Hermeneutical Studies for Human-Engaged Computing: Theoretical Justification, Practical Reflections, and Next-Generation User Interface Design

by

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Author's Preface

With this preface, I would like to talk about the writing motivations of this doctoral dissertation in a sincere tone - that is, the confusion and thoughts I have encountered in the entire process of my doctoral study and even up to the present life experience.

Although my undergraduate and master's degrees were in software engineering, my real interest has been in design, and this has become increasingly clear, regarding all kinds of design. There may be two main reasons for this. Firstly, my accumulated interest in sculpture from a young age has given me preliminary experience and personal fulfillment in the creativity and aesthetics, leaving me with a persistent obsession and primal urge to create something of my own. Secondly, due to this interest, I have become more curious about what the sources of inspiration are for those landmark creators, and why "good" things are good, whether they are in the form of art, products, or some kind of structure. By exploring how to "understand" them, I also hope to find my own style and system of thinking, in order to create my own work - to find and express the hidden beauty of orders underlying complexity and phenomena. This may be the common urge of all those who are passionate about intellectual activities. These two preliminary reasons combined have always given me an overly divergent curiosity, so from the undergraduate stage to the present, I have been exposed to and learned about many fields that are not very relevant to my main profession, from industrial design and automotive engineering (originally planning to take the cross-disciplinary postgraduate entrance examination, but later this in-depth understanding has influenced me to rethink the philosophy and aesthetics of "software engineering"), to preliminary enlightenment in design, architecture, literature, classical music, etc. (this is closely related to my learning experience in Japan, understanding why those symbolic creators like Kenya Hara, Tadao Ando, Haruki Murakami, Seiji Ozawa, and Ryuichi Sakamoto can be so influential). These interests, combined with my main profession of software engineering, have also led me to proactively identify HCI and my first research topic - computational aesthetics - as my research field.

But from the above, it can also be seen that my "self" will is always very prominent, with "the five aggregates ablaze, inverted dreams/五阴炽盛，颠倒梦想" using Buddhist terminology. Because I always feel that there is a subconscious urge, after all, life is but a moment, and with the continuous contact with external books and ideas, I still hope to connect and understand a little bit with these "beautiful" and "good" things, rather than completely acknowledging and being submerged in the high standards of reality, and this so-called reality always feels a bit off. This has actually become one of the basic awareness and motivations for my willingness to research HCI and HEC - although there are many excellent studies and products, they could still be better. If I accept this reality as the true art and ideal, my "self" will be very uneasy, because this has a hint of abandoning thinking. As for how to make it better, this is the problem I have been pondering day and night. But perhaps due to my growth experience, I always have a high sense of insecurity and anxiety within me, eager to pursue as much knowledge and understanding as possible, including up to now, always feeling that there is still too much material to read, hoping to find better words, answers, and liberation from it; but the more I think, the more divergent, dragging, and tired I become, acting hastily and judging too quickly, it is difficult to coordinate the relationship between thinking and reality. This is the cost of persisting in the clash between "self" and "reality", this "divergent curiosity" has led me to experience many lessons and pains, and is also my personal reflection on the "Intellect" human capacity mentioned in my research.

If the above is a kind of unconscious divergence and experience from my own personality, then from 2020 onwards, I have entered a chaotic stage of reflecting on "how I should live". My mother's sudden passing forced me into this transformation, although the seeds were sown long ago with my father's. This transformation suddenly made me realize that when the original "spiritual protection" from the outside world is no longer there, I now have to face a "dark forest" alone, but I have no understanding of this "self", "people" and "the outside world" - not in the understanding of a certain phenomenon - why emotions are uncontrollable, why some people can be rational, but why there are so many irrational behaviors, why seeking "truth" is not the pursuit of reality, because there are too many phenomena. Instead, I want to see the underlying reasons behind the phenomena, as an internal support to do things, to live, or to avoid, so that as an individual, I can at least alleviate some of the anxiety and uncertainty. To explain it in the words of the humanist Yang Zhao that I often listen to about "existentialism," if I used to only seek answers for the Questions that interested me, now I must seek a Solution for the Problems of my life, or else I cannot function at all. Therefore, I deeply resonate with the statement by Camus: "There is but one truly serious philosophical problem and that is suicide."

External stimuli combined with internal characteristics have led me to experience and reflect on many things in these chaotic four years, including understanding that most people - including those symbolic creators - are actually very anxious (which is also part of the phenomenon). After perceiving various social phenomena, I have found that even though most people are good, why do things go wrong? In an era where material abundance is great, why are so many problems still unsolved? If this is a systemic issue, where is the root? Where is the root of the pervasive suffering, impermanence, and inequality in the world? There is not a small and specific problem here. If not thought about, it seems it won't affect my real life, but between dealing with nothingness and avoiding pain, perhaps it is a 'not to want to commit a mental suicide' that makes me choose to deal with nothingness. I don't want to simply attribute these issues to the complexity of humans or the resolution of problems to human rationality, but I want to find an explanation that is more convincing to myself, even though it involves a lot of thinking and physical pain. Of course, this kind of pain is not entirely negative for me, because without these experiences, from a knowledge perspective, I might not fully understand the significance of those philosophical and ideological nodes. This is a valuable, personal connection to people behind knowledge and language; including in this process, I have received a lot of help (please see Acknowledgment), which has given me the opportunity to further understand what kind of existence "wisdom" of humanity is for "knowledge" - these form the core interpretation of this article - "Biophysics-Intellect-Xin."

So to come back to the topic of this dissertation, the reason why I value HEC so much is not just due to a design interest but because I see the potential of ideas in improving the relationship between individuals and society, and the possibility of being involved in it. However, if we want to develop it from the perspective of ideas, truly understand and solve human problems through technology, and make it a true theoretical foundation for HCI and technology, we need to construct a systematic approach. We need to see the current position of HCI in the history of ideas, understand that technology is never just a technical issue, and connect with the spirit of everything, "to find and express the hidden beauty of orders underlying complexity and phenomena." I have also questioned whether this is too idealistic or metaphysical, but one day when I saw the humanities scholar Prof. Liqun Qian say, "...the fundamental responsibility of intellectuals is to create utopias, not just criticize, but to provide society with new value ideals, new development

models...,"[1] I suddenly realized that not everyone exists for some kind of "idealism," which gave me some reasons to counter my own doubts. Regardless of what we/HEC can actually change, without this basic idealism, without the ability to discover something better, and treating all current limitations as the only "reality" without considering the "ought," research cannot even begin.

All these factors have shaped me, accepting my own experiences, using myself as a method and analytical subject, combining observations and reflections on HEC, HCI, overall technology, and social phenomena over the past few years. I have organized my notes as systematically as possible into the *problématique* of this doctoral thesis, the stage framework and answers, and my own healing process - hoping to reach a state where "I have nothing more to say." It is important to emphasize that these experiences, which are organized and developed based on HEC as a pivotal framework, largely stem from Prof. Ren's support and collaborative efforts. This includes many discussions among various conferences and speeches, both large and small, online and offline, within and outside of our university, as well as continuous writing (e.g., the paper in Science & Technology Review, the HEC book draft in both English and Chinese). This Preface is actually an early supplementary explanation for 3.1.1 "Self as Method." To clarify and develop HEC, this dissertation should not be approached solely as a scientific report but should also embody characteristics of a humanistic essay (Bardzell & Bardzell, 2015). This serves as a medium for my thought process and aims to establish an interpretive system for HCI that includes, but is not limited to, scientific explanations. Despite I constantly remind myself to stay connected to real human life, many people are not interested in abstractions, and abstraction and knowledge cannot save human life. However, sometimes I have no choice but to stick to my writing style because it will help me derive the technological forms of Engaging Computers or MIRROR.

Of course, I must also say that I have not been able to fully practice what I have written in my real life, including often also avoiding in daily work. I think this is partly because I still lack a full understanding and experience of this subject, and partly because I still need some time to digest and organize these issues, which are not so simple. But this is not a doubt about HEC and our work. In this learning process, after seeing the different interpretations of social issues and technological development given by different people, I am more and more convinced of the value of the answers we have provided, whether it is The Thought System, or in the consideration of the future technological architecture of The Computing System. Our work could contribute to the freedom of the human Xin, the peace of the world, and the pursuit of an ideal and artistic form for technology.

In the process of learning Eastern thought and history, I deeply feel the spiritual essence of Sima Qian's writing of the "Records of the Grand Historian": "Investigate the relationship between heaven and man, understand the changes of past and present, and establish one's own perspective." I naturally do not dare to compare myself to this level, but I do hope that this dissertation can serve as a response: Faced with the increasingly complex reality of today, I can no longer project my own confusion onto the "visions" given by leading technologies, enterprises, research, and elite politics, but rather need to try to see more systematic answers myself, to break through the entanglement and troubles with my own problems and professional subjects, which is a reckoning with Professor Ren and myself, and can also be called a preliminary HEC manifesto.

Finally, the theoretical completeness of this dissertation may still need some time, as there are still many materials to be read and supplemented, and some points may be somewhat immature (of

[1] https://youtu.be/d6X3L6VEt3g?si=5BFHxThRWD3V6uB9

course, our writing can only be a self-interpretation and contemporary interpretation of others' thoughts, and we cannot fully understand others). My intention is not to do any overinterpretation or word games, but only to say that by writing it down, there is a possibility to move forward. Our overall direction should be correct, and we welcome everyone's critique. As the main framework continues to take shape, whether in content or expression, in the next two to three years we will deliver a more satisfactory version, to establish a connection for thinking and integration of HEC in various fields. Following this, the practical and empirical application of the computing system based on this theory will come. On the one hand, we look forward to delivering a systematic blueprint for Engaging Computers or MIRROR. On the other hand, how to truly establish such a research community will need further discussion. As Alan Kay said, "the best way to predict the future is to invent it," and I also hope that this dissertation can contribute to the self-realization of the HEC concept.

Abstract

This dissertation aims to provide a more systematic interpretation of the overall thought of Human-Engaged Computing (HEC) and its five key concepts: Antibiosis, Engagement, Engaged Humans, Synergized Interactions, and Engaging Computers. Our research is guided by perspectives from the field of Human-Computer Interaction (HCI), to explore the essence behind various technological phenomena and historical developments. By combining the problems faced by individuals and society in today's highly technologically advanced world, and the future ideal relationship between humans and computers, we ask: Where are humans heading? What kind of technology do we need to achieve this vision? Thus, HEC is aimed at to bridge humanistic thought and technological development for establishing a macroscopic theory. Our approach involves organizing a wide range of multi-disciplinary perspectives and reflecting on how Western dominant thoughts have led to the overdevelopment of human Biophysics and Intellect meta-capacities, while introducing Eastern concepts of "Xin/心" as a way to the transcendence of humanity - a neglected essence and experience that may guide us out of current difficulties. This dissertation leads to two critical contributions: The Thought System, which demonstrates the theoretical justification of HEC in analyzing ideal human-computer relationships; and The Computing System, offering potential design ideas for future computer forms, with the goal of providing directional inspiration for the development of human-computer interaction and related information technologies.

We structure this dissertation as follows:

(1) *Problématique*: To explore the relationship between current HCI and individual, societal, and overall human issues, we first review the developmental history of HCI at the level of understanding human-computer relationships (its enlightening nature surpasses its utility). This leads to the theoretical position of HEC, with corresponding content in Chapter 1, 2, 3.
(2) Theoretical Justification of HEC: We integrate HCI with perspectives from various fields to try to discover the patterns from the history of ideas. Especially through contrasting core ideas of Eastern and Western thoughts, we develop a framework for understanding humans centered around "Biophysics-Intellect-Xin." Based on this, we provide a legitimate interpretation and extension of the deeper reason and root cause of Antibiosis, and the core concepts of HEC - Engagement, Engaged Humans, and Synergized Interaction - with corresponding content in Chapter 3, 6.
(3) Practical Reflections and Envisioning Next-Generation Interfaces: By reviewing our cases in GUI Aesthetics and Information Interaction, we interpret our contributions from an HEC perspective and reflect on potential core understanding issues in HCI Aesthetics and Information Interaction. Corresponding content in Chapter 4. Regarding the interpretation and design of specific Engaging Computers, we have constructed an initial prototype based on the content expressed by The Thought System, with corresponding content in Chapter 5.
(4) For the Conclusion and Contribution of this dissertation, please refer to Chapter 7.

Through the interpretations and derived reflections above, this dissertation hopes that HEC can become a point of convergence that integrates multi-disciplinary perspectives to explore the trajectory of human destiny and technological development. It aims to identify the fundamental threads of human issues amid the myriad external phenomena we face today. By viewing technology as a formal carrier of Eastern and Western wisdom to expand its possibilities, HEC

seeks to realize the wholeness of human capacity through the subtle interactions between countless individuals and technology, while exploring the potential for genuine freedom and world peace.

Keywords

We consider HEC as an iterative work, continuously enhancing its normativity and rigor throughout the process, involving the understanding of many fundamental keywords. Therefore, here, we aim to write this dissertation in a more structured manner, providing predefined definitions for many of the keywords involved. We also seek to avoid the pitfalls of language games as much as possible.

For the sake of readability and to reduce ambiguity, we hereby provide a summarized description of the keywords involved in this dissertation. We adopt a method similar to defining variables or structures in programming to correspondingly clarify the scope and attributes of certain keywords.

I and We: As a doctoral dissertation, the author naturally is Chen Wang. However, for the interpretation and construction of the HEC theory, "we" refers to a broader set of authors, including Prof. Xiangshi Ren, Chen Wang, and the Center for Human-Engaged Computing. The usage of these terms may vary depending on the context and is not meticulously distinguished.

Human-Engaged Computing {

Thoughts vs. Philosophy: Here, we refer to a systematic set of thoughts as "thoughts" (not necessarily articulated), explaining and guiding a series of concepts and actions, including impacts on various fields. In the context of this dissertation, this involves macro-level Eastern and Western thoughts, including the Human-Engaged Computing we expound on, which is primarily a type of thought. Regarding the difference between thoughts and philosophy, traditionally, a philosophical system needs to include necessary components like ontology, epistemology, cosmology, or corresponding writing styles. Due to its specialized or extensive nature, this dissertation tends to refer to the knowledge-based (articulated) aspect of thought as philosophy (reflection). Anyway, they share the same spirit, so this dissertation does not make a specific distinction, using "HEC" or "HEC Thoughts" as a broad expression.

Theory: Human-Engaged Computing can be seen as a theory originating from the HCI or Computing fields, addressing issues ranging from technical philosophy to technical design. Therefore, "HEC Theory" specifically refers to its expression in HCI and technology, relatively narrower compared to "thoughts."

Framework: A framework can be seen as a structured set of thoughts, divided into two in this dissertation: the original HEC framework, comprising five Concepts: Antibiosis, Engagement, Engaged Humans, Engaging Computers, and Synergized Interaction; and the Engaged Humans understanding of human structure, namely "Biophysics-Intellect-Xin."

Concept: Abstract knowledge that summarizes a certain type of phenomenon. In the context of this dissertation and HEC, it mainly describes units for Antibiosis, Engagement, Engaged Humans, Engaging Computers, and Synergized Interaction. Contrary to the slightly engineering-focused "Component" used in the original HEC, "concept" is more general.

Idea: Involves "intuitive perceptions, associations, or inferences" about things. In the context of this dissertation, it mainly refers to various thoughts on technology by peers, such as Human-Computer Integration.

Method: More flexible, such as the design guidelines we propose, tending to be localized.

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Antibiosis: Divided into Phenomena (Section 3.2.1), Deeper Reason (Section 3.2.3), and Root Cause (Section 3.4.1).

Scoping (Problematic & Contribution): Categorized into Microscopic, Mesoscopic, and Macroscopic levels, please refer to Section 3.2.1, Chapter 7.

Capacity, Capability, Potential: Please refer to Section 3.2.2 & 3.3.1.

The Goal of HEC Value/Synergized Interaction: Realizing the Wholeness of Human Capacities, please see Section 3.4.2.

Designer: The readers advocated in this paper are collectively referred to as designers, without further distinction between researchers, designers, developers, etc. Similarly, we primarily use "design" to describe activities, without further distinction between research, design, and development, etc.

HCI, Computers, Computing, Technologies, & Artifacts: On a superficial level, these terms refer to macro technologies and designs involving humans, sharing essential qualities, progressing accordingly; depending on the context, they may be used interchangeably.

On a deeper level, although there are some distinctions in scope, technology and science are intertwined and cannot be simply separated in a binary manner. While we continue to use these five terms to address related issues, our spirit is one of "**Useful Knowledge**," meaning that a concept can interconnect with real human needs, knowledge, economy, technology, and various other aspects to create significance. This term was first used by Nobel laureate in economics, Simon Kuznets, in discussing the modern sources of economic growth and the systematic theory primarily stems from economic historian Joel Mokyr's work on the knowledge economy and the Industrial Revolution (Mokyr, 2011).

Engaged Humans & Human Capacity Framework {

Biophysics {
Ideological Foundation: Darwin, Freud
Human Factor/Quality: Behavior, Cognition, Emotion/Instrumental use, Experience
Human-Type: Natural Humans
Antibiosis: Polarization
Survival Principle: The Pleasure Principle
}

Intellect {
Ideological Foundation: Kant, Adam Smith, Descartes, Max Weber, Karl Marx
Human Factor/Quality: Constructive Intelligence/Knowledge, Judgement, Identity, Instrumental Rationality

Human-Type: Constructive Humans (Rational Humans, Social Humans, Cultural Humans, Economic Humans)
Antibiosis: Alienation
Survival Principle: The Reality Principle, Outward Transcendence
}

Xin {
Ideological Foundation: Confucianism, Buddhism and Taoism (Xin/心; sharing a similar inner spirit with primitive Christianity)
Human Factor/Quality: Awareness, Initiative, Enlightenment/Original Position, Positive Liberty, Mindfulness, Aesthetics, Empathy, "Passion"
Man-Type: Transcendent Humans
Limitation: Difficult to formalize
Survival Principle: The Ideal Principle, Inward Transcendence
}

Downward Spiral of Hybridization: Polarization + Alienation

}

Contributions: **The Thought System** (Antibiosis, Engagement, Engaged Humans, Synergized Interaction) & **The Computing System** (Engaging Computers). The two actually overlap in interpretation.

Justification vs. Legitimacy: Mainly refers to the arguments supporting the establishment of HEC. I ultimately chose the former term "Justification" because it tends to describe the various prerequisites of a theory being in place, while the latter term "Legitimacy" leans more towards arguments based on the will of human society in legal or political discourse.

Chapter 1: Introduction

Drawing on an understanding of the current development of HCI and technology, this chapter will preliminarily unfold the *problématique* of this dissertation. This is also the motivation behind HEC - namely, what the dilemma that HCI and humanity face is, and what the underlying reasons HEC attempts to analyze are, and what HEC can do. Subsequently, this chapter introduces the aims and structure of the dissertation. I am well aware that I am discussing a macroscopic, and perhaps not very concrete, grand issue, but this is not merely a philosophical problem. It is a question that everyone will sooner or later have to contemplate.

1.1 Background: HCI and Its Dilemma

As the digital wave has extended into various aspects of human life in recent years, Human-Computer Interaction (HCI) has gradually moved from being an unfamiliar professional term to entering people's vision. Terms like "interaction," "experience," "design" are increasingly becoming common keywords in technological reports. User evaluations of digital products now focus more on their direct interaction experiences rather than specific technical parameters or algorithms. With the continuous expansion of Information and Communications Technology (ICT), in today's society, the vast majority of people can use various forms of computer devices such as smartphones anytime and anywhere. This includes the support of various HCI theories and technologies, from visible elements like WIMP (Window, Icon, Menu, Pointer) to invisible interaction systems like usability and user experience design. HCI has expanded from the narrow sense of single-user-machine or multi-user-machine interactions to the infrastructure for human interaction with the broad information space, deeply intertwined with modern human life. Especially since 2020, we have seen more and more major technological concepts continuously being proposed - such as Artificial Intelligence, Large Language Models (LLM), Embodied Intelligence, Quantum Computing, Metaverse, Web3, Non-Fungible Tokens (NFTs), Brain-Computer Interfaces (BCI)[2], Spatial Computing[3,4]. This also includes some government-led technological and social concepts such as Japan's Society 5.0[5], Moonshot Program[6].

However, despite these technological visions all carrying the slogan of "Make the World Better," amidst this progress, we seem to witness individuals and society experiencing increasingly real troubles. On a micro level, from many individuals' addiction experiences of smartphone or gaming, privacy breaches (Milano et al., 2020), mental fatigue, echo chambers (Jamieson & Cappella, 2008; Sunstein, 2006), distraction (D Griffiths et al., 2012; Eyal, 2014; Olson et al., 2022), to societal and group-level abuses of technology, online trolling (Phillips, 2015), widespread dissemination of fake news, and the technological innovation bottlenecks and diminishing marginal effects faced by businesses. On a macro level, there are various uncertainties threatening the overall human survival, whether it's the crisis of meaning for humans due to new technologies like AI, or the common challenges on economic and sustainable stagnation, issues of identity and populism, and even

[2] https://www.reuters.com/science/elon-musks-neuralink-gets-us-fda-approval-human-clinical-study-brain-implants-2023-05-25/

[3] https://www.apple.com/newsroom/2023/06/introducing-apple-vision-pro/

[4] https://www.apple.com/newsroom/2024/04/apple-vision-pro-brings-a-new-era-of-spatial-computing-to-business/

[5] https://www8.cao.go.jp/cstp/english/society5_0/index.html

[6] https://www8.cao.go.jp/cstp/english/moonshot/top.html

geopolitical conflicts and the chaos revealed during the pandemic process. I cannot cover all aspects of these two opposing sides (developments and problems) comprehensively, but these problems are not as simple and scattered as they may appear. I just want to ask - maybe many people also intuitively experience this conflict - what is the root of these problems?

Whether it's HCI or tracing back to the broader history of Human-Machine Interaction (HMI) and Media, it can be seen as a history of the transition into the information age. In a world of high-density development of computation and information, where all these problems are directly or indirectly connected to HCI, what role does HCI play in all of this? This is the dilemma that current HCI faces, a fact that we cannot avoid. As HCI and even as technical researchers, what is the significance of our work in the face of these challenges? We need to approach these problems with a more macroscopic perspective, not only to explain the primary issues and secondary problems arising from technology in solving them, but also to explore what an ideal relationship between humans and technology might look like, striving towards finding solutions with this goal in mind. Such a *problématique* from HCI is hard to come by in purely humanistic or technical fields, because it requires balancing both human and technological aspects, constructing the reasonableness of a certain technology or research through humans or society as a pivot point. However, the reality seems to be not so straightforward, prompting us to rethink the theoretical foundation questions about HCI and even the entire technological system.

1.2 A BIG Why: How HCI Ought To Be?

The understanding of the dilemma facing HCI leads to A BIG Why: How HCI Ought To Be? As Herbert Simon stated: "Natural science concerns itself solely with how things are, whereas the sciences of the artificial are concerned with how things ought to be (Simon, 2019)." HCI cannot be viewed through a purely scientific lens; it is a combination of science and humanities - including human patterns, will, experiences, contexts, needs, cultures, morals, and values - projecting the basic framework of design in abstract form and manifesting as technology in concrete form. This fact often overlooked in reality.

Therefore, behind the complex and numerous phenomena and problems, the fundamental logic of HCI lies in how we interpret humans, even though this interpretation may not necessarily fall within the current scope of "science." Nevertheless, most notably, Human-Centered Design has led the instrumental development of HCI design as an "ideology" for decades (Bannon, 2011; Kling & Star, 1998; Xu, 2019). Today, all HCI and even AI research can be said to be Human-Centered to some extent. However, this Human-Centered approach in understanding humans is often based more on an underlying utilitarian need that serves commercial purposes. This is evidenced by the background descriptions of aesthetics research in current HCI (Liu et al., 2016; Miniukovich & De Angeli, 2015; Wu et al., 2019). As a result, humans have become means rather than ends, with an ever-expanding demand and consumption of content, supported by this Human-Centered technological bandwidth. The human mind grows different models nurtured by this information, lacking literacy and awareness in the intake of information, while practitioners also fail to critically examine it. Consequently, when we talk about technology, users, and human-centeredness today, we inadvertently create the soil for nurturing problems such as trolling and addiction. These issues at the human mental level are not within the traditional contexts of ICT or HCI theories. Of course, if we continue to evaluate the current information technology industry by the inertia of industrial standards or expect for new technologies to save us from the current predicament, we may choose

to selectively ignore these issues. However, as time accumulates and technological bottlenecks become inevitable, the cost of addressing these human-related issues will undoubtedly grow larger.

Apart from serving as a fundamental tool, another social significance of HCI, computers, or technology in a broader sense is as a form of enlightenment. From the industrial age to the electrical age and now the information age, each wave of new technology not only brings a set of new tools but also impacts societal cognition, which in turn influences and shapes human thinking and educational methods. However, society's understanding and comprehension of new technologies often seem passive and retrospective. For example, it took many years after the invention of the automobile for inventors to realize that it was not just a horseless carriage. In the field of computing, some early computer scientists actively recognized that along with computation came not just a narrow technical skill but a means to potentially develop human thought processes. Whether it's Douglas Engelbart's Augmenting Human Intellect or Alan Kay's Dynabook and other technological concepts, the primary intention was how to enlighten, followed by utility. This mindset has influenced subsequent commercial practitioners like Steve Jobs. These pioneers, beyond designing tools for production and daily life, showcased another way of creating and applying technology - exploring the deep logic of developing human intelligence and thought processes to change how humans learn and think through technology. In a sense, many commercial products and concepts that influence our daily lives are merely byproducts of such a series of thoughts. Nowadays, the enlightening significance of some technological products cannot be denied. For example, products like TikTok have notably enhanced the public's ability in information retrieval, social transparency, and even political engagement. However, as we will further analyze, this is an enlightenment of "quantity." Once a certain stage is passed, issues might arise from this kind of enlightenment. So, what is the true enlightenment today (Pinker, 2018), and how can HCI initiate an enlightenment of "quality"?

From the above, it is evident that our fundamental attitude towards How HCI Ought To Be: HCI is both instrumental and enlightening. In the process of its implementation, HCI must be accompanied by the enhancement of certain human capabilities and, of course, potential problems, which are even the fundamental premise of overall technological development. However, as we observe an increasing diversity in HCI research and phenomena, this awareness is becoming increasingly fragile. HCI's role in technological development is increasingly tending towards instrumentality and empiricism, often serving as a mere embellishment to pure technology (like AI today), drifting towards a form of nihilism in a certain direction. As a result, the industry as a whole has reached a bottleneck in application. It can even be asserted that this confusion is not just limited to many individual projects but also affects the leaders in the field (such as Apple).

In the face of such a profound problems (not limited to HCI), The BIG Why, many thinkers are attempting to provide insights. The philosopher of technology Bernard Stiegler believes that it is through the use of technology as a mediator that humans externalize their memory, accumulate experiences, transcend time and space, and create human societies and civilizations (Stiegler, 1998). However, he has also suggested in recent years how one could imagine an incomputable future, transforming the computing technology of the algorithmic era into incomputable technology - proposing a set of information technology theories... [7,8](Stiegler et al., 2020). However, the specifics of this theory are left for future generations by Bernard Stiegler. On this matter, HCI inevitably

[7] https://fddi.fudan.edu.cn/_t2515/f2/cd/c18965a258765/page.htm

[8] https://cn.ambafrance.org/贝尔纳-斯蒂格勒-警钟已响

needs to contemplate not only how to unravel phenomena but also how to form a philosophy, considering what computation symbolizes.

1.3 Human-Engaged Computing as a Response

The above background has fostered the emergence and development of the Human-Engaged Computing (HEC). Proposed by Prof. Xiangshi Ren, HEC took shape in 2013, with its initial public presentation in August 2016 in the flagship journal Computer by IEEE, formally introducing its concept with the title "Rethinking the Relationship between Humans and Computers" (Ren, 2016), and further structurally supplementing it in the subsequent 2019 paper "Human-Engaged Computing: the Future of Human–Computer Interaction" (Ren et al., 2019).

The contemplation behind HEC mainly stems from two subjective experiences:

(1) The initial trigger for this work stemmed from a note penned by Douglas Engelbart, the visionary who defined the predominant HCI paradigm. In 2006, he wrote to Prof. Xiangshi Ren: "Let's focus our HCI attention on increasing human capabilities to develop, integrate and understand the knowledge required for improving society's survival probability." This challenge prompted Prof. Xiangshi Ren to ponder the philosophical foundations and practical aims of HCI, as well as the relationship between humans and computers.

(2) After a 30-year research and educational career in the field of HCI, Prof. Xiangshi Ren was able to view the development and changes in HCI from a more macroscopic perspective. The former part of his career focused on HCI directed towards specific technological research and development (such as pen-based interaction interfaces, behaviour models, etc.), while the latter part emphasized HCI oriented towards human and societal issues. Simultaneously, he continuously reflected on the limitations of current work in HCI, pondering and exploring the ideal relationship between humans and computers (broadly defined as any artificial objects or technology created by humans).

In past literature, the core theme of HEC has been described as designing engaging computers for high-level wisdom, which enhances our human survival probability and our full potential as humans (Ren, 2016; Ren et al., 2019). As a directional thought, HEC posits that HCI and future computing technologies should focus on understanding the significance of humans, developing human capabilities (especially inner capacities, innate capacities, or soft skills), becoming pathways or environments for human development, rather than just serving as means of input and output. To achieve this goal, it necessitates that HCI and HEC no longer simply inherit the thinking models and evaluation methods of the current industrial information age but first need to re-understand what roles and abilities humans have in computational systems, contemplate the ideal relationship between humans and technology, and establish Engaging Computers that adapt to the development of the times above interdisciplinary factors. Through Synergized Interaction between humans and computers, surpassing the limits that humans or computers could reach individually, both can continuously promote each other to new levels.

While HCI has made significant contributions to global dissemination of computing, HEC aims to find more meaningful missions and developmental space for HCI by exploring a more fundamental context, reinterpreting, integrating, and utilizing past interaction research. For instance, when

discussing user experience, how can experience design be used to develop human senses to ensure the effectiveness of conveying a concept or feeling, providing a foundation for enhancing human capabilities? When contemplating next-generation computing technologies like artificial intelligence or autonomous driving, how can we identify the mental significance they will have for humans within which categories? When reevaluating the value of basic interaction, the focus should be on how to balance the continuity of humans in the virtual world and the real world, thereby understanding what kind of information retrieval interaction humans need to help construct their mind, enhance information literacy and aesthetic abilities. Building upon the integration of these issues, further reflection on the metaphor and presentation of future systemic computer models and interaction methods.

In conclusion, as an initial vision, HEC aims to construct a system of technological philosophy and corresponding implementations, not only to clarify the position of HCI in such a value system and history but also to see the broad human-computer relationships and the potential essence of human activities. Through extensive interaction with technology, individuals can gain awareness of their own existence, consciousness of the external world, and overall improvement. However, up to the current writing stage, the explanations of HEC in the literature are mainly based on the 2019 paper, and primarily geared towards an HCI context. Despite numerous discussions and lectures over the past two years, a more systematic text has yet to be formed (the Chinese version of the HEC Book is a preliminary but incomplete reflection). Especially regarding the five main concepts of HEC - Antibiosis, Engagement, Engaged Humans, Synergized Interaction, Engaging Computers, we need to organizing various materials from the past into a more systematic and extensive textual interpretation, helping readers understand our *problématique* and the approach of HEC.

1.4 The Aims and Structure

The positioning of this dissertation is to interpret the HEC thought. We expect that this interpretation will help derive two key aims or outputs of the entire HEC thought:

(1) The Thought System: What we care most about is not the phenomena of technology but why this thinking soil gives rise to either "correct" or "incorrect" technologies. This is a systemic and structural issue, but if we uncover its operational logic, it is possible to explore ideals and mitigate risks, thereby driving the self-realization of HEC. Therefore, this dissertation aims to interpret HEC from being a value direction extending from HCI to how it can further evolve into a universal theory. This part mainly includes interpretations of Antibiosis, Engagement, Engaged Humans, and Synergized Interaction. The HEC interpreted by The Thought System is a set of thought experiments (or one could say the "operating system" within humans). It is primarily philosophical, from both Eastern and Western perspectives, secondarily sociological, anthropological, educational, and communicational, then possibly psychological and physiological, and lastly technological.

(2) The Computing System: As the ultimate projection and self-realization of The Thought System, HEC needs to materialize into a computing system, a form of Engaging Computers, to test its significance in the real world. However, this projection also requires a transition - including both interpretation and design of Engaging Computers - connecting The Thought System and computer concepts to establish feasibility, which is the purpose of The Computing System.

Validating Engaging Computers requires more specific experiments, but this dissertation does not include this aspect at the moment.

Under these two aims, the contents in each chapter are shown as follows:

Chapter 1: We attempt to analyze the challenges faced by current HCI, though HCI has enabled everyone to use computers while continually introducing numerous big technological concepts - whether they be Artificial Intelligence, Large Language Models, Embodied AI, Quantum Computing, or Metaverse, Web3, digital currency, Brain-Computer Interfaces, and Society 5.0. We observe individuals and society experiencing more and more difficulties on both the micro and macro levels. At a microscopic level, this includes individual daily experiences of smartphone or gaming addiction, privacy breaches; at a macroscopic level, it involves facing various uncertainties threatening human survival, such as the crisis of meaning in the wake of AI and other new technologies, economic stagnation, and sustainability issues. These problems are related to the current high-tech context but have been difficult for HCI's tool-oriented perspective to address.

We need to propose a more systematic theory for future HCI development directions, which is even a fundamental premise for the entire technology development process - this is the motivation behind HEC. The core theme of HEC revolves around designing Engaging Computers that enhance our human survival probability and full potential as humans. It suggests that HCI's position in future research should not be limited to input/output methods but become a path or environment for human capacity (especially inner capability) development. The main work of this dissertation is to offer a more systematic interpretation of HEC for its significance.

Chapter 2: Regardless of whether it is to identify the current issues in HCI or to position the theory of HEC, both need to be placed within a broader macroscopic history of HCI, and to make a rationalization of the evolution of HCI. The history of HCI development can be said to be also the history of the entire information era. This dissertation first reviews the four paradigm shifts in the general sense during the development process of HCI history to gradually identify the changes in academia's understanding of human factors - behavior, cognition, society, emotions, and neural ways. This is also the mainstream recognition of HCI today.

Secondly, we have reviewed how the powerful idea of Augmenting Human Intellect proposed by Douglas Engelbart, Alan Kay, and others as a milestone in the development history of HCI, which serves as a guide and critical significance for us today. Additionally, we have also reviewed various concepts proposed by the HCI community, from Ubiquitous Computing, Social Computing and Embodied Interaction to Human-Centered Computing, Natural Interaction, and User Experience. We attempt to explore the research motivations and thought axes of these concepts. We have also reviewed HEC theory and made a preliminary positioning.

Chapter 3: Based on the HEC ideas, this chapter mainly constructs a more complete "The Thought System" of HEC through "interpretation". The basic methodology of interpretation combines three aspects: 1. "Self as Method" - related authors' experiences in HCI and their own problems awareness; 2. Organizing multiple interdisciplinary perspectives on technology and humanities, such as philosophy and thoughts in the East and West, anthropology, psychology, sociology, psychoanalysis, communication studies, computer science, design, etc. to form relevant insights; and 3. discovering the unity within these interdisciplinary perspectives, i.e., how history of human

ideas can be a main thread helping to converge research phenomena and inner spirits of various fields. On this basis, we have further interpreted four important concepts in the HEC framework:

- Antibiosis: Inheriting our basic methodology's "big picture", we list the major problems threatening Human Survival from three levels - Microscopic, Mesoscopic, and Macroscopic - and regard them as Antibiosis. We believe that the reasons for Antibiosis are related to traditional human understanding limitations. Through reviewing the history of Western thought development on two aspects of human - Natural Humans (animal nature) and Constructive Humans (rational humans), we have proposed two classes of human meta-capacities in HCI - Biophysics (including Behavior, Cognition, and Emotion) and Intellect (human subjective construction) as an understanding of human capacity classification. We also list their respective manifestations in HCI. We generalize the original problem between humans and computers, Antibiosis, to negative actions of humans towards the outside world, and its deeper reasons lie in the Polarization of Biophysics (animal desires without limits) and Alienation of Intellect (the revealed rational defects in modern society over the past 500 years), as well as the Downward Spiral of Hybridization formed by the two. Humans cannot rely on their limited "Biophysics" body and infinite knowledge of "Intellect" to support real life. However, Antibiosis cannot be effectively addressed by various philosophical, sociological, and technological solutions based on Biophysics and Intellect. Furthermore, we analyze the root cause for Antibiosis is the conflict between the external world's duality and human non-duality.

- Engagement: To respond to this current situation, we need to consider the complete human experience and ultimately return to the origins of civilization. Through discussions on the axes of Eastern and Western thoughts - the differences between Inward Transcendence and Outward Transcendence, and their formation in real historical context, we aim to reevaluate the neglected experiences of Eastern thoughts since the advent of modernity. As the common concept in Eastern thought (mainly Confucianism, Buddhism, and Taoism), we introduce "Xin/心" to discuss human responses to ultimate questions about existence when facing oneself, and thus complete our understanding of the "Transcendent Humans" beyond the "Natural Humans" and "Constructive Humans". In the current era where Biophysics and Intellect continuously strive for outward transcendence under the dominance of Western thought, humans urgently need to recognize their Xin capacity - from Awareness, Initiative, to ultimately achieving an inwardly transcendent Enlightenment state as a response to Human Nature, Life, and Survival. We start our discussion from the theoretical position of Xin and further explore the ideal human Engagement and its differences with previous proposals such as Flow theory and self-realization in wellbeing.

- Engaged Humans: We propose a Human Capacity Framework based on "Biophysics-Intellect-Xin" to understand humans, and put forward the concept of Engaged Humans as an ideal model within the HEC thought. We believe that the human innate capabilities, e.g., Mindfulness, Aesthetics, Empathy, Trust, Loving, etc., can serve as paths for recognizing Human Xin Capacity because these capabilities core lies in human development as ends rather than mere means. We emphasize that understanding these capabilities should ultimately be based on the context of Xin, not merely from a knowledge-based Intellect or a physical experience-driven Biophysics.

- Synergized Interaction: Facing the wide range of duality between the external world and non-duality within humans, Synergized Interaction aims to realize the wholeness of human capacities as its ultimate value. We proposed several conditions for finding a balance between various human capacities and technology, striving for an ideal relationship between humans and

computers. Lastly, using "Biophysics-Intellect-Xin" structure as the core of analysis, we pointed out the essential differences in understanding human-computer relationships between HEC and past HCI ideas.

Chapter 4: This dissertation takes previous attempts on GUI computational aesthetic and information interaction within HCI as cases. Starting from a HEC perspective with enhancing overall human capacity at its core, we attempt to discuss the ways of transforming understanding of human abilities from Biophysics to Intellect within HCI, while also reflecting on the lack of value rationality and true meaning in current research regarding concepts such as "humans", Xin, and "aesthetics".

In the computational aesthetics case, we discuss the current state in which computation-based aesthetics metrics are overly inclined towards predicting visual sensations but ignore how designers understand and improve aesthetics. This point is particularly evident in the difficulty of understanding aesthetics evaluative scores. Our work proposes an interpretable aesthetics metric for GUI design that integrates visual aesthetics (visual similarity and spatial proximity) and GUI structure (semantic similarity and white space) to model visual grouping distribution. Two experiments were conducted to validate the metric's ability to predict aesthetics and interpret outputs. Experiment 1 showed that our metric had a stronger correlation with users' impressions of GUI visual aesthetics than past metrics. Experiment 2 suggested that our metric was easier to interpret and appeared more useful to Visual/Graphic/GUI designers than a conventional score-based alternative, by visualizing the metric outputs as an experimental tool. Furthermore, this work provided five potential insights to further advance computational aesthetics research.

In the information interaction case, we look at the limitations of existing designs and guidelines in the current usability paradigm, considering fake news, continuous rumors, and prejudiced opinions from digital platforms and social media. Under the framework of HEC, we propose 12 research agendas from the theoretical, principled, and practical aspects, in order to develop future Synergized Interactions between humans and information. The present crisis presents us with a good opportunity to reflect on the need to empower humans in relation to the tools they use and to consider the next paradigm shift for designing information interaction.

