, and argues that artefacts are crystallisations of modes, methods and operations of use, and not activity and goals (Leont'ev, 1974, p. 26; Leontiev, 1978, p. 102), bearing a certain resemblance to the notion of 'affordances' (2002; Gaver, 1991; Gibson, 1977; Kaptelinin and Nardi, 2012b; McGrenere and Ho, 2000; Norman, 1999).

Just as our world evolves, the terms we use to describe it should evolve with it. In the networked and digital modernity that most of us live in, screen-based user interfaces are ubiquitous. They have become a natural and almost transparent part of both our private and professional life. Therefore, leaning on, e.g. Kaptelinin and Nardi (2012b), and Gaver's non-static sequential affordances (Gaver, 1991), observing that also screen representations like buttons, sliders, metaphors or abstractions of real-world objects, represent affordances as well. A button affords clicking. A slider affords sliding. Even as elements on a screen, mediated as they are, they afford goal-directed use-activity–actions. They are what Kaptelinin and Nardi coin as mediated affordances (Kaptelinin and Nardi, 2012b). This is also supported by McGrenere and Ho, who argue that a screen element that affords acting upon is 'an affordance that is built into the software' (McGrenere and Ho, 2000, p. 6).

2.8 Chapter Summary

In this chapter I have presented activity theory, its historical roots and central tenets. I have described its basic principles, with the concepts of object orientation, pointing towards the underlying motivation for the activity, and how the process of human activity is divided and distributed in a hierarchy of levels, showing how an

activity consists of actions—consciously chosen sub-tasks, which in turn are undertaken by a string of single operations, tasks that could be undertaken unconsciously; mediated by mental and physical tools towards the achievement of a primary goal. Also, the notion of functional organs, that within the context of computer-mediated activity is a key concept, is presented, followed by a review of a core collection of the literature within activity theoretical HCI.

Mediating thoughts and streams of actions.

Complex intuitive interactions
in a skilled worker environment.



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