Chapter 5: Based on the above overall interpretation and reflection, we discuss the vision and characteristics of "The Computing System" of HEC - Engaging Computers that possess both outward transcendence and inward transcendence. We also discussed the significance of the balance relationship between “reality” and “virtual”. Based on the analytical interpretation given in Chapter 3, we listed some key design ideas based on Xin and showed a preliminary demo called MIRROR (which will be continuously supplemented) as an inner projection of "Biophysics-Intellect-Xin".

Chapter 6: We extended our discussion of "The Thought System" and "The Computing System". On one hand, we discussed HEC's position in the development of eras from a natural society dominated by Biophysics to a modern society dominated by Intellect, and then to an era led by Xin, the next stage of human civilization. We also considered whether HEC can provide suggestions for the transition of Xin in more extensive fields such as humanities. On the other hand, we analyzed potential factors that affect the feasibility of Engaging Computing: 1. Social needs for the artifacts integrating both “Rites” and “Laws”; 2. Economic model transformation required to fundamentally address Antibiosis. HEC can offer some thoughts on these two points.

Chapter 7: We concluded our contribution in terms of "The Thought System" and "The Computing System" across three levels:

(1) Microscopic (Tools, Self, Small Communities): The concepts of HEC and "Biophysics-Intellect-Xin" can serve as the foundation for individuals to understand their own capacities, discovering their complete and perfect human nature, and enjoying their lives and creativity in an Engagement of Enlightenment. Users can gradually enhance their capacities and understanding through daily interactions with computing devices and artifacts, thus improving themselves and addressing surrounding issues.

(2) Mesoscopic (Technology, Society, Nation): HEC aims to provide a theoretical understanding that enhances human and societal capabilities by integrating valuable insights from the East and West for HCI, multiple fields, overall technological considerations, and even at the policy level. It envisions ideal human-computer relationships and interpersonal relationships and offers a paradigm shift for technological innovation and societal service.

(3) Macroscopic (World, Humanity, Ecology): HEC aspires to predict changes in the human era through a systematic theoretical framework, detailing how society can transition from the dominance of Intellect in modernity to a possible future centered around Xin. It also explores how computers and artifacts as a whole can serve as a medium for humanity to enter the next stage.

Through the structure outlined above, this dissertation aims to provide a more systematic interpretive text for HEC by organizing past materials, discussions, and reflections. This dissertation serves as a thinking foundation for our current stage, and makes it easier to supplement more materials and details in the future. Most importantly, we invite experts and readers to question and critique.

Chapter 2: Review of HCI Thoughts: On the Relationship between Humans and Computers

HCI originated and evolved from various fields such as Human Factors & Ergonomics, Information Systems, Computer Science, and Library and Information Science[9]. However, due to its nature as the field within computer science that is most focused on humans - inevitably necessitating experiments or discussions about humans - it has attained comprehensive development through a broad and interconnected perspective encompassing technology, humanities, and the environment. The overall development of HCI is increasingly rapid, whether it's the mainstream HCI systems constructed based on GUI/WIMP concepts, recent advancements like generative artificial intelligence represented by ChatGPT, MidJourney (Wei et al., 2022; Yin et al., 2023), Apple's first-generation augmented reality product Vision Pro, breakthroughs in physics, new materials, and other technological advancements. But if we seek to identify the phenomena and bottlenecks of HCI, and to understand the positioning of HEC, we need to find a structural starting point to explain the relationship evolution between humans and HCI, or technology, within a deeper historical background of HCI.

In previous writings, by examining different narratives of HCI history (Grudin, 2017, 2022; Harrison et al., 2007; Ren et al., 2019), we divide it into three levels - "Humans," "Computers," "Interaction" - and discuss each level along with potential futures (Wang & Ren, 2024). From the perspective of the historical evolution of HCI, on the one hand, its driving force stems from a deep understanding of humans leading to application directions, which is the main focus of this dissertation. On the other hand, it also arises from the push of pivotal technological ideas towards platform technologies - such as breakthroughs in computing theory, physics theory, and foundational technological concepts. Whether this "pivotal" can be achieved depends on whether from basic research, ideas, to platform applications or technologies like online conferences and shopping, the replicability, degree of automation, and compatibility can support a large ecosystem, creating scenarios and support for new interaction methods.

Looking back at the history of the HCI field, whether it's today's deep neural networks or pivotal technological ideas behind multiple touchscreens, the World Wide Web, graphical user interfaces, programming languages and software, communication, and even the entire system behind Moore's Law, all provide crucial support for the further development of HCI. The combination of these two forces forms specific interactive systems and research, with these three aspects constantly evolving and influencing each other (Wang & Ren, 2024). In Jonathan Grudin's narrative (Grudin, 2017), he also briefly summarizes several stages of computer development that drive HCI - from vacuum tubes to mainframes, minicomputers, microcomputers, handheld/mobile devices, embedded systems, and how this technological development influences the focus of interaction design, shaping understandings of human performance in computer systems.

However, such descriptions bring about a crucial question - not about historical accounts, but about how we can see the first principles within them to identify the real issues. Especially if HCI is purportedly driven by so-called pivotal technological ideas or stages of computer development,

9 Here we referenced Jonathan Grudin: "HCI is often used narrowly to refer to work in one discipline. I define it broadly to cover major threads of research and development in four disciplines: human factors, information systems, computer science, and library and information science." Please see 1.2 DEFINITIONS: HCI, CHI, HF&E, IT, IS, LIS in Grudin, J. (2017). From tool to partner: The evolution of human-computer interaction. *Synthesis Lectures on Human-Centered Interaction*, *10*(1), i-183.

what is the core significance of HCI? Pivotal technological ideas can be seen as a necessary coincidence because they stem from a narrative of liberalism and modern commerce where the birth of the next generation of technology is inevitable. However, it is also contingent, as no one can guarantee when it will emerge. From this perspective, computer science is akin to natural science in terms of how we "discover." The challenge lies in the endless array of existing and non-existing materials, leading to infinite interactive phenomena and combinations, ultimately testing human reactions, finding valid needs and directions, and determining what kind of computing systems are necessary. This transition from understanding humans to transforming mere technological discoveries into "Useful Knowledge[10]" explains, to a certain extent why although breakthroughs like LLM have been achieved today, many fancy AI technologies from a historical perspective have not been directly accepted. We cannot also definitively claim that interactions like those in ChatGPT are "correct." Thus, when we position the understanding of humans in the transition from general technological innovation to forming "Useful Knowledge," it becomes a process of refining the form of computing. It is important to note that not all technological steps introduce an understanding of humans. The focus mainly lies in the exploration process that includes real human needs within knowledge or technology. Conversely, prematurely introducing a bias simulating human behavior in knowledge or technology can potentially hinder progress, as seen in early artificial intelligence attempts to construct AI through understanding human symbolic cognition, or in the relationship between "modern aircraft" and "birds."

Therefore, while we do not deny the complex interplay between understanding human thought and technological development, we believe that fundamentally it still rests on human self-awareness (similar to how economics is founded on the assumption of rational self-interested individuals). This deduction leads to a human-computer relationship, where computers are seen as interventions in this process of human understanding. From a phenomenological perspective, the so-called "interaction" can only arise through the interaction between humans and computers, meaning that humans are essentially the structure behind interactive phenomena. We will use this narrative structure to understand the history of HCI. We aim for completeness in our writing, as this is a necessary condition for elucidating the HEC approach.

Furthermore, it is important to note that the relationship between humans and technology, as a macroscopic topic, actually has a long history when viewed from various perspectives such as philosophy (Stiegler, 1998), communication studies (Postman, 2011), and so on. This history could be endless if we were to enumerate it. We choose to analyze it through the lens of HCI as a microcosm because, formally, HCI fulfills the necessary conditions for discussing technology (unlike the "Big names" in technology philosophy, such as Martin Heidegger and Marshall McLuhan, who themselves did not experience or even anticipate the complexities of the current digital world). The discussion of the human-computer relationship can be adequately contextualized using HCI in both narrow and broad senses.

2.1 General HCI Paradigm Shift: Understanding Human Factors

Regarding the general perspective on approaches to problem solving in a particular field, the concept of a paradigm can be understood as "...the entire constellation of beliefs, values, techniques, and so on shared by the members of a given community... employed as models... for the solution of

[10] Please see the Keywords Section.

the remaining puzzles of normal science." (Kuhn, 1997), representing the mainstream view of the academic community on the approach to solving a particular problem. According to different literature, the historical development of HCI can be broadly divided into similar 3-4 paradigm shifts (Grudin, 2017; Harrison et al., 2007; Ren et al., 2019). The core of these paradigm shifts is primarily from a technical perspective, but more come from the gradual understanding of human factors, discussing the changes of humans in technological interventions.

The first paradigm of HCI focused on human factors and ergonomics in a fixed context (Bødker, 2006; Harrison et al., 2007), inheriting the experience of industrial engineering and ergonomic design for large industrial products such as cars and aircraft. HCI focused on optimizing the physical fit between humans and computers, and Human Factors began to be introduced into the discussion of computer-related design. This perspective also echoed the tendency of the academic community at the time to observe humans from a behaviorism paradigm.

In the 1980s, the second paradigm of HCI was influenced by Card and Moran's book on "The Psychology of Human-Computer Interaction" (Card et al., 2018) where cognitive science (memory, perception, and motor control) were the main themes in the interactive design. As computers began to influence the field of cognitive psychology, this wave emphasized the similarity between information processing in humans and machines, using "cognitivism" to understand the process of human use of computers. During this period, the HCI research community gradually took shape and established international conferences (such as CHI - The ACM Conference on Human Factors in Computing Systems, HCI International, etc.). However, it is worth noting that "behaviorism" was not completely replaced by "cognitivism", as they each have philosophical reasons: not introducing speculation beyond behavioral experience vs. behavior stemming from internal mechanisms and motivations. They also face the division between "experts" and "novices" in terms of research objects, but they are still mostly in a context of ergonomics engineering, emphasizing usability. Their acceptance of innovative interaction methods such as graphical interfaces and personal computers also does not seem to be as strong (Grudin, 2017).

Around the late 1990s, the third paradigm of HCI was influenced by the notion of Human-Centered Computing (HCC) (Kling & Star, 1998). Since then, HCC has evolved to contain multiple research foci, such as addressing the social and emotional aspects (e.g., user experience) of human computer interactions (Rogers, 2012). Humanistic psychology emerged in the US as early as the 1950s (e.g., Maslow's Hierarchy of Needs), and the concept of human-centered design had also been proposed, but it was not until this time that HCI formally incorporated the humanistic perspective into its design thinking. Steve Harrison believes that the third wave of HCI was driven by the sociological and phenomenological perspectives of embodied interaction from the continental philosophy (Dourish, 1999; Harrison et al., 2007; Merleau-Ponty, 1965). This change was largely catalyzed by the historical period of the transition from single-user-machine to multi-user-machine, which led to the inclusion of social sciences and anthropology in HCI research, giving rise to directions such as Social Computing and Computer-Supported Cooperative Work (CSCW). HCI then incorporated all the phenomena in the process into its research and design observation. We believe that the fermentation of these two from the ideological source to the specific influence on HCI is due to the fact that on the one hand, the development of computers has become increasingly mature, objectively supporting the construction of more complex and personalized computing systems. On the other hand, the cycle of the influence of ideas has gradually been understood and accepted by people. Corresponding applications that embody the ideas have also emerged, beginning to discuss the importance of subjective meaning to humans after behavior and cognition. With the gradual

development of the third paradigm and the fusion of different perspectives, concepts such as Embodied Interaction, Tangible Computing, Ubiquitous Computing, Natural Interaction, Affordance, Affective Computing, Multimodal Interaction, User Experience, and Accessibility have been introduced or proposed by HCI, beginning to question the essence of HCI design and its potential impact.

The fourth paradigm and the continued development around human well-being and diversity beyond the understanding of humans as simply needy, in the new technological context (e.g., Mobile Computing, AI), for example, Positive Computing (Bannon, 2011; Calvo & Peters, 2014) based on positive psychology, Value-Sensitive Design (Borning & Muller, 2012), and embodiment (Kuutti & Bannon, 2014). This also includes "Humanistic HCI," which seeks a humanistic and philosophical foundation beyond the psychological underpinnings of traditional HCI research (Bardzell & Bardzell, 2015), and reflects on the biases brought by the researcher perspective (WEIRD - western, educated, industrialized, rich, democratic) (Linxen et al., 2021). HCI can thus extend to discussing interaction issues from the perspectives of more identity groups, including the more emotion-oriented and empathetic feminist perspective (Kannabiran & Søndergaard, 2023; Light, 2023), smart aging interaction (Sarcar et al., 2021), design for disabled groups, and emotional support from communities and religions (Hiniker & Wobbrock, 2022; Naqshbandi et al., 2022), moving from an engineering and usable interaction approach to a more open-ended understanding of interaction.

Furthermore, the developments in cognitive neuroscience, artificial intelligence, large language models, and computing infrastructure have brought new demands on the traditional HCI methods and models that focus on human behavior, cognition, and emotion. For example, Computational HCI complements the traditional more explanatory behavioral models with more predictive computational models (Banovic et al., 2019; Oulasvirta, Kristensson, et al., 2018).

From a developmental perspective, each paradigm shift does not completely replace the previous one, but rather expands the understanding of HCI itself, constantly seeking more explanatory theoretical approaches, though the latest paradigm is also not perfect. At a macro level, the above four paradigms also come from the progress and driven by various forces such as philosophical consciousness, culture, society, and the spirit of the times. These paradigms are actually all trying to answer the same question, that is, according to the current level of understanding, which human factors are primary or at least more real and scientific based on various phenomena. Due to the interdisciplinary nature of HCI, this understanding of human beings is not isolated from other fields, and also reflects the evolution of the academic community (e.g., psychology, cognitive science, etc.) in understanding the human problem.

The way we understand and experience human beings actually provides a basic premise for what kind of products will emerge. But on the other hand, there is an epistemological dilemma, that is, the deeper we understand human beings, the more likely we are to tend towards what cannot be expressed in language, and more based on individual sensory experiences, and a generally understanding human paradigm is only an experiential framework.

Connecting to the current innovation in interaction technologies and product forms, in a nutshell, what people can be aware of is what can be done, but the problem is that people even lack understanding of themselves, and may not be as interested as it appears. Due to the long-term view of technology (and even the wider environment) as an object and a tool, without realizing that one's

own thinking and feelings have been constrained by the operation or design of technology, this human-computer relationship remains more at the perspective of technology consumers in terms of the development and value of interaction and technology.

2.2 Powerful Ideas: The Line of Augmenting Human Intellect

The paradigm shift in HCI presents to us the mainstream academic and industrial understanding of "humans" in interactions at a macro level. However, such experiential understanding often lacks inherent systematicity and a purposeful drive to become Useful Knowledge. In this section, we will explore some of the pioneers in the HCI field and their foundational thoughts and research motivations within what is arguably the most representative, influential, yet easily overlooked perspective in HCI - Augmenting Human Intellect - which is referred to by Alan Kay and others as Powerful Ideas[11, 12]. We will briefly examine the basis of these ideas and research motivations, and how these considerations about human-computer relationships offer guidance for us today, elucidating their relationship with HEC.

2.2.1 Augmenting Human Intellect

In 1945, Vannevar Bush published "As We May Think" (Bush, 1945), articulating a vision that anticipated the challenges scientists would face as scientific research expanded and deepened. He recognized that traditional modes of knowledge exchange were insufficient for scientists to become polymaths across disciplines, necessitating large-scale research collaborations. Bush, an organizer of the Manhattan Project and later founder of the National Science Foundation, highlighted the importance of managing intangible assets like scientific research and knowledge as opposed to relying solely on tangible resources for productivity. A few months before the birth of the first true computer, ENIAC, he introduced the concept of the "MEMEX" in this article.

The MEMEX, modeled after an office desk, envisioned a comprehensive process for inputting, storing, processing, and outputting knowledge. Bush envisioned this machine would centralize the knowledge of humankind while also supporting individuals in building databases to store personal materials and communication records, providing a fast and flexible retrieval method - "an enlarged intimate supplement to his memory" (Bush, 1945). Due to the limitations of the time, Bush's envisioned technical details leaned towards a combination of existing mature technologies, such as using a microfilm camera for storing data and circulating small rubber copies. Although subsequent developments in computing did not precisely align with Bush's vision and in many ways surpassed it, the concept of the MEMEX profoundly influenced many computer scientists, with its motivations and architecture becoming a prototype starting point for modern computing, such as the Desktop Metaphor. The MEMEX mapped a new way of managing knowledge onto a machine, transcending traditional paradigms of machinery and heralding a new era.

One of the followers of the MEMEX concept was Douglas Engelbart, who realized that the essence of information processing lay in supporting humans to better collaborate on complex problems, with a consistent emphasis on Collective IQ (Engelbart, 1995). Engelbart articulated an initial but systematic idea in an article entitled "Augmenting Human Intellect: A Conceptual Framework" and

[11] https://www.ted.com/talks/alan_kay_a_powerful_idea_about_ideas?language=en&delay=30s&subtitle=en#

[12] https://worrydream.com/refs/Kay_1995_-_Powerful_Ideas_Need_Love_Too.html

continued to support it through his subsequent work (Engelbart, 1962). During the active period of AI, Engelbart emphasized that he would not seek to replace human thinking with artificial intelligence. Instead, he proposed a unified environment where human intuition and computer abstraction and processing capabilities could merge to enhance human-computer coexistence. He provided numerous examples in his article to illustrate the potential applications of Augmenting Human Intellect, such as how designers could use computers to conceptualize architecture or professionals to flexibly create reports with graphics (Bardini, 2000; Engelbart, 1962; Isaacson, 2014; Markoff, 2016).

Engelbart's work gained recognition and funding from J. C. R. Licklider, the proponent of Man-Computer Symbiosis (Licklider, 1960; Waldrop, 2018), while leading a department at ARPA. In 1968, Engelbart unveiled his oNLine System (NLS), an event that later became known as "The Mother of All Demos."[13,14] During this demonstration, Engelbart and his colleagues showcased a range of concepts including the mouse, remote control, version control, and hypertext. Innovations like the mouse, representing ergonomic achievements, leveraged the unique hand-eye coordination system of humans, revolutionizing the cumbersome and inefficient interaction details of computers and paving the way for the industrial development and widespread adoption of future computers. In contrast to Artificial Intelligence (AI), Engelbart revealed another path for computer development: Intelligence Augmentation (IA) (Markoff, 2016).

This pertains to the historical relationship between HCI and Artificial Intelligence. In the early stages of computer development, pioneers in the field contemplated the value of technology. Scholars like John McCarthy leading AI and Engelbart advocating IA held different expectations regarding the ideal relationship between humans and technology, thus delineating two distinct historical paths of AI and HCI. Based on the success of the Turing machine model, the AI camp sought to further understand human cognitive systems, aiming to formalize a "rationalist" vision of "creating humans" through mathematical logic, using machine intelligence to solve real-world problems. This can be seen as the foundational premise for today's generative AI and even the concept of digital immortality. The development of AI has experienced several setbacks before reaching its current peak. Conversely, during each trough in AI development, HCI has managed to explore new possibilities for human-computer interaction from a different perspective (Grudin, 2009).

The IA camp focused on how computers could enhance human capabilities and collective intelligence, demonstrating a systematic and purposeful human-computer relationship (Engelbart, 1962). This led to the creation of the "human-centered (albeit relative to technological thinking)" computer prototypes we see today, including early conceptions of the mouse, GUI, and many professional software tools, as well as the initiation of ideas like personal computing and mobile computing, laying the foundation for the HCI field and accelerating the process of computer accessibility to everyone. Today, in many respects, AI and IA no longer exhibit the stark differences seen in their early development stages; both are built on some form of "human-centered" design. However, it is precisely the differing interpretations of "human-centered" and the various issues that arise from this that necessitate clarification for AI, IA, and HEC.

[13] https://www.youtube.com/watch?v=yJDv-zdhzMY

[14] https://dougengelbart.org/content/view/223/

Today, we can even assert that mainstream computing is still an extension of Engelbart's vision, although not all of his ideas were fully adopted[15]. For instance, Engelbart aimed to fully leverage human capabilities by designing the mouse with as many buttons as possible to engage all of the user's fingers. Additionally, he sought to promote extensive collaboration as a key aspect of Augmenting Human Intellect, including but not limited to collaboration between individuals, between senses, and between humans and machines. For example, in Engelbart's remote control concept, there were two mouse pointers, allowing both parties to control the computer simultaneously - although part of this setup stemmed from the prevailing notion at the time that computer users were predominantly experts and systems were built around complexity (Grudin, 2017). Research groups continue to pursue Engelbart's ideals, with projects like Dynamicland[16] embodying this vision. Bret Victor, the founder, once remarked: "Engelbart's vision, from the beginning, was collaborative. His vision was people working together in a shared intellectual space. His entire system was designed around that intent."[17]

2.2.2 Personal Computing

"The Mother of All Demos" profoundly influenced Alan Kay when he was still a student at the time. Several years later, when Kay was working at the Xerox Palo Alto Research Center and began designing his ideal personal computer, the Dynabook, he published a manifesto titled "A personal computer for children of all ages" (Kay, 2011). In contrast to tools designed for specific tasks, Kay believed that computers, as programmable "mediums," should serve as tools to enhance personal creativity and validate experiences. Influenced by the educationalist Seymour Papert (the designer of the LOGO programming language) (Papert, 2020), Kay realized the enormous potential of changing the way children (and early humans) think through personal computers. The envisioned Dynabook by Kay took the form of a touchscreen tablet at the hardware level, with an ideal GUI serving as the human-computer interface at the software operating system level, encompassing a set of concepts including the Desktop Metaphor (Hiltzik, 1999), which featured visual graphic displays - WIMP (windows, icons, menus, pointers), "What You See Is What You Get (WYSIWYG)," and intuitive interactions supporting Object-Oriented Programming (OOP). By aiding children in conscious creation and enabling them to verify truths in the process of programming, the Dynabook became a tool for fostering "media guerrillas" capable of discerning quality information.

The prototype machine "Xerox Alto," designed by Kay and his colleagues based on the Dynabook blueprint, featured flexible display methods, simple interactions, and laid the foundation for milestones in HCI development - the Graphical User Interface (GUI) and the maturity of Personal Computing.

Beyond discussing these specific achievements, we are more curious about what influenced Kay's thinking. In this regard, we investigate that at least four aspects of thought sources influenced Kay. Firstly, the development of cognitive theories[18], from Jean Piaget’s theory of cognitive development, Jerome Bruner’s theory of instruction, Marshall McLuhan’s theory of communication to Papert’s implementation of the LOGO prototype (Papert, 2020), enabled Kay to understand the

[15] https://www.youtube.com/watch?v=yMjPqr1s-cg&t=31s

[16] https://dynamicland.org

[17] https://worrydream.com/Engelbart/

[18] https://amturing.acm.org/award_winners/kay_3972189.cfm

cognitive and educational foundations that allow human progress and their possible directions for concretization. Secondly, Engelbart's demonstration of the oNLine System (stemming from Augmenting Human Intellect, Man-Computer Symbiosis and MEMEX) showcased to Kay the powerful potential of computers as tools for human intelligence augmentation and early GUI design concepts. Thirdly, inspired by his mentor Ivan Sutherland's "Sketchpad," which not only introduced the concept of light pen interaction but also laid the groundwork for OOP through the inheritance relationships of basic shapes at the theory level of computer graphics. Lastly, Kay's background in biology, such as neurotransmitter communication between cells, likely influenced the design of programming interactions (the essence of Smalltalk, designed by Kay, revolves around messaging rather than objects[19,20]). The intertwining of these thought processes likely shaped Kay's systematic design thinking regarding Personal Computing, GUIs, Desktop Metaphors, OOP, and more, showcasing different manifestations of the same foundational ideas. This also demonstrates the power of guiding thoughts in practice, at least from the perspective of an HCI researcher.

Alan Kay's thoughts on human-computer relationships are not solely about technology but stem primarily from contemplations about humans and human progress. Drawing from anthropologist Donald Brown (Brown, 2004; Merchant, 2017), Alan Kay shared his understanding of what he calls "Human Universals." These are abilities that all human civilizations can naturally evolve, such as language, storytelling, or basic tool-making. On the other hand, "Non Universals" are not universally evolved, such as writing, reasoning, or model-based scientific construction[21]. As a standard for evaluating whether a design represents human progress, a tool should help enhance human "Non Universal" capabilities. Kay illustrated this by explaining why he believed telegraphy was superior to the telephone. He argued that while the invention of the telephone continued human's universal oral abilities, telegraphy advanced human writing skills, a "Non Universal" capability. Another example is about the Gutenberg printing press, which, before being used to spread knowledge, was primarily used to print bibles (which, considering the historical context, led to religious reform). The essence here is how we transform our way of thinking about the existence of tools. This viewpoint does not neglect the significance of new tool creation but rather focuses more on how a new perspective's emergence might better help humans themselves and not just invent another physical computer. To this day, Kay continues to preach his vision for the future (Kay, 2019).

From Bush, J. C. R. Licklider to Engelbart, and then to Kay, including other practitioners such as Norbert Wiener (Wiener, 1988), Ted Nelson[22], all the way to Steve Jobs[23], Bret Victor, etc., from Human-in-the-loop to the line of Augmenting Human Intellect, they are actually showing us a solution to the relationship between humans and computers. That is, computers for humans are not just a simple instrumental use but can also serve as a medium for enlightenment and enhancing human capabilities. Their thoughts, models, and applications have a strong sense of inheritance, which is reflected not only in the advancement of the times but also in the key words in their work, such as the development and understanding of "Intelligence" and their grasp of standards for evaluating human progress. Many of the concepts they envisioned have now become reality.

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19 https://wiki.c2.com/?AlanKayOnMessaging

20 http://www.purl.org/stefan_ram/pub/doc_kay_oop_en

21 http://worrydream.com/oatmeal/universals.pdf

22 https://xanadu.com/xanademos/MoeJusteOrigins.html

23 https://www.youtube.com/watch?v=ob_GX50Za6c

However, when it comes to the design of so-called computing systems, introducing a new hardware device or a new user experience, or meeting a specific demand, these may not directly be considered standards for "progress"; instead, when the creation itself serves as a tool for thought and provides a perspective for the world, it may promote further development of computers and find a position in the history of ideas.

Of course, as a whole, on the one hand, the various influences that may exist behind that historical period, such as intellectual liberation and cultural waves (e.g., the 1960s counterculture movement), also had various impacts on the thoughts and practices of the above pioneers, disrupting a mechanistic narrative. On the other hand, the reason why computing became the tool of choice for the pioneers to Augment Human Intellect was, compared to traditional machines, we have summarized three basic characteristics:

(1) Integrability: Computers allow for the construction of various possibilities in a parallel world, whether it is the rendering of GUI at every pixel point or the various fantasies about the Metaverse today, which are actually based on the premise of computing/computer operation (such as bits).

(2) Programmability: The emergence of programming allows computing to replace traditional specialized machines as general-purpose machines, and the appearance of hardware, whether personal computers or touchscreens, supports this characteristic of computing - allowing infinite possibilities to be realized on limited hardware devices.

(3) Encodability: If computing theory supports the above two characteristics, encodability under information theory supports the translation and circulation of information. Encoding not only promotes the flow of information at the online level but also breaks down the barriers between human language and various machine languages, enabling mutual understanding, whether through text, graphical interfaces, or gesture interactions, all of which are extensions of this characteristic of encoding.

Regarding these three summarizations, we will explain their inevitability in Chapter 3. Simply put, modernity demands that tools or technological units can be continuously atomized, as can be seen in human understanding of "time" under modernity. The overall idea of Augmenting Human Intellect still has strong guiding significance today, but we can also see opportunities in its train of thought. The mainstream operating system GUI paradigm today (such as iOS, Windows, macOS, and even Vision OS) can be said to be based on the Desktop Metaphor contributed by MEMEX, NLS, and Kay and his colleagues. Although many interaction studies are trying to break away from this paradigm (Jacob et al., 2008; van Dam, 2000; Weiser, 1994), this design is hard to completely replace and has become more of an extension. We believe that the success of the Desktop Metaphor as a paradigm is essentially manifested in three aspects:

(1) Its modeling is close to life experience, simple, intuitive, and easy to learn.

(2) As a low-level abstraction, it has sufficient capacity to contain different symbols, serving as the foundation of the operating system level, compatible with the performance of complex applications at the interface level.

(3) After it (or in the entire history of HCI), there are almost no stronger paradigm competitors.

However, due to the great success of the Desktop Metaphor as a system-level "Artifact" design, designers find it difficult to realize its two significant problems, thus unable to break the paradigm itself:

(1) It abstracts the world into a two-dimensional plane, and its expressive capabilities can still be said to be limited. On the one hand, "The world is not a desktop" - Mark Weiser proposed Ubicomp to counter this, which we will explain in the section on "Ubiquitous Computing"; on the other hand, people are not desktops, when people's perceptions of the world are completely abstracted into a two-dimensional graphical concept, human alienation begins subtly. We must emphasize that even though we see spatial computing today, its concept is merely an extension of this two-dimensional plane - the Desktop Metaphor, rather than a true understanding of humans.

(2) Its profound theoretical significance is limited. We can see that the theoretical foundation behind the Desktop Metaphor comes partly from the NLS demonstrated by Engelbart and partly from theories related to cognition, pedagogy, and psychology. However, these theoretical backgrounds do not present a more systematic, philosophical understanding of the human context. Augmenting Human Intellect can be a goal, but it does not consider the essence of humans and real problems, and whether intelligence is still the most fundamental ability in the current context is a point for discussion.

Human-Enhanced Computing (HEC) can be said to critically inherit the spirit of Augmenting Human Intelligence. By integrating Eastern and Western thoughts, we will discuss realizing the wholeness of human capacities, rather than just a single Intelligence, as a more fundamental level, supporting the basis of human performance.

2.3 Other Ideas on Human-Computer Relationship

In addition to the general paradigms mentioned above and the concepts derived from Augmenting Human Intelligence, HCI also encompasses several mainstream design principles that reflect the varying understandings of human-computer relationships among HCI thinkers. Here, we briefly introduce and comment on some of these principles, and for some of them, we will seek further philosophical comparisons in Section 3.4.3.

2.3.1 Ubiquitous Computing、Social Computing and Embodied Interaction

In the early 1990s, Mark Weiser of Xerox PARC argued that interactive systems based on the traditional Desktop Metaphor were no longer sufficient to support the advancement of computing. He believed that the future form of computing should not be limited to specific external forms, and that computers were not just tools with singular functions; computing should be omnipresent. Weiser wrote, "What is the metaphor for the computer of the future? The intelligent agent? The television (multimedia)? The 3-D graphics world (virtual reality)? The StarTrek ubiquitous voice computer? The GUI desktop, honed and refined? The machine that magically grants our wishes? I think the right answer is 'none of the above', because I think all of these concepts share a basic flaw:

they make the computer visible" (Weiser, 1994). Thus, the concept of Ubiquitous Computing (Ubicomp) emerged.

The understanding of Ubicomp often veers towards "Pervasive Computing" (although they are indeed intertwined), but Weiser emphasized more on "Invisible Computing/Calm Technology," embedding computers into any object, device, or environment to minimize distractions to human attention, allowing people to focus on tasks. Ubicomp aims to become the third generation of computing, following the mainframe era and the personal computer era (Want, 2010). Today, various mobile computing devices, the Internet of Things, sensors, and more are pervasive, all rooted in the industry's understanding and development of the Ubicomp concept. The mobile internet we see today is essentially a fusion of the design ideologies of the Desktop Metaphor and Ubicomp, moving towards a sort of design fiction scenario akin to Weiser's "The Computer for the 21st Century," as Gregory D. Abowd stated, "the disappearance of ubiquitous computing" (Abowd, 2012). The concept of Ubicomp has also influenced the generation, development, and merging of subsequent HCI ideologies, such as Mobile Computing.

In contrast to the Desktop Metaphor as a design paradigm, the metaphor presented by Ubicomp can be said to lack a fixed form. We believe that the success of Ubicomp lies in:

(1) Complementing the missing positioning of personal computers, such as in sensor, accessory, and infrastructure scenarios.

(2) Having unconstrained hardware forms and functionalities, allowing for greater freedom.

However, we believe that its limitations arise from its varied forms of expression, making it challenging to advance towards deeper system-level design principles. This depth is not about supporting numerous functions but about how they can be organized to embody a thought purpose oriented towards human significance, rather than merely as an invisible input-output form. Therefore, in the fusion of the Desktop Metaphor and Ubicomp paradigms, Ubicomp is still a supporting role and may temporarily be unable to depart from the organization form centered on system-level GUI. Additionally, from a socio-technical perspective, the more invisible a medium is, the greater its influence on shaping human (meta) perceptions and societal biases. This is a topic that lacks discussion. In other words, while Ubicomp's core idea emphasizes computing devices and infrastructure that do not distract human attention, this technical-centric thinking is drifting further away from a holistic understanding of humans. Both the Desktop Metaphor and Ubicomp need to find a new form of unity and collectively seek a foundation based on a deeper understanding of human nature.

Beyond Ubicomp, as discussed in Section 2.1, between the second and third paradigm shifts, HCI has gradually attracted the involvement of sociologists and anthropologists. This includes computers entering offices and the study of how computing technologies support groups, organizations, and communities. In the convergence of these factors, Social Computing and Computer Supported Cooperative Work (CSCW) emerged (Grudin, 1991). Because the ways users interact with computers are not only self-derived but also influenced by their relational networks and environmental factors, Social Computing seeks to integrate techniques and settings from sociology and anthropology into system design and phenomenon analysis. For instance, utilizing ethnography and field studies to determine the necessary requirements and characteristics of system design for specific groups (Grudin & Poltrock, 2012). It's important to note that although they all

study the relationship between groups and computers and are gradually converging, Social Computing, CSCW, and ECSCW have slight differences in understanding human issues. For more details, please refer to (Grudin, 2010, 2017).

In the late 1990s, Paul Dourish emphasized the insights into intuitive interaction revealed by the human cognitive coordination demonstrated through the extension of the Tangible Computing concept associated with Ubicomp, as well as the interactive behaviors and their social significance implied by the Social Computing concept. These clues needed a larger framework for synthesis (Dourish, 1999). Inspired by the research methodology of the phenomenology of perception (Merleau-Ponty, 1965), he further proposed the Embodied Interaction framework in the early 2000s. This framework focuses on the connection between a unified perception of interaction involving both mind and body and the meanings derived from it, extending to the holistic nature of phenomena. Embodied Interaction asserts that technology, practices, and environment are inseparable, extending and evolving together as parts of phenomena, viewing all involved factors as a whole. Within this framework, theoretical foundations of HCI concepts such as Natural Interaction, Affordance, and User Experience were further refined.

Overall, from the perspective of human-computer relationships, Ubiquitous Computing, Social Computing, and Embodied Interaction are all exploring new objectives beyond a singular historical positioning of usability, recognizing that computers are not just fixed devices but should integrate with various possibilities - such as the environment, groups, and embodiment. Despite these ideas aiming to continuously explore their depth and constantly refine the thoughts of visionaries like Engelbart when envisioning the future, this development is increasingly leaning towards empirical observations of computing, instrumental use, and computational forms, neglecting the philosophical aspects akin to the early philosophical musings of Augmenting Human Intellect.

2.3.2 Human-Centered Computing/AI, Natural Interaction and User Experience

As mentioned in Section 2.1, the emergence of the third and fourth HCI paradigms, coupled with the maturation of computing technologies and social environments, have propelled the core design concept of Human-Centered Design (Kling & Star, 1998; Norman & Draper, 1986), alongside numerous derivative concepts such as Value Sensitive Design (VSD) (Borning & Muller, 2012) and Positive Computing (Calvo & Peters, 2014). Today, almost every research endeavor can be more or less linked to the idea of being "human-centered." The divide between AI and HCI in addressing human issues has also significantly narrowed (Markoff, 2016). However, the human-centered concept, much like the interpretations of Western liberalism, offers various (often highly subjective and implicit) paths of explanation (Shneiderman, 2021, 2022; Xu, 2019). Yet, if we delve deeper, is AI usable in a human-centered way? Is it responsible AI? AI that doesn't substitute for human ethics? The crux of this issue lies in deconstructing and interpreting "how to understand humans" and "how to be human-centered," rather than solely relying on experiential understanding[24,25]. Human-Centered Computing/AI is a concept with a significant degree of subjectivity, where individuals express their views based on their experiences and understanding, underscoring a

[24] https://www.interaction-design.org/literature/topics/human-centered-design

[25] https://en.wikipedia.org/wiki/Human-centered_design

critical theme in understanding human-computer relationships that cannot be overlooked, a topic we will revisit after elucidating on HEC.

Following the three concepts mentioned in Section 2.3.1 and the human-centered approach, two important concepts have emerged - Natural Interaction and User Experience. Natural Interaction seeks to find the most intuitive ways for humans to interact - whether through gestures, clicks, or tangible interfaces (Valli, 2005), often intertwined with Affordance. As a successor to Usability, User Experience attempts to address the theoretical deficiency in determining what "subjective satisfaction" entails in the evaluation process. Neither Natural Interaction nor User Experience can be defined in an ontological manner; rather, they require a bodily-based epistemology. This leads to questions about defining the theoretical foundations of concepts like User Experience: spanning philosophical and aesthetic realms, from John Dewey's "An Experience" (Dewey, 2008; McCarthy & Wright, 2004), to Somaesthetic (Höök et al., 2015; Shusterman, 2000, 2008); and psychological frameworks that establish the holistic experiential needs of aesthetics and emotions (Hassenzahl & Tractinsky, 2006).

These three concepts remain central to current HCI discussions on technology design, which drives the main interactive forms today (Hornbæk & Oulasvirta, 2017). However, when viewed from a more holistic perspective considering the ideological roots and practical disparities in the development of these concepts, we encounter a shared issue with the notions in Section 2.3.1: when discussing human-centered approaches, whether it's Maslow's hierarchy of needs or the various frameworks proposed around User Experience, the discourse often shifts from essential needs to user desires, frequently equated with convenience or entertainment. This is particularly pronounced in industrial and product design. The unresolved question lies not in how many facts a framework encompasses but in that origin point - what is a human, lacking the necessary discourse.

2.4 The Alternative: Human-Engaged Computing

In Section 1.3, we briefly introduced the origins of Human-Centered Computing (HEC), largely stemming from its connection with Augmenting Human Intellect. After reconsidering the conventional perspective of HCI, which still remains vague in terms of long-term development goals (Rogers, 2012), and acknowledging that its evaluation methods are constrained by performance dimensions and criteria such as "easy to use," "efficiency," "natural," or "experience" (MacDonald & Atwood, 2013), Ren proposed the theoretical concept of "Human-Engaged Computing" (HEC) in the paper "Rethinking the relationship between humans and computers" (Ren, 2016), and detailed the HEC framework (Ren et al., 2019).

HEC describes the Synergized Interaction between high-level human capacities (Engaged Humans) and high-level technological capabilities (Engaging Computers). In order to reach truly Synergized Interaction, we should maintain a good proportional balance between humans and computers. In fact, HEC argues that there is a current imbalance between humans and computers in favor of computers and to the atrophy of human capacities and human well-being.

The human capacities emphasized by HEC is a kind of inner capacities (or innate capacities, soft skills), e.g., focus, mindfulness, self-control, self-motivation, empathy, or trust (Ren, 2016), rather than the human outer performance measured by conventional HCI, e.g., motor control, perception,

or information processing efficiency. On the contrary, HEC perceives the long-term improvement of human outer performance in nature depends on such human inner capacities.

HEC primarily describes five components in its framework as outlined in past literature (Ren et al., 2019). The following are quoted components:

(1) ***Engagement and Engaged Humans*** "Engaged-" refers to the engagement and activation of human capacities (e.g., mindful attention in a task, flow). Humans are engaged when their inner capacities are progressively developed and thoroughly integrated into a given activity. In its purest form, engagement isn't dependent on the nature of the activity. Rather, it's a state of consciousness in which one is fully immersed in and aligned with the activity. Pure human engagement can't be produced by external incentives such as fun mechanisms because these require a divided mind. During this state, one would perform to their maximum potential with little or no awareness of fatigue. Inner capacities such as subjective learning efficiency, creativity, and problem-solving capability are maximized, in which a person is completely involved in a particular activity. In such a state, the participant does not even make conscious judgments about the degree or quality of his/her involvement; he/she "just does it."

(2) ***Engaging Computers*** (including both devices, software applications, advanced technologies and interactive artifacts) are engaging when they enhance human capacities. In other words, the merits of technologies in HEC aren't determined by traditional quantitative or qualitative metrics, such as whether they increase productivity or are fun to use, but by their ability to realize human potential. A key challenge in designing such systems is determining what to do if a technology increases one capacity but decreases other capacities.

(3) ***Synergized Interaction*** refers to a state of optimal balance between engaged humans and engaging computers, an Eastern concept detailed in the sidebar "Human-Engaged Computing: Getting the Balance Right." In this harmonious state, computing technology isn't merely harnessed to accomplish some predefined goal or purpose; for example, to do something faster or more efficiently. Instead, the technology is designed to complement and enhance human capacities—both existing and potential—to achieve a higher-level and perhaps as-yet undefined purpose. In some cases, Synergized Interaction might mean not deploying an otherwise useful technology. A holistic consideration of our innate capacities and technological hindrances to those capacities is essential to achieving greater synergy between humans and computers.

(4) ***Antibiosis*** refers to an association between two entities in which one of the entities is adversely affected and the efficiency of the synthesis is compromised. Naively attributing equal time and investment to unlike partners in a symbiotic relationship leads to antibiosis, i.e., wastage on the "partner" that by its nature requires less expenditure proportionately, and a deficit in the treatment of the other "partner" which by its different nature and priority requires more expenditure proportionately considered.

As computing has become the infrastructure of the current world, HEC believes the essential contribution of HCI to humans is far more than designing the way of human use of computing, such as "computing tools" or "constructions", but through activating, engaging, and enhancing human inner capacities, the technological development can find its "right" way to minimize the conflicts, i.e., Antibiosis in HEC (Ren et al., 2019), between humans and computers, thus help humans fulfill their own significance and inner wellbeing in nature. Since its proposal, the concept of HEC has

been applied in some fields such as Human-Engaged AI (Ma, 2018a, 2018b), information interactions (C. Wang et al., 2020; Yuan & Ren, 2021), human capability development (Niksirat et al., 2019). The HEC community (Law et al., 2015; Salehzadeh Niksirat et al., 2018; Wang et al., 2018) has also received much attention, e.g., CHI panel discussions on the relationship between humans and computers (Farooq et al., 2017; D. Wang et al., 2020; Wang et al., 2021).

However, in the current version of HEC, there is still a lack of systematic and textual interpretations for its theoretical construction, which hinders further understanding of HEC for HCI researchers about how to integrate their research with the perspective of HEC. Therefore, in this dissertation, we will provide a systematic interpretation of HEC.

2.5 Summary

If we were to categorize and summarize the HCI ideas mentioned above in terms of human-computer relationships, we would tend to describe the ideas in Sections 2.1 and 2.3 as more empirical HCI ideas. This is because they consider how to construct a more instrumental use of the computing environment by understanding human factors (Hornbæk & Oulasvirta, 2017). In comparison, we would lean towards describing the ideas in Section 2.2 as more constructive (albeit somewhat biased). In reality, visionaries like Engelbart and Alan Kay initially exemplified a "philosophical multilayered thinking" regarding placing humans as the purpose, with computing serving the purpose later. Further elucidation on these human-computer relationship musings will be provided later in the text; however, regardless of interpretation, we believe that the original intent of these thinkers was for computers to realize their full potential.

As HCI expert Professor Jeffrey Bardzell stated in "Humanistic HCI": "...Jonathan Grudin describes this movement of the computer from a narrow technical specialist domain to something ubiquitously around us as 'the computer reaching out'....But we in HCI are not just passively 'being reached' by the computer. It is our profession that, along with others', pushes the computer out..." (Bardzell & Bardzell, 2015). We tend to interpret this "pushes the computer out" as a profound philosophical and systematic contemplation, because envisioning the future of computers is not a problem that can be solved by "science fiction scenarios." Reality shows us that the good and bad in this world are both human-made. The essence of the human-computer relationship lies not in the relationship itself, but in first understanding humans. If we cannot see the fundamental reasons behind this, "human-in-the-loop," AI, computers, and science fiction are all mere projections of humanity, incapable of saving humankind. Jonathan Grudin also once said: "Technology has changed rapidly, human nature very little" (Grudin, 2017). While this is true, do we have alternative ways of understanding human nature?

Therefore, technical issues have never been just technical issues. When we begin to discuss what kind of interactions to design, what kind of computers to create, we need to transcend the traditional computer (science and technology) framework to address HCI issues. When past usability solutions designed for computers are insufficient to solve increasingly complex societal and individual problems in the future, how can we utilize perspectives from other fields to improve our misunderstandings of certain aspects of human nature? As we delve deeper, we find that understanding human nature requires seeking answers within the accumulated human wisdom derived from all human experiences. In our context, this involves the Eastern and Western philosophical thoughts behind HCI design, the origins, similarities, differences, inertia, and

complementary aspects of understanding relationships between humans, objects, and ideals. This is a crucial foundational contemplation overlooked by past HCI and even the entire technological development field, which could potentially help us see the unseen. The way HEC contemplates these issues is precisely what HCI can contribute most in the future.

Chapter 3: Hermeneutical Studies for Human-Engaged Computing: Towards the Theoretical Justification

Building on the foundation of Human-Engaged Computing, starting from this chapter, we will focus on five core concepts - Antibiosis, Engagement, Engaged Humans, Synergized Interaction, and Engaging Computers, seeking a deeper theoretical construction and interpretation of HEC. This chapter will interpret on the first four concepts, which constitute one of the significant contributions of HEC - The Thought System, while the fifth concept is another contribution - The Computing System. In our past experiences of lectures, the audience is often more interested in directly understanding what The Computing System or Engaging Computers projected by HEC looks like. However, from our perspective, without an interpretation of The Thought System at the level of theoretical thoughts, a mere description of The Computing System's design principles is untenable.

Why does HEC need interpretation? There are three reasons for this. First, Human-Engaged Computing is not a term that can be simply understood at face value. It involves considerable theoretical reflection and requires gradual exploration to understand how to apply it. Similar to the term "Liberalism" in the Western context (Bell, 2014), behind it lies qualitative frameworks like "Spontaneous Order" (Hayek & Stelzer, 1960) and quantitative arguments like "General Equilibrium Theory" (Arrow & Debreu, 1954). There are also many sub-theoretical branches internally, eventually forming a thought system. Relying solely on literal, everyday experiential understanding may not only overlook truly valuable explanatory paths but could also lead to misunderstandings. Second, as the founder of hermeneutics, Hans-Georg Gadamer, mentioned (Gadamer, 2013), interpretation involves its historical and linguistic context. This not only pertains to the author's thought process but also encompasses the entire history of thought from an HCI perspective, including valuable insights from figures like Alan Kay, Steve Jobs, etc. Understanding how to connect these perspectives within a framework is essential to interpretation. Furthermore, the theoretical justification of HEC stems from the shared dilemmas and focal points resulting from cross-disciplinary perspectives. Third, and perhaps most importantly, from a technical standpoint, our current technological level cannot guarantee a "carefree" life for everyone. From a human perspective, we cannot clearly answer human neural, physical and mental distress based on current neuroscience and physical explanations. Yet, how individuals as subjects can confront the realities of their lives and survival issues so urgently requires a broader explanation, and finally, serving to innovations.

In conclusion, why HEC is said, what is said, how it is said, and what is to be done later are equally important. These contexts are part of the ongoing exploration process of interpreting HEC. We must emphasize here that HEC is a thought system that incorporates both science and philosophy. By abstracting and summarizing various viewpoints and phenomena from both Eastern and Western thoughts as well as HCI, we aim to provide a contemporary interpretation of human understanding and technological future, followed by practical applications. Specifically in this chapter, we aim to discuss how, beyond the Western traditional historical thought on the human meta-capacity of Biophysics based on naturalness and empirical aspects (including behavior, cognition, and emotion) and the human meta-capacity of Intellect based on intellectual construction, we propose a third kind of human meta-capacity of Xin based on the inward transcendence from Eastern thoughts, to address the prevalent Antibiosis in the contemporary world and respond to how humans can survive. These three human capacities collectively form the Human Capacity Framework, with "Realizing the wholeness of human capacities" as the core value. Through the interpretation in this

chapter, our fundamental aim is to establish a "philosophy of humans" or "anthropology" under HEC, exploring the theoretical justification of HEC.

3.1 Fundamental Methodology

Before seeking the interpretation of HEC content, we need to introduce a fundamental methodological approach to explain our underlying thoughts and interpretive structure, including why we encounter such questions and why we develop a corresponding discourse and thought experiments in the face of such a systematic set of issues. This should be part of the overall interpretation to help readers deepen their understanding. Building upon this, there will be interconnections and supplements to the interpretive content, and perhaps only after several steps will there be relatively general empirical experiments. As the interpretive material accumulates, I have to admit a fact that many of these materials I am uncertain about or even misunderstand, necessitating continual re-reading and revision. I strive to express my entire interpretive thinking as complete and clear as possible, connecting the intellectual essence of the materials, so that in future expansions and corrections, the structural changes are not overly extensive.

3.1.1 “Self as Method”

Italian philosopher Benedetto Croce once said: "All history is contemporary history." In the context of HCI, simply put, what we see in HCI and its issues are a part derived from our current perspective. We ourselves need to be understood as one of the phenomena posing questions. Our perspectives, regardless of whether their underlying logic is based on a demand for technological performance improvement under a progressive historical view or a search for relationships between different variables under a scientific view, require a sense of vigilance to prevent a fundamental deviation in understanding. To interpret the background of HEC being proposed, personal experiences must be brought in rather than excluded, helping us to see its history, origins, limitations, and then seek innovative opportunities. In fact, "Self as Method" (Xiang & Wu, 2022), problematizing one's own experiential background, has formed a consensus at the epistemological level in fields like literary criticism, history, and social sciences (Bardzell & Bardzell, 2015), yet it is rare in current HCI and technological thought writing. This means that the emergence and interpretation of HEC are inseparable from the context and discourse of Prof. Xiangshi Ren and Chen Wang.

I cannot and should not provide a more detailed description or speculation on Prof. Xiangshi Ren's personal experiences, and I expect that one day he can help fill in this part. However, we have at least four more evident clues to help readers understand the emergence of HEC as a natural result of Prof. Xiangshi Ren's personal experiences:

(1) 30 years of experience and observation in the HCI field: As a scholar who entered and remained in the field early on, especially in the branch of pen-based interaction, Prof. Xiangshi Ren has witnessed the development of this field, leading to a highly skilled research approach and expression - with infinite properties for combination - prompting reflections on the technicization of HCI and the lack of value goals.

(2) Reflections from meetings with Engelbart: Prof. Xiangshi Ren has mentioned multiple times the influence of Engelbart on his entire transformation of understanding in HCI, and from a

philosophical standpoint, HEC itself is a reflection and development of Engelbart's Augmenting Human Intellect approach.

(3) Cross-cultural intersections: Being a Chinese scholar who has lived and worked long-term in Japan, along with experiences in the international academic and educational environments, Prof. Xiangshi Ren can observe more clearly the differences in cultural thoughts and even individual differences, reflecting different ways of acting and prompting reflections on the nature of human behavior.

(4) Timing of the publication of HEC: Although the original idea of HEC was formed in 2013, it was officially published in IEEE Computer in 2016, a time when the international academic community began gradually focusing on human-computer relationship issues. This was likely influenced largely by the increasing prevalence of mobile technology, the growing popularity of deep learning, but more importantly, by technological achievements such as AlphaGo representing the beginning of a new era of "artificial intelligence," leading to greater acceptance and understanding of this pioneering concept.

(5) Any others...

Chen Wang's subjective experiences are largely articulated in the Preface and Acknowledgments sections. His evolving understanding of the HEC interpretive system is detailed in Sections 3.1.2 & 3.1.3. These points will not be reiterated. Building upon these experiences, over the past few years, a growing ideological disenchantment or openness towards many phenomena in his mind has emerged, leading to considerations on how HEC can serve as a new technological ideological construct to help address the core issues within these phenomena (further elaboration can be found in Section 3.2). In summary:

(1) Simply criticizing advanced technological developments for not benefiting everyone or for not making society better is unfair. However, there are indeed numerous problems in this process, leading to even greater destruction. "Technological Problems" are only "Technological Questions" on some levels; on a broader scale, they are human problems. As long as this context exists, technology, and indeed all capabilities and concepts, are double-edged swords.

(2) Economic development has cycles and prerequisites. Eternal high-speed growth is a modern illusion - we are bound by a progressive historical view, but how much are our ideologies constraining us, and to what extent are past experiences viable? The question of how we are shaped is not uncommon in postmodern philosophical thinking and discussions, but how can we take a step further to see more deeply into the essence of more problems?

(3) High levels of consistency in qualities related to humanity such as truth, goodness, beauty, sincerity, morality, ideals, and artistry regarding Xin are rare (to make a loose analogy), serving as transcendental forces for human progress and overcoming bottlenecks, which also form the basis for the feasibility of HEC. Conversely, double standards are a human norm. The operation of general social forces - such as modernity or capital - makes it impossible to casually step out to improve human conditions; this is the inevitability of conceptual alienation. Through enlightenment brought about by technology, sparking transcendental powers within individuals, we expect to find a balance in practicing HEC.

(4) Kochi is the birthplace of Sakamoto Ryōma, a revolutionary who required high levels of action and passion (Jansen, 1994). It's difficult for me to be passionate or to rapidly implement a system or start a business through HEC; I lean more towards Max Weber's "worries here, worries there" type of concern. As an ordinary person, there isn't much I can tangibly change, but what I can do is propose more ideas from a thought perspective - using this set of ideas for thought experiments and providing blueprints for the future of computing.

In reality, these insights may not be profound, but they illustrate how Chen Wang's inherent cultural concepts as a Chinese individual are at play - the "Orthodoxy," where anyone or anything in a high position should embody a high level of moral sentiment, though this is not the reality in most of cases. This power is undeniably strong and must also be analyzed as a context.

As an interpretation of the author's background phenomena, we aim to illustrate that the *problématique* and the proposed stance on HEC did not arise out of thin air. It's essential to understand not just why we propose HEC, but also the underlying structure behind it. On one hand, HEC is a natural outcome of the author's experiences, but on the other hand, it is a rather personal approach. Discussing HEC without considering the author's experiential context actually overlooks many premises, leading to misunderstanding or misinterpretation. "Self as Method" is crucial for the author personally, not only as a thought process but also as material for reflection. In our overall writing, we expect readers realize that HEC is a narrative we construct regarding technological issues and developments. Readers can also integrate their personal experiences to understand HEC, enabling them to objectively assess its validity and reasonableness, rather than being a preachy narrative laden with our emotional excitement.

3.1.2 Horizontally: Multi-disciplinary Perspectives

The interpretation and *problématique* of HEC are largely associated with the cross-disciplinary perspective of HCI, as it involves studying both humans and technology simultaneously. This mutual consideration provides us with an opportunity to reflect on the entire system, but it also necessitates considering various issues. Therefore, throughout our interpretation, the discussion on how to develop the corresponding technology for HEC, which may be of greater interest and more intuitive to many, only constitutes the latter part of this dissertation. The larger portion focuses on how this chapter examines the theoretical justification of HEC through interdisciplinary connections, particularly from the humanities and social sciences, because technology is never simply a technological issue. This underscores the importance we continuously emphasize on the "perspective."
Additionally, "interpretation" naturally aims to help everyone analyze the content contained in HEC through a textual means, but the fundamental purpose of interpretation is to transcend the textual "understanding" of HEC. In order to enhance understanding, it is also necessary to explain in advance the influences brought to us by a multidisciplinary perspective and even encourage readers to first understand the core ideas of these multidisciplinary perspectives, making it easier to comprehend our theoretical interpretation (see Figure 3.1).

The following are the multidisciplinary perspectives involved in this dissertation (Some upcoming content will be mentioned in advance):

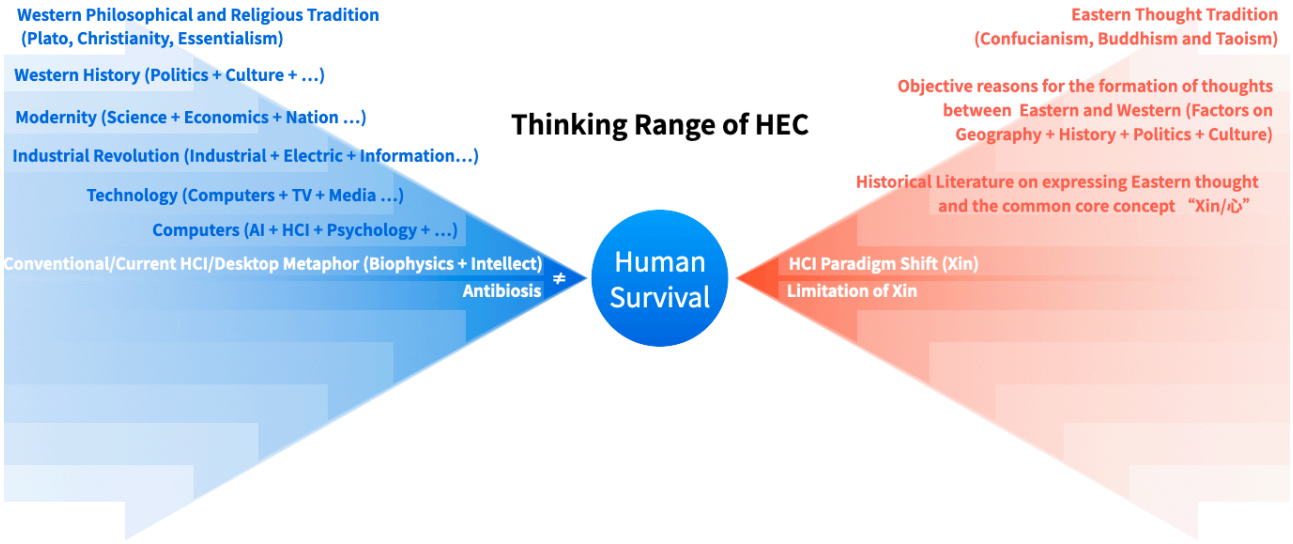

Figure 3.1. The thinking range of HEC based on our experience, multi-disciplinary Perspectives and the history of ideas

(1) Eastern and Western Philosophy and Thoughts: HEC continuously questions the phenomena of HCI technology and issues, ultimately leading to a fundamental discussion on the differences between Eastern and Western philosophy and thoughts in understanding human problems. Western philosophy and thoughts not only form the main framework behind current HCI technological reflections and science but also constitute the primary spirit of the modern world. The origins of these ideas encompass not only Platonic and theological worldviews but also shape the Western intellectual spirit's direction of "essentialism" - using a dualistic analysis as a basis to explore the essence of all things. Throughout the interpretive process, we continuously reexamine and deepen our understanding of these ideas. In contrast to the increasingly secular rational thinking in Western philosophy since modern times, the holistic philosophy and thoughts of the East provide a wealth of insights for the direction of HEC's contemplation, mainly including Confucian, Buddhist, and Daoist thoughts. Specific concepts such as Dharma and Śūnyatā, Xin and human nature, the relationship between individuals and the external world, the consideration of the true subjectivity of individuals, and the differences in thought between Eastern and Western philosophy, such as the discussions on reality in logic and physics, the "Brain in a vat" concept in Western philosophy, Jacques Lacan's "The Real," and the Eastern interpretation of "truth not being illusory/真实不虚" are explored. Having a relevant foundation will make it easier to understand the core ideas of HEC. Otherwise, it may require a process of acceptance. Initially, I actually resisted Buddhism, but as I gradually understood its core ideas, it greatly inspired my entire thinking process, significantly enriching the interpretive system of HEC. Eastern and Western philosophy and thoughts each have their own value and problems in the real historical development process. We are not here to praise one and disparage the other but to integrate their values, become aware of and avoid their problems.

(2) Anthropology, History, and Cultural Comparison: Influences primarily stem from two aspects. On the one hand, there is the classical understanding of humanity, where many characteristics and concepts of humans can be explained from physiological and social perspectives, providing evidence for our classification of Biophysics and Intellect. Of course, anthropology also faces

the dilemma of how to solve many problems after explanation. On the other hand, the formation of differences between Eastern and Western philosophy and thoughts did not happen overnight. These differences are not only about how specific texts are written (as a result) but are also shaped by very apparent relativities at geographical, political, historical, cultural, and even archaeological levels. This also serves as a response to our past experiences - especially in domestic Chinese lectures - where some listeners often find it "mysterious": 1. What we discuss, whether HEC or its background, is a serious academic argument based on in-depth research, and the formation of related ideas can be traced historically, rather than being a fragmented introduction to relevant concepts; 2. "Mystery" itself is a form of conceptual formation, especially in Chinese thought, which, in the background of undergoing significant pragmatism and transformation in the twentieth century, has taken another extreme cultural path.

(3) Psychology and Psychoanalysis: HCI is closely related to cognitive psychology from its inception, discussing system design from the perspectives of behavioral or cognitive psychology. In recent years, humanistic psychology and positive psychology have increasingly influenced HCI towards mainstream paradigms. However, based on my personal experiences and reflections on the research process in psychology and consulting therapy, I must admit that I have a bias towards the role of psychology in HCI. This bias stems from the fact that its role is overly instrumental, scientific, and empirical, making it difficult to provide guidance on larger issues concerning human life and survival. These existential issues cannot simply be matched by a linguistic or a "meaning model" or a "certain effect" on the CBET level in psychology; they are hard to withstand questioning (ultimately either leading to discussions in philosophy or religion, becoming language games, or being left undiscussed). Alternatively, one could say that my expectations or applications of current psychological research are possibly too high. One significant reason for this may lie in the fact that general psychology still retains strong mechanistic undertones based on modern science, unable to provide a systematic answer to problems encountered by individuals or humanity as a whole. Therefore, relatively speaking, the details may be left to psychology, but within the broader interpretive framework of this dissertation, many philosophical and psychoanalytic discussions have been introduced. These discussions may be difficult to empirically validate, but they have the capacity to help us explain and analyze significant issues and context.

(4) Psychiatry and Modern Medicine: My experiences in the psychiatric ward have led me to develop two fundamental understandings of human illness: on one hand, illness is influenced by both physiological and psychological factors, which formed my initial understanding of what I will later discuss as Biophysics and Intellect. On the other hand, the presence or absence of illness, and whether a person is "normal," are often defined within a quantitative testing or subjective scale framework of modern medical thinking, which contains significant relativity. Meeting these standards is equated with being "healthy" or "normal." I am not quick to dismiss these methods because their essence lies in approaching objective descriptions of phenomena. The problem lies in their tendency to bring about misunderstandings in classification, leading people to rashly deny the rationality and potential behind those deemed "abnormal," and to overlook the deeper theoretical reasons behind the "causes" of these conditions. Therefore, in the overall interpretation of HEC, I hope readers understand that even though I may use similar expressions, I am striving to avoid using evaluative terms such as "good," "bad," "positive," "negative," "positive," or "negative." Later on, we will also discuss how human Biophysics and

Intellect capabilities are double-edged swords, initially treating them as phenomena rather than making value judgments.

(5) Sociology, Political Science, and Law: When facing current global or local issues, we may try to discuss our own feelings, opinions, or complaints, but how are these judgments based on personal experiences made? How do these issues arise? Do we truly understand what is real? This dissertation aims to move beyond phenomena to discuss the fundamental reasons for the emergence of Antibiosis. Therefore, in the research process, this dissertation examines the basic principles, historical evolution, and theoretical models of sociology, political science, and law. These fields deal with choices and institutional designs in the face of real-world problems, and further reflect on the relationships between social thought, political philosophy, legal philosophy, and Western fundamental ideas - a dualistic hierarchical differentiation, a system of checks and balances, and the fundamental issues that arise from this. This comprehensive understanding owes much to the inspiration of Max Weber. For HEC, these research attempts have at least three layers of significance: 1. Understanding the abstract logic of the modern world; 2. Understanding the basic structure of why Antibiosis arises in modernity; 3. Reflecting on potential methods to address Antibiosis.

(6) Economics/Economic History: Complementing the previous point, one could say that one of the underlying principles of the logic of the modern world is technological progress and economic growth. However, this itself is an ideological view of modern progress that, in fact, cannot guarantee sustainable progress, and the notion that "slowing down is a sin" may lead modern society to overextend itself in meeting ever-increasing demands for growth, risking internal collapse. Despite being criticized repeatedly, there may be no better universal standard or ideology beyond this. Prompted by the concept of transcending the normal load of the entire system, a distortion of values and the emergence of Antibiosis, causing harm to individuals, and the idea of economic "balance" remains an ideal. In this age of relative material abundance, when HEC contemplates technological and economic issues, it must first recognize what true scarcity is - from the surface-level spiritual energy of individuals to the deep-level Xin - and how to help identify this scarcity and design formalized orders to avoid spontaneous Antibiosis behaviors, starting from maximizing the "subjectivity" of each individual. Additionally, the interpretive development of HEC inevitably involves real economic discussions - why HEC is feasible in reality and not purely metaphysical.

(7) Communication Studies, Linguistics, and Pedagogy: In the current high-tech context, it is challenging to solely discuss computer technology and its current and future forms from a purely technical perspective. Schools of thought such as the Frankfurt School, Communication School, or the Alan Kay team all view technology as a medium through which environments exert influence on individuals and society, and what we can do about it. We view technology, Engaging Computers, as a medium for practicing HEC values and intervention in the environment. We must realize that this environment actually mirrors and shapes human language structures - what kind of media we have determines how we think and speak (McLuhan, 1994). This is an ongoing recursive process: the grammar shapes the language, influencing overall thinking patterns or ideologies, down to everyday casual conversations and naming conventions, such as the connection between the proliferation of online media forms, colloquial expressions, and language games. In this sense, interaction is an extension of human language ability (which is essentially Intellect). If a technology can combine with everything, it becomes a language, providing the foundational material for thought and projection, becoming

the backdrop for human thinking, such as AI, the Metaverse, short videos, etc. However, with the plethora of intelligent devices today and the countless conscious or unconscious interactions humans engage in daily, if we consider "realizing the wholeness of human capacities" as a value, technology can fully support this concept on a large scale. Therefore, the structure of its language and communication influences The Thought System and The Computing System considerations.

(8) Phenomenology and Hermeneutics: As mentioned earlier, the importance of "why say," "say what," and "how to say" are equal. Without revealing this thought process, without analyzing the author's own experience as a phenomenon, it is difficult to clearly interpret the relationship between HEC and HCI, among other concepts. In addition, phenomenology and Eastern thoughts have significant similarities in their approaches to problem-solving, which constantly help us understand and refine the differences between them. This is inspired by phenomenology and hermeneutics.

(9) Computer Science: The influence of computer science on us is not only about specific programming skills or implementations, or because of its close relationship with HCI. More importantly, it lies in the "essence" of the world that is mapped by its underlying models (such as data structures, low-level design of programming languages, characteristics, or paradigms). Many humanities can actually be mapped to such an abstract model discovered by computer science, such as the potential similarity between the hierarchical structure of sociology and binary trees/forests, the potential similarity between economic liberalism and the maximum entropy model, the models of civil law and common law, with the potential similarity between top-down and bottom-up design concepts in computers. Programming languages, as the foundation of computational theory, are highly abstracted essences that designers extract after understanding things (including describing them in language), thus being able to highly describe world phenomena. On the one hand, they share a high degree of internal consistency with the real world. But on the other hand, the foundation of technology begins with a binary classification.

(10) Software Engineering: This perspective brings us not only knowledge issues about how HEC is implemented as a computational system but also how to understand the world from an engineering philosophical perspective (Auyang, 2006), and how to project understanding of humans into a simple yet robust systematic structure arrangement. Compared to the current inertia thinking of HCI and even broader software design (such as Microsoft Word just amplifying the phenomenon of writing needs in the real world but making writing itself more and more complex), the engineering design of Engaging Computers needs to be based on the underlying structure behind this complex phenomenon of the world.

(11) Humanities and Arts: If the above fields are the "training set data" in the construction process of HEC, then humanities and arts are a kind of "test set data". That is, beyond "science," we hope to explore how humanities and arts can be compatible with and interpreted under HEC. The current compatibility and interpretation have at least three points: 1. From the perspective of Intellect, symbolically inclined writers and artists have certain or leading positions in theoretical thinking behind their works, helping us understand what people of this era are thinking or will be thinking; 2. From the perspective of Biophysics, different artistic expression media, whether it's literature, classical music, contemporary art, architecture(Wang, 1988), film, animation, under such a positioning, continuously explore the boundaries of human sensibility, countering

standardized rationality towards individuals; 3. From the perspective of Xin, symbolically inclined, especially the more mature works of authors, share a similar transcendental and regressive spirit behind them, such as the relatively recent Ryuichi Sakamoto. In this sense, we further confirm the value of "realizing the wholeness of human capacities" with HEC, and the feasibility of using HEC methods from the perspective of intellectual history.

(12)Design Perspective: Finally, the significance of design lies in how to integrate the perspectives and derived thoughts mentioned above, by projecting theories, more interactive tasks, and detailed designs in an aesthetic way onto Engaging Computers.

Here are the main multidisciplinary perspectives that interpret HEC at the current stage or are deeply influenced by it. In the research process, it also involves fields such as biology, management, business, finance, etc., which have more or less influenced the process of interpreting and constructing HEC, without going into detail. We will continue to deepen our understanding in the near future. I do not intend to list all the treasures. I am simply naturally led here while studying how to understand and interpret HEC, and then I discovered that all perspectives are naturally, philosophically, and perhaps even initially interconnected, not just for the sake of reading.

As Goethe said: "Those who know nothing of foreign languages know nothing of their own (Goethe, 2010)." Integrating all issues for comprehensive thinking, that is, the extent of the context determines the extent of rational purpose, the consistency of evaluation criteria, and the adjustment of instrumental rationality. Without the interconnectedness and checks and balances of these perspectives, and without understanding the respective ways of thinking and interpreting the world, and if we solely look at technical issues from a technical perspective, talking to ourselves, not only will HEC not be convincing, it will be difficult to see the fundamental problem. We may even lead to a utilitarian inertia and cause trouble - "If the only tool you have is a hammer, it is tempting to treat everything as if it were a nail" - and this has been all too common in past technologies. We will frequently switch perspectives to discuss the value and justification of HEC, even going as far as to say, using HEC as a lever to build a unified theory that integrates technology and humanities, establishing a universal connection of disciplinary thoughts between multiple fields, and then discussing what technology is and how to do it, continuously explaining and integrating new phenomena. This universal connection lies in the most profound thread in the formation of the history of human ideas, simultaneously becoming the shared spirit of "art" in different fields.

3.1.3 Vertically: History of Human Ideas

The process of reflection and innovation occurs every day, and with so much accumulation of phenomena, it becomes challenging to clearly discern the position and true value of a certain concept. We should still refer to the phrase "All history is contemporary history" - when people of a certain era observe and judge from their own perspectives, is there a unified underlying structure within this? For this dissertation, how can we find this structure and use it as a foundational tool? The most obvious structure here is attempting to organize phenomena through an analysis of the history of human ideas, in order to position HEC.

Whether it's the history of HCI or a multidisciplinary perspective - analyzing sociology, psychology, natural sciences, architecture, music - we find that within a certain timeframe, many fields share a fundamental concept, and these fundamental concepts themselves are manifestations of deeper

thought patterns and the Zeitgeist (Hughes & Hoffman, 2017; Schorske, 1979). If various phenomena are seen as a door, these fundamental concepts, thought patterns, and spirit of the times are its "axis", and no matter how subsequent thoughts or phenomena develop, oppose, or become our subconscious at present, they are all on this extended line. We also aim to position HEC from the "meta-thought", seeing the complexity and basic principles of phenomena from the perspectives of ideas history and knowledge archaeology (Foucault, 2013; Honneth, 2020; Jin & Liu, 2008; Lovejoy, 2019), ideally trying to understand what to do next. Consequently, we indeed find it challenging to empirically prove at this level. It is more of a reasoning and thought experiment using an abstract "Ideal Type"[26].

Uncovering the context of major nodes in the history of ideas actually constitutes a way of connecting the two main contributions of HEC - The Thought System and The Computing System - a kind of structuralist correspondence. This is not only the structure of various phenomena in HCI, but also the structure of Antibiosis, and the structure of the history of ideas. Structuralist pioneer and anthropologist Claude Lévi-Strauss once said that the logic behind cultural phenomena cannot possibly have hundreds of aspects, it is likely just a handful two or three. This is also similar to Wolfram's research on complex science and Cellular Automaton: simple rules can generate numerous phenomena (Wolfram & Gad-el-Hak, 2003). Therefore, in direct terms, the structure we have discovered is the concise "Biophysics-Intellect-Xin", which is then reflected in the design of Engaging Computers, and we will further elaborate on this in the future. Some might ask: But isn't structuralism an outdated paradigm? To this, we say:

(1) Regardless of whether structuralism is outdated or not, it forever remains a theoretical node that those "sub-paradigms" cannot bypass.

(2) "Biophysics-Intellect-Xin" itself is what we see as the ultimate structure upon deconstruction, including our subsequent work, which may just be an extension based on this structure.

3.2 Theoretical Dilemmas Within and Beyond the HCI Context

Following the "broad perspective" of our fundamental methodology, we rethink the major challenges faced by humanity today - not only limited to HCI but also to perceive the unity of these issues. Our *problématique* ultimately involves the understanding and limitations of "what is human" stemming from the Western philosophical origins behind technological advancements.

3.2.1 The *Problématique* of HEC: Universal Antibiosis to Human Survival

The *problématique* of HEC originates primarily from our long-term observation and research on HCI. We seek to inquire into the extent to which HCI, computational usability, and related fields can address the current challenges faced by individuals and humanity, as well as the real issues confronting humanity. Despite acknowledging that HCI has to some extent propelled the information age or the progress of human civilization, and has generated significant commercial value, we still observe many serious and pressing issues. If we believe that the problems that current HCI can explain and solve are not extensive enough, we need to broaden our perspective beyond

[26] https://en.wikipedia.org/wiki/Ideal_type

HCI. By organizing the perceived current human predicaments, we can understand what these issues and phenomena signify.

We categorize the human issues that we are conscious of into three levels, including but not limited to (see Figure 3.2):

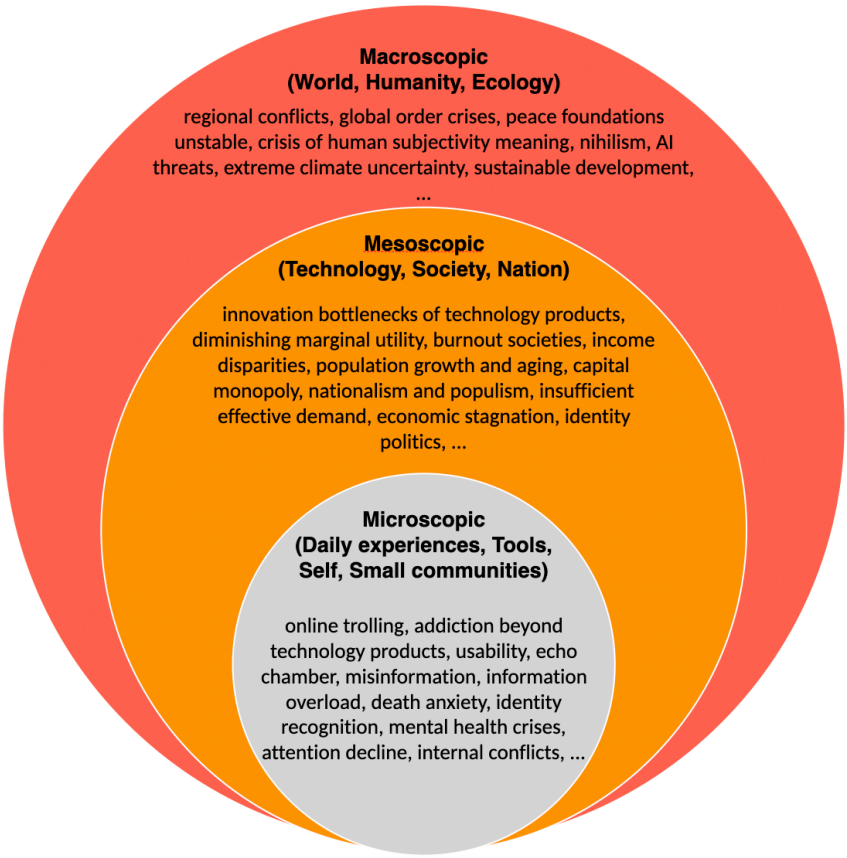

Figure 3.2. Universal *a*ntibiosis to human survival

(1) Microscopic (Tools, Self, Small Communities):
- Tools: usability, echo chambers (Jamieson & Cappella, 2008; Sunstein, 2006), misinformation (Liu, 2021), information overload, privacy, etc.
- Self: death anxiety, identity crisis, mental health crisis (Geiselberger, 2017), distraction[27] (Carr, 2020), addiction beyond technological products (Schüll, 2012), etc.
- Small Communities: online trolling (Phillips, 2015), internal conflicts, etc.

(2) Mesoscopic (Technology, Society, Nation):
- Technology: innovation bottlenecks in technological products, diminishing marginal effects of demands, etc.
- Society: burnout society, consumerism, wealth disparity, societal divisions, aging population and declining birth rates, capital monopolies, etc.
- Nation: populism and chauvinism, inadequate effective demand, economic stagnation (Sharma et al., 2023), identity politics (Fukuyama, 2018), The Banality of Evil (Arendt, 2006), etc.

[27] https://www.wellbrookrecovery.com/post/average-attention-span

(3) Macroscopic (World, Humanity, Ecology):
- World: geopolitical conflicts, receding globalization, unstable peace foundations, etc.
- Humanity: crisis of human subjectivity and meaning, nihilism, AI threats, etc.
- Ecology: uncertainties of extreme climate, sustainable development, etc.

In the early context of HEC, conflicts between humans and technology were collectively termed Antibiosis. Here, we have expanded this concept to define Antibiosis as the antagonistic conflicts arising between humans and the aforementioned issues in the Microscopic, Mesoscopic, and Macroscopic realms. The above list can be continuously supplemented. We may not be able to provide a definitive definition for each Antibiosis, but borrowing from Wittgenstein's idea, these issues share a "family resemblance" in common. This commonality is reflected in at least two aspects:

(1) Antibiosis is inseparable from our high-tech background. In other words, humans cannot return to a world without technology to evade these issues. Some may question the specific relevance of these issues to HCI. This is precisely because the global informatization affects the occurrence of these phenomena and various derived amplification effects (for example, we can see extensive use of drones in the Russia-Ukraine conflict in the news, suggesting that future soldiers may be better suited from those skilled in electronic games rather than solely based on physical fitness). Hence, HCI cannot operate in isolation. Instead, these are precisely the issues that HCI needs to consider. However, pure HCI issues represent only a minority, and these issues clearly cannot be addressed solely from a technical standpoint.

(2) Although many Antibioses are caused by external factors, inappropriate human or technological interventions lead to various secondary damages in the process of resolving Antibiosis, whether these interventions are offensive or defensive in nature. Therefore, from this perspective, identifying the root causes of Antibiosis primarily involves understanding how we comprehend humans and their needs in our consciousness and subconsciousness, and how we correspondingly design technology.

When we view Antibiosis as a whole, we also see the challenging aspects that we need to address:

(1) Systemic: Factors at various levels are interconnected, universally linked, pulling one thread affects the entire system.

(2) Structural: Sometimes we might attempt to patch things up step by step, but such repairs could lead to new issues. When problems become unfixable, they can trigger collapses, ultimately threatening Human Survival across all levels—whether physiological or psychological, external or internal, individual or societal. Despite humanity overcoming many challenges, it has come at a significant cost to individuals, and who can guarantee that this isn't the "last time"? This is the limitation of methods under human intervention.

We cannot attribute these issues to mere "societal mistakes" because society is primarily a constructed concept and not strictly a tangible entity. Moreover, within various social positions, there are predominantly ordinary people. It's crucial to emphasize that, in reality, the current society is, in comparison to any historical period, relatively better, as human survival has struggled to break free from the "Malthusian trap" even amidst these Antibioses today. However, these Antibioses should not be accepted as an inevitable cost. The ideal expectations that humanity can establish

should not be this grim, societal resilience could be better. The current human experience is more characterized by rapid growth, making it challenging to objectively assess any "ought to be," thereby leading to potential social and economic crises. Faced with real Antibiosis, what can we, HCI, and technology actually do? HEC aims to provide a more systematic answer to the internal and external dilemmas of current HCI, placing Antibiosis and its *problématique* within the same explanatory framework of technological design. Only by recognizing the limitations in our understanding of "humanity" can we discuss how future computers should address these limitations.

3.2.2 "Biophysics" and "Intellect": Conventional Western-driven Narrative on Humans

So, from a "modern" perspective, how do we understand humans in our consciousness and subconsciousness?

The Limitation of HCI on Understanding Humans

Let's first start from the perspective of traditional HCI experiences. We might often say things like "the user needs this..." or "we want to create something that can help people...", but are we really talking about a living, breathing person? Despite utilizing Human Factors, user research, participatory design, and other methods, people in such contexts are often referred to and abstracted as specific user identities or symbols (as basic as UML in software engineering). Scientifically, this might further connect to cognitive psychology, demographic factors, cultural backgrounds, personalities, and other secondary symbols when considering how computational technology can meet the functional and experiential needs of people. This provides designers with potential suggestions to design in a way that aligns with the habitual, conscious, or unconscious experiences of people, offering more universal principles. However, once this understanding inertia dissects people into various human factors or variables, there arises a question of whether their combination can truly represent the complete individual. This is not only a challenge faced by HCI but also a question that the entire modern scientific system confronts. While we can say this is at least a form of "procedural justice" analytical method, incomplete comprehension of methods and conclusions, and an unconscious lack of integrity towards people, can significantly bias designers in their actual design practices (for example, the Mental Model is a pieced-together concept that can be used to a certain extent, but it should not be mistaken for the essence of a person). If these concepts further develop into widely used products, they may bring about corresponding (disadvantageous) social impacts.

Although we mentioned the phenomenological shift in HCI in Chapter 2, transitioning from a symbolic analytic approach to a more "human-centered" interpretation of phenomena (Bardzell, 2009), this highly personalized, expert-experience-demanding mode of work is actually challenging to replicate. The larger issue lies in what we aim to do after interpretation, what problems we seek to solve, often ending up in a singular realm of meeting a user's task requirements - why meeting needs itself is worthy of reflection but lacks such introspection. This is also a modernity's inertia that we will continually revisit in subsequent discussions.

This is why HEC strives to establish a philosophical foundation for HCI, driven by motivations such as:

(1) Is our current understanding of people "right"?

(2) Is the mechanistic system also a human system?

This is also why HEC advocates for an integration with humanities disciplines, as different perspectives from fields like philosophy, psychology, sociology, economics, anthropology, and neuroscience offer varied ways of understanding people. Because a singular technological perspective struggles to illuminate broader issues. The convergence of these fields with HCI is not merely about cross-disciplinary knowledge exchange to design some expert system but about understanding the shared *problématique* of these fields and HCI when it comes to understanding people. By finding a point of integration, HCI needs to establish its own explanatory framework for understanding people, rather than just taking things for granted. At the core of this issue is the need to recognize the subconscious of current HCI—the narrative logic in Western history of ideas that drives the approach to understanding people.

Human Capacity on "Biophysics" and "Intellect"

Firstly, it should be noted that, relative to examining a static individual, needs or what Human Factor is, HEC places the integration point of understanding people on "what human capabilities are." The capabilities that people possess represent what needs, problems or Antibiosis they can solve, which at a micro level correspond to the basic units in HCI - interactive tasks. In terms of the theoretical justification of capabilities as an integration point, economist Amartya Sen has constructed how human societal progress is possible by examining human capability development (Robeyns, 2011; Sen, 2014). Sen's Capability Approach consists of two parts: Functions and Freedom. Functions refer to the various activities a person values doing/being or has reasons to do/be, such as being happy, being moral, being creative, doing a good job. Humans require freedom to achieve these various activities no less than to achieve in matters of simple mechanistic utility. This freedom encompasses two aspects: the ability to act on what matters (one's goal/objective) and the opportunity to choose to act from among various good possibilities (choice). In other words, human capabilities provide the opportunity and ability to produce personal and contextually relevant functioning according to individual and group distinctions. This approach includes and promotes what humans are capable of, what humans want to be capable of, what humans should be capable of, and what humans choose to preemptively and presumptuously exclude. Sen's collaborator Nussbaum further encapsulated the Capability Approach into 10 capabilities, including life, bodily health, bodily integrity, senses & imagination & thought, emotions, practical reason, affiliation, other species, play, and control over one's environment (Nussbaum, 2011). In essence, Sen and his collaborator's theory positions traditional Western liberalism as a necessary but insufficient condition for welfare societies. The key to individual and collective well-being lies in whether individuals possess actual capabilities and the motivation to exercise them, rather than just external freedom. From a certain perspective, this resembles today's AI and intelligent devices, which can provide individuals with the freedom to create, but the specifics of what creation entails and whether it matters requires individual understanding and capability.

Sen's perspective originates from economics, and the human capabilities he describes tend to be based on the concept of rational individuals (society) and skill construction. On one hand, we agree on the importance of human capability development, but on the other hand, these expressions of capabilities are overly complex and fragmented, making it challenging for them to be systematically understood in HCI. Similarly, we believe that a more profound foundation is needed to explore individual, specific capabilities (such as someone having good vision or exceptional programming skills) and to discuss the limitations and costs of these capabilities. In order to develop a human

capability framework for HCI/HEC, and to avoid the impact of minutiae on overall understanding, we currently refrain from exploring individual, specific capabilities (For example, someone has good eyesight or exceptional programming skills). Instead, we explore the meta-capacity classifications abstracted from a series of common capabilities and their potential limitations. From a Western philosophical and social science perspective (especially from an anthropological standpoint), the "Ideal Type" method typically addresses two aspects of "what a human is" or "human nature," namely "Natural Humans" and "Rational Humans" (Roughley, 2023; Trott, 2012; Wilson, 1978). This naturally leads to the emergence of two types of Human Meta-Capacities in HCI - Biophysics and Intellect.

(1) Natural Humans primarily refer to the biological characteristics that humans possess as animals (Morris, 1994), including their innate physical form, cognitive foundations, bodily responses, and fundamental impulses such as the pursuit of "The Pleasure Principle (Laplanche & Pontalis, 2018)." Representative figures of this understanding of natural humans include Darwin (who proposed the natural evolution from animals to humans, challenging the concept of divine creation) and Freud (who suggested that human external behaviors are driven by subconscious primal urges). These figures emphasize the importance of human objective biological characteristics and evolution in defining what a human is. Even today, we can observe how perspectives from genetics, evolutionary psychology, psychophysics, biological anthropology, neuroscience, brain science, and other physicalist directions explain subjective consciousness, judgment, emotions, and even how economics encourages the promotion of human animal spirits in socio-economic contexts (Akerlof & Shiller, 2010), all based on the external stable phenomena and natural order of humans as natural beings.

    In the context of HCI, we refer to the meta-capacity corresponding to natural humans as Biophysics: it is primarily based on the traditional HCI understanding of human bodily experiential phenomena (such as Self-Regulation (Eschler et al., 2020; Strauman et al., 2013), psychological CBET, etc.), mainly divided into three major aspects: Behavior, Cognition, and Emotion (Dolan, 2002). However, due to the broad traditional definitions and usage, based on this understanding, we have redefined its scope of interpretation:

    - Behavior: Encompasses human physical functions manifested in ergonomic characteristics, sensations, strength, motor control, bodily reflexes, etc.;

    - Cognition: Traditionally defined as including the biological support provided by humans for perceiving, processing, remembering, focusing, animal impulses, and other external signals (such as neural networks, brain tissues, hormones, etc.). It's worth noting that because the traditional vast definition of "cognition" almost covers various aspects of individuals from modes of thinking to brain composition, it is overly vague in HCI understanding and method usage. So, here, we specifically refer to the objective physical/psychophysical aspects of individuals as the subjects of tasks like information processing, excluding subjective conscious thinking, knowledge understanding, decision-making, and judgment;

    - Emotion: Refers to the bodily responses generated by individuals in response to external stimuli (such as unconsciously swaying to music) or cognitive overflow, which then affects the internal fluctuations of psychic energy in individuals.

From an embodied perspective, behavior, cognition, and emotion are interconnected and influence each other (Gordon et al., 2023). From a materialistic perspective, natural humans as the embodiment of individuals and Biophysics as the most basic meta-capacity of humans, if one wants to explain human phenomena, it is impossible to avoid the biological aspect of natural humans.

In HCI, a significant amount of work aims to model or adapt human factors and related phenomena from the perspective of Biophysics. This work is dedicated to establishing more efficient, effective, and enjoyable interaction methods for various practical purposes of using computers, including understanding the establishment of human behavior models, designing cognitive ergonomics keyboard layouts to improve information processing (Jokinen et al., 2017), considering emotional experiences (Peter & Beale, 2008; Rousi et al., 2020), optimizing hand-eye coordination (Jiang et al., 2020), and improving input/output design. To evaluate the effectiveness of system and interface design, comprehensive assessments are usually conducted based on user experience data.

(2) Rational Humans primarily refers to the intellectual features that distinguish humans from general animals, including knowledge reasoning, conceptual understanding, thought processes, logical construction, etc., pursuing a "useful" "The Reality Principle" (Laplanche & Pontalis, 2018). The concept of rational humans arises from human reflection on daily experiences, discovering that things that appear natural are not as natural as they seem. The admiration for human rationality can be traced back to ancient Greece, where the Greeks believed that possessing reason was the highest quality of a human, further influencing the conceptual construction of Western civilization. Subsequent influential figures include Kant (who proposed that individuals should courageously apply their reason and define the boundaries of rational understanding) and Adam Smith (who advocated for the free market equilibrium formed by rational self-interested human behavior), affirming human knowledge, subjective will, and agency. Although human intellectual activities rely on the body, from this perspective, human's unique intelligence determines what it means to be human.

Similar understandings of individuals include Social Humans, Cultural Humans, Moral Humans, Economic Humans, etc., but the enduring appeal of the rational humans perspective lies in its ability to theoretically deduce the behaviors of Social Humans, Moral Humans (Dennett, 2004; Ridley, 1997), and even Natural Humans, becoming a fundamental perspective. However, in our analysis, we lean towards calling it "Constructive Humans," meaning that while human rationality is considered to have a natural component (about 40% in psychological studies), its judgment ability is largely constructed postnatally (about 60%). Psychology refers to this entire constructed thinking model from basic cognition to rational judgment as crystallized intelligence, with constantly expanding new knowledge as fluid intelligence. In essence, we want to emphasize that the subject of humans and the many social, moral laws, economic modes, and even any behaviors in human life are not necessarily naturally occurring but are deeply intertwined with processes of self, identity, discourse, and historical construction. Whether this construction system is mesh-like or pyramid-like, it merely becomes a part of the human subconscious and may not be easily noticeable. For example, from the perspective of Biophysics, the formation of a "country" can be attributed to humans' innate biological tendency towards group living; however, from the perspective of Intellect, the formation of a "nation/state" is also seen as an "imagined community" constructed by different individuals through shared language, culture, and identity (Anderson, 2020). There seems to be a tendency

in English for many words to have such explanations, such as "freedom" and "liberty" (Mill, 1966), "sex" and "gender,". This also includes the understanding of User Engagement, where pure immersive experiences are considered a form of Biophysics (such as in games), while guided discourse-based flow or meditation involves elements of Intellect.

In the context of HCI, we refer to the meta-capacity possessed by Constructive Humans as Intellect: emphasizing the construction and application of human intelligence to understand themselves and the world, guiding their actions. The Intellect covers language, logical thinking, concepts, identity, ideology, rationality, anticipation, judgment, signifier, concepts, quantification, imagination, meaning, stereotypes, and even "ego" and "super-ego." The results of these constructed thoughts influence external behaviors and emotional responses through subjective will, enabling individuals to transcend the limitations of the body to imagine and predict.

The Intellect we describe differs from the traditional philosophical and psychological categories of "cognition" and "mind." Intellect refers to a more specific range of human intelligence. In comparison, we believe that the traditional definition of "cognition" is too broad, encompassing various perceptual-related functions such as perception and memory, which belong to the realm of Biophysics mentioned above. In the context of traditional cognitive science, Biophysics leans towards perception, while Intellect leans towards conception. Some use "Mind" to refer to this, but "Mind" refers to a larger and more comprehensive human capacity, covering a series of human functions beyond the physical body, including conscious sensation, perception, thinking, reasoning, memory, beliefs, emotions, and motivations. This can lead to misunderstandings, as the Mind in the dualism of body and mind could trace back to the ancient Greek dualism of body and soul (Descartes, 2013). Therefore, we do not use Mind partly because it is a super-concept with broad references, leading to potential misunderstandings. Moreover, we will explore the other aspects covered by the convention understanding of Mind later on, further distinguishing it from Intellect.

In the field of HCI, Intellect can be seen as the outward projection of the intellectual part of the human Mental Model (Rocha, 2015; Staggers & Norcio, 1993) in interactive tasks (the remaining part of the Mental Model is used to predict human information processing performance and user experience in the interaction process, falling under the realm of Biophysics). This includes creating human knowledge repositories (as exemplified by Engelbart's Augmenting Human Intellect, a milestone in understanding), transforming traditional task flows, and involves designers' understanding of problem-solving workflows, algorithms, task modeling, and values. Specific examples include personal computers, the internet, Wikipedia, various expert systems (such as online meeting platforms enhancing communication and collaboration, CAD software facilitating complex structure planning). Additionally, artificial intelligence technologies like ChatGPT can be viewed as powerful extensions and external manifestations of human knowledge and logic (Wolfram, 2023).

Natural Humans and Constructive Humans (Rational Humans), along with HCI designs oriented towards Biophysics and Intellect meta-capacities, form the basic generalization of our understanding of humans and past HCI. One can say that interaction and technology are extensions of these two meta-capacities of humans. Biophysics focuses on designing and/or enhancing interactive technologies consistent with human biological or physical factors to facilitate information transmission. On the other hand, Intellect involves efforts around

"Augmenting Human Intellect." The classification of these two capabilities not only stems from anthropological theories and empirical knowledge of HCI but can also be traced back to a more general dualistic discussion seeking to define the "first principles of humanity," including body versus mind, nature versus nurture, empiricism versus rationalism, concrete versus abstract, gene versus meme (Dawkins, 2016), Materialism-driven Max (Marx, 1990) versus Idealism-driven Weber (Weber & Kalberg, 2013), and System 1 versus System 2 (Kahneman, 2011).

In this context, we do not engage in traditional debates about dualism or monism (Kim, 2018) or advocate for one side. On one hand, we acknowledge the high degree of interdependence between Biophysics and Intellect. Designing interactions and finding solutions does not imply making a deterministic choice between the two but rather seeking the tension or tendency between them, or even transcending them, as Weber (2013) point out that there is no definitive "resting point" in this dualism[28]. This indirectly reflects the increasing vitality of embodied cognition in HCI in recent years. On the other hand, our aim is not just to classify Biophysics and Intellect but to recognize the significant impact of Antibiosis they have on humans and, more importantly, to seek solutions for the dilemmas faced by Biophysics, Intellect, HCI, and humans.

3.2.3 The Deeper Reason of Antibiosis: The Polarization of Biophysics and Alienation of Intellect

Now the question at hand is, where do we see the emergence of so many Antibiosis phenomena, and what kind of relationship exists between these phenomena and the two meta-capacities of humans understood as Biophysics and Intellect? From the perspective of Human-Engaged Computing (HEC), Biophysics and Intellect are essentially double-edged swords. On one hand, they represent the functional meta-capacity of humans, while on the other, they manifest in the unaware Polarization of Biophysics and the Alienation of Intellect. In other words, Antibiosis represents the cost of human meta-capacities. Technology, as an extension of human meta-capacities, enhances not only human meta-capacities but also the costs associated with those meta-capacities.

(1) The deeper reason of Antibiosis resulting from Biophysics lies in Human Polarization. This polarization can be understood more as a result of the innate instincts of humans as animals - if someone enjoys spicy food, they seek even spicier dishes; if someone experiences violence, they may seek a more violent form of retaliation. This animalistic behavior, as described by Freud, is driven by "Libido (the primal desires constituted by sex and greed)" and follows the "The Pleasure Principle," constantly seeking outward expansion of desires far beyond actual needs. This constant expansion of desires and the dual anxiety of desire and insecurity continually stimulate the instinct of outward aggression. Unfortunately, HCI designs that cater to this polarization are common. For example, catering to users' immediate emotions to increase engagement inadvertently fosters a narrow view of human needs, breeding issues like online violence and addiction. Deliberately shaping user behavior under the call of "Libido" or attention economics, through inappropriate content direction that disrupts emotions and amplifies desires, or through shallow incentive measures that hinder focus, are also common. Additionally, when novelty and usability become universal concepts or even "virtues," developers' and users' obsession with them greatly limits the depth of technological thought and

[28] http://www.pacilution.com/ShowArticle.asp?ArticleID=9345

application, turning technology into a shackle. When evaluating the negative effects of Biophysics, one could argue that it is based on the "evil of conformity." But on a larger scale, it distorts human metacognition, leading individuals and society further away from reality.

(2) The deeper reason of Antibiosis resulting from Intellect lies in Human Alienation. Alienation, initially a significant concept from Marx's "Capital," describes how laborers in the industrial age could not access the products of their labor - Humans start as producers but end up as slaves to what they produce. In a broader sense, this alienation is when individuals are ensnared by identity and ideological thinking labels or frameworks, blindly clinging to and misusing unexamined value systems, ultimately inverting means and ends. This situation, while widely acknowledged, is prevalent - individuals originally aim to develop themselves and society through (certain) ideas, technologies, capital, work, medicine, education, and marriage, but eventually the ideas, technologies, capital, work, medicine, education, and marriage themselves become the ends. For example, pursuing growth for the sake of growth, "What has always made the state a hell on earth has been precisely that man has tried to make it heaven (Hayek & Caldwell, 2014)," turning humans into means for constructing these artifacts[29] (Marx & Engels, 2023).

Compared to the relatively easily identifiable natural polarization of Biophysics, the roots of alienation are more hidden, as we need to dig into the very foundations of human or societal thought constructs - even into some unknown basement. From a historical perspective, the emergence of alienation is clearly based on the transition of natural humans into the "modern" era. From the viewpoint of Western intellectual history, the theme of the past 500 years of the modern world (not absolute, but indicative of events that mark modernity such as the age of exploration, enlightenment, scientific revolution, religious disenchantment, modern nation states, industrial revolution, capitalism, individuality, etc.) has been the gradual liberation of individuals from traditional theological constraints, moving away from the state of natural human production life to develop the concept of the "individual." The overall society promotes a "modernity" that showcases human rationality and a progress narrative centered around "development" and the belief that tomorrow will be better. Hence, based on this extension of modern concepts, HCI tends to favor evaluation metrics such as "efficiency" and "utility." However, over time, rationality has become increasingly extreme, and both radicalism and conservatism have begun to undermine the original intentions of development in various fields in the name of reason (Horkheimer, 1947; Horkheimer et al., 2002).

Sociologist Max Weber pointed out over a century ago that as time passes and social organizations become more complex (such as bureaucratization), instrumental rationality (following procedural rules) will gradually replace value rationality (questioning true problems) in humans. Within the entire social system, the existence of individuals will diminish, with symbolized individuals replacing real ones. Human Biophysics and Intellect are increasingly controlled by the social positions of bureaucratic systems (such as division of labor, subject positions) and value systems - such as consumerism and excessive demands promoting the development of art and science (Mandeville, 1806), the ethical paradigm of Utilitarianism in economics (Cheung, 2005; Graafland, 2009), the physics worship of human issues, the meritocracy that deviates from the original intentions of various professions, and the omnipresent power discourses in society and markets. These aspects are difficult to recover

[29] https://ptext.nju.edu.cn/b6/7e/c13353a243326/page.htm

from their sanctification and valorization, making it challenging to restore human integrity - "Specialists without spirit, sensualists without heart" (Weber & Kalberg, 2013), and it becomes increasingly hard to truly find that purpose or value rationality.

As humans' natural animalistic rhythms are excessively suppressed or carried, various phenomena emerge: the one-dimensional man (Marcuse, 2013), financial bubbles and Ponzi schemes, acedia and burnout society (Han, 2015), ultimately creating a universal "modern disease" (Arendt, 2013; Geiselberger, 2017). Despite romanticism, post-modernism, and anti-modernism attempting to dilute the over-development of modernity and rationality, these reflections and expressions have not shaken the role of modernity as a pillar of society, leaving a pile of unresolved issues due to their lack of systematization and populism, becoming a kind of radical subculture - "opposing for the sake of opposing," and "what to do after the resistance" (Lu, 2005). The emergence of psychology and psychoanalysis has rationalized even the last trace of sensibility and romance in humans. These trends are actually on the extension line of the concept of Modernity or Intellect, and are also reflected in the current development of HCI.

Furthermore, although contemporary society exalts rationality, since humans cannot exhaust complete information about things, this rationality is inevitably limited, corresponding to Hayek's discussion on why liberalism is important: singular rationality/values in social life are prone to error, hence relying on collective rationality of all individuals is necessary. However, it has been found that collective rationality also has similar issues (Arendt, 2006; Le Bon, 2017). Returning to individual lives, modern individuals easily over-rely on limited rationality and its external metaphors, whether in language, concepts, thoughts, or in derived judgments, classifications, meanings, quantifications, or even the "ego," leading to misuse or addiction to certain concepts, ultimately showcasing human alienation (and polarization). Moreover, regardless of how much individuals depend on external concepts, humans are not those concepts, and excessive reliance on concepts leads one towards nihilism, as no individual can find the ultimate meaning of life through "knowing" any concept.

In HCI, design elements that cater to the inertia of Intellect are quite common, such as endless user tasks in various applications or games, data quantification and comparisons, tangible and intangible reward systems, all of which can be seen as potential alienation and discipline of individuals, making means of developing humans dominate the purposes of humans (this is notably evident in the gaming industry, where games have transitioned from being a means of enjoyment to becoming a form of "work"). On a micro level, these designs may seem human-centered but are actually driving shaping consumer identities, excessive marketing of needs, and phenomena like online violence where individuals oppose each other; on a macro level, the supposedly human-centered holistic thinking falls into extreme Anthropocentrism and Scientism dilemmas. As digital life extends our perceptions into real experiences, the severe disconnect between virtual and real experiences leads to various inconsistencies becoming triggers for internal obstacles such as anxiety, addiction, hostility, and escapism. Kevin Kelly described the significance of technology in his book "What Technology Wants," but paradoxically, has "What Technology Wants" become evidence of human alienation (Kelly, 2011)? To some extent, can it be said that humans have already been replaced by AI in terms of technology's ideology and Intellect?

Overall, HCI addresses the issues of information bandwidth and user experience by focusing on the physiological aspect of human Biophysics and aids in building the human knowledge repositories

by reinterpreting specific entities through the intellectual aspect of computation. However, the excessive unconscious use of these two meta-capacities eventually leads to human dilemmas (Antibiosis) - the emphasis on efficiency and pleasure serving Biophysics evolves into fostering attention economy phenomena such as addiction, online trolling, and the spread of fake news (information overload, dissemination of misinformation), while the alienation of Intellect reinforces issues like privacy concerns, echo chamber, identity confusion, and consumerism. Users may seem proactive in highly informational services, but in reality, they passively accept label shaping. This discrepancy leads to a lack of personal and societal well-being, which can be understood as "obstacles" in the human capacity development process.

In traditional views, the notion that "every step of technological innovation more or less requires a cost from humans" has become a common belief. However, HEC suggests otherwise - the crucial point lies in whether we are conscious of this. While these issues extend beyond HCI, interactive design creates a structural technological intervention and environmental premise that fosters the emergence and amplification of these problems. Antibiosis fundamentally reflects the industry's incomplete understanding of humans and the resulting polarization and alienation. It is an unconscious aspect of traditional perspectives pursuing "efficiency" and "innovation" that disregards human significance, akin to the early industrial development's unaware harm to the ecological environment. The essence of Antibiosis does not focus on individual phenomena but on the high degree of unawareness in humans' two meta-capacities - Biophysics as natural humans and Intellect as constructive humans (rational humans). These facets are exposed to various interactions and social interventions, projecting a multidimensional image. Consequently, even if we develop good tools or solutions, the question arises whether the "one-dimensional man" has the capacity to perceive a better environment. The emergence of Antibiosis may have unfolded at a rather subtle granularity level, such as influencing user thoughts, rather than necessarily violating written ethical constraints. Often, these constraints are a form of powerless consensus or even a means to justify the current choices with further reasoning. This can lead to a situation where many seemingly powerful tools actually exacerbate existing problems rather than effectively addressing the needs and dilemmas of individuals - "band-aid solution" - potentially making the original issues even more severe.

It's essential to clarify that human capabilities are often intertwined with human needs, whether at the micro level concerning user needs in HCI or at the macro level encompassing the diverse needs of the entire economic and social spectrum. From a psychoanalytical perspective, whether in terms of Biophysics or its polarization, or Intellect and its alienation, these meta-capacities and corresponding demands (the tendency towards possession of resources (e.g., food, shelter, spouse) and the inclination towards constructing power (e.g., knowledge, identity, social relationships)) are subtly linked to individual or collective survival needs and anxieties. The more prevalent these anxieties, the more nourishment polarization and alienation receive. The spiral of individual polarization and alienation, leading to a Downward Spiral of Hybridization, eventually magnifies across humanity. It can be argued that this is a significant factor behind various issues today - from individual psychological and physiological problems to violence, economic crises, and recurring wars. Within this unaware cycle, capabilities become pathways towards self-destructive instincts and resistance to human integrity. So we see that in many events of real history, the entities or popular concepts that ultimately (or temporarily) achieve survival are not necessarily those noble human qualities (which are also rare), such as "truth," "goodness," "beauty," but are more often presented in a way that echoes "Bad money drives out good," "Social Darwinism," "Zero-sum

game." In this sense, we will also elaborate on what survival refers to in the context of HEC in the following text.

Let's revisit Jonathan Grudin's statement: "Technology has changed rapidly, human nature very little (Grudin, 2017)." This statement is correct, but it can be said that the problem of technological development lies precisely here. Because "Human Nature" has not been improved by technology (of course, how we interpret "improvement" requires criticism from ethical and political perspectives), the environments shaped by the fundamental logic of traditional Biophysics and Intellect, such as HCI, artificial intelligence, and all artificial constructs, are likely to trap humanity in the negative effects stemming from these two meta-capacities. On the other hand, a significant issue arises as philosophical contemplation about oneself and the world, historically the domain of philosophers, has now become a widespread inclination. Consequently, discussions on technology and the future development of HCI transcend mere mechanical concerns. While current needs are cloaked in the guise of Biophysics and Intellect, core human needs are shifting. Individuals will eventually realize the limitations of their physical bodies and the boundlessness of knowledge, identity, and meaning. Relying solely on the development of Biophysics and Intellect to address life's challenges becomes insufficient, and unexamined capabilities may themselves become problems. This internal crisis raises the question of how individuals can continue to live and survive. This shift is exemplified in Michel Foucault's late-life focus on ancient Greek ways of life, interpreting practices of self-transformation as aesthetic phenomena, which he further explores in "Aesthetics of Existence" and "Technologies of the Self" (Foucault, 1988), as well as in the reflections of Irvin D. Yalom, the author of "Existential Psychotherapy" (Yalom, 2020), following the passing of his wife (Yalom & Yalom, 2021).

3.2.4 Where's the Way Forward?

Objectively speaking, whether it's polarization or alienation, these phenomena are not new issues exclusive to AI or the information age. They can be traced back to the entire history of humanity facing new forms of media (such as television and radio)(Benjamin, 2018; Postman, 2005), the industrial age (Marx, 1990), "modernity," and even the emergence of human civilization (Freud, 2015; Marcuse, 1974), and the birth of language (Lacan, 1988). From the perspectives of Western theology, Western philosophy, and even secularism, this is the interpretation to support the "Theory of Evil Human Nature". From a Buddhist perspective, the accomplishments of these eras have also amplified human tendencies towards "Desire" and "Anger" at the Biophysics, and "Ignorance," "Arrogance," and "Doubt" at the Intellect. Since the 20th century, some Western philosophers, sociologists, and artists have critically analyzed these phenomena - especially in terms of human relationships with artificial constructs. However, their proposed solutions often exist in a vague realm. For instance, philosopher Jürgen Habermas of the Frankfurt School proposed communicative action based on strict rationality (Habermas, 1985a, 1985b); Oxford professor Paul Collier suggested solutions in "The Future of Capitalism" to prevent regional fragmentation, prevent class and family division, and assist those who fail in the conditions of global competition (Collier, 2018); Herbert Marcuse of the Frankfurt School hoped that automation in large-scale production would help humanity gain more time to rebuild itself (Marcuse, 1974); Susan Sontag opposed interpretations of art to restore human sensory sensitivities at the Biophysics level (Sontag, 2001); while the French artist André Breton proposed liberation from "reality" in the "Surrealist Manifestos" (Breton, 1969)...

Some of these judgments seem to contradict reality today, some are still being contested, and some are challenging to evaluate further. They all serve as food for thought, but we hope that HCI can make a more concrete contribution in everyday life.

The 21st century is the time of technocrats or physicalists, one may argue: "Why bother with so much, as long as we focus on economic growth and technological progress, we will always find solutions. For example, brain-computer interfaces will allow people to act through thoughts and turn the human brain into a library." Controversies like the 2024 Apple ad dispute actually stem from this subconscious inclination[30]. To some extent, this statement is not wrong, but we must realize that this narrative is told from a specific perspective, and past experiences do not necessarily predict the future. We have spent so much time discussing "modernity," "civilization," and Antibiosis precisely because what we pride ourselves on today - the information age, artificial intelligence, economic models, various product innovations, and even the deconstruction of modernity itself - are all extensions of this line based on Intellect and modernity (The understanding before modernity can be seen as human organizational forms based on Biophysics, such as "empires."). While it seems that there is no better model than liberalism's spontaneous order to promote scientific and technological progress and innovation, this does not mean that humanity can continuously satisfy its needs and growth, nor does it mean that tomorrow we will be able to control tools with our thoughts (Grudin, 2017). The consequences of many existing cases warn us that once economic growth and other indicators stagnate, and needs are not met, internal conflicts within humanity will magnify. The rationality and civilization concepts constructed in the past based on Intellect will be challenged by the excessive suppression of human inner animality, and concepts of civilization will be dismantled back to a kind of jungle rule due to the continuous polarization of Biophysics. From this perspective, the deeper role of science, research, and technology is to serve as a buffer zone as much as possible, continuously delaying and balancing the outbreak of internal conflicts. Although we often see various technological products promoting slogans like "Make the World Better," when we consider various events since modern times, we realize that this narrative does not encompass everyone, as more individuals will inevitably be silently replaced, leading to social issues on multiple fronts. In short, every individual is also a victim of their capabilities; it's just that many are not consciously aware that this is a form of "harm."

This is clearly not the direction that HEC hopes to develop in. We are not opponents of technology, and we must acknowledge that excessive mechanization and uncomfortable work should be replaced. We simply believe that technology can be manifested in more appropriate ways and should focus on addressing the existential dilemmas of humanity during the process of solving specific problems. Although we have been discussing the issues of Biophysics and Intellect in describing Antibiosis, we have retained a key term - unawareness/unconscious. What does unawareness mean? Why are people unawareness? Is it possible for humans to pursue happiness? This is why we will explore "Xin/心" in Eastern thought as a potential answer to resolving Antibiosis in the next discussion.

[30] https://www.forbes.com/sites/danidiplacido/2024/05/09/the-backlash-against-apples-new-ipad-pro-ad-explained/

3.3 Interpreting Human Engagement and Engaged Humans

The Antibiosis brought about by Biophysics and Intellect is, on a smaller scale, a problem faced by each individual, but on a larger scale, it is a challenge that modern society as a whole is confronting. Building upon the history of Western thoughts, whether in philosophy, sociology, or even in specific technical design, there hasn't been substantial progress in addressing this dual-edged sword issue. As Joseph Jaworski stated: "I gave serious consideration to the Western scientific-materialistic worldview – our underlying belief system, which has prevailed in the West for over two hundred years. I believe that this belief system is no longer adequate for the issues our society is facing; that a historic shift is now occurring; and that a more comprehensive worldview is emerging (Jaworski, 2012)." HEC aims to shift perspectives, seeking a more complete understanding of humanity from a broader, foundational perspective of the evolution of human thought and experience, inevitably focusing on the similarities and differences between Eastern and Western thoughts.

Here, we continue to employ the "Ideal Type", envisioning an ideal state for individuals to discover theoretical pathways against Antibiosis. By engaging in a binary comparison of Eastern and Western thoughts, we can more easily discern their disparities and value orientations. It is important to note that this presentation may raise suspicions of nationalist tendencies to some readers, as certain arguments within Eastern thoughts might subtly challenge the ingrained Western-oriented thinking in our daily thoughts and in HCI practices. It is our expectation that readers recognize we do not intend to evaluate superiority or inferiority but rather aim for a valuable complementarity. Moreover, our approach to Eastern thoughts particularly involves viewing them through the lens of the history of ideas and knowledge archaeology, striving for an objective understanding of their essence and variances in comparison to Western thoughts.

3.3.1 The Theoretical Position of Xin/心 from Eastern Thoughts

The formation of Eastern and Western thoughts has been significantly influenced by factors such as geographical location (continental vs. maritime), civilization (agrarian vs. migratory), and political systems (centralized vs. feudal), which then manifest a dualistic understanding and developmental path in issues (Watkins, 1948; Wu, 2023) ranging from philosophy (morality and knowledge) to views on human nature (Theory of Good Human Nature vs. Theory of Evil Human Nature), interpersonal relationships (ritual vs. contract), language and writing (which is the first driven), and perspectives on the morality of states and societies (Sheng, 2016; Xiang, 2010). However, as history progresses, the success of the Western scientific and technological systems in reshaping society and nature has to a large extent overshadowed some redeeming aspects present in Eastern thoughts. Moreover, within Eastern societies themselves, due to the necessity of accepting a more pragmatic internal and external demands, many individuals exhibit a sense of conflict, criticism, and rejection when attempting to reconcile Eastern and Western thoughts.

Yet, faced with numerous issues in contemporary society, we are compelled to reevaluate the rationality behind the evolution of Eastern thoughts throughout history and their value in future HCI and technological development. In essence, it is challenging to perceive the essence, modes of existence, and significance of humanity solely through everyday experiences, concepts, and highly secularized understandings. Beyond the comprehension of Biophysics and Intellect, Natural Humans and Constructed Humans, is there a theoretical and practical approach that can explain and

address real-world problems? History encompasses the entirety of human experiences, and we need to engage with all human experiences throughout history to understand the ideal types of humans.

Regarding the development of human civilization, the philosopher Karl Jaspers once introduced the concept of the "Axial Age" (Jaspers, 2014), signifying a period where humanity transcended mere superstitions of early deities, and humanistic civilization and philosophical ideas began to emerge intensively from the 8th to the 3rd century BC in ancient Greece (science and philosophy), ancient Hebrew (Judaism), ancient India (Hinduism and Buddhism), and ancient China (Confucianism, Taoism and various other schools of thought). The term "axial" implies that regardless of how a door opens, the subsequent diverse thoughts and cultures are always extensions of this axis, thus also referred to as "Axial Thoughts," a point we briefly touched upon in our methodological introduction.

Building upon this argument, the historian Yu Ying-shih further elaborated on the differences between Western (ancient Greece and ancient Hebrew), Eastern (primarily ancient China in his book, with the addition of ancient India in this dissertation) civilizations as "Outward Transcendence" and "Inward Transcendence" (Yu, 2003)[31].

What is Outward Transcendence? It refers to the pursuit of human existence meaning outside of oneself. Although the worldly spirit of "Secularization" has become a prevalent modern concept, its axis primarily resonates in the Essentialism worldview constructed by the philosophy of Platonic theory of Forms and the primitive Judaism and Christianity. Regarding the former, philosopher Alfred N. Whitehead once stated: "the safest general characterization of the European philosophical tradition is that it consists in a series of footnotes to Plato (Oglesby, 2018)," seeking the ultimate origins - *idéa* - of all things externally. Even today, we attribute everything from a physical perspective to the Big Bang, always searching for that "First Principle Thinking." Descartes' "I think, therefore I am" further emphasizes the outward subjectivity essence established on rational thinking - the Thinker. Concerning the latter, anthropologist Marshall Sahlins expressed in "The Sadness of Sweetness: The Native Anthropology of Western Cosmology," that since humans are created by God, inherently imperfect and can never reach the perfection of God... human needs always exceed their capabilities, defining life as the pursuit of happiness, which in the long run seems to be unhappy. In summary, the outward projection of happiness and ideals beyond oneself defines the fundamental form of outward transcendence, leading humanity out of pre-modern natural society into modern civilization. Traditional HCI exploration of Biophysics and Intellect can be said to inherit this outward transcendent background.

However, combined with our expression of Intellect and Alienation, this highly developed Outward Transcendence encounters difficulties in contemporary times. These challenges stem from religious reform, secular eras, Nietzsche, various liberations, and resistances. After realizing the emptiness of that first driving force or any idol, individuals struggle to find a fundamental grounding to settle themselves. Individuals must be strong enough to construct their personal lives brick by brick relying on their own rationality. However, they find themselves in a tightly controlled rational cage, losing the protective shell of deterministic meaning. Consequently, individuals are compelled to

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[31] Yu Ying-shih's predecessor term for "Inward transcendence" was "immanent transcendence," but it was modified due to the English term "immanent" being a theological noun, referring to the existence of something god-like. For more details and expansion, please see (in Chinese Interview):

1. https://www.time-weekly.com/wap-article/24343
2. http://www.zgscph.org/html/2020/zhyj_1108/1417.html

weave one sacred narrative after another to cope with their seemingly meaningless daily lives. This is the cost of modernity, a dilemma of theory and experience.

In contrast, the significance of Inward Transcendence lies in the pursuit of human existence meaning within oneself. Happiness and ideals exist in the "Here" rather than the "There," independent of the abundance of knowledge, social relationships, or external environments. Its axis mainly manifests in Confucian, Buddhist (including original Buddhism and Chinese Buddhism), and Daoist thoughts. While Western thoughts has long focused on epistemological inquiries such as "What is something/somebody?" Eastern thoughts can be said to have entered an "existentialist" phase quite early, fundamentally questioning "how should one live," arising from reflections on the external circumstances of the time. For example, primitive Confucianism endured centuries of escalating disorder and chaos during the Chinese Spring and Autumn and Warring States periods, and original Buddhism questioned the essence of ultimate issues like life, aging, sickness, and death. These primitive thoughts were later endowed with expanded interpretations and derivations as history, politics, society, and other environments changed (such as various schools of thought in China tracing back to the axis of Confucianism). Concerning the question of "how should one live," Eastern thought focuses on understanding the "Xin/心" of individuals, recognizing the "Tao/道"[32], and then practicing the "De/德"[33] of aligning with the "Tao/道" to bring individuals to the ideal of perfection (achieving Sage or Buddhahood), rather than resorting to the "Absolute Dependence" on religious emotions between individuals and personified gods (Behrens, 1998). Hence, HEC also turns its focus to this concept commonly mentioned in Eastern thought - "Xin/心," aiming to understand and complement the understanding of "what is a human" from an Eastern perspective, relative to natural humans and constructive humans.

So what is "Xin/心"? In traditional interpretations and translations, "Xin/心" has been understood as representing the mind or heart-mind aspect at the level of intellect, indicating human abilities to think, will, cognize, and feel. It also carries the meaning of the heart at the biophysics level. However, these interpretations do not capture the essence of "Xin/心" as conveyed in systematic Eastern thoughts. In this context, "Xin/心" refers to the intangible, transcendent, and ineffable inner consciousness that remains after suspending social relationships, material goods, the body, sensations, thoughts, emotions, and especially the subjective construct of the "ego." It is considered the true essence of a person, implying that "Xin/心" is viewed as the core of a person, and desires and emotions are not the true self detached from nature and unconsciousness. This is why we refer to Intellect as "construction" or "constructing humans," which is closely related to Eastern thoughts. Similarly, Biophysics, due to the behaviors, cognitions, and emotions mostly being unconscious and not self-aware, is also linked to this understanding.

Efforts in the world are made to first understand this essence (Enlightenment of "Xin/心"/明心见性) in order to find peace within, rather than focusing entirely on the ever-changing external phenomena. This aligns with the teachings of the Diamond Sutra, which states, "Dwell upon nothingness and set your Xin/心 at ease/應無所住而生其心." When one comprehends this essence, various phenomena in the world naturally align with the conscious tendencies of the mind

[32] https://en.wikipedia.org/wiki/Tao

[33] https://en.wikipedia.org/wiki/De_(Chinese)

(compassion, shame, respect, right and wrong/恻隐、羞恶、恭敬、是非), rather than being judged deliberately. The essence is illuminated, and one's actions remain highly coherent with it.

Unlike the externalized explanations found in phenomenology, psychology, or psychoanalysis regarding subjective consciousness and concepts, "Xin/心" aims to address the innermost life goals and ultimate concerns of individuals (Mou et al., 1989). Thus, from this perspective, the meta-capacities of Biophysics and Intellect, traditionally seen as internal capacities, are not considered internal or self-aware from the viewpoint of Eastern thoughts.

Furthermore, it should be noted that although "Xin/心" is often associated with morality and ethics, according to modern ethical classifications, it leans more towards a virtue ethics perspective in its manifestations. However, "Xin/心" forms the fundamental basis of virtue rather than simply being about affect or empathy (Nardi & O'Day, 2000), along with the ethical construction based on utilitarianism or capabilities at the level of Intellect.

Modern hermeneutics in translation studies provides a more nuanced interpretation of "Xin/心" - referring to the process where individuals go through "feeling-becoming-thinking," but with a particular focus on the experience represented by "-becoming-" (Robinson, 2021). This explanation also corresponds to some empirical conclusions about how humans form judgments. For example, judgments of objects being good or bad are made within 20ms, and judgments of beauty or ugliness are made within 50ms (Lindgaard et al., 2006). This rapid judgment is often based on unconscious intuition, reflexes, or quick judgments relying on stereotypes in daily experiences, thereby often neglecting a conscious process of "becoming." This hastiness in judgment can lead to inner turmoil and conflicts within individuals. The influence of Zen teachings on Western psychology has also led to a growing emphasis on concepts like "non-judgment" and "Mindfulness"[34], but fundamentally, this trend arises from the long absence or misinterpretation of the concept of "Xin/心".

In this theoretical position, on one hand, many Western thinkers also draw similar conclusions. Concepts such as "Authenticity" and "Original Position" proposed by thinkers like Rousseau, Marx, Heidegger, and Rawls seek to explore how humans and societies change or what the ideal form of humans is, placing human prototypes at a primal, pure, and undisturbed starting point. However, compared to the concept of "Xin/心", these notions are more academic tools, not embedded in life philosophy and practices.

On the other hand, philosophers like Daniel Dennett, in explaining cognition and consciousness, leave a question unanswered: if the entire consciousness of a human (the thinking activity of the Mind) is like a computer, who is controlling this computer (Dennett, 1993)? The connection between cognitive science and the Buddhist concept of the Middle Way (Varela et al., 2017), and the question of what connects language to the body and what constitutes the subject of a human (McLuhan, 1994), all leave room for further exploration of the theoretical position of "Xin/心."

As a highly abstract concept, we need to further interpret the definition of "what is Xin/心" by gradually explaining the developmental process of "Xin/心". Firstly, it is important to note that "Xin/心" is mentioned in Confucianism, Buddhism, and Taoism, although the discourse varies (due to including not only original thoughts but also numerous derivative thoughts). However, they share

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https://www.youtube.com/watch?v=oIjCjGszu64

a similar spiritual core, which forms the theoretical basis for the gradual integration of the three thoughts. From the perspective of Chinese history, the early concept of "Xin/心" emerged in ancient Chinese Confucian literati culture, introduced by Confucius (derived from the conceptualization of existing social customs and the spirit of royal rituals and etiquette (Legge, 2022)[35]). Early on, it was referred to as "Ren/仁"[36] and expanded by Mencius. Confucian thought believes that by fully understanding the guidance of "Xin/心" in life, individuals can comprehend their true inner nature, gain a deeper understanding of "Tian/天" (the ultimate natural law), practice the "Unity of Heaven and Humanity/天人合一," fulfill a highly moral personal mission, and a societal mission that transcends personal interests.

During the historical period known as the "Axial Age," similar ultimate concepts such as the Buddhist "Śūnyatā (Emptiness)" and the Taoist "Tao/道" emerged successively. These concepts, including various ideas like "Innate Nature/自性," "Innate Knowing/良知," "Centrality/中," "Chitta"[37], "Kokoro/心," and others in subsequent Eastern wisdom and doctrines, share a spiritual core. The use of the Chinese term "Xin/心" is merely for convenience as a name and does not claim exclusive ownership of such a value system. In essence, even early Christian emphasis on spirituality is quite similar, such as the origin of the term "Passion"[38]. Spiritual experiences are not sudden revelations but are found through practice. The difference lies in whether this spirit is projected inward or outward in a theoretical sense. This spirit tends to project outwardly towards a transcendence in Christ in philosophical form, while religion as a kind of experience, has always been in a weaker position in contemporary philosophy.

During that profoundly chaotic historical period, all these concepts were put forth to address fundamental existential questions, namely how individuals confront and respond to the impermanence of the world, the universal suffering in life, and the ultimate fate of humanity. According to Eastern thought, one of the primary causes of human suffering is the attachment and control of the "Xin/心" by external phenomena, thoughts, and emotions. The solution lies in individuals having a "Xin/心" that is free to do good, even when their bodies and surroundings are constrained, maintaining freedom from external influences. This is also mentioned in various materials, such as the idea that even when a person loses complete physical freedom, they can still choose inner freedom (Covey, 2020; Frankl, 1985). Through this process, the nature of humanity and phenomena is revealed, as explained in Wm. Theodore de Bary's interpretation of "The Liberal Tradition in China" (De Bary, 1983).

In the medieval period, the introduction of Buddhism greatly stimulated the systematic development of traditional Chinese Confucian and Daoist thought. Despite differences in explanations of the heart between Buddhism and Confucianism (e.g., "no existence of self-nature" versus "existence of self-nature: whether all things can find their nature), the emergence of Zen Buddhism played a critical role in expanding theoretical perspectives on "Xin/心". Indigenous Confucianism also culturally promoted the independence of thought within Chinese Buddhism/Mahayana Buddhism,

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[35] https://sheng54.net/2023/09/24/礼与普通法-为什么要研究礼与普通法？ | 盛洪/

[36] https://en.wikipedia.org/wiki/Ren_(philosophy)

[37] https://en.wikipedia.org/wiki/Chitta_(Buddhism)

[38] https://onceuponawrittenword.wordpress.com/2018/02/19/the-metamorphosis-of-passion/

as well as the integration of Confucianism, Buddhism, and Daoism, giving rise to the comprehensive Confucian Yangming School, widely spread throughout East Asia.

Compared to early Confucianism and Buddhism, the overall Eastern thoughts during this period underwent two significant changes: First, from seeking enlightenment to determining what to do after enlightenment, clarifying the overall development approach of Eastern thoughts towards altruism. Second, from "teaching monarch practices the Way/得君行道" to "enlightening people to practice the Way/觉民行道," shifting the focus from persuading enlightened monarchs or governments to achieve an ideal society towards dedicating thought to the awakening of each individual.

From this historical heritage, it is evident that while "Xin/心" is a highly abstract concept, particularly within the context of Chinese culture, it has become a foundational idea and the root of many linguistic terms. Words such as "thinking/想," "feeling/感," "condition/態," "affection/情," "nature/性," "in peace/安心," "worry/担心," "careful/用心," and "determination/决心" all reflect a cultural tendency where the heart is considered the true subject of humanity, with everything originating from the heart rather than from a person's Biophysics (body, behavior, cognition, emotions) and Intellect (mind, intelligence). All external stimuli are viewed as interventions to observe how the heart of a person changes. Particularly in Confucian thought, whether in daily experiences or theoretical justification, moral, behavioral, existential, and various other concepts are attributed to the "Xin/心," much like how constructs such as "reason," "democracy," "the invisible hand," "life experiences," and "liberalism" have laid the foundation of Western philosophy. This dual pivot ("Reason" and "Conscience") is jointly inscribed in Article 1 of the Universal Declaration of Human Rights[39].

This further involves the differences in understanding human capabilities or potentials between the East and the West. Through our summary of Biophysics and Intellect, the Western understanding of human capabilities is more focused on skills, functioning, social achievements, economic status, undeveloped economic value, and merit (Sandel, 2020). Concepts such as capabilities discussed in Amartya Sen's economics, embodied cognition, etc., all describe what individuals can "know" or "do" within an observable range to continually improve themselves. From an Eastern perspective, while Biophysics and Intellect are undoubtedly important, capabilities and knowledge are limitless, and destiny and social achievements are not within human control. One should not become so fixated on them as to obscure the existence and clarity of "Xin/心" (for example, the Zen sect's determination to "Not based on the written word/不立文字" was prompted by the excessive reliance of traditional religious leaders on scriptures). Because of the existence of the foundation of "Xin/心" that individuals can consciously balance the polarization of Biophysics and the alienation of Intellect, realizing their inward perfection and potential for self-sufficiency and the essence of everything external being "as it should be." This inward focus leads to altruism, giving, creating, and uniting more people with motivation. Conversely, regardless of how many skills a person possesses, whether they are a specialist (偏材) in one area or versatile (兼材) in many, without the balancing ability of "Xin/心", they cannot become a person (中庸之人) of "balanced virtue (兼德)" (Di Giacinto, 2002).

[39] https://www.un.org/en/about-us/universal-declaration-of-human-rights

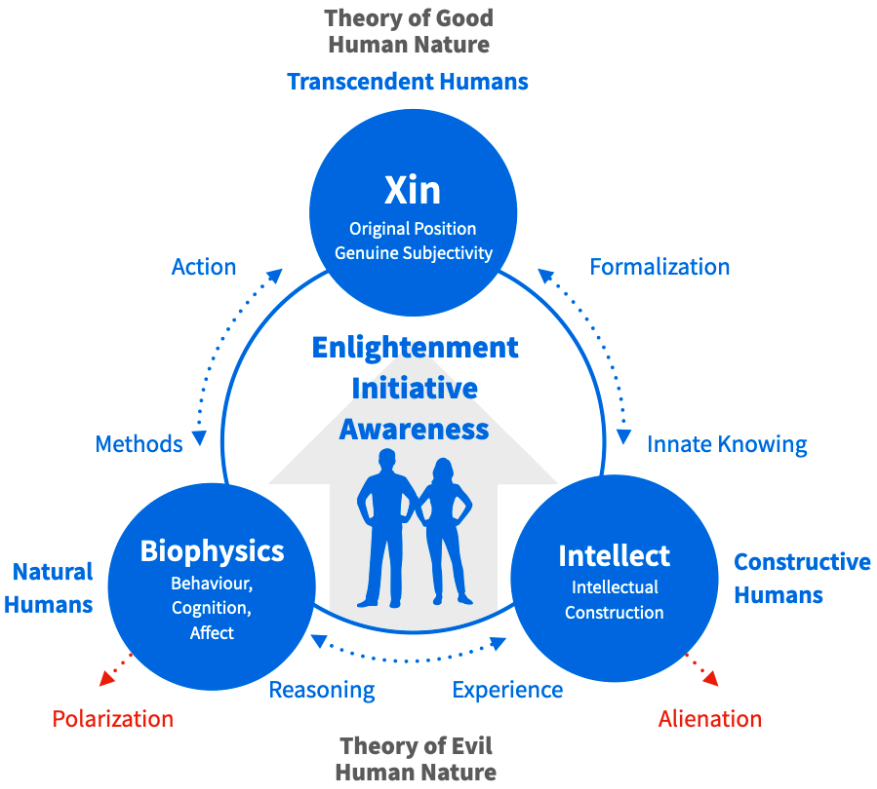

Figure 3.3. The philosophical origin, relationship and antibiosis of "Biophysics-Intellect-Xin"

In conclusion, in the process of discovering the complete capabilities of humans, HEC regards Xin (please note that "Xin/心" represents the original theoretical concept, while "Xin" represents a type of human meta-capacity in HEC) as a third human meta-capacity beyond Biophysics and Intellect, proposing the concept of "Transcendent Humans" outside of Natural Humans and Constructive Humans, incorporating important human experiences overlooked in the traditional Western HCI paradigm (see Figure 3.3). It is important to emphasize that we focus on the combination of "Inward Transcendence" and "Outward Transcendence," rather than leaning towards one side. Historically, although both sides have noble intentions, imbalanced development often leads to alienation and more severe issues.

Xin reflects the transcendent aspect of humans. The issue it faces (in HCI) is: amidst the constant emphasis on the reality of Biophysics and Intellect externally, how can individuals use the capacity of Xin to return from the extensive polarization and alienation of Antibiosis to a highly conscious awareness? To borrow from Zen teachings, from "seeing the mountain as a mountain" in Biophysics, to "not seeing the mountain as a mountain" in Intellect, and "finally returning to seeing the mountain as a mountain" in Xin, instead of regressing to the pre-modern state of "noble savages." Please note that Xin is not aimed at resisting desires but at understanding the nature of desires, avoiding the emergence of "surplus repression" (Marcuse, 2013), reconstructing the relationship between the true subject of a person and their desires. In other words, Xin represents the ultimate "value rationality" sought in Eastern thought.

Thus, the work of HEC is also exploring new transcendent directions for technology:

(1) The Thought System (Engagement, Antibiosis, Engaged Humans, Synergized Interaction): How to depict the thought of comprehensive understanding on humans.

(2) The Computing System (Engaging Computers): How practice can keep up with the thought.

3.3.2 Inward Transcendence towards Human Xin Capacity

In the discourse on "Xin/心," as it integrates the core ideas of Confucianism, Buddhism, and Taoism, we primarily draw insights from the understanding in the School of Xin/心, mainly derived from the "Record of Instructions for Moral Cultivation" and "Questions asked by someone about the Great Learning" (Ivanhoe, 2009; Van Norden, 2022; Wu, 2019). We summarizes that the HEC involves three key stages in developing the meta-capacity of Xin for human inward transcendence accordingly: (1) Awareness, (2) Initiative, and (3) Enlightenment.

(1) Awareness refers to individuals beginning to connect their experiences, judgments, emotions, and difficulties with their existential questions, and initially realizing that the body and thoughts are products of sensation and thought (studies indicate that people generate over 6000 thoughts per day (Tseng & Poppenk, 2020)), rather than their true selves. This awareness is not an "Aha! moment" regarding a specific issue but triggers an individual's second-order consciousness or reflexivity, enabling them to observe their inner self while engaging in everyday experiential activities or tasks. This distinguishes Xin from Intellect. Furthermore, Awareness should not be viewed simply as reasoning or psychoanalysis of an individual's unconscious or depression from an Intellectual perspective.

    Eastern thought emphasizes that everyone possesses the potential to be aware of their Xin and innate nature. However, this potential is often obscured by the demands of daily life, stereotypes, and fluctuating emotions, hindering individuals from observing their true subjectivity. When individuals are stimulated to truly become aware of their fundamental inner needs in life, unable to find meaning in external demands - the infinity of knowledge and the limitations of the body. Awareness of Xin serves as a starting point, establishing a fundamental existence for individuals.

(2) Initiative refers to the ongoing practice individuals engage in after initial awareness, actively liberating their Xin from its preliminary and incidental state of awareness to gain a clearer understanding of Xin. This guides good daily living and life practices. It is noteworthy that the cultivation of Xin is not a form of subjective idealistic philosophical speculation. Instead, it involves breaking free from the constraints of language and thought on individuals, encompassing all aspects of daily life, and aligning innate knowing with external actions. Therefore, philosophical dilemmas like the "Brain in a vat" often discussed in Western philosophy are not the focus of Initiative of understanding self.

    In the practice of cultivating Xin, Eastern classics such as the Heart Sutra, the Eightfold Path (Right View, Right Thought, Right Speech, Right Action, Right Livelihood, Right Effort, Right Mindfulness, Right Concentration/正见、正思维、正语、正业、正命、正精进、正念、正定), and the Great Learning (Three Guiding Principles: Cultivate personal virtue, Serve the people, Rest in the highest good; Eight Points: Investigate things, Acquire knowledge, Be

sincere, Cultivate the self, Regulate the family, Govern the state, Bring peace to the world/三纲领：明明德、亲民、止于至善；八条目：格物、致知、诚意、正心、修身、齐家、治国、平天下) provide concise and progressive practical methods. The commonality among these methods lies in:

- Individuals continuously practice observing their Xin by recognizing subtle changes in thoughts, desires, speech, judgments, stereotypes, and emotional biases, avoiding attachment and projection to any concepts and phenomena, thus learning to truly exercise freedom. For example, mindfulness meditation involves consciously observing thoughts and emotions without judgment, resulting in relaxation of the body and inner peace. The Daoist classic "Zhuangzi" advocates for a thorough empathy and emphasizes the inherent equality between human beings and all things, teaching individuals to release the "self" and experience true freedom.

- Guided by an uncontaminated Xin, individuals can practice goodness (high moral discipline and altruism) in daily life, achieving unity of innate knowing (ought, 名, should) and action (is, 实, 实然), where "action" starts from the intentions and thoughts. Regarding the unity of innate knowing and action, Zen Buddhism, compared to early Buddhist sects, sees "prajna (wisdom)" and "zen (practice)" as inherently unified, not solely attained through Buddhist knowledge or mechanical training like meditation, hence advocating for "Not based on the written word/不立文字" to reduce misunderstandings. Zen practice without classics was very popular in 1960s Europe and America (due to the difficulty in translating classics, direct bodily experiences were more immediate, influencing current trends in meditation and somaesthetics in HCI), but often lacked a deep understanding of the concept of Xin, limited in the body experiences.

In conclusion, the key insight shared in these practice methods is that individuals can transcend the dominant status of the "ego" driven by Biophysics and Intellect, residing in a state of positive freedom, reflecting on their actions in a pure and focused manner, seeking to discover the inner laws and essence of phenomena. Aligned with the spirit of equality and altruism in Confucianism and Mahayana Buddhism, Initiative not only focuses on individual liberation but extends to include the ultimate goal of improving society.

(3) Enlightenment refers to a long-term state where individuals are able to:

- Internally stabilize in a conscious, peaceful, and sincere inward transcendence, truly understanding their true and perfect nature, being self-sufficient, breaking free from the control of phenomena and unconscious judgments, and transcending the anxiety of death. Therefore, from this perspective, the fundamental context of Eastern thoughts regarding survival does not depend on the physical body but on realizing one's nature and wholeness of capacities, which are ultimate requirements.

- Externally, through practice, individuals can form a non-dualistic flexible intellectual system that understands the inner laws of phenomena and knowledge, thereby improving society. The essence of enlightenment is indescribable, but it emphasizes a high degree of consistency and balance in different external practices to avoid extremism. Eastern traditions further divide

enlightenment into sudden enlightenment and gradual enlightenment, but there is no difference in their outcomes.

The process of cultivating the abilities of Xin generally demands a high level of commitment because its goal is for individuals to achieve their utmost potential, regardless of their surrounding environment and conditions, thereby reaching a state akin to that of Sage and Buddhas, inheriting the "Orthodoxy (道统)" to become a spiritual exemplar. On the other hand, the ideal state of humanity described in Eastern thoughts is not a mystical or transcendent spiritual experience. It emphasizes that individuals can achieve inner peace and unity of innate knowing and action in their own life practices. This ideal view based on "Here" differs from the ideal view of becoming a particular deity or going to heaven ("There"), as well as from the modern societal value of extreme gratification of desires.

It is important to note that we are not the originators of these ideas, and regardless of Eastern or Western origins, our aim is to convey how various thoughts on understanding humanity and wisdom can be applied in HCI and technological development. Many of these viewpoints may be challenging or counterintuitive to some readers, but they are not transcendent - they are practical and achievable. Through classical texts, it is evident that the ideal societies and inner peace emphasized by philosophers from both Eastern and Western traditions are all founded upon or return to a deep understanding of humanity, serving as an action goal. Similar thoughts also include Eastern cultural values like "Li/禮 (Rites)", "Mingde/明德," "Daotong/道统 (Orthodoxy)," "Śūnyatā (Emptiness)," "不二 (Non-Duality)," and "Cheng/诚 (Sincerity)," as well as Western ideas such as "Kabbalah," Carl Jung's "Self," Martin Heidegger's "Dasein" (Ching, 1978), Karl Marx's utopian society where everyone contributes according to their abilities, Erich Fromm and Isaiah Berlin's "Positive Liberty" (Berlin, 1969; Fromm, 2014), and Maslow's "self-actualization", all of which reflect the ideal existence of humans in relation to Xin. These concepts or wisdom cannot be understood merely through an intellectual perspective but must be grasped through practical experience to enlighten one's Xin.

Of course, from a historical perspective, the concept of Xin or "Xin/心" also involves several significant issues:

(1) On a subjective level, due to the inherently subjective and indescribable nature of Xin and its derived behavioral rules, there is a lack of unified specific standards, granting everyone the right to define it, which can easily be abused, leading to various chaotic situations. Therefore, from this perspective, the basic assumption of rational individuals based on self-interest is actually not wrong. Because when "high consistency" is difficult to practice, there is always a tendency for instrumental rationality to turn into value or purposive rationality. In essence, this is one of the motivations behind our desire to establish a structural consensus through the design of computational systems.

(2) On a societal level, the underlying philosophy of Confucian benevolence and the historical political background of early unified China have prevented the establishment of a rational and mature system of checks and balances in society (such as contracts and the spirit of liberalism) (Ch'ien, 2012; Fukuyama, 2011), often leading to either excessively high moral thresholds for individuals to practice ethics or accelerating individuals from one extreme to another through either intense moral criticism or moral abandonment (Huang, 1981).

(3) On a practical level, the concept of "Xin/心" originated from ancient agricultural societies, a time when there were fewer phenomena, but its modern interpretation and theoretical positioning are not yet fully developed, especially in a technological context. These are also reasons why we strongly need the assistance of Biophysics and Intellect to complement and formalize the practical application of Xin.

Overall, both Eastern and Western philosophies are grounded in the wisdom that enables human Survival, happiness, and overcoming adversity. Over the long term, the West has been more inclined towards a bottom-up pragmatic spirit, achieving great accomplishments and becoming a global thinking template, but is currently facing increasing Antibiosis brought about by Biophysics and Intellect. Despite the continuous enrichment of material conditions, the modern world and its values developed over the past 500 years may not necessarily be the enduring answer to human survival. In contrast, Eastern thoughts represent a top-down humanistic ideal, hoping that individuals can possess the capacity to approach worldly matters with a transcendent mindset. In the face of various crises prevalent in contemporary society, the fusion of Eastern thoughts with technological development holds immense potential. Computing can serve as an environment to help individuals undergo conceptual and habitual transformations and corrections, rather than simply perpetuating the inertia in real-world society that leads to Antibiosis. We will delve deeper into this discussion in Chapter 5 of Engaging Computers.

3.3.3 Human Engagement in the Context of Xin

When we discuss Xin, especially in its trajectory towards Enlightenment, and the description of the good state of human life or well-being, this also leads us to how we should interpret Engagement. At this point, we first compare this with some similar concepts in HCI and psychological theories.

In the current context of HCI and computing, the industry's focus on user experience related to "well-being" in the Human Factor is increasingly leaning towards "User Engagement." In the HCI field, the original User Engagement serves as a significant metric describing the degree of interaction between people and tasks during user interactions with applications or services, such as user click counts (Harden & Heyman, 2009), user stickiness (Chapman, 1997), positive impacts (O'Brien et al., 2022; O'Brien & Toms, 2008), task dependency (Laurel, 2013), time spent, and emotional states (Goethe et al., 2019), serving as the basis for related reports like user immersion, activity level, and ad effectiveness. As understanding has evolved, Engagement now describes a high level of involvement when interacting with a computer, consisting of three sub-indicators (Ma, 2018b; Silpasuwanchai et al., 2016):

- Behavioral Engagement: physical participation and involvement.
- Cognitive Engagement: psychological dedication to a task, involving active thinking, reflection, and attentional engagement.
- Emotional Engagement: affective responses towards the task, including interest, excitement, frustration, and boredom.

From a more foundational psychological or other humanities theoretical lineage, we can see the basis of User Engagement in HCI, including but not limited to Flourishing, Emotion Theory (Lazzaro, 2009), Positive Psychology rooted in Self-determination theory (Deci & Ryan, 2000),

discussions on Self-realization, and Flow Theory (Czikszentmihalyi, 1990) concerning outcomes and processes.

In comparison to the scope of Xin's description, I have no intention of seeking the minutiae of experience itself, not only because I believe there is a highly relevant sense of human empathy within it, but also because excessively describing differences amounts to a form of language game. Moreover, fundamentally, language is also inherently indescribable and subject to scrutiny. This dissertation believes that the key issue lies in the "Context" of discussing the theoretical foundations of various Engagements representing Wellbeing. Without considering the contexts of these various concepts, their definitions and intentions are moot.

When User Engagement gradually becomes an industrialized evaluation standard, it involves a highly commercialized context. Especially when it is equated by interaction elements such as View, Like, Comment, Post (Aldous et al., 2019), such theoretical constructs tend to stay more on the surface. The concept of Flourishing originates from ancient Greece but is more about participation in the political life of the city-state to achieve self-realization. Although it still holds practical significance today, its scope determines that it cannot serve as a pivot for a grand theory but must be reinterpreted.

Self-realization (Maslow summarized 15 characteristics of self-actualizers and described Peak Experience and Plateau Experience) and the context of Flow Theory are deeply tied to a modern spiritual experience where various regulatory means, such as Mindfulness, anchor on how to better engage in the next real task within secularism. This also reflects the gradual domination of instrumental rationality, where entering Flow while playing a game, doing math problems, or carrying out experimental tasks with participants can be said. Norman & Kirakowski (2017) mentioned that before addiction, individuals typically go through a period of highly engaged non-pathological engagement; Khalid & Iida (2021) propose that addiction occurs when a person maintains motivation and attention in a state of flow or engagement but loses control. Finally, this unconscious engagement as a form of "Biophysics" shows a strong relationship with addiction (Goethe et al., 2019). Such theory construction like Flow without context is incomplete and thus prone to misuse.

We hope to delve further into Engagement, interpreting it from the context of Xin, where Biophysics and Intellect return from dominant positions to their rightful instrumental positions, allowing individuals to consciously, choose and engage in their capacities for positive freedom, leading towards Enlightenment of human wholeness and inner peace as a rational value, maintaining a high level of consistency in all external practices. As a core requirement, within this context, lies the differentiation from one-dimensional engagement of individuals (an overly simplistic understanding of needs). We can say that Engagement born from Xin is the pure foundation of states like Flow. This is why we distinguish Human Engagement from User Engagement. From a more metaphysical perspective, ancient Chinese thought, such as in the Daoist classic "Huainanzi," even suggests that a high degree of spiritual focus can promote harmony between heaven and humanity, thereby affecting changes in the natural world, indirectly emphasizing the position of Engagement as an ideal quality of humanity in the history of thought.

We can also see that in various interdisciplinary fields, many experts have given similar consensuses on such a state. For example, what true luxury is - lies in a rare state of being rather than external symbols (Blanckaert, 2011); including how community autonomy and religion can

form enduring "utopian" societies; and in the descriptions found in many literary works, such as Hermann Hesse's "Siddhartha" (Hesse & Appelbaum, 1998), Somerset Maugham's "The Razor's Edge" (Maugham, 2011), and Shūsaku Endō's "Deep River" (Endō, 1994). In essence, every field has similar views on real wellbeing and value recognition. Our task is not to deny but to collectively maintain and interpret a more basic, pure and consistent context.

3.3.4 Human Capacity Framework and Engaged Humans

According to the interpretation above, the Human Capacity Framework summarizes three meta-capacities: Biophysics, Intellect, and Xin. Within the overall framework of HEC and its context (including HCI), let's briefly review the human meta-capacities corresponding to Biophysics and Intellect, and provide a detailed introduction to the human inner capabilities corresponding to Xin, as well as the relationships among these three.

(1) Biophysics: Mainly corresponds to three aspects of human capabilities related to direct interaction between technology and individuals: Behavior (such as physical form, motor control, body reflexes), Cognition (including perception, processing, memory, attention to external signals), and Emotion (such as happiness, fear, bodily experiences and responses based on external stimuli or thoughts). From an embodied perspective, behavior, cognition, and emotion are interconnected. Its fundamental need lies in the physical reproduction dominated by Libido as a means of survival. Instrumentality constitutes the basic interaction between humans and computers. The Antibiosis dominated by Biophysics lies in unconsciousness; individuals are prone to follow their biological motives and external interventions, leading to Polarization.

(2) Intellect: Mainly corresponds to the thought processes in technology and HCI, including the construction of knowledge models, mutual mapping, conceptual understanding, logical construction, imaginative anticipation, and rational judgment. Its fundamental need lies in the outward projection and control transcending the flesh as a means of survival. In HCI, this includes the digitization and semanticization of offline tasks in the virtual world. The Antibiosis of Intellect is semi-conscious because, on one hand, it leads to reflection on natural behavior; but on the other hand, individuals can easily become trapped in themselves if they lack a clear awareness of the "self" dominated by Intellect, thereby promoting Alienation.

(3) Xin: Mainly corresponds to a primordial consciousness that transcends bodily and thinking representations, and the subsequent integration of innate knowing and action, with survival depending on enlightenment to recognize one's own perfection, accepting everything naturally rather than being attached to projection or reproduction. HEC refers to the specific direction of human capability practice as Soft Skills or Inner Capabilities, such as mindfulness, aesthetics, empathy, love, and more. However, explanations of these capabilities cannot be understood based on our daily experiences alone. They are based on the experiences of Biophysics and the knowledge of Intellect, but ultimately they are indescribable and immeasurable. One must start from the philosophical context of Xin to understand their purity. For example:

- Mindfulness: In the context of Eastern thought, mindfulness (including formalized meditation, Zen practice, etc.) does not entirely imply the suppression of the arising of thoughts. Rather, it means letting sensations and thoughts flow, practicing fundamentally emptying oneself back

to the original mind without dwelling on appearances, thereby generating a state of natural awareness, focus, acceptance, and relaxation in the current environment. Specific behaviors also carry philosophical significance, such as breathing as a fundamental activity of life, resetting the rhythm of life through resetting the rhythm of breathing.

- Aesthetics: Beauty, as a fundamental value, does not primarily stem from the visual or auditory pleasures received by the senses or the attribution of specific meanings. Instead, it arises from an inner joy based on self-completeness without judgment. In the Buddhist worldview, "The six paths are the pure land," where beauty encompasses everything with the self-awareness of Xin.

- Empathy: As described in "Zhuangzi (Yan, 2022)," the premise of empathy (or sympathy) is a highly inclusive spirit, representing a state where individuals abandon the ego, seeking unobstructed connections and absolute equality with others, objects, and the world. This equality is not only the emotional equality and mutual recognition based on democracy promoted by Tocqueville but also a universal connection to the fate of humanity and all beings.

- Loving: The essence of love is not in biological attraction or control over others but in realizing one's completeness and capacity to give love (Fromm, 2000), consequently leading to sincerity and enjoyment in relationships between individuals.

- Creation: Just as previously discussed, while AI provides us with passive freedom in creation, the active freedom in creation lies in individual introspective exploration. This form of creation is not about meeting a certain standard but is about whether individuals can engage in artistic creation. True engagement and social vitality are ensured only when each individual's creativity is fully liberated, making everyone to some extent researchers and creators. However, we need to reflect on what experiences in the growth process suppress individuals' willingness to create or alienate certain work.

The important characteristic of these specific soft skills derived from Xin is their undeniable aspect of human development purpose rather than just a means. This significance distinguishes human existence from artificial intelligence and fundamentally determines how human external behaviors manifest. However, regardless of the soft skill, all require an Awareness, Initiative, and Enlightenment-driven understanding and inward transcendence process.

On a social level, ideal relationships between individuals first require the fostering of a connection rooted in Xin and the mutual coordination of the aforementioned soft skills, leading to overall task efficiency as a natural outcome. Human cooperation fundamentally cannot solely rely on any form of identity alignment (Intellect) or emotional contagion (Biophysics) to organize together, as historical facts and human inertia indicate that individuals tend to project their own incompleteness onto larger social entities for completion, risking self-loss and freedom (e.g., Fromm's psychoanalysis of the origins of Nazism), amplifying individual Antibiosis caused by Biophysics and Intellect to a collective level, resulting in larger issues.

In summary, the three meta-capacities of "Biophysics-Intellect-Xin" are reflected in varying proportions in each individual and represent a mutually influential developmental process. These meta-capacities are not distinct but more like a spectrum, often seen in relative terms to understand

the differences between various meta-capacities and their corresponding natures. Focusing solely on an individual's Biophysics and Intellect can lead to an imbalance, potentially pushing towards alienation or polarization, as neither of these can serve as the foundation of a person's life meaning. Xin's meta-capacity is innate, yet often overshadowed by the overemphasis on Biophysics and Intellect. The proposal direction of HEC/Engaged Humans aims to gradually help individuals recognize and return to Xin's meta-capacity within a computational environment, requiring individuals to progress from the first two stages of perceiving a mountain as a mountain (Biophysics) to not seeing a mountain as a mountain (Intellect), and finally returning to seeing a mountain as a mountain (Xin) in the process of understanding oneself and the world. Due to the rarity of Xin's meta-capacity, it naturally evokes projection from others, creating a "charismatic authority" akin to Max Weber's concept.

The three human meta-capacities derived from Natural Humans, Constructive Humans, and Transcendent Humans - "Biophysics-Intellect-Xin" - constitute the three facets of human understanding in HEC. This structure is referred to as the Human Capacity Framework, representing HEC's holistic understanding of human capabilities. From a computing system design perspective, these three aspects help us perceive three different interpretations of the same interactive concept.

Let's discuss the theoretical positioning of Engaged Humans. Based on a structure like the Human Capacity Framework, what sets Engaged Humans apart? Simply put, let's forget about any structural concepts and bring Engagement and Engaged Humans back to a non-dual, authentic concept of "human." In our final design, we need to reconcile the interpretations represented by the "Biophysics-Intellect-Xin" meta-capacities, not neglecting any aspect of human beings and integrating them into a unified whole. Drawing on holistic Eastern thoughts, in the face of the current and future technological world, technology (especially interactive technology or digital environments) impacts human life like air and water, permeating one's entire lifespan beyond its instrumental significance, necessitating an ultimate concern for the completeness and quality of human existence transitioning from "partial usage experience" to "whole life experience."

Engaged Humans also prompt us to rethink a fundamental theme in HCI - what constitutes human-centered design. While HCI has historically constructed human-centered systems by exploring various human factors, behavioral needs, and embodied perspectives, the definition of "human" remains unclear, often existing as a somewhat symbolic entity. Therefore, whether it's the Human Capacity Framework or Engaged Humans, both have the potential to define a pivotal point for the next phase of human-centered design and further contemplate what evaluation methods are needed.

3.4 Revisiting Antibiosis and Synergized Interactions

After interpreting the concepts of understanding humans in HEC - Engagement, Human Capacity Framework, and Engaged Humans - we will once again explore the root cause behind the deeper reason of Antibiosis, and provide an interpretation of the ideal relationship between humans and computers as understood by HEC - Synergized Interaction.

3.4.1 The Root Cause of Antibiosis: Conflicts between Non-Duality of Humans and Duality of Technologies

In section 3.2.3, we attribute the deeper reason of Antibiosis to the Polarization of Biophysics and Alienation of Intellect, suggesting that the current array of issues essentially stem from a Downward Spiral of Hybridization between the two. When we interpret "human" or "Engaged Humans" as a non-dual existence, we can take a step further and abstractly understand the root cause of Antibiosis as a conflict between the non-duality of humans and the duality of computers, technologies, individuals, societies, the world, between the infiniteness of humans and the limited nature of technology.

As Marshall McLuhan referenced in "Understanding Media" drawing from the Eastern classic "Zhuangzi": "...He who does his work like a machine grows a heart like a machine...It is not that I do not know of such things (that machine is useful); I am ashamed to use them[40]" (Heisenberg, 1958; McLuhan, 1994). What does "a heart like a machine" entail? Today, we observe that on a micro level, whether in the basic binary tree data structure in computers, various machine learning and AI algorithms, including so-called human languages (as in the story of the Tower of Babel), and current philosophical speculations - postmodernism, deconstructionism, opposing traditional philosophical notions of duality or binary classification, this opposition itself becomes a form of duality - fundamentally still involving classification. On a macro level, the functioning of society relies on a larger binary tree structure - "The Hierarchy of Bureaucracy[41]". This is why we discussed the importance of computer science in section 3.1.2, as it fundamentally provides a formalized way to describe the world, rooted in ubiquitous dualistic thinking and methods. Applied to human life, this manifests as "separation", "judgment", or "discrimination". Ultimately, regardless of human lifestyles or ways of thinking about technology, this fundamentally results in a native "mismatch" with the non-dual perfection of Xin of humans.

In such a highly passive context, influenced by various external factors, individuals are compelled to live in a dual manner, leading to a "spiritual split", which from Freud's perspective means "everyone is mentally ill". When discussing early Chinese Confucian classics, we often encounter concerns like how Confucius addressed the issue of "the collapse of rites and music" - when the feudal system (the bureaucratic system) serving the overall development of humanity becomes excessively bloated and distorted over time, alienating all individuals involved in the structure. Confucius' solution was "let rulers be rulers, ministers be ministers, fathers be fathers, and sons be sons" and "governance is about rectitude" - only when everyone fulfills their roles well and returns to that original position can the bureaucratic system regain its rationality as a tool or method. Of course, there are two fundamental prerequisites: 1. The design of the bureaucratic system itself is towards value rationality; 2. Every individual needs to approach from the perspective of "Ren/仁 (Benevolence)" (which is Xin).

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[40] In Chinese:
子贡曰：“有械于此，一日浸百畦，用力甚寡而见功多，夫子不欲乎？”为圃者仰而视之曰：“奈何？”曰：“凿木为机，后重前轻，挈水若抽，数如汤，其名曰槔。”为圃者忿然作色而笑曰：“吾闻之吾师，有机械者必有机事，有机事者必有机心。机心存于胸中，则纯白不备。纯白不备，则神生不定。神生不定者，道之所不载也。吾非不知，羞而不为也。”子贡瞒然，俯而不对。《庄子·外篇·天地第十二》

[41] https://en.wikipedia.org/wiki/Bureaucracy

Today, although HCI has reflected upon evaluation standards inherited from the Industrial Revolution, mainstream HCI development predominantly focuses on enhancing human capabilities or performance from an external perspective, emphasizing metrics like motor control, accuracy, efficiency, or user experience, while overlooking their broader and deeper impacts on individuals and society - such as comparison, classification, quantification, judgment, projection, etc., forming the inertia of human life. Despite the benevolent aims of technological construction, if this dualism remains unconscious and transforms from a means to an end, it significantly veers into polarization and alienation, failing to align with the innate needs of human life. This situation is prevalent today, exemplified by the narrow interpretation of gamification. Therefore, for HCI, finding a path that reconciles the duality of mechanistic thinking with the non-duality of humans is a necessary condition for Xin or HEC-oriented approaches.

3.4.2 Synergized Interaction: Addressing Antibiosis through "Right Balance"

How can we address the conflict between non-duality and duality? This question has many similar cases in the context of Buddhism. For example, in the Vimalakirti Sutra, when Vimalakirti is asked, "What is Dharma?", he simply remains silent. This silence is not a binary distinction between answering and not answering; rather, it allows the question, and the language of the inquiry, to pass by like a phenomenon. Using the idea of "Madhyamaka," this serves as a non-binary correspondence to "emptiness," which also includes the realization that any so-called "method" is merely a patch for the problem, not a final solution. However, this approach is not applicable in HCI and technology design. While we understand that any formalized method may lead to Antibiosis, we cannot completely detach ourselves and ignore the significance of technology in alleviating real-world issues.

Thus, we draw on another possibility of "center" from Eastern thought—"Doctrine of the Mean/中庸" - to explore how the "Right Balance" between non-duality and duality can be achieved. This is where Synergized Interaction, as a means to promote Engaged Humans and realize an ideal human-computer relationship, suggests its value direction. Unlike the usual translation of "Doctrine of the Mean," Prof. Tu Weiming translates "中庸" as "Centrality and Commonality" (Tu, 1989), which applies a highly consistent evaluative standard to universal situations - this "Right Balance." This perspective effectively informs the theoretical position of Synergized Interaction.

In the previous text, "Synergized Interaction" refers to a state of optimal balance between engaged humans and engaging computers. We expect to provide a clearer explanation of what the Centrality and Commonality of achieving this "optimal balance" mean in Synergized Interaction and in real HCI scenarios.

When we synthesize the previous descriptions, whether it’s the pressure of reality or the situation where individuals become trapped in their purely developed Biophysics and Intellect while trying to address these real-world issues, we recognize that these are not fundamental solutions. This approach can lead to the accumulation of alienation and polarization, though it may temporarily address certain issues, and it is often the best option among many poor methods or inaction. However, if we fail to recognize the limits of these incomplete capacities and withdraw them in a

timely manner, we will continue to create Antibiosis at its core. In this sense, we cannot fully accept Keynes's assertion that "in the long run, we are all dead," because these short-term solutions suppress the real problems. This is also reflected in the cycles of intellectual history, where ideas oscillate between rationality and emotion due to the inability to find better solutions.

Therefore, when we advocate for Centrality, the ultimate resolution returns to "Realizing the Wholeness of Human Capacities." We have two reasons for this: (1) one at the level of capacities and (2) the other at the level of reality:

(1) The fundamental difference between complete and incomplete capacities lies in whether the capacity of Xin is aware and involved in the interaction process. Any issue should first be analyzed from the perspective of Xin, and only then considered within the realms of Intellect and Biophysics. The awareness of problems associated with complete capacities corresponds not only to general issues but also to the ultimate context of these general issues, which we can refer to as Human Survival. It is important to recognize that this Survival pertains to Xin's Survival, the maintenance of subjectivity, rather than discussing traditional physical or spiritual forms. In such a context, general issues can find connections and share a "base class," which is the fundamental meaning of Commonality.

    At the same time, we need to emphasize that the enhancement of capacities we refer to is not about the usual context of daily task handling, such as frequently evaluating creativity in certain tasks. Instead, it is about the enhancement of "Biophysics-Intellect-Xin" under the ultimate context of Survival, allowing individuals to genuinely discover their subjectivity. From the perspective of Biophysics, people often experience significant gaps in understanding or capturing "enjoyment," which is a key issue emphasized by Somaesthetics. From the perspective of Intellect, the reality tells us that even in modern society, most people do not possess a corresponding modern "Intellect" capacity, such as the understanding of rule of law, let alone the easy discovery of Xin. Therefore, comprehensive enhancement or realization for individuals includes not only physical robustness and sensory acuity or the systematic construction of knowledge as a foundation, but also finding stability and principles at the essential level of "心/xin." This involves consciously using Biophysics and Intellect, while also overcoming the limitations and constraints imposed by "finite bodies" and "infinite knowledge," ultimately achieving a combination of outward and inward transcendence to experience "Human Nature."

    With this Centrality, reflecting from the perspective of Xin reveals that traditional evaluation systems, such as "slow" versus "fast," also hold significance (Odom et al., 2022; Rapp, 2022). The evaluation standards inherited since the Industrial Age are merely convenient methods, especially in the industry's habitual downward compatibility with the issue of "humanity." In light of the recent emphasis on "technological benevolence," it may only be through awareness and the activation of the inherently good aspects of human "心/xin" that we can ensure technology becomes more advanced without being misused.

From this perspective, the overall evaluation criteria for computers may change significantly. Methods such as quantifying performance and comparing techniques may no longer apply to humans. Instead, the focus should be on how interactions can stimulate awareness of our nature and engage individuals' proactive tendencies to approach their true selves, enhancing their overall insight into both internal and external realities.

(2) When each individual enhances their capacities proactively, leading to a positive feedback loop, it becomes possible to reduce the likelihood of various forms of Antibiosis occurring. We believe, as Marx and Nietzsche stated, that creativity is a fundamental impulse of human nature. Through this spontaneous human quality, we can find solutions to many problems without necessarily resorting to coercive discipline or collectivism, thereby constructing an environment where everyone can maximize their potential and foster universal peace. Thus, the possibility of stimulating human transcendence is also the possibility of promoting Human Survival.

Of course, we need to recognize a practical issue: the enhancement of capacities and the resolution of problems will not happen overnight. It is a long-term, incremental process rather than a revolutionary one. However, the distinction lies in the fact that Synergized Interaction can consciously reduce the probability of severe Antibiosis and general issues, thereby preventing polarization and alienation. While difficulties will inevitably arise in the process of meeting natural needs and enhancing capabilities, these difficulties should not stem from secondary, excessive challenges imposed by technology or systems, which distort "Natural Outcoming."

Similarly, although we often extend our understanding of various interaction concepts and many aspects of life through all or some of the three perspectives of "Biophysics-Intellect-Xin," whether consciously or unconsciously (which we will discuss further in Chapter 5), it is precisely this inconsistency—sometimes from Biophysics, sometimes from Intellect—that creates challenges for practicing Commonality. This is indeed a high standard, but recognizing this issue through Synergized Interaction allows us to move closer to that goal.

Additionally, while we reflect on the boundaries between Eastern and Western thought and whether the classification of "Biophysics-Intellect-Xin" is overly simplistic, it is this recognition of the high homogeneity of these three capabilities and their corresponding external phenomena that makes us aware of the rarity of Xin and the challenges and necessities of practicing a high degree of consistency in Xin.

Here, we depict Synergized Interaction as a solution and a value direction. A complete Synergized Interaction requires designers to realize the wholeness of human capacities, while the role of computers is to enhance human capacities within the current level and facilitate transcendence between levels. However, current efforts to enhance human capacities through computers remain focused on Biophysics and Intellect, lacking the incorporation of Xin, which leaves work to be done by Engaging Computers. This may also reflect another reality: while technology certainly helps us enhance our ability to understand and reshape nature, the conscious journey of allowing technology to assist humanity in exploring its own nature has only just begun. We will discuss the theoretical and practical significance of Engaging Computers in Chapter 5.

3.4.3 Comparative HCI: : Difference between HEC and HCI

Next, we attempt to compare the thoughts and differences between HEC and other past HCI concepts through interpretation. We are well aware that the various ideas to be discussed all possess their unique value, corresponding research communities, and directions for extension, making it impossible to conduct a comprehensive alignment comparison. Therefore, our focus in comparison lies in diligently excavating the philosophical positioning of the initial proposal of the idea through various phenomena - that is, its understanding of the relationship between humans and technology. We categorize them into two main (though not absolute) categories for comparison: one leaning towards mainstream HCI design and technology-driven perspectives, and the other inclining towards introducing new perspectives driven by humanistic values. Through these discussions, we aim to elucidate the theoretical positioning and distinctions of HEC thinking.

The former category of mainstream HCI design and technology-driven perspectives includes:

(1) HCI Paradigm Shift on Human Factors: Much of the reflection in HEC is built upon a comprehensive review of the HCI paradigm shift, where HCI has progressively identified human factors in behavior, cognition, social aspects, emotions, and neuroscience (Bødker, 2015; Harrison et al., 2007; Ren, 2016; Ren et al., 2019; Rogers, 2012). Historically, these paradigms reflect a gradual understanding and evolution of human self-awareness and thought. On the level dimension of HCI research categories, based on Hornbæk and Oulasvirta's summary of HCI phenomena, they are divided into seven main types: dialogue, transmission, tool use, optimal behavior, embodiment, experience, and control (Hornbæk & Oulasvirta, 2017). Such categorization helps in providing a basic overview of the complexity within HCI.

    From a holistic perspective, the combination of longitudinal and latitudinal organization reflects an industry understanding of the naturalness - "Random Walk[42]" - of human-computer relationships, where the combination of human factors, interactive technologies, and environmental elements has become fundamental in HCI research, identifying underlying human needs and achieving instrumental use. We can say that under this understanding, HCI has contributed a wealth of knowledge, but its limitations are also apparent. HCI is not just an empirical science. Although many technologies have emerged from this process, the lack of holistic thinking has hindered the development of a more systematic theory to compensate for its lack of philosophical foundation and developmental vision, leading it to become a mere embellishment in more macroscopic development directions such as hardware or artificial intelligence algorithms. This is also one of the reasons why we establish HEC.

(2) Natural Interaction: As one of the fundamental ideas in current HCI, natural interaction aims to seamlessly align with inherent human characteristics, enabling people to unconsciously, intuitively, and without the constraints of additional devices, use computational resources. The contemplation of natural interaction can be said to stem from the influences and refinements of numerous concepts such as "Ubiquitous Computing," "Affordance," "Embodiment," and also includes some similarities and philosophical foundations (e.g., empiricism) shared with concepts like User Experience. However, within a broader technological development context, whether it's Natural Interaction, User Experience, or even more proposals, they are

[42] https://en.wikipedia.org/wiki/Random_walk

methodologies or even methodologies about technological design but cannot become a vision (at least when facing larger societal issues).

(3) Human-Centeredness: Design, Computing, and AI (Kling & Star, 1998; Norman & Draper, 1986; Shneiderman, 2022; Wiener, 1988; Xu, 2019; Zhao et al., 2023): From Norbert Wiener's early description of the role of humans in Cybernetics as an early prototype of "Human-in-the-loop" (Wiener, 1988); to Norman incorporating cognition and emotion into HCI and design as a balanced consideration of mechanism; and further as a supplement to traditional empirical behaviorism or cognitivism in understanding humans, proposing a human-centered design with one of the cores being Maslow's hierarchy of needs... The human-centered perspective has many versions. But since it is a proposal that needs to be understood by others, the core of "human-centeredness" lies not in how to define this concept but in the underlying structure and explanatory path behind the proposition itself. For example, in Zhao's Heads-up computing, "human-centered" focuses on how humans can break free from the spatial constraints of computing devices (Zhao et al., 2023). Shneiderman's human-centered AI advocates that autonomous machines cannot replace human intelligence, creativity, and responsibility, emphasizing machine intelligence that is fully secure, dependable, controllable, and trustworthy, enhancing transparency and accountability to boost innovation and various values (Shneiderman, 2021). Xu's human-centered AI emphasizes the interpretability, understandability, usefulness, and usability of artificial intelligence or computing technology (Xu, 2019). However, because the "human" in these explanations is just a role in a specific context, these different perspectives on human-centered ideas lack a more macroscopic philosophical explanation, ultimately appearing somewhat phenomenological. Although everyone aims to make the world a better place, the fundamental basis of this "good" lies in understanding human beings, which is indispensable for explaining technological ideas. However, in the current context of HCI, human-centeredness is more of a highly phenomenological nature, leaning towards a personalized Biophysics, which may lead to the risk of polarization.

(4) Augmenting Human Intelligence (Engelbart, 1962): The original concept proposed by Engelbart stems from how computers can facilitate and enhance collective intelligence, which is a necessary condition for building a better world and overcoming challenges. Engelbart's proposal in "Augmenting Human Intellect" and his systematic demonstration of the oN-Line System can be considered a milestone in advancing HCI awareness, also inspiring Alan Kay's concept of Personal Computing. Today, the construction of a human knowledge repository has become a reality, but whether Engelbart's or Alan Kay's complete visions have been realized, we can see that the major issues in the world today cannot be solved solely through cooperative collective intelligence. These pioneers also did not further plan how human nature, on the level of the "Theory of Evil Human Nature," could be amplified by computing systems. (The active periods of Engelbart and Alan Kay can also be seen as a lively period of Western social science critique of modernity and rationality (counter-culture movement). In this regard, Alan Kay was greatly influenced by Marshall McLuhan, but in terms of results, there was no further questioning of the limitations of rationality.) This leads to what we refer to as Antibiosis triggered by Biophysics and Intellect. Therefore, based on this foundation, Augmenting Human Intelligence needs to take another step forward, which is also the direction that HEC strives to pursue based on Engelbart's legacy.

(5) Human Augmentation (Daily et al., 2017; Raisamo et al., 2019) or Enhancing Humans (Maes, 1997): This type of enhancement tends more towards augmenting external capabilities of humans, such as mechanical arms, exoskeletons, and even brain-computer interfaces (BCI). While these advancements can significantly improve the lives of specific workers and disabled populations, when designing enhancements to human Biophysics, we need to consider their value within a broader context of human capacities to prevent polarization in their applications.

(6) (Human-Computer/AI) Symbiosis (Licklider, 1960), Integration (Farooq & Grudin, 2016; Mueller et al., 2020), Collaboration (D. Wang et al., 2020)[43], and Teaming: With advancements in AI and other technologies, these concepts have been proposed advocating for establishing intimate partnerships between humans and technology where computers can appropriately match and process information for humans in daily life, and allocate tasks in a way that suits either humans or machines better to achieve optimal outcomes. Jonathan Grudin's thoughts reveal that within the framework of Symbiosis proposed by J. C. R. Licklider, while the first phase of "Human-Computer Interaction" has been largely achieved, "Man-Computer Symbiosis" is still just the beginning, and many technologies and interactions do not appear as symbiotic as initially envisioned. Hence, there is a need for a deeper understanding of people, technology, and interactions, and the concept of "Integration" has gained its theoretical position as a result (Grudin, 2017). Recent developments have indeed introduced many interactive technologies aimed at expanding human channels. There are numerous similar proposals, including human-computer teaming. We are not inclined to nitpick the differences between HEC and these concepts, but we must ask, even if these ideas are realized, their fundamental *problématique* has not risen to address real human societal issues, which cannot be solved solely through the scenarios set by technology in work and life.

Different from the mainstream HCI focus on computing usability, building knowledge repositories, or achieving optimal human-computer interaction, the latter type of humanistic perspective aims to deconstruct hidden problems beneath the human subconscious. It seeks to find more possibilities for human conditions and computational forms to address a potential crisis of existence. These reflections are more rooted in philosophy, psychology, sociology, psychoanalysis, and religion, seeking connections with technology design.

(7) Positive Computing (Calvo & Peters, 2014): Originating from positive psychology, positive computing explores "Wellbeing" after researching various fields such as philosophy, psychology, and Buddhism. It contemplates how universal forms of technology can enhance human happiness. Drawing from self-determination theory as a pragmatic perspective on personal fulfillment, and like HEC, it offers directions such as mindfulness, empathy, and compassion as paths to "positivity." Positive computing is further compatible with approaches like somaesthetics, mindful-based mobile applications (MBMA) (Niksirat et al., 2019), mindful design (Akama et al., 2017), and digital art therapy (CBET)(Du et al., 2024) aimed at inducing relaxation at a theoretical level. However, despite incorporating viewpoints from Eastern philosophies (Buddhism), a drawback of positive psychology or positive computing is its overemphasis on the "meaning" and "positive" intellectualization, without a comprehensive focus on Eastern philosophical systems, where wisdom primarily relies on transcending language through moral practice. Without clarifying these premises or the scope of "positive," it's challenging to generate real effects and may even lead to misunderstandings, entering

[43] https://zhuanlan.zhihu.com/p/537181894

linguistic traps. In contrast, HEC aims to emphasize human capabilities like mindfulness, empathy, and compassion, rooted in Xin. Such capabilities are experiences and practices beyond Intellect.

(8) Humanistic HCI (Bardzell & Bardzell, 2015): Unlike traditional HCI studies that have a simplistic understanding and use of concepts related to people or technology, humanistic HCI aims to offer an expert perspective through intersections with humanities and social sciences. It provides a critical lens to reveal that behind commonly accepted concepts lie various potential interpretations and avenues for improvement. It seeks to prompt reflections beyond mere usability on aspects such as self and sustainable development. Humanistic HCI inherently carries a "leftist" hue, drawing from diverse "meta-approaches" like Marxism, psychoanalysis, feminism, and post-colonialism to uncover inequalities or irrationalities behind various interactive phenomena, aiding in societal and individual consciousness liberation, and fostering discussions on identity and community. Similar concepts include Reflective HCI (Sengers et al., 2005) and Sustainable HCI (DiSalvo et al., 2010). While we acknowledge the care for humanity within Humanistic HCI, on one hand, its *problématique* is built upon the extension of classical humanistic theories into technological design, but lacking a systematic understanding and generalization incorporating a technical perspective to reveal fundamental human problems. On the other hand, Humanistic HCI is largely driven by Western thoughts and reaches a bottleneck in ultimate meaning through language-based Western critical questioning. We believe that Xin's theoretical position holds promise in inspiring insights on this matter.

(9) Existential HCI (Kaptelinin, 2018; Karlström, 2006; Light et al., 2017): Based on the philosophy of existentialism, it constructs a bridge between the humanities, psychology, and philosophy, aiming to raise awareness of our own existential state through the everyday use of technology and contribute to establishing a possible sense of meaning in life. However, as noted by experts in the field (Kaptelinin, 2018), despite existentialism being an important theme in phenomenology (a crucial idea in the third paradigm shift of HCI), it has not received sufficient attention due to its *problématique* differing from traditional HCI themes. This also resonates with broader societal trends where people often lack true reflection on their lives during times of peace and prosperity, only becoming conscious when faced with difficulties, whether it be the rise of existentialism post-World War II or the renewed interest in existential philosophical during the Covid-19 era. HEC views human survival, existence, and the exploration of the meaning of life as fundamental *problématiques* and prerequisites for technological development, followed by problem-solving for specific tasks. However, the difference lies in the fact that, on the one hand, both Eastern philosophies and HEC do not consider "meaning" as an ultimate concern, as the attachment of meaning itself is first and foremost a constraint on discovering Xin. This point is similar to our reflections on Positive Computing, and does not need further elaboration. Furthermore, while existential philosophy offers some critical methods, Existential HCI is still in its infancy. We hope that HEC can serve as a complement to Existential HCI (similar to how Eastern philosophies complement existentialism), and also aim to move beyond mere explanations to offer more concrete solutions.

(10) Religions in HCI: In recent years, HCI has begun drawing inspiration from religions to construct a transcendent view of happiness beyond everyday secular life (Claisse & Durrant, 2023). For instance, Hiniker and Wobbrock propose that HCI can foster connections between individuals and communities by learning from Christian spirituality (Hiniker & Wobbrock, 2022). Similarly, extraordinary HCI explores similar themes. The spiritual aspects of Buddhism

are also gaining attention in HCI due to potential links with cognitive science and phenomenology. Discussions on mindfulness meditation, human emotions (like compassion in human-robot interactions), actually stem from traditional Buddhist concepts and methods, aligning with certain aspects of positive computing. Additionally, concepts like "Wabi-Sabi" as a significant symbol of Japanese Zen aesthetics have been applied in the design of interactive artifacts (Tsaknaki & Fernaeus, 2016). HCI research that learns from religious spirituality aims to provide new interpretations and design spaces for modern human inner and outer lives. However, these studies often lack exploration of the core of Buddhism or other Eastern philosophies, focusing more on representative religious symbols and secularizing them to some extent (e.g., the *problématique* of interactive meditation applications primarily revolves around relaxation), a key aspect that HEC aims to elucidate profoundly.

Through the above comparisons, we can roughly summarize two core differences of HEC:

(1) In contrast to technical proposals, we believe in the expertise and reflections of experts, but this is fundamentally a communication and hermeneutics issue - not only must we present what our key terms themselves are, but also what the recipients can understand. Without that ultimate premise, the questioning and interpretation of humans and meaning, how can we talk about defining or explaining "usefulness"? This is also what HEC hopes to propose after focusing on Biophysics and Intellect, a design scope centered around Xin. On the other hand, many root issues of real-world problems cannot be solved solely through technical innovation. While everyone aims to "Make the World Better," we need to push the *problématique* to the survival of humanity, the overall sustainable development of the world, and peace to find the fundamental reasons.

(2) Humanistic proposals generally stem from Western worldviews on understanding and observing humans, capable of generating a set of explanations but lacking a complete construction of philosophical theories about "humans," leading to methodological dilemmas. HEC introduces Eastern philosophical approaches not to exclude Western systems but to strive for a complementary approach, providing inspiration for academia and industry.

In the realm of human-technology relationships, besides the various proposals as reflections in the academic field of HCI, there are also considerations from various other domains. Academic aspects include "AI and Friendship" (Deguchi, 2023), David Levy's "Love and Sex with Robots" (Levy, 2009) and related international conferences[44], professional fields like Science, Technology and Society (STS) [45]and Digital anthropology[46], cultural domains like classic works such as "Cyberpunk," "Ghost in the Shell," "Matrix," and industrial concepts like "Effective Accelerationism[47]" or "Superalignment[48]". From the perspective of HEC, these considerations more or less still linger within the bottleneck of Intellect and Biophysics. If individuals cannot realize their wholeness, then the results, to some extent, escape from the Antibiosis of "High Tech, Low Life" (Gibson, 2017).

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[44] https://www.lovewithrobots.com/

[45] https://en.wikipedia.org/wiki/Science_and_technology_studies

[46] https://en.wikipedia.org/wiki/Digital_anthropology

[47] https://www.nytimes.com/2023/12/10/technology/ai-acceleration.html

[48] https://openai.com/index/introducing-superalignment/

3.5 Summary: Towards “The Thought System”

In this chapter, we start from the phenomena of HCI and interpret the positions of four important concepts in HEC - Antibiosis, Engagement, Engaged Humans, and Synergized Interaction - in a multi-disciplinary and historical way. We aim to illustrate two conclusions through this: (1) the purpose of "The Thought System"; and (2) how "theoretical justification" is explained.

(1) In Section 1.4, we have already mentioned the significance of The Thought System, namely that The Thought System itself is the intrinsic "operating system" of each individual. As a method for revealing reality, if we can unravel the various reasons within it, we may find a potential path to discover the fundamental causes of Antibiosis and thus find possible forms of future computers. Using "Biophysics-Intellect-Xin" as a core method, some may ask, "Is this feasible?" or "Is this too idealistic?" To this, we say that the essence of this question lies not in the immediate feasibility but in our ability to provide The Thought System as a philosophical foundation for thought. If this Thought System or this goal can be articulated, more people begin to understand our approach or even have a thought in that direction, forming a research community - many historical experiences tell us that this could potentially drive the self-realization of this concept, enabling individuals to understand themselves in the process. However, textual interpretation is a necessary but insufficient condition for true understanding, so we hope to further project The Thought System into The Computing System to aid understanding, with The Thought System itself being the logical prototype of a computational system.

(2) This chapter is titled "Towards the Theoretical Justification." What does "justification" mean? In fact, justification is the ability to prove and persuade people to accept a theoretical construct through a set of reasoning (Weber, 2019). For HEC, the basis of this reasoning or thought experiment lies in the introduction of multidisciplinary thinking - some leaning towards analytical Intellect, such as philosophy, sociology, psychoanalysis, computer science; others towards bodily Biophysics experiences, such as arts like music, literature, and architecture. Afterward, it is discovered that at the core issues, everyone has undergone similar paradigm shifts, similar thoughts, faced similar dilemmas, and similarly wondered how to proceed in the future. This actually forms a natural connection and constitutes a common *problématique*— the limited sensibility and rational capacities of humans in facing current challenges, with Xin becoming a potential answer. This answer is not something we provide but a complete understanding of human nature left by the entirety of human experience, which has long been overlooked. Seeking a position in the history of ideas itself is a manifestation of thought at the Intellect level. How this discourse is accepted also requires more people to have experiences at the Biophysics level, for this need to manifest and be understood at the level of Xin.

Chapter 4: Practical Reflections on GUI Computational Aesthetics and Information Interactions

In the context of HEC's deliberations, this dissertation attempts to incorporate previous case studies in GUI Computational Aesthetics and Information Interactions into the HEC framework for interpretation. This is done not only to reposition the significance of these case studies but also to integrate HEC in reflecting on the issues faced within and even across these two directions.

4.1 From "Biophysics" to "Intellect": An Interpretable Computational Metric of Visual Aesthetics for GUI Design

Computation-based aesthetics metrics have been developed to help designers predict visual aesthetics scores for GUI design. However, designers find these evaluative scores difficult to understand. This work proposed an interpretable aesthetics metric for GUI design that integrates visual aesthetics (visual similarity and spatial proximity) and GUI structure (semantic similarity and white space) to model visual grouping distribution. Two experiments were conducted to validate the metric's ability to predict aesthetics and interpret outputs. Experiment 1 showed that our metric had a stronger correlation with users' impressions of GUI visual aesthetics than past metrics. Experiment 2 suggested that our metric was easier to interpret and appeared more useful to Visual/ Graphic/GUI designers than a conventional score-based alternative, by visualizing the metric outputs as an experimental tool. Furthermore, this work provided five potential insights to further advance computational aesthetics research.

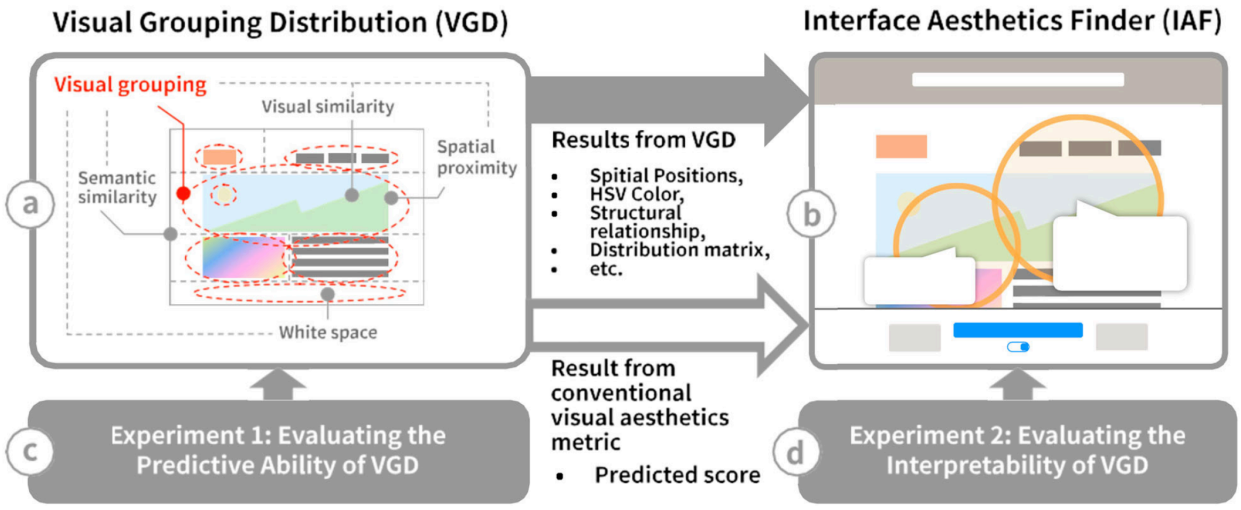


Figure 4.1. The Overview of VGD

(a) Our proposed metric, VGD, measures GUI aesthetics by integrating perspectives from both visual aesthetics and practical GUI design to generate multiple types of results. VGD is based on four design principles: visual similarity, spatial proximity, semantic similarity, and white space, which are used to cluster visual groupings. (b) To interpret metric-generated results, we developed a metric-driven experimental tool called 'Interface Aesthetics Finder'. IAF addressed aesthetics issues and suggested potential webpage improvements. (c & d) Two experiments were conducted to demonstrate VGD's predictive ability and interpretability through IAF, respectively.

4.1.1 Introduction

The visual aesthetics of graphical user interfaces (GUIs) plays a critical role in determining usability, satisfaction, trustworthiness, and other perceived indicators of system quality (Lindgaard et al., 2011; Miniukovich et al., 2019; Moshagen et al., 2009). It further affects users' experience and behavioral outcomes, influencing purchase intention and the likelihood of recommending the system to others (Liu et al., 2016; Wu et al., 2019). GUI designers aim to create visually appealing interfaces that impress users "at first sight". However, attaining a high level of visual appeal demands significant design expertise and hands-on experience, which may not always be easily accessible to startups and independent developers. Furthermore, the high costs associated with outsourcing visual design projects, conducting empirical user studies, crowdsourcing tasks across a large number of designs (Luther et al., 2015), and implementing A/B tests (Nasir et al., 2022) may also impose financial challenges.

One potential solution to assist GUI design is to model computational metrics that automatically predict GUI aesthetics based on user aesthetics (Dou et al., 2019; Miniukovich, 2016; Miniukovich & De Angeli, 2015; Miniukovich et al., 2018; Oulasvirta et al., 2018; Reinecke et al., 2013; Xing et al., 2021). However, the computed predictions, often a single score per GUI screenshot obtained through pixel-based processing, may be too general for GUI designers to understand without substantial design and visual-perception expertise. Even if the score is based on a metric-described aesthetics feature, it leaves designers uncertain about the exact changes that could or should be made to actually improve their design.

Our main motivation is to enable designers to comprehend the automatic evaluation results, thereby contributing to GUI design and aesthetics improvements. To achieve this, this work proposed an interpretable aesthetics metric to describe the quality of Visual Grouping Distribution (VGD), taking into account the relationship between visual aesthetics and practical GUI structure. VGD was based on four design principles: visual similarity, spatial proximity, semantic similarity, and white space (Figure 4.1(a)), which helped designers to visualize design improvement interpretations (Figure 4.1(b)). To evaluate the usefulness of VGD, we conducted two experiments. In Experiment 1 (Figure 4.1(c)), we compared VGD to previously proposed metrics. The results showed that VGD could explain unique aesthetics variance and had a stronger weight than past metrics in predicting users' aesthetic impressions. In Experiment 2 (Figure 4.1(d)), we compared a score-based tool to our experimental tool based on VGD, the 'Interface Aesthetics Finder (IAF)', which could highlight potential GUI aesthetics issues and generated visualized interpretations. The preliminary results suggested that IAF could complement the score-based tool to provide designers with more intuitive and informative insights into potential design improvements.

The following are the contributions of our work:

(1) Our work will help in the interpretation of aesthetics prediction scores and their potential use for designers in a GUI design context. It presents a new metric, namely Visual Grouping Distribution, by considering both aesthetics theoretical justification and design principles. Previous computational aesthetics approaches primarily focus on only the variance in aesthetics to predict users' a general impression by modeling metrics from visual arts or employing deep learning techniques.

(2) VGD processes both screenshots and HTML structures, thus improving interpretability over conventional methods processing webpage screenshots or HTML elements only. We developed a visualization tool to interpret VGD outputs; this is intended to complement current computational aesthetics applications and inspire working designers to improve GUI aesthetics.

(3) Finally, our research provided five potential insights to advance computational aesthetics modeling by integrating designers' comments. These implications included highlighting more aesthetic issues and learning from designers' feedback.

4.1.2 Related work

Research on computationally predicting GUI visual aesthetics has been primarily informed by HCI studies of aesthetics antecedents and outcomes (Tractinsky, 2013), but it has also been influenced by research in psychology and the arts.

4.1.2.1 GUI visual aesthetics

In early HCI research, terms like "beauty", "visual appeal", or "visual pleasure" are used interchangeably to refer to aesthetics (Tractinsky et al., 2000). Aesthetics is treated as an important aspect of user experience (Hassenzahl & Tractinsky, 2006). Research has validated aesthetics as a crucial part of the user impression within the first 50 milliseconds (Lindgaard et al., 2006; Miniukovich & De Angeli, 2015; Tractinsky et al., 2006), and its effect persists throughout the later stages of the interaction (Thielsch et al., 2014). As a result, measuring aesthetics as a part of the first impression has become a common practice (Miniukovich & De Angeli, 2015; Reinecke et al., 2013; Zheng et al., 2009).

Psychological research has developed several theories of aesthetics. The early theory by Berlyne viewed aesthetics as a function of stimulus unfamiliarity, complexity, uncertainty, and similar concepts, which increased up to a point and then dropped back down, resulting in a U-shaped relationship between the predictors and aesthetics (Berlyne, 1973). Leder et al. developed a model that included several determinants of aesthetics (Leder et al., 2004), of which visual complexity and unfamiliarity were tested (Tuch et al., 2009; Tuch et al., 2012). The model produced two aesthetics-related outputs: (1) aesthetic appraisal, which reflects an immediate reaction to stimuli, and (2) aesthetic judgment, a weighed judgment put into perspective, often in an artistic sense. Reber, Schwarz, and Winkielman formulated the processing fluency theory of aesthetics (Reber et al., 2004), which was the most commonly relied-on theory in GUI aesthetics computation. The theory suggested that processing fluency, the effort to mentally process a stimulus, correlates negatively with aesthetics, which fits with the perceptual mechanisms of Gestalt tradition and principles (Treisman, 1982; Wertheimer, 1938). Recent research (Miniukovich & Marchese, 2020) has reviewed several theories of aesthetics and their validation in HCI studies, suggesting that more evidence supports a negative aesthetics-complexity relationship rather than a U-shaped relationship.

While these theoretical grounds sought to understand the underlying mechanisms of visual aesthetics, little research focused on discussing aesthetics in a practical GUI design setting. Thus, it could be difficult for designers to understand and improve aesthetics.

4.1.2.2 Computational aesthetics

Computational aesthetics research has developed various metrics, often based on arts-related or psychological studies of aesthetics. These metrics processed GUI screenshots through pixel-based algorithms and validated them by matching computed scores against user scores of aesthetics (Hasler & Suesstrunk, 2003; Michailidou et al., 2008; Miniukovich & De Angeli, 2015; Miniukovich et al., 2018; Ngo et al., 2003; Purchase et al., 2011; Reinecke et al., 2013; Rosenholtz et al., 2007; Zheng et al., 2009). For example, Zheng et al. (2009) tested several metrics based on computational Quadtree decomposition of webpages, such as visual balance, symmetry, and equilibrium, and found that some of them correlated with different aesthetics-related evaluations of webpages, such as appearing professional, captivating, or appealing. Similarly, Reinecke et al. (2013) described several metrics, some of which were similar to those tested by Zheng et al. (2009), and found that they affected webpage aesthetics via visual complexity and colorfulness. Their work was further extended in a large-scale crowdsourcing study that investigated the relationship between aesthetics perception and demographic factors (Reinecke & Gajos, 2014) and localized diversity (Nordhoff et al., 2018).

Several studies have developed or listed metrics with the aim of integrating them into a tool for designers. For example, Miniukovich and De Angeli (2015) intended to include eight metrics in a tool called "tLight", which addressed visual clutter, color variability, symmetry, figure-ground contrast, contour congestion, and layout quality. When combined in a linear model, these metrics explained 49% of webpage aesthetics variance. Aalto Interface Metrics (AIM) developed by Oulasvirta et al. (2018), integrated 17 different metrics from past studies. AIM could process a screenshot or URL of a webpage and show predictions for each of the metrics. GUIComp, developed by Lee et al. (2020), offered design feedback, including example recommendations, user attention, and visual complexity evaluation. Its visual complexity evaluation panel, which integrated six metrics, presented numerical indexes and best value as the primary result to measure aesthetics. However, the predicted scores from these tools were difficult to interpret in a GUI design context. For example, the metric of contour congestion was described as "all contour pixels that have neighbors in a 20-pixel vicinity are marked as congested" (Miniukovich & De Angeli, 2015). This left much unclear for designers about how to optimize a GUI, even if the score informed about user impression.

Several studies have used sophisticated statistical methods, including machine learning, to achieve higher prediction accuracy than linear-model-based methods. However, they have often lowered the potential interpretability of their features. For example, early work by Ivory, Sinha, and Hearst (2001) collected HTML-based features, such as counts of webpage buttons, text fields, and hyperlinks, and relied on decision trees to explain up to 65% of variance in webpage quality evaluations. However, their tree-based profiles of good designs might have been too complicated for realistic use in design. In contrast, O. Wu, Hu, and Shi(2013) used multiple element-based and pixel-based measures as features for support vector machines (SVM), resulting in a higher accuracy of 77%. More recently, there was a branch of research to computationally model user aesthetics based on deep learning neural networks (Dou et al., 2019; Soui & Haddad, 2023; Xing et al., 2021). For example, Webthetics (Dou et al., 2019) was trained on Reinecke's data (Reinecke & Gajos, 2014). The neural networks achieved a high prediction performance of 85% of webpage aesthetics. However, understanding the black-box mechanism of why a neural network assigns a high or low score was still unclear to current AI researchers, along with the interpretability in designers' practice. While additional perspectives on image/video aesthetics assessment within the context of deep learning methodologies offer insights into the key factors of semantics and composition (Hou et al., 2022; Hou et al., 2023; Wu et al., 2023a, 2023b), their methods of evaluating images may not

directly apply to GUI evaluation. Moreover, these approaches might lack the necessary aesthetics and theoretical support required for interpreting and providing concrete improvements to designers.

In summary, the current state-of-the-art computational aesthetics research consists of two branches. One branch draws inspiration from art or psychological theory to model aesthetics metrics for evaluating GUI design, the other branch utilizes trained deep learning or machine learning models for general GUI aesthetics evaluation. However, the predicted aesthetic scores from both branches pose challenges for designers in terms of interpretation and practical improvement of GUI design. Our metric, Visual Grouping Distribution (VGD), was inspired by psychology (Reber et al., 2004; Treisman, 1982), and can be explained at the GUI level. Compared to past research that solely process webpage screenshots or HTML elements to generate prediction scores in techniques, our metric processes both the screenshot and HTML structure of webpages, which potentially enables the interpretable visualization of results for designers. We expect this to provide a more comprehensive understanding of GUI aesthetics design and offer practical insights for designers.

4.1.3 Visual grouping distribution

The VGD metric was based on an unimplemented metric "ease of grouping" (Miniukovich & De Angeli, 2015), which was derived from the processing fluency theory and describes the relationship between the organization of information complexity and visual aesthetics (Reber et al., 2004). In the context of Gestalt-based design guidelines, "ease of grouping" describes the ability of the visual system to seamlessly integrate individual features into a perception of coherent regions, structures, and objects (Rosenholtz et al., 2009). This suggests that designers should place semantically-related objects together and make them visually similar to each other to produce good gestalt which is aesthetically preferred (Brumby & Zhuang, 2015; Feldman, 1999; Leder et al., 2004; Palmer et al., 2003).

We augmented "ease of grouping" as "visual grouping distribution" to measure GUI aesthetics with two concerns. First, from a visual aesthetics perspective, the whole grouping distribution of the GUI could work as a more complete metric to capture users' aesthetic impressions instead of seeking a local visual grouping feature. Second, from a GUI design perspective, visual aesthetics are inextricably linked to the underlying GUI structure and content. Therefore, we can address aesthetic issues by identifying their actual location and suggesting content improvements based on the global distribution of visual groupings.

While our metric was theoretically derived from processing fluency, its operationalization was informed by the Gestalt principle of grouping and based on existing design conventions. We draw on insights from various UI-specific design conventions that are adhered to by professional designers. These conventions include avoiding useless and excessive white space, minimizing the margins between elements, clustering webpage elements with little space between them, balancing element distribution to avoid clustering on one side of the webpage, and avoiding "orphaned" elements (small elements positioned far away from other elements, and thus appearing visually detached from the rest of the webpage content). To achieve a cohesive and visually appealing design, designers often combine multiple visual elements to form a larger functional element. For example, a set of menu items can be combined to create a function block with uniform structure and semantics, as well as a harmonious visual aesthetic style. Therefore, we defined Visual Grouping Distribution as the goodness of GUI content distribution in which each visual grouping is also both

perceptually and functionally homogeneous. By considering both perceptual and functional aspects of visual grouping, the VGD metric offered a more comprehensive approach to evaluating GUI aesthetics.

The above design conventions have not been fully accounted for by the past HCI computational-aesthetics research, as it often grounded its metrics in general visual perception theories of aesthetics (e.g. the processing fluency theory (Reber et al., 2004) informing research in (Miniukovich & De Angeli, 2014)) or abstract visual arts-related rules originally developed for and tested on a set-of-rectangles type of stimuli (Altaboli and Lin 2011; Ngo, Teo, and Byrne 2000). In both cases, past research has overlooked GUI-specific dimensions of GUI aesthetics, with studies on computing document aesthetics (Balinsky et al., 2009) being an exception.

Building on the above theoretical justification, our metric was designed to form visual groupings with four principles: visual similarity, spatial proximity, semantic similarity, and white space. Based on these principles, the VGD partitions a GUI into content clusters and evaluates their relative sizes – uneven sizes, with many small or large clusters, flags poor use of white space, poor content spacing, or element grouping.

The clusters (Figure 4.2) represented the visual groupings of items that the mind perceives to be independent and separate from each other. The cluster formation was based on two Gestalt principles (Treisman, 1982): visual similarity (if two items are visually similar, e.g. have the same color, shape, or texture, they are likely parts of a larger item) and spatial proximity (if two items are close to each other, they are likely parts of a larger item). Past research often attempted to apply the Gestalt principles to design and aesthetics (Koch & Oulasvirta, 2016; Palmer et al., 2003; Yan et al., 2018), even suggested complex models that mimicks the perceptual processes of visual scene sense-making (Rosenholtz et al., 2009). In contrast, our approach augmented these principles with GUI-specific information – semantic similarity (Lin et al., 2017): whether a designer intended several visual items to be grouped together as part of a larger meaningful or functional block. We did this by considering the GUI structure and integrating a webpage DOM tree in our algorithm to identify close relationships among structural and functional webpage elements. Within such a cluster, the visual form and GUI elements were interconnected and fit with each other to serve the same functional design intention (Krippendorff, 2005). Additionally, the rest of the clusters without text/images information were identified as white space.

We developed an algorithm based on the above design of VGD that estimates webpage aesthetics, which takes both a screenshot and the HTML source of a webpage as inputs. The algorithm for partitioning webpages into clusters included several steps, implemented with a mixed pixel and GUI structural analysis. First, a webpage screenshot was divided into 6400 rectangles for modeling visual groupings (an 80 × 80 grid over a screenshot; 23 × 11-pixel rectangles in practice). Each rectangle was represented by a normalized six-element vector. The first three elements described the mean pixel hue, saturation, and value, which closely correspond to the perceptual visual similarity. The other two elements described the vertical and horizontal position of each rectangle for computing spatial proximity. Describing semantic similarity, the final element represented an ID of a high-level DOM tree node or white space that the rectangle spatially and functionally belongs to. We labelled this information using Selenium (a Python-based package for processing DOM structure) to iteratively seek the parent–child structural relationship between DOM leaf nodes (text/images) and their underlying functional blocks. To prevent processing exceptions caused by

irregular HTML source code writing, we applied a computer-vision-based segmentation (Oulasvirta et al., 2018) to calibrate the blocks.

The 6400 vectors (each element of the vectors was normalized to a 0–1 interval, except that the two spatial elements were scaled to 0–0.3 to reduce their impact) were used to group the rectangles into larger clusters. Hierarchical agglomerative clustering (Euclidean distance, Ward's agglomeration method) was used to mimic the effect of the two Gestalt laws and structural relationship. This combined rectangles with nearby rectangles of similar color and function until a threshold was reached (cophenetic distance = 4.88, empirically chosen). The sizes of the resulting clusters (the final visual groups) of rectangles were recorded as the number of contained rectangles, and the mean difference between cluster sizes was used as the metric score. The distribution matrix of clusters could be also saved for further interpretation of the score.

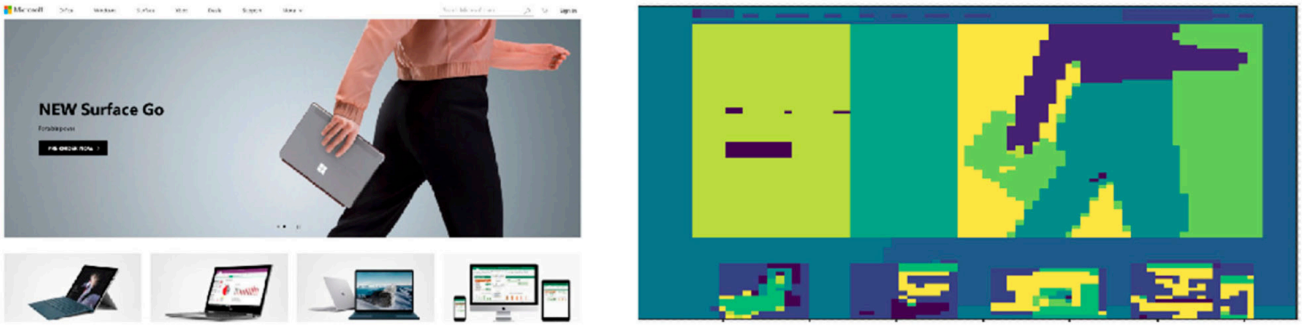


Figure 4.2. A webpage (left) and its partitioning in visual clusters (right, each cluster is shown in its unique colour).

4.1.4 Experiment 1: evaluating the predictive ability of VGD

Experiment 1 aimed to assess the predictive ability of VGD by comparing it primarily to five relevant metrics (Table 4.1): Grid Quality, White Space, Pixel Symmetry, Amount of Information (also known as "set size" (Rosenholtz et al., 2007)), and Amount of Images (Cyr et al., 2009; Miniukovich & De Angeli, 2016) in predicting the visual aesthetics of webpages.

We selected these five metrics based on (1) Grid Quality, White Space, and Pixel Symmetry (Miniukovich & De Angeli, 2014, 2015) were conceptually related to VGD, as they measured the organisation of GUI information. We included them in the study to ensure that VGD explains unique variability in aesthetics. Grid Quality was represented by the number of vertical and horizontal content alignment points (as a composite metric, see (Miniukovich & De Angeli, 2015) for further detail). (2) Amount of Information and Amount of Images were identified as the two primary determinants of web aesthetics. We were concerned that the metric algorithm could have been sensitive to them instead of measuring what we intended. Therefore, we measured the Amount of Information as the number of detected contour pixels (Miniukovich & De Angeli, 2014; Rosenholtz et al., 2007) and the Amount of Images and graphics as the number of used RGB colors of webpage screenshot pixels (as some research has shown the number of colors to correlate with the amount of graphics (Miniukovich & De Angeli, 2016)).

We also compared VGD with 14 metrics proposed in previous studies (Miniukovich & De Angeli, 2015; Reinecke et al., 2013) that examined their correlation with user scores (Table 4.2). All metrics were compared employing open-source algorithms published in Oulasvirta et al. (2018), which utilized webpage screenshots as inputs.

4.1.4.1 Participants

We enrolled 30 individuals (17 males, 13 females; 17 Japanese, 13 Chinese) to participate in our study on predicting end-users' aesthetic impressions of webpages. The participants included bachelor's, master's, and Ph.D. students, as well as university employees, with a mean age of 23.8 years (SD=4.38). All participants had normal or corrected-to-normal vision and reported spending over 5h per day on the Internet. Seventeen participants had a technical background, while 7 participants had practical experience in visual or GUI design.

4.1.4.2 Stimuli

To sample webpages for our study, we followed the criteria outlined in past studies (Miniukovich & De Angeli, 2015). Specifically, we selected webpages based on (1) low familiarity to the average user, which minimized the potential confounding effects of familiarity on first impressions, and (2) representing one of four genres: corporate, e-commerce, online portfolio, and blog post webpages.

Using these criteria, an initial set of webpages was collected by six students and cleared of webpages with obvious quality issues and incomplete source code. The final sample included 145 homepages, which were saved as both screenshots (1900 × 900 pixels, webpage top part only, PNG format, 24-bit per pixel) and HTML/CSS source code.

4.1.4.3 Design and procedure

The online data collection began with a consent page and a demographics questionnaire, following the experimental procedure outlined in previous studies (Miniukovich & De Angeli, 2015).

Participants were asked to view and rate 145 webpages in a random order. In each trial, participants first looked at a fixation cross on a background of noise (1500 ms). Then, a webpage appeared on the screen for 500 ms, followed by 1000 ms of black-and-white noise. Participants were asked to rate the webpage on a 9-point Likert scale, ranging from "unappealing" to "appealing". There was no time limit for rating, and the average completion time was approximately 30 min. The experiment consisted of: 30 participants × 145 webpage stimuli = 4350 trials.
At the end of the session, each participant was paid $8.

4.1.4.4 Results

The average score for intraclass correlation coefficient was high (ICC2k = .934; 95% CI is .917 to .948; $F(146, 1386)=17$, $p<.001$), indicating that different participants rated webpage aesthetics consistently. This suggests that participants understood the task and were not distracted or overloaded. Individual aesthetics ratings were aggregated by computing the mean across all participants, which yielded a single score for each webpage. The analysis of these scores revealed that the sample included both appealing and unappealing webpages (rated from 1.6 to 7.0 on a 1-to-9 scale).

The estimates for the output score of visual grouping distribution were negatively correlated with aesthetics, $r(143)=-.56$, $p<.001$. Visual inspection of aesthetics scores plotted against metric

Table 4.1. A linear model of webpage aesthetics, with VGD and five metrics as predictors.

Predictor	Beta coeff.	*t* values
Visual grouping distribution	−0.44	−5.08***
Grid quality (Number of horizontal alignment points)	0.23	3.49***
Grid quality (Number of vertical alignment points)	−0.19	−3.14**
White space (Amount of white space)	−0.29	−3.48***
Pixel symmetry (Ratio of mirrored edges)	−0.08	.07 (n.s.)
Amount of information (Number of contour pixels)	−0.47	−7.15***
Amount of images (Number of colours, log-normalised)	0.17	2.04*

$R^2 = .60$ (adj. $R^2 = .58$), $F(7,137) = 29.00$***.
*** $p < .001$; ** $p < .01$; * $p < 0.5$.

estimates and resulting Lowess curve did not reveal a non-linear relationship (Figure 4.3). A linear model including the past aesthetics measures and the metric explained 58% of the variance in aesthetics scores (Table 4.1). This was 8% more than the model without the metric, and the

Table 4.2. Pearson's correlation coefficients between metric prediction scores and user scores.

Metric	Pearson's *r*(143)	*p*
Visual grouping distribution	−.56	<.001
Metrics in (Miniukovich and De Angeli 2015)		
Edge congestion	−.56	<.001
PNG size	.50	<.001
Number of colors	.50	<.001
Luminance	.35	<.001
Edge density	.38	<.001
White space	−.34	<.001
Grid quality	−.23	.005
Pixel symmetry	−.21	.01
Figure ground contrast	−.04	.60
JPEG size	−.04	.63
Metrics in (Reinecke et al. 2013)		
Balance	.41	<.001
Symmetry	.25	.002
Equilibrium	.17	.03
Number of quadrants	.39	<.001

difference between the two models was significant, $F(1,137) = 25.77$, $p < .001$.

Of the six past aesthetics-related metrics, four performed as expected, with larger numbers of vertical alignment points, amount of white space, and number of contour pixels corresponding to lower aesthetics, and a larger number of colors corresponding to higher aesthetics (Table 4.1). However, a larger number of horizontal alignment points corresponded to higher aesthetics, which was unexpected. Pixel symmetry did not explain unique variance and was an insignificant predictor. The estimates for the output score of visual grouping distribution were negatively correlated with aesthetics ($r(143) = -.56$, $p < .001$), which is stronger than all proposed metrics with the Edge Congestion being an exception (Table 4.2).

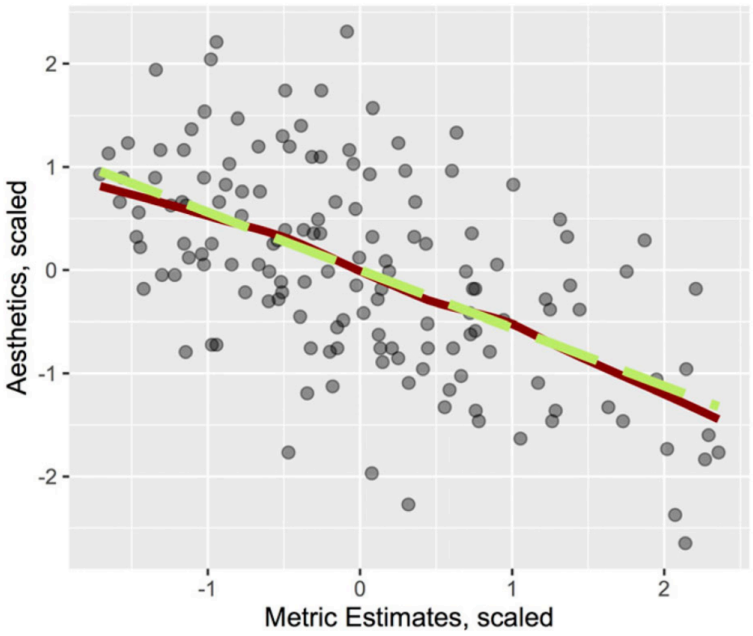


Figure 4.3. Plot of webpage aesthetics against metric estimates.

Higher metric estimates correspond to worse visual grouping distribution, which is seen as a negative correlation that a regression line (dashed green) demonstrates. No non-linear tendencies of the aesthetics-metric relationship is visible, demonstrated by an almost straight Lowess curve (solid red).

Visual inspection of low-aesthetics high-metric webpages (Figure 4.4) suggested that high metric scores corresponded to design issues such as excessive white space use, excessive between-element padding, unbalanced content distribution, and other issues with content positioning.

4.1.4.5 Discussion

The results of both the metric-aesthetics correlation and the predictor in the linear model indicated that our metric explained unique aesthetics variance and more of users' aesthetics impressions than past-proposed metrics. The negative correlation between the metric and aesthetics suggested that higher aesthetics were associated with lower VGD estimates. This trend might indicate to designers that a relatively more segmented interface with even-sized interface clusters might reflect a more balanced distribution of content. Conversely, a higher metric score might suggest that a webpage interface could be potentially perceived as a few large clusters with uneven size.

Considering aesthetics-design experience, it was more likely that an interface containing several excessive blank chunks, monotonous color use, or leaving most of the information in a compact corner would result in a higher metric score. This was also reflected in the metric results of white space and contour pixels. In contrast to other pixel-based aesthetics metrics that might suggest reducing the number of contour pixels to improve aesthetics, VGD provided more actionable insights in a design context. For example, designers could adjust the spacing between visual groupings or split a large information structure into smaller sections based on the results obtained from VGD.

4.1.5 Experiment 2: evaluating the interpretability of VGD

The objective of Experiment 2 was to evaluate the interpretability of VGD. To achieve this goal, we have developed an experimental tool "Interface Aesthetics Finder (Figure 5(a and b))". This tool can not only present a prediction score, but also visualize the metric-generated results in an intuitive manner to inspire designers with novel design ideas (Rosenholtz et al., 2011) or help them identify smaller areas for improvement.

We compared IAF to Aalto Interface Metrics (AIM) (Oulasvirta et al., 2018). AIM is an open-source service that collected 17 state-of-the-art algorithms for evaluating webpage aesthetics computationally, complemented by other attention distribution and accessibility metrics. While it might not yet be a globally recognized benchmark to compare computational aesthetic evaluation tools against, it appears to be the most suitable existing option for this. (Figure 4.5(c and d)).

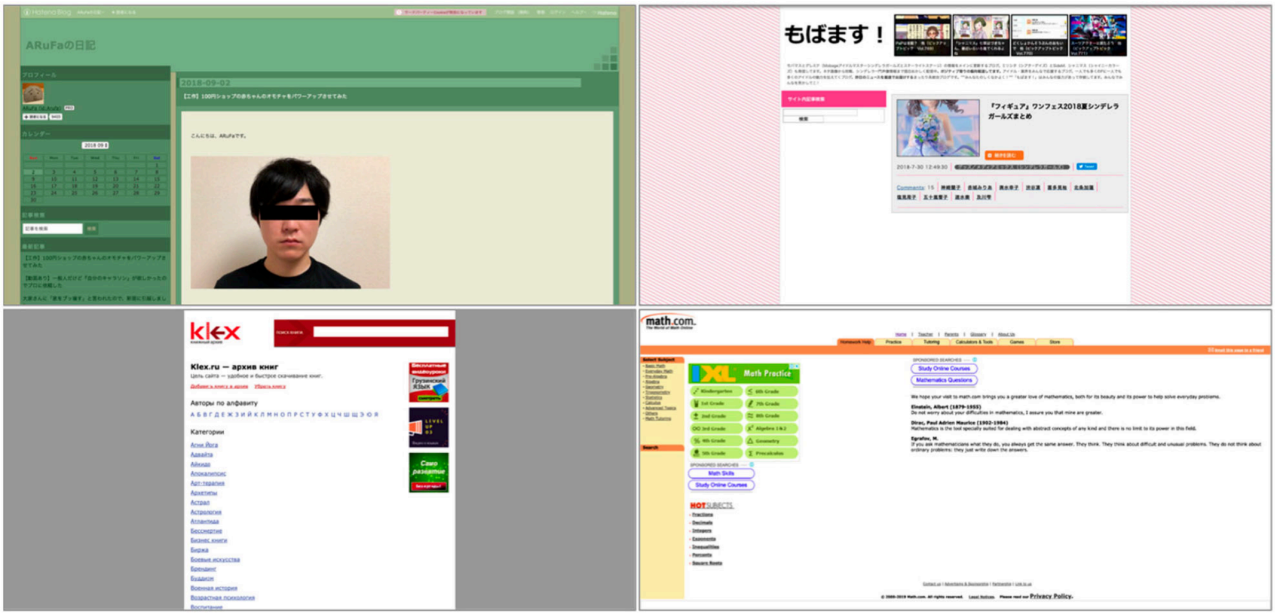
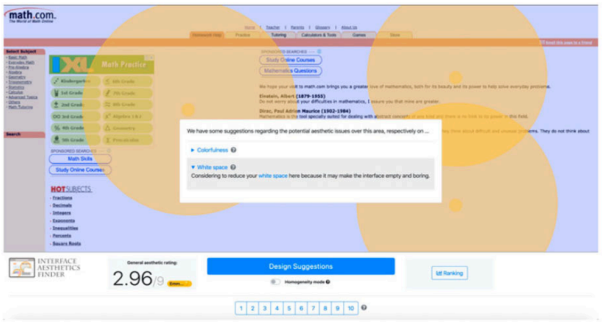


Figure 4.4. Four low-aesthetics poor-content-distribution webpages, exemplifying the type of element-positioning issues that our metric could detect.

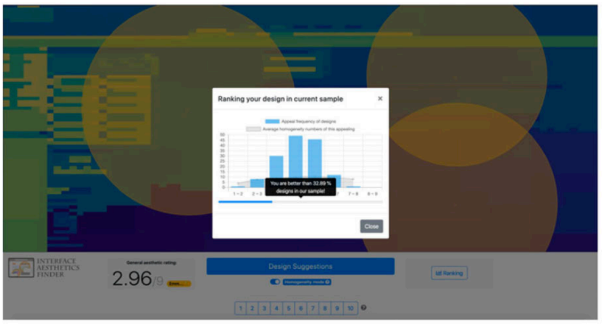
4.1.5.1 Interface aesthetics finder

IAF consisted of two components: frontend and backend. The frontend was responsible for receiving input and visualizing the results. The backend was based on a linear aesthetics model wrapped by Tornado (a Python-based web framework) to respond to the request. The linear model integrated VGD and the metrics specified in Table 4.1 to achieve a relatively higher prediction rate (R2 = .60 (adj. R2 = .58), with a single VGD at .56) and prevent the single VGD from generating extreme results, e.g. an unrealistic placement of all content in a single corner. As the key feature of IAF, design interpretations were primarily generated from VGD for three reasons. First, the weight and predictive ability of VGD in the model were more significant than other metrics. Second, other metrics mainly emphasized discrete or local features of webpages, making it challenging to generate design interpretations that are both clear and effective. Third, the overlap among all metrics could be technically challenging to identify and process.

The workflow of IAF consisted of the following four steps. (1) Designers entered a URL, and the backend of the IAF captured and analyzed both the screenshot and source code of the target webpage. (2) Based on the computed cluster distribution matrix, the VGD algorithm searched for parameters that would produce a sub-optimal cluster distribution (i.e. smaller clusters that should have been one), mainly by cutting the hierarchical tree at different heights. Such distribution could lead to smaller between-cluster size differences and potentially higher aesthetics compared to the original prediction. The algorithm selected the best set of parameters, and the resulting cluster distribution was compared to the original distribution. (3) Visualizations were then processed. Based on the six-element vector (HSV values, XY coordinates, and HTML-tree position) of each rectangle in clusters, IAF calculated the differences between the original and high-aesthetics clustering distributions. (4) Three continuous areas with the largest difference were then selected for highlighting (Figure 4.5(a), orange circles), and interpretations were generated by considering the local changes of other metrics in the model and wrapping them with prepared suggestion templates. For example, IAF might suggest reducing perceived local content density by using fewer dominant colors: "Seeking to decrease color variability here. Fewer colors will reduce visual complexity and ensuing cognitive load. To learn more about colorfulness in interface design, knowledge of HSV and Adobe Color may help", which was generated by analyzing the changes of color number in the local area. Within the interpretations, some keywords might include hyperlinks to Wikipedia articles or related resources.

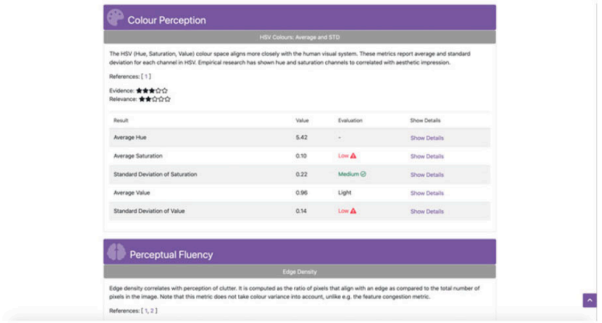


(a) IAF can address aesthetics issues (yellow areas) and generate suggestions accordingly (white dialogue box).



(b) IAF also offers both prediction and ranking functions.

(c) The segmentation function of AIM.



(d) The metric prediction lists of AIM.

Figure 4.5. Two aesthetics tools in Experiment 2: (a & b) Interface Aesthetics Finder. (c & d) Aalto Interface Metrics

Besides the key features above, to align with the functions of AIM, IAF presented a prediction score for a quick evaluation, and a relative ranking to other webpage samples, which was useful for designers interested in comparing webpage designs (as shown in Figure 4.5(b)).

4.1.5.2 Participants

We recruited 16 participants with design experience (8 males, 8 females), with a mean age of 25.5 years (SD = 2.45). Ten participants had or were pursuing a master's degree, and 6 had or were pursuing a doctoral degree. All participants had digital design experience across various fields such as visual graphic design, HCI design, game interface, art, or user experience design. Additionally, 10 participants had worked as designers for over two years.

4.1.5.3 Stimuli

To evaluate the interpretability of VGD outputs, we randomly chose the URLs of 10 webpages from the samples used in Experiment 1, including 2 high-rated (6–9 scores), 3 middle-rated (4–6), and 5 low-rated (under 4) aesthetics webpages. The stimuli selected were dissimilar to the actual distribution of webpage ratings (11: 93: 41), as our main focus was on suggesting design interpretations for middle-to-low-rated webpages. These webpages covered various genres, including corporate, e-commerce, online portfolio, and blog post webpages.

4.1.5.4 Design and procedure

Since improving webpage design in real environments is subjective, complex, and lacks standardization, we adopted a free-form exploration to evaluate the interpretability between two computational aesthetics tools (i.e. IAF and AIM). Half of the 16 participants were randomly selected and asked to use IAF first, then AIM, while the other half did so in the reverse order. AIM was modified to provide feedback on four properties (HSV Colors, Edge Density, Grid Quality, and White Space) among its diverse set of metrics for comparisons with IAF. The experiment consisted of: 16 participants × 2 tools × 10 webpage stimuli = 320 trials.

All participants conducted the experiment by accessing online IAF and AIM services on their own computers, they were asked to respectively experience the automatic feedback generated by two tools on all webpage stimuli in random order. To evaluate the effectiveness of easy-to-understand interpretability, for each of the tools, participants were then asked to rate their perceived cognitive load (using 7-point Likert scales for five of the six NASA TLX indexes, including effort, frustration, mental demand, temporal demand, and performance, excluding physical demand (Tanner et al., 2019)), ease-of-learning associated with each tool (using a 5-point scale from "Not very intuitive" to "Very intuitive"), potential helpfulness of each tool in design (using a 5-point scale from "Not very helpful" to "Very helpful"), and their willingness to adopt each tool (using a 5-point scale from "Not very often" to "Very often").

In addition to numeric ratings, participants were encouraged to provide free-form feedback and comment on each tool's features, shortcomings, and potential improvements. After using both tools, participants were asked to comment on their general expectations regarding future aesthetics tools in design.

4.1.5.5 Results

We calculated the cognitive load by averaging individual-index scores (Tanner et al., 2019). The results showed that the cognitive load was higher when using AIM (mean = 4.6) compared to IAF (mean = 3.1), with the difference being significant (Wilcoxon-Pratt Signed Ranks test, $Z = -2.90$, p

< .01). Additionally, participants rated IAF as easier to learn than AIM (mean score 3.8 vs 2.8, $Z = -2.50$, $p < .01$), and there was no significant difference in perceived helpfulness between IAF and AIM. Furthermore, participants were more willing to try IAF in their work than AIM (mean score = 3.5 vs 2.8; $Z = -2.09$, $p < .05$).

Participants provided several insightful comments, both positive and negative, about IAF. One participant (P3) mentioned, "It is characterized by clear functions and puts forward some design suggestions to help designers further optimize the webpage. As for the disadvantages, when the positions to be improved on the webpage are close, it is difficult to distinguish what the highlighted fields refer to."

Another participant commented, "I think the visualization tool is a very good guide tool and entry tool. Although the suggestions cannot be fully applied (the suggestions sometimes are not suitable), it can remind designers where they need to pay attention" (P4). Additionally, one participant commented, "The visualization is a good aesthetics tool for UI designers, especially for novice designers, to conveniently point out the weakness of current UI as well as to help them acquire more design knowledge and terminology" (P11). However, there are also concerns among participants regarding performance: "There is a certain discrepancy between algorithm recognition and human recognition, indicating the need for algorithm optimization" (P8).

Participants also provided suggestions for improving IAF, such as providing more types of interpretations and displaying the importance level of optimization suggestions. One participant suggested, "The service could compare different designs or give examples of different designs, and a design could be adjusted directly. Anyway, I want to know what a better design should look like" (P12), "and whether this tool can be used as a plugin for PowerPoint design". Some participants provided user experience feedback, such as suggesting that when a suggestion is clicked, the previous one should automatically become hidden. P13 even suggested that the "Design Suggestions" button could be removed for more intuitive results, as IAF was specifically designed to provide design suggestions. P9 requested the addition of a feature that "shows the average aesthetics score among the entire ranking sample".

Participants also provided feedback on AIM, with some commenting, "All parameters, metrics, and terms are particularly professional, providing specific visualized effects would be appropriate" (P2). "Based on the evaluation results of AIM, the design will be safer and have reduced errors (e.g. avoiding the use of unbalanced colors). The provided results exhibit a high level of credibility" (P11). Another participant commented, "I think this tool should be useful for professionals due to its detailed analysis and data, but for novices or laymen, it may not be easy to use and get inspired. For example, what does low' or medium' mean?" (P7).

Participants also suggested improvements for AIM, such as making the interface simpler and the analyses and charts more intuitive, as one participant mentioned, "The interface could be simpler, and the analyses and charts more intuitive, so we don’t need to pay much attention to think about it or search for it" (P6).

When discussing their expectations for future aesthetics tools, participants suggested various improvements. Five participants emphasized that, if aesthetics/design examples were included, the tool would enhance the intuitive interpretability of suggestions, e.g. "incorporating a direct hyperlink within the suggestions, enabling designers to view examples of websites that excel in a

specific aspect" (P10). Additionally, one participant suggested, "Future tools should have a refutation function to indicate when algorithms fail, and it can also help optimize machine learning algorithms processing screenshots in the background. I may not care about specific score indicators, but I want to use this tool to improve my personal design capabilities through modifying interface cases and using the tool." (P12)

Another participant mentioned, "The tools should help me think. Even if I don't know how to describe what I want, the tools can help me find inspiration" (P11). Participants wondered if a tool could help evaluate interface fonts and provide suggestions (P7) such as how to mitigate the impact of ads on website aesthetics (P13). Another participant suggested that future tools should focus on optimizing algorithms and considering the real "What You See Is What You Get" for a design tool (P8).

4.1.5.6 Discussion

Our research found that designers have a strong need for a specific aesthetics tool. Participants preferred IAF as it produced less cognitive load and is more intuitive than the conventional score-based results. Qualitative user comments supported our motivation that a single score may not be easily understood by participants. Based on the mechanism of our metric, IAF could visualize the content distribution in a "2D" output, which allows for more interpretable space than past "1D"predicted scores. As such, our metric contributes to basic implications for interpreting computational results of HCI metric modeling and inspiring further improvements.

Participants rated both tools as equally helpful, their comments showed that AIM was informative in terms of rich metrics and professional descriptions of terms, while IAF was advantageous due to clear and interactive visualization and practical interpretations. We believe that future developments could benefit from integrating the strengths of both IAF and AIM, particularly by offering various types of information, comparable examples, interactive feedback, and specific design interpretations through the integration and interpretation of outputs from multiple metrics. Since there are currently few specific aesthetics evaluation tools, services, or plugins in the app store or designers' toolbox, offering more heuristic aesthetics improvement ideas rather than pure interpretations will be a promising direction for future work.

We found that most participants we able to interpret the qualitative suggestions and visualizations on the tool, e.g. they, particularly novice designers, paid attention to both positions which shows potential issues and terminologies in the dialogue box. A few participants mentioned that they needed more quantitative and precise suggestions. This requires us to, (1) provide designers with concrete reference examples based on aesthetics evaluations; (2) enhance the aesthetics modeling and performance of the VGD algorithm to generate more detailed suggestions, e.g. moving a content block 50 pixels to the left to create a visual grouping with other content. Such suggestions have been assigned to future work.

Regarding other features in the tool, participants did not extensively comment on them such as the "ranking" feature. This showed that the features may not be the primary focus for them compared to visualizations and evaluation scores in the experiments. However, for example, since the ranking could be useful for referencing aesthetics/design examples, we will likely include this feature into design examples in future work.

Participants also commented that enhancing their design capabilities was more crucial than relying solely on powerful tools (P12). This indicates that fully automated design tools, such as an automatic poster-making tool, need to work well as an assistant to humans instead of displacing them. The development of aesthetics largely depends on individuals' experiences and understanding of the subject. For designers, especially those who are new to the field, it is crucial to actively engage in practical experiences from the outset of their profession.

In response to P8's feedback on "What You See Is What You Get", we can explore incorporating computational metrics and visualization effects into pervasive apps like the interactive web inspector (Tanner et al., 2019) to aid designers in their tasks. Furthermore, it is important to investigate more intuitive ways of interacting with these metrics to better understand aesthetics. One potential avenue for development is to allow for adjustment of the distribution of visual groupings in real-time on touchscreens.

4.1.6 General discussion

We presented a new aesthetics metric, VGD, by reviewing low-aesthetics webpages and identifying common aesthetics issues based on design and aesthetics-computation experience. Unlike other past proposed metrics (Miniukovich & De Angeli, 2015; Ngo et al., 2003; Oulasvirta et al., 2018; Reinecke et al., 2013), which largely relied on searching through visual perception or arts literature to identify metric candidates, we also modeled visual aesthetics from a GUI design perspective.

In Experiment 1, VGD was validated and explained 8% of the unique variance in aesthetics ratings, in addition to the variance explained by the five past metrics with which it conceptually overlapped. Besides, VGD was validated to have a stronger correlation than other previously proposed metrics. In Experiment 2, we tested the interpretation of IAF and AIM. The findings indicated that designers found value in IAF because it could interpret aesthetics predictions more intuitively and generate improving suggestions. This preference for visualization and analysis of designer feedback allowed us to demonstrate our interpretability from the perspective of design practice.

Through our studies based on our two experiments, we suggested five potential insights for researchers:

(1) The theoretical foundations of computational aesthetics should consider practical GUI design dimensions, not solely limited to psychology or the arts. Although psychology and the arts can provide valuable research starting points, their insights may not always directly apply to GUI design, as many of these aspects are already evident or implemented in real designs, such as the use of clear images on websites. Nonetheless, the various perspectives of aesthetic studies can all influence GUI/HCI design to some degree (Haimes, 2021). For researchers, a comprehensive understanding of aesthetics is necessary to develop interactive tools that can help designers gain a deeper understanding of aesthetics.
(2) It was crucial to seek modeling methods that incorporate both perceptual and practical perspectives of aesthetics. Our work presents the relationship between aesthetics and GUI through VGD. This goes beyond the previous works that only focused on the visual aspects. We anticipate that more methods could be proposed to make them compatible with different theoretical grounds, which could also inspire current machine learning algorithms to increase their rationality regarding aesthetics.

(3) Researchers could explore more intuitive and clearer interpretation options for computation results and tools. The inclusion of aesthetics/design cases in various forms should be a key aspect of the generated suggestions, this was highlighted as one of the most important comments. Other potential options could also be considered and applied, for example, by showing a design dimension in isolation (e.g. color clutter and visual saliency dimensions, as in (Rosenholtz et al., 2011)), highlighting design issues, or using already known terminology (e.g. referring to between-element margins instead of contour congestion, as in (Miniukovich & De Angeli, 2015)), or detailing new concepts, preferably by mapping the results on designs as an overlay. Such overlaid visualizations would focus designers' attention on specific areas of designs and provide inspiration for possible solutions. Furthermore, we expect more types of suggestions, such as fonts, icons, and style guides, to be extended in the future.
(4) Aesthetics tools should be able to learn from designer feedback, potentially adapting to their style, requirements, or circumstances. These tools could allow designers to explore design opportunities, such as comparing several designer-provided alternatives side-by-side or finding similar-looking past designs of high aesthetics. Future, more sophisticated tools could also attempt to generate design alternatives. Furthermore, it is essential to address multiple dimensions of design and aesthetics, possibly ranking them based on their importance to designers. Some dimensions may affect aesthetics more than others, depending on the GUI type (Miniukovich & De Angeli, 2016), while others may not be changed due to usability-related reasons or third-party content. Designers would want to have a choice in what to change and know how changing one dimension affects others.
(5) AI-driven design tools, such as auto-layout or auto-design (Beltramelli, 2018; Huang et al., 2019), are having a significant impact on HCI and computational aesthetics, as they offer the potential for dramatically improved efficiency compared to manual design. However, the use of such tools raises concerns about the powerful generated designs, default templates, and black-box interpretation. These factors may not necessarily help designers, particularly novices, to develop an awareness of the importance of aesthetics in their work, which could result in a decline in their skills over time. Future computational aesthetics could be strengthened by integrating AI in terms of better prediction rates and generating more types of inspiration beyond logical analysis. The key issue is how to balance the weight between human behavior modeling and algorithmic modeling to achieve better aesthetics interpretation for designers (Banovic et al., 2019). The current neural networks only process pixels, whereas our VGD offers a novel modeling approach for neural networks, providing designers with more meaningful interpretations.

4.1.6.1 Limitations and future work

Although VGD has integrated visual aesthetics and GUI design conventions, we encountered the challenge of avoiding overlap between VGD and other metrics. As a result, VGD was unable to generate quantitative suggestions or define valid tasks for participant steering in Experiment 2. As design improvements also relied on designers' subjective expertise and taste, we primarily relied on a qualitative free-form exploration. This approach needs further refinements in future work to overcome its limitations and increase its rigor.

From a technical standpoint, we plan to improve the real-time analysis of VGD and aesthetics modeling, which will aid in evaluating IAF in real-world design task scenarios. Moreover, we aim to enhance VGD/IAF by incorporating more robust aesthetics and design features, such as collaborating with AIM or introducing the semantics of a 12-column grid to identify the use of meaningful white space, and aim to generate clearer quantitative suggestions accompanied by

relevant examples. Although our experimental design did not take into account demographic factors such as gender, age, or language, future studies with larger samples could explore the impact of these factors.

4.1.7 Conclusion

Our work primarily focuses on the interpretability of GUI aesthetics metrics for designers, distinguishing it from previous research that primarily focuses on prediction scores. Therefore, our work introduced a novel and interpretable aesthetics metric, Visual Grouping Distribution (VGD), which integrates visual aesthetics with GUI structure. Experiment 1 confirms VGD's predictive ability, showing a stronger correlation with users' aesthetic impressions than previous metrics. In Experiment 2, we present a visualization tool, Interface Aesthetics Finder (IAF), to demonstrate the ease of interpreting VGD for potential GUI improvements.

Our work aids designers in making sense of computational aesthetics outputs and enriches the domain of computational aesthetics modeling. Moreover, our work provides a prototype to inspire the development of future aesthetic tools for researchers and designers.

4.2 Reflections on Aesthetics

From the perspective of HEC, our work in computational aesthetics progresses from a "Biophysics" cognitive psychology level of understanding the visual mechanisms of beauty to an "Intellect" GUI design level of promoting the quantification and practicality of beauty. However, as our understanding of aesthetics evolves, we have also reflected on some limitations of this work. On one hand, there is a lack of user research in addressing aesthetic needs in design. On the other hand, more importantly, there is a need to explain and formalize "beauty" from the standpoint of Xin, viewing it as the ends rather than a means, with a true inspirational significance and inner pleasure for individuals, rather than solely considering aesthetic needs within a commercial context. In explaining beauty, there are classic topics in HCI, specifically the relationship between User Experience and Aesthetics, considering how Dewey's pragmatic philosophy serves as a philosophical foundation in this context and how to reconcile the conflicts between the psychological and humanistic paths in aesthetic foundational theories. With the construction of the HEC framework, the philosophical significance and potential of "beauty" in interactions are expected to receive new interpretations.

Furthermore, it is worth mentioning that the original intention of Section 4.1 was to explore the potential quantitative relationship between visual aesthetics and Entropy, as past experiments have indicated a U-shape or negative correlation between visual aesthetics and visual complexity. The computational metric we designed in Section 4.1 - visual grouping distribution - is aimed at discovering the cohesion of web block content (different web page sections) in terms of style design to calculate the area of each content block as an input in the entropy formula. We have preliminarily validated the similarity between entropy and our current calculated average values (Wang & Ren, 2018). However, due to limited writing capabilities and insufficient support from related work, this

was not formally presented in this dissertation. Nonetheless, we believe it is a discovery worthy of discussion[49].

4.3 Reflections on Information Interactions

We have received information from authentic and inauthentic sources. Fake news, continuous rumors, and prejudiced opinions from digital platforms and social media have the capacity to disrupt social harmony, to stall personal development, and to undermine trust on all levels of human interaction. Despite the wide plurality of perspectives, the diversity of contents, the variety of voices, and the many often-conflicting reasons for publishing, our interactions with information on digital devices are progressively shaping such situations and affecting decisions on all levels. We look at the limitations of existing designs and guidelines in the current paradigm, and we ask to what extent researchers and developers can focus and contribute, through their innovations, to the reduction of uncertainty and cases of misdirection, how they can mitigate tensions between information and humans, and how they can contribute to the maintenance and enhancement of worthy human values. Human-Engaged Computing (HEC) calls for innate user capacities to be enhanced rather than displaced by digital technologies so that the human factor in interactions is fully exploited and truly efficient symbiotic relationships between humans and devices can be achieved. Under the framework of HEC, we propose 12 research agendas from the theoretical, principled, and practical aspects, in order to develop future Synergized Interaction between humans and information. The present crisis presents us with a good opportunity to reflect on the need to empower humans in relation to the tools they use and to consider the next paradigm shift for designing information interaction.

4.3.1 Introduction

With the fast development of computing technologies and digital services, along with the rapid construction of information infrastructures, people are able to source information from television media, radio broadcasts, social media, and various Internet avenues. Technologies are playing a central, critical, and arguably indispensable role in our daily lives during the pandemic. But the new efficiency afforded by new technologies is a two-edged sword, and each edge is capable of healing or harming human relationships and enterprises. For example, our newly experienced potential for global public supervision in the interests of human health and well-being (Lee, 2020; WHO, 2020) also runs the risk of undermining some freedoms either surreptitiously or via legislation. On the other hand, efficient private and personal access to information, accessible publishing, and new modes of social interaction open the door to the dissemination of fake news, to trolling, and to prejudiced opinions that overwhelm and confuse people more efficiently and effectively than ever before (Eyal, 2014; Phillips, 2015; Rainie et al., 2013).

There is nothing in the nature of information that renders information *per se* immune to corruption, misperception, and/or distrust. Restated, our hope and trust in information *per se* are naïve, and it is now evident that the addition of more information cannot resolve the serious “trust deficit” that has emerged with regard to all information and information itself. This should not surprise us because information has always been subject to powers and influences of many types, the main difference

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49 This article references our work but does not clearly articulate our core thoughts on entropy： Wang, X., Tong, M., Song, Y., & Xue, C. (2024). Utilizing Multiple Regression Analysis and Entropy Method for Automated Aesthetic Evaluation of Interface Layouts. *Symmetry*, *16*(5), 523.

now being that the good and the bad, the true and the false, the surreptitious and the transparent are transmitted, received, and swallowed globally, and at the speed of light¼ and from all levels of society and authority.

The challenge of now is not so much about access to information, as people are already overly exposed to information from ubiquitous digital sources and formats, but regarding how to identify and resist the increasing flood of manipulative disinformation (Tang, 2018). This challenge places a burden on researchers to help users synthesize, assess, deselect, and make use of information (Tang et al., 2019) and to make wise and discerning decisions. However, although traditional technical actions, e.g., detection, may help enhance the quality of information, they are still limited because they can hardly enhance users' information literacy *per se.* Responding to this situation, how can we, as researchers, not only help ensure that people are secure and satisfied with the information they find via digital media, and that barriers hindering people from accessing essential information for the public can be overcome, but also help people distinguish useful and trustworthy information from rumors, fake news, and fraudulent communications and thereby promote the health and development of their minds and characters in an effort to strengthen their defenses against the negative impacts of deficient media contents and technologies?

This work aims to raise awareness of how human–computer interaction (HCI) and information retrieval (IR) researchers can help develop and enhance the user's ability to distinguish between inauthentic and authentic information during and after the current crisis. From the recently developed perspective of human-engaged computing (HEC), the next challenge for researchers and practitioners is to facilitate the activation, engagement, and progressive enhancement of the inner capacities of users and thus enable them to distinguish truly edifying information from surrounding noise. We want to encourage researchers to seek methods and insights that maximize the positive assistive aspects of technology and minimize negative dehumanizing factors while achieving synergized interactions (Ren et al., 2019) between humans and technologies with human outcomes as the priority. Informed design decisions regarding the well-being of those who use technologies can only be made when designers fully account for the potential of their technologies not only to strengthen, but also to quantitatively and qualitatively diminish, innate human capacities and potentials.

This work seeks to accomplish the following: (1) raise the awareness of potential dilemmas for future information interaction development; (2) offer a new perspective to rethink the further development of information interaction; (3) propose research agendas for researchers by considering the general field from three aspects - theoretical, principled, and practical, calling for the exploration of ways to enhance inner human capacities by means of digital technologies. Our current area of specific interest is to find potential solutions that help users identify authentic contents and then evaluate and use them according to their personal and informed integrity. Specifically, we promote constructive understanding of the following research question:

Can we ensure our interaction design processes consciously engage and enhance inner human capacities (e.g., wisdom, intuitive skills, and personal integrity) to help users face future challenges with a sense of personal responsibility, rather than merely developing conventional technologies for functional needs or potentially diminishing their skills and responsibilities through the use of our technologies?

We expect that the HEC perspective can set a clear goal for researchers and practitioners about how to promote innovations to specifically and progressively improve innate human capacities; on the other hand, researchers are capable of recognizing this significance to explore more principles and methods to fulfill and extend these agendas as important information interaction case studies for further HEC practices and applications. We believe that such effects will integrate to contribute toward the next paradigm shift in the field of information science.

4.3.2 Related Work on Information Interaction

Since we specifically and consciously seek to facilitate wisdom and community compassion rather than mere knowledge as data/information, information is defined, in this work, as the macroscopic digital content that general users can interact with via computing technologies and online media, which differs from the analytical microscopic data used in information science. We also use the terms "information" and "digital content" interchangeably in this work. In the following sections, we will state how the general design paradigms of information interaction shift and explain the perspective of HEC values.

Information interaction has been one of the most important topics in the field of IR and information science. IR is "inherently interactive" (Savage-Knepshield & Belkin, 1999). Brooks, Daniels, and Belkin (1986) analyzed existing research on IR and proposed that it is critical to understand human-to-human information interaction for the purpose of designing an intelligent information system interface. According to Toms (2002), information interaction is "the process that people use in interacting with the content of an information system".

Under the umbrella of information interaction, issues such as methods that motivate information interaction (Belkin et al., 2003), models/techniques/systems/apps supporting information interaction design (Sa & Yuan, 2020; Yuan & J. Belkin, 2014; Yuan et al., 2015), and factors affecting user perception of information interaction design (Begany et al., 2016) or information-seeking behavior (El-Maamiry, 2020) have been widely researched. In a Wizard of Oz experiment comparing a spoken language search interface through voice and touch gesture input with a textual input search interface, Begany, Sa, and Yuan (2016) analyzed the transcribed exit interview data and found that such factors as user familiarity with the system, ease-of-use of the system, speed of the system, as well as trust, comfort level, fun factor, and novelty, affected user perception.

During the coronavirus pandemic, researchers from HCI and IR have shared their perspectives according to their expertise to provide various kinds of technical agendas including the following: (1) how data science can facilitate more efficient and timely responses regarding potential cases and crises and develop a reliable and trustworthy information environment (Xie et al., 2020); and (2) how to help the most vulnerable generation, the elderly, get digital information promptly, e.g., by supporting service organizations that cater to seniors (Fingerman & Xie, 2020). There is now a pressing need for researchers and practitioners to rethink methods of information interaction that can help deal with emergencies.

The above work informed that paradigms of information interaction are progressively shaped by the corresponding requirements and concerns of certain periods and states of society in their respective times (Harrison et al., 2007). Defined as “the entire constellation of beliefs, values, techniques, and so on shared by the members of a given community¼employed as models... for the solution of the

remaining puzzles of normal science"(Kuhn, 1997), the conception of paradigm is regarded as a general perspective for planning problem-solving methods. The first significant paradigm shift of designing information happened in the 1980s, extending from the system-oriented to a user-centered focus (Dervin & Nilan, 1986). Using the traditional perspective of the system-oriented paradigm, researchers focused on developing input and output methods of IR by evaluating the performance of information systems (e.g., speed, accuracy, and bandwidth), to ensure that essential information can be retrieved effectively and efficiently. With the ensuing user-centered paradigm, researchers sought to improve user experience and user satisfaction while users interact with information; they extended their considerations to noninstrumental factors such as emotional and other subjective experiential indicators (Hassenzahl & Tractinsky, 2006), e.g., satisfaction, pleasure, and trustworthiness. Meanwhile, some new paradigms propose an ecological framework that connects people, information, behaviors, technology, and context (Fidel, 2012; Marchionini, 2008; Nardi & O'Day, 2000). Nevertheless, at present, as Tang, Mehra, Du and Zhao (2019) commented: "they still tend to be centered on information seeking¼ and remain questionable whether the transition to an ecological perspective of human information interaction has successfully taken place". Pushed by the two main emerging technological trends of mobile computing and powerful artificial intelligence (AI) respectively, richer input and output methods of information interaction can be designed based on natural language processing (NLP) and computer vision (CV) on various mobile modalities. However, without concrete definitions of experience and guidelines for technological development, past paradigms gradually lost track of their goals and became vague to designers, and the developments potentially devolved from aiding human needs to satisfying human desires (Bardzell & Bardzell, 2015). We also argue that little work has actually addressed the need or development of a philosophical basis that would be capable of generating a reasoned, coherent, and adaptable way forward while maintaining human responsibilities and human interests at the

Table 4.3. The key points of the proposed agendas for information interaction development considered from the theoretical, principled, and practical aspects.

Theoretical aspect	Principled aspect	Practical aspect
(1) Expand the range of models representing human interactions with information (2) Establish priorities for new design paradigms (3) Define human engagement taking multiple perspectives into account (4) Identify the pros and cons, gains and losses relating to technology and how these come about (5) Identify levels of meaningfulness of information to humans	(6) Facilitate inner human capacities beyond conventional cognitive, behavioral, and performance factors (7) Establish a consciously dynamic approach to intra- and interdisciplinary values and ethics (8) Anticipate social and educational effects beyond the dedicated instrumental intentions of technologies	(9) Extend our understanding of conventional information interaction tasks (10)Reposition concrete technical properties and human factors in the HEC context (11)Develop qualitative and quantitative HEC evaluation metrics (12)Develop applications to optimize existing designs and realize new manifestations to serve inner human capacities

center of such developments (Ren et al., 2019). A general goal and an inclusive philosophical outlook are needed for future agendas and developments.

4.3.3 Twelve Agendas

Addressing potential media information issues such as rumors, fake news, trolling, and addictions from the HEC perspective, we seek a path that understands, activates, engages, and progressively enhances inner human capacities through the development of engaging computing technologies and interactions, rather than developing a specific technical solution for tool use only. Toward this goal and based on the theory of HEC, we propose 12 agendas according to three aspects: the theoretical, principled, and practical aspects (Table 4.3).

4.3.3.1 Theoretical Aspect

The theoretical aspect is proposed based on HEC theory in terms of definitions and components (Ren et al., 2019), and it focuses on how to extend the understanding of both humans and information, clarifying related keywords, and considers a new conceptual interaction framework in the information interaction context. Basically, following the HEC perspective, we ask researchers to reconsider the HCI design paradigm by moving from what we now experience to what we can progressively improve. With this in mind, we seek to create more holistically integrated interface conceptions that exploit micro- and macro views while defining and applying key factors, such as human engagement, and then considering how conventional human and information models could be extended and pertinence progressively sustained while our technological and social backgrounds are quickly changing. A conceptual framework is needed to discuss possible information interaction issues at the level and pace of the human mind. The following questions need to be answered:

(1) How do we complement or extend the current HCI paradigm regarding human and information models respectively, e.g., by clarifying a hierarchical-level table of keywords? And/or, how do existing conceptual frameworks promote the evolution of human-oriented HCI? Or, what limitations of existing frameworks need to be addressed, modified, or displaced?
(2) From the HEC perspective, how are we to order the priorities of new design concerns and potentials?
(3) After considering views from the fields of humanities, psychology, and pragmatism, how are we to define the state of "the engaged mind" or "the engaged human"? How are we to define “human engagement” with regard to human behaviors and human mind states?
(4) Why and how can conventional designs address the crisis of digital content, e.g., “trust deficits”? Considering conventional approaches to design, can we better identify the positive potential and negative effects of technical factors and then find balance or trade-offs between the positive and the negative and find an elevated “middle way”?
(5) How can we identify, evaluate, and classify the worthiness of information to humans? What distinguishes different genres of information?

4.3.3.2 Principled Aspect

The principled aspect is proposed based on the HEC theory in terms of principles (Ren et al., 2019), which calls for the articulation of human capacities and ethical/values that assist designers to be conscious of the need to positively engage end-users as intelligent and responsible factors. As an essential human requirement, the expression of the achieved human capacities while accessing and

interacting with available information should be a suggestive and promising design path toward future technological development. Meanwhile, we must be careful to critically evaluate the technical factors that would be applied or developed because we have already experienced and evidenced the effects of rumors, trolling, and addictions and how they were formed and channeled through conventional instruments and practices. To achieve synergized interactions and to avoid the diminishment of human values, HEC requires researchers and practitioners to be conscious of such principles whether they apply specific insights in further designs or not, i.e., to make widely informed decisions regarding inclusions and omissions in design and innovation.

The following preliminary statement regarding design principles can be extended by researchers and practitioners in the future:

(6) Develop and extrapolate on considerations regarding how to improve and exploit inner human capacities beyond conventional cognitive, behavioral, and performance factors when designing information interactions.
(7) Establish a consciously dynamic approach to intra- and interdisciplinary goals, values, and ethics. On the one hand, accept the potential that designs and innovations may produce very negative effects (antibiosis) (Ren et al., 2019) beyond the specific tasks and purposes for which a device or system may be designed, e.g., effects on the realized and potential mental capabilities of developing children; disregard for and/or diminishment of respective human values and value systems; the degeneration of mental capacities such as thinking skills, reason, and unquantifiable comprehensive conditioning qualities like empathy and compassion, as well as contravening or ignoring of rights. On the other hand, users are required to grow and be willing to realize their own capacities with the assistance of facilitating augmentations and technological factors. HEC assumes that humans want to be empowered rather than disenfranchised by their tools.
(8) The design aspects of information interfaces and interactions have peripheral and collateral social and educational effects beyond their dedicated instrumental intentions. These collateral effects progressively shape the way users interact with information and with life itself. Interaction designs should be aligned with respective human values to produce maximum benefits in real human contexts and over the long term rather than merely focusing on the speed and volume of data traffic in the short term.

4.3.3.3 Practical Aspect

The practical aspect considers “Engaging Computers” as the corollary to fully engaged human participants, i.e., the consideration and development of computers that are specifically designed to sustain and enhance innate human capacities is a particular component of HEC theory and is essential to the goals of the HEC framework (Ren et al., 2019). This aspect is concerned with how to rethink tasks, evaluation methods, and future applications in information interaction design according to HEC principles and priorities. It also seeks to extract, create, and present practical guidelines and to design engaging technologies that incorporate, exploit, and facilitate human capacities. We are particularly interested in the following questions:

(9) How can we extend our understanding of conventional information interaction tasks, e.g., searching, retrieving, or posting, and how can we establish and facilitate the real significance or purpose of the humans behind such tasks?
(10) How can we reposition concrete technical properties and human factors in engaging information interaction design?

(11)How can we develop qualitative and quantitative metrics for engaging information interaction to evaluate long-term effects on humans and, thus, to generate practical guidelines regarding the potential positive or the negative factors?
(12)How can we develop concrete applications or methods to optimize existing designs, e.g., current social media? Can we achieve new information applications or manifestations for promising directions serving inner human capacities, e.g., human mindfulness?

4.3.4 Raising Awareness

We proposed 12 research agendas from three aspects in order to help designers rethink the design of information interactions for future development. The fundamental HEC design principles are concerned with how humans can sustain and improve their innate capacities while interacting with information and technologies and, conversely, how design guidelines can avoid diminishing innate human skills and capacities. The improvement of human skills and capacities is not only in regard to external or physical performance but also in regard to the development of inner capacities and responsibilities. This approach may help render humans immune to diminishment through their use of powerful technologies.

In sum, the critical problem that gives rise to the above agendas and discussion is how to develop suitable evaluation criteria for HCI researchers and practitioners to respond to the rapid development of the world and to align our work with human values and survival.

Alan Kay shared his insights into "human universals", which are functions that all humans or civilizations can evolve naturally, (e.g., language, stories, and basic tools) and also the "non-universals", which are progressive inventions that we are less genetically predisposed to, e.g., writing, progress, and model-based science (Merchant, 2017). As evaluative criteria for the advancement of designs, a tool should facilitate the adoption of human "non-universals". Kay gave the example of the superiority of the telegram over the telephone saying that the telephone still keeps the human universal of spoken language but the telegram facilitates the "non-universal" art of writing. This view does not ignore the importance of a new tool or interaction, but it focuses more on what could have been better with a new perspective. For example, Dynabook, a key idea of Alan Kay, influenced by Douglas Engelbart (1962) and Papert (2020) and conceived 50 years ago, aimed at teaching children to be "media guerrillas" when identifying information. It was designed as a media platform to practice "learning by doing", but not merely as another new computer (Kay, 2011). According to the HEC perspective, we regard inner human capacities like personal discernment and critical judgment to be fundamental to human maturity and to be developed based on the above perspective of Augmenting Human Intelligence (Engelbart, 1962). We believe that the next promising evaluation criteria would value "holistic human engagement" across micro and macro levels.

Toward further HEC practices or case studies of "Engaging Computers", information interaction has more potential to develop inner human capacities than other interactions due to its global presence. However, as information, techniques, and interactions were too closely integrated and too rapidly developed to reveal clear borders among them, it also posed a great challenge for designer groups to learn understand and distinguish meaningful contents from the flood of ambiguous and misleading information. Despite this, faced with both emerging opportunities and inevitable challenges, researchers and practitioners should still remember their increasing ethical and educational

responsibilities to humans while reconsidering and designing new and better information interactions.

Researchers should contribute to the development of human “information immunity” through technologies as an essential step toward realizing more fully Synergized Interaction. One important challenge would be to facilitate this kind of consensus without compromising respective values and traditions. We expect the research community of HCI and IR will be able to conceive and develop more engaging manifestations of these agendas in different and more wholesome directions, e.g., information media, telemedicine, tele-education, service design, and visualization, and thus help build more highly synergized and coherent relationships among governments, communities, individuals, and enterprises to prepare for future challenges without diminishing the integrity and sacredness of private, personal, and cultural values.

4.3.5 Conclusion

Under the umbrella of the HEC framework, we wish to raise awareness of the potential to develop Synergized Interaction between humans and information in order to improve innate human capacities, specifically, the ability to discern authentic and reliable information, to address information interaction issues with respect to human well-being (e.g., immunity to online rumors and so on). We therefore presented 12 research agendas from the theoretical, principled, and practical aspects. The theoretical aspect mainly focuses on how to engage and extend the understanding of humans and how to form a conceptual interaction framework for developing a trustworthy information interaction context. The principled aspect calls for more attention to human capacities and ethical issues while designing interactions. The practical aspect lists open questions about how to rethink tasks and evaluation methods, in addition to presenting future directions for information interaction. We encourage researchers and practitioners to deeply consider how techniques and methodologies in the information interaction context can help humans improve their minds while solving problems in the real world. This adaptable approach will facilitate the understanding and implementation of ensuing paradigm shifts in the field of HCI and IR by offering a fuller evaluation of human potentials and HEC-based applications.

4.4 Summary

This chapter primarily describes the work we have done in previous research case studies on GUI Computational Aesthetics and Information Interactions, as well as the reflections conducted within the framework of HEC. In general, HCI involves specific topics related to some form of Human Factor that must be seen in the context of its position in "realizing the wholeness of human capacities," transcending conventional commercial logic in understanding humans, and contemplating the significance of HCI research for addressing genuine human issues.

Chapter 5: Envision of Engaging Computers

This chapter introduces three general design principles and a preliminary prototype - MIRROR - intended for the design of Engaging Computers. These general design principles outline a pathway towards Activating Human Awareness, Engaging Human Initiative, and Realizing Human Enlightenment, which hold the potential for application within Engaging Computers. We examine the significance of Engaging Computers in maintaining a balance against Antibiosis in the real world.

Computers are projections and metaphors of human consciousness as understood by their designers on computing devices. As the next generation of computational forms, placing Xin at the core of Engaging Computers serves as the fundamental metaphor, projecting interrelations among three human meta-capabilities to foster a deeper understanding of one's essential nature and thereby avoid Antibiosis. This approach diverges from relying solely on the psychological cognitive metaphorical "toolbox" of desktop interfaces. This distinction is why we refer to this prototype as "MIRROR."

Our aspiration is for Engaging Computers to serve as a medium to help individuals realize the wholeness of their capacities. We expect users could gain a sense of fulfillment in their use even without a theoretical understanding.

5.1 General Principles: Xin in the Context of Computing Systems

In this section, we aim to understand and explore the potential architecture for designing Engaging Computers. Since Xin serves as a fundamental non-dual context, how do we develop Xin-oriented designs by utilizing HCI as an environment to empower technology end-users to achieve Xin and be compatible with current computing systems (essentially discussing the relationship and formalization issues between Xin, Biophysics, and Intellect within the Human Capacity Framework)? As general design principles, the Engaging Computers projected inwardly from Xin's perspective should involve three stages in realizing human capacities: Activating Human Awareness, Engaging Human Initiative, and Realizing Human Enlightenment.

5.1.1 Activating Human Awareness: Interpreting Interactions in Three Meta-Capacity Perspectives

Although some past interaction concepts or designs have aimed to stimulate users' awareness of their actions or situational information (Krippendorff, 2005; Sengers et al., 2005), their tendency towards critical reflection is different from the reflexivity emphasized by HEC, which involves understanding Xin and existence. The purpose of Activating Awareness towards Xin is beyond the empirical tasks of users. According to the philosopher Heidegger, when individuals encounter conflict, difficulty, or any form of unnaturalness in tool usage, they transition from a natural "ready-to-hand" state to a reflective "present-at-hand" state, reflecting on both the tool and themselves.

To fundamentally address the Antibiosis issue, we need to establish a transcendent interpretation from the perspective of Xin, beyond the natural experiences (Biophysics) and meanings (Intellect) traditionally endowed by HCI. This aims to awaken individuals to their own capacities during tool

use. This approach seeks to restore a holistic understanding of human wholeness, as outlined in the three meta-capacity perspectives within the Human Capacity Framework.

These three interpretations can be described as follows:

Xin: Interaction as the Metaphor of Human Original Position - Striving to restore individuals' understanding of the world and their own existence in a state of "ought to be[50]," free from subjective distortions, while intervening in detached environments and stereotypes.

Intellect: Interaction as Constructive Modeling - Aimed at symbolizing, formalizing, or presenting an optimal workflow within computational environments.

Biophysics: Interaction as Natural Affordance - Emphasizing aligning human external physiological factors with the basic usage requirements of computational resources to meet instrumental usability and experience.

Further explanations are provided below:

(1) Interpretation of Xin: In general, whether it's the external form design of computers, the logical architecture design of OS-level interfaces, or the interactive behaviors in specific input-output processes, there should be formalized spaces left for various levels of human meta-capacities. Especially concerning system-level interactions, attention to the problems being solved should not only focus on understanding specific functions. Although this context is often unconsciously overlooked, every issue occurs at the level of Xin, which is rooted in human life and essence.

    The interpretation and design related to Xin often go against intuition because individuals have developed a certain inertia in polarized and alienating environments, believing that "reality" is often "normal." These questions about human nature are situated within the realms of philosophical discourse. While they may not be easily proven by science, they form the foundation for specific tasks. Although much of HCI research discusses human behavior and corresponding design from the perspective of cognitive psychology, as it does not delve into the essence of humanity, it is challenging to say that it truly creates internal happiness for humans beyond functionality.

    Or rather, the happiness we mention in current research or visions often relies on rational or knowledge-based "happiness" rather than originating from a fundamental awareness of Xin. This is the fundamental issue confronted by current technologies. The question then becomes: How can individuals return to a primal state before being pulled by emotions and thoughts after various experiences?

    The philosopher of technology Bernard Stiegler shares the view that technology is a significant transcendent event that externalizes human memory and accumulates experiences. However, we also see that the continuous construction of technology does not inherit the insights and understanding gained from exploring Xin or Human Nature. Traditional technology primarily inherits knowledge to reshape the world rather than the wisdom of exploring Xin or Human

[50] Similar to but not limited the phenomenological principle of "back to the things themselves."

Nature, which may lead to the misuse of knowledge and concepts, disregard for returning to human nature, and consequently, a discrepancy between intention and outcome. In other words, when technology lacks this context of human nature, the tool merely conveys a logical phenomenon and surface experience without inheriting true understanding and essential experience.

Exploring design based on human Xin inevitably involves fundamental concepts of human existence, such as being and non-being, speed and slowness. The foundation of design cannot detach itself from this fundamental dialectic of being and non-being, yet in past designs, this is often treated as a default. Non-being is not nothingness, and being is not about total occupation. Eastern philosophies of "emptiness," "Tao," and even Western philosophical contemplations on "existence" provide similar clues. Therefore, from a holistic perspective of human capacities, when we attempt to envision the future, considering any tangible technological form is not primary. Instead, it is the question of consciousness for designers about where humans (or other living beings) are ultimately headed as users or audiences of any technology. Similarly, concerning speed and slowness involves conflicting evaluations of "fast" since the industrial era and the understanding of "slow" in Eastern philosophies, literary studies, and beyond (Odom et al., 2022). The various inertial understandings we witness in technological development today are just one fragment when placed against the entirety of human experience. It is crucial not to form a bias due to short-term interests and simply deny other values.

We believe that although fundamentally all HCI or computing devices ultimately manifest in formal reality, this reality merely reflects a mirror of designers' awareness of human Xin, Intellect, and Biophysics specific activities. The designers' consciousness is transmitted to their users through interaction, further limiting users' perception and understanding of the root of problems. However, is it feasible to design based on Xin or Human Nature in such an abstract manner? Firstly, from the perspective of HCI, the future forms of computing are not fixated on specific hardware, software, or others, because regardless of the method, the constructed manner of reality is actually a duality of designers' consciousness. Even with the powerful generative AI we see today, showcasing rational deduction in language and emotive induction in visual representation, it seems there is still room for improvement in exploring human nature issues.

Moreover, what is the relationship between powerful technology and humans? When society's initial reaction to advanced technology still stems from anxiety about whether it will replace humans, it can also be said that since the industrial revolution, technology has not enhanced human understanding of its nature. Second, the specific manifestations of Xin still need the knowledge structures brought by Intellect and the sensory experiences of Biophysics to build upon, but we must realize that the purpose of these external representations and methods is to guide human nature rather than overpowering human consciousness in one aspect.

Therefore, in terms of embodying Xin, HEC advocates that Engaging Computers should help individuals generate awareness leading to human nature and wisdom, fundamentally shaping and changing human thought and existence through the enhancement of "soft skills" (such as mindfulness, empathy, aesthetics, etc.). From this perspective, we believe that both phenomenology's advocacy for intuitive perception of the essence of things and HCI's understanding of the nature of user "experience," "sensory" ergonomics, interactive art, or affordance, are not only about functionality or entertainment, but should strive to restore the

completeness that has been obscured from humans, thereby serving as the foundation for connecting human nature and specific procedural frameworks.

Furthermore, Engaging Computers in the expression of human Xin also lies in providing an "ought to be" explanation for the deconstruction of everyday human concepts and the reconstruction of true experiences, aiming to restore the distorted conceptual forms that have been twisted through long-term alienation and polarization. For example, the design of clocks and calendars helps us confirm time, while the design of electronic maps helps us understand our position. However, human experiences of time and space are fundamentally not symbolic systems but rather "Now, Here, Me." The ways in which past and future are represented are not entirely graspable through, for example, some form of visualization. They are means, not ends. Based on this spatiotemporal foundation, many interactions in "Augmented Reality," while providing a certain predictability or showcasing relationships and positions to "me," actually unconsciously convey illusions contradictory to the real world to users. While the understanding constructed by Intellect regarding visualization, to-do applications, comparisons, classifications, quantifications, and evaluations is not inherently problematic, it often transmits unconscious inertia (such as believing time can be grasped, when in reality, the only time humans experience is the present), prompting users towards discrimination.

(2) Interpretation of Intellect: We can see that the current understanding of humans by computing devices and applications mainly stems from the rational construction at the Intellect level. Broadly speaking, computing, information technology, and automation are manifestations of typical rational spirit - precision, logic, stability. The strong reasoning and knowledge domain possessed by current AI represent the culmination of the so-called Intellect meta-capacity. On a micro level, discussions such as the functions and forms a piece of electronic equipment should have, the shopping logic of e-commerce, dialogue processes between humans, or between humans and AI, the design and social extensions of music applications, all follow this capacity. However, whether it's how corresponding concepts are reinterpreted and constructed, or if specific users have such needs, these discussions often occur within the realm of rational thinking while lacking the foundation of Xin or Human Nature, and even further, they become an "ideology" that restricts users' understanding of a certain process.

In Chapter 2, we discussed the work of Engelbart, Alan Kay, and their colleagues in the realm of Augmenting Human Intellect, which can be considered a significant breakthrough in HCI history. In contrast to the traditional ergonomic designs centered around human behavior at the time, they recognized the importance of humans further harnessing their intrinsic rational capabilities. This led to the definition and invention of a series of new computational and application forms, marking a paradigm shift in the historical development of computers. However, we also emphasize that especially during Kay and his colleagues' phase, their theoretical foundation stemmed from an understanding of human cognition and learning abilities, which were then projected onto Desktop Metaphor (specifically expressed as GUIs). Yet, the incomplete revelation of human capacities led to an overuse of rational construction in the industry, where, in meeting or creating needs, computers also became tools of power to shape user thoughts, trapping individuals in an egocentric mindset.

For many modern individuals today, many concepts and ideas constructed by computing have become part of their language system, where the information architecture and navigation logic projected by an application correspond to a part of their thought structure. From this

perspective, the technological dominance over human ideas and even value judgments is subtle, profound, and worthy of deep consideration. From a problem-solving standpoint, lacking a consideration of the wholeness of human capacities, rational construction often remains confined to empirical phenomena and cannot address human problems within a nested series of concepts.

The construction of concepts, functions, and meanings under the Intellect category for Engaging Computers needs to be based on discussions of Xin or Human Nature. In short, the expression of any concept at the Xin level should possess a certain rationality and fundamental value, reflecting rationality's self-discipline as a tool and avoiding conflicts between the meaning systems generated by concept construction and humans. In terms of specific design, we provide the following three points for readers to consider:

First, the necessity and baseline of the Intellect meta-capacity: Due to the varying perceptions and utilization of their own capabilities by individuals, as one of the most "universal" and "effective" abilities of humans, we ultimately need to use rational methods for concept construction to solve problems and thereby stimulate and enhance users' capabilities and integrity. However, these concepts should not only reflect the process of construction but also the process of deconstruction, thus embodying limited value and intrinsic meaning, rather than, for example, trapping users in a construction centered around "needs," thereby conveying a singular value core based on consumerism. This understanding may contradict traditional business logic. For instance, the traditional evaluation criterion for "engagement" hopes that users stay on an app for as long as possible, but the inherent Xin of users will perceive whether respect for humans is present in the method.

Second, system naming in harmony with human consciousness: Whether at a macro level with broad external material or at a micro level with each element constituting an HCI interface, they may all be metaphors manifested underpinning by a small number of inherent concepts or principles. With the continuous consciousness of human Xin, the rational functions and concepts exhibited by computing systems should inherit from human intuitive perception, for example: precise "naming" to activate users' thinking in order to reflect and define functions:

- Suspension: As a phenomenological concept, it means temporarily suspending any intuitions and preconceived notions about the world, refraining from making any subjective judgments and interpretations. This concept can be constructed or named in the creative process of information interaction or context management, enabling users to consciously handle potential biases or viewpoints in their information.
- Being: Establishing a certain lifecycle for system functionalities, making people aware that their existence is not about infinite usage as seen in traditional computers.
- Perspective: Refers to a particular attitude or way a person thinks about something. We view each user as a unique perspective (replacing the concept of a "main screen" or "window"), where interactions between the system, others, and rules essentially involve collisions of various perspectives (user's own, designers, others, disciplines), while traditional interfaces lack further meaning within the human context.

Through this consciousness, we also hope to deconstruct and merge a set of inherently similar concepts, thereby reducing the fragmentation of human integrity by rationality.

Third, enhancing the Intellect of users: HEC is particularly dedicated to enhancing human whole capacities, with Intellect being the one of most important aspect here. Enhancing a person's Intellect begins with increasing their awareness of rationality, followed by the transmission of specific methods and conceptual understanding. The reason for advocating the significance of HCI in enhancing the Intellect of users is that we realize that most people, including ourselves, may not initially understand the modern world, environment, society, material aspects, and the construction of self with a consciously modern knowledge system. This is partly due to a widespread disconnect between education and the demands of the times and applications, and partly because humans have not been sufficiently mobilized by the extensive knowledge repositories and information network. What Engaging Computers can do is, in combination with the second point, reflect the framework of the human constructive system in the basic information architecture at the OS-level, e.g., simply, reflecting a kind of taxonomy theory in the layout of applications.

(3) Interpretation of Biophysics: The traditional interaction between computers and humans is based on the study of basic human factors in HCI. This is manifested, for example, in matching human motion control systems, incorporating perceptual patterns into relevant interaction designs, and in narrow natural HCI. Evaluation primarily focuses on productivity, usability, bandwidth, efficiency, speed, accuracy, and user-friendliness in classic ways. Additionally, HCI has shaped new human behaviors or cognitions, such as the emergence of the mouse shaping human high-frequency clicking behavior, a behavior rarely seen in human life prior to this technology. The theoretical foundation for Biophysics of human behavior, cognition, and emotions largely comes from cybernetics, ergonomics, and cognitive psychology. However, in traditional HCI, other human capacities are often lacking as context (even though "embodied interaction" emphasizes "body-mind unity"), and purely physical attributes are often understood as part of the input-output tools for information, with humans and computers frequently being compared unconsciously. Efficiency as a natural but unconscious consequence.

From the perspective of Engaging Computers, comparing humans to computers often marks the beginning of designers' alienation, which is then further transmitted to users. The problem lies not only in comparative evaluation metrics but also in methodological comparisons. From a rational perspective, in computer algorithms, classification and reward-punishment inherit basic methods people use to deal with everyday things. However, when this concept is applied to the design of computer systems, it is continuously amplified, to the point where it becomes the dominant inertia in how users perceive things during interactions. Users unconsciously view these as mere "methods," and many such methods end up fragmenting human integrity, stimulating a sense of separation, and hindering people from realizing their true nature. In short, methods applicable to machines and understanding nature may not necessarily apply to humans. Likewise, when cognitive psychology emphasizes the similarity between human information processing and computer processes, this is a parallel relationship and just an occasional intersection - we need to pause and question this assumption.

Regarding the relationship between humans and media/technology, Marshall McLuhan once stated that "the medium is the message," including extensions of human senses like vision and hearing, and more complex extensions such as the human nervous system, which can alter human thought processes. However, this argument primarily revolves around Biophysics or Intellect aspects of humans. It can be said that the way media functions enhances (or diminishes) human sensory perceptions and even knowledge concepts at a technical level, but

ultimately this is an outward transcendence. If technological enhancements continue infinitely, humans may end up merely consuming technology, facing a significant risk of alienation and polarization.

Engaging Computers, concerning on fundamental interactions with Biophysics, should be understood as the first step towards enhancing human capacities and Activating Human Awareness. Based on this foundation, we can then discuss the significance of traditional metrics and help individuals surpass their capacities at various levels, embodying the essence of "Engagement." From this perspective, the concept of Engaging Computers should be compatible with current technologies. However, whether in conceptual construction or specific interaction design, it is essential to understand their significance within the context of human abilities and integrity. Overemphasis on secondary incentives (such as performance metrics) can disrupt the cooperative nature of tasks and the true meaning of designing computers/ applications, diminishing users' agency in task integration and self-awareness. This is also why some misunderstood concepts of "gamification" in the past have failed to be effective.

In summary, the development of computing technologies that correspond to realize the wholeness of human capacities, and even any interactive artifacts, is collectively referred to as Engaging Computers. Its mission is to Activating Human Awareness, Engaging Human Initiative, and Realizing Human Enlightenment to return to their perfect nature, and further self-realize in the external world. It is important to emphasize that the reason for making such a classification not only reflects the progressive understanding, experience, and practice of individuals in understanding people but also hints at clues to the entire field of HCI's understanding of people. Furthermore, for human capacity development, the reason why we consider HCI as playing a milestone role is not only because it combines multiple understandings from philosophy and science, humanities and technology in its domain attributes, but also because user interfaces are egalitarian and universal, providing everyone with the opportunity to enhance themselves from the concepts and experiences conveyed by their devices/interfaces and return to integrity.

Through the explanation above, we can understand that possibly all interaction concepts carry the significance of the three human meta-capacities (including noting their negative impacts, with Biophysics bringing polarization and Intellect bringing risks of alienation; Xin's negative aspect lies in its difficulty to be formalized because it is easily misunderstood) and derive corresponding design spaces to activate users' potential awareness of these interaction concepts.

Let's provide two simple examples.

The first example is understanding the significance of GUI aesthetics from the perspective of the three human meta-capacities. In a typical HCI context, the aesthetic design of GUIs not only provides users with a pleasant experience but also influences their overall usability (including satisfaction and credibility) (Lindgaard et al., 2011). In current HCI, research on aesthetics mainly focuses on the Biophysics and Intellect aspects of humans. From the Biophysics perspective, aesthetics can be theoretically explained visually, including aspects such as cognitive processing fluency (Processing Fluency Theory) or attention allocation (Attention Distribution) to optimize interface layout, assess, or enhance the visual appeal of GUIs through automated algorithms. From the Intellect perspective, GUI aesthetics can also be discussed in terms of the personal significance of colors, interpretive aesthetic symbols, or concise structural designs.

However, regardless of Eastern or Western ideologies, as a supreme value judgment, the potential essence of aesthetics lies in its ability to evoke internal appreciation and insights beyond language. Yet, this aspect remains largely unexplored in the HCI field (Haimes, 2021). From the Xin perspective, aesthetics should not only serve as a means to enhance utilitarian user experiences but should also be the design/task goal itself, aiming for a "perfect experience" (Dewey, 2008). Under a similar understanding, the integration of somaesthetics, poetics, and HCI offers a Western philosophical standpoint to capture the essence of aesthetics. The incorporation of Xin or the underlying Eastern thoughts are expected to help HCI further recognize the aesthetic commonality behind these different formalizations, with the anchor of aesthetics lying in the complete manifestation of Xin, serving as an entry point to help users become aware of their Xin and establish a connection between human Xin and the essence of aesthetic objects. Even in certain Buddhist classics (such as the "Avatamsaka Sutra"), there are metaphors (e.g., "the six paths are pure lands") suggesting that as individual consciousness unfolds, their perceptions will gradually change, and true beauty will manifest in all aspects of reality (related to some anthropological theories, indicating that individuals' perceptions of beauty, purity, and impurity are largely constructed by the culture they are in).

In Eastern thoughts, the consciousness of Xin-oriented aesthetics is closely linked to the experience of being present in the moment. This concept can be further elucidated through the second example, which involves understanding time from the Xin perspective (briefly mentioned in the preceding section). Humans exist within the dimension of time, and as a universal characteristic of computational systems, the expression of time demands surpassing traditional methods. From the Biophysics perspective, individuals organize their daily lives based on natural rhythms such as sunrise and sunset. In the context of computational systems, this can be simulated by incorporating features like light/dark modes to adapt to human eyes, schedules, and other physiological elements. From the Intellect perspective, time in computational systems is primarily represented through various digital clocks (which can also be traced back to modern concepts of time awareness and the invention of modern clocks), providing measurements in symbolic formats. However, from the Xin perspective, time can only be perceived by humans as a composition of the past, present, and future (Heidegger, 2010; Stiegler, 1998; Tolle, 2004), with the present being the true realm of freedom where humans can actively experience and control, receiving increasing attention in phenomenological studies. From a practical standpoint, consciously immersing oneself in the present moment may lead to a deeper understanding of life than traditional time planning methods.

In HCI, there may still be a need to explore formalized explanations of "time" in terms of Xin. When humans fully engage with their lives, they may discover the presence of beauty at any moment. Similarly, all interaction concepts should be reinterpreted from the perspective of Xin. Interpreting Xin in relation to traditional concepts not only helps users become aware of pathways and capabilities of Xin but also interrelates with each other, finding the spiritual unity of Xin through formal diversity.

Explanations derived from the perspectives of the three meta-capacities essentially provide a scope for understanding how interaction concepts can be interpreted. Especially concepts like Xin, the Kabbalah in Judaism, as well as existential notions of the "unspeakable wisdom" found in Camus' "The Myth of Sisyphus" and other beliefs (Wittgenstein, 2023), it is important to note that attempting to define them through any form of codified language is inherently flawed and needs to be understood beyond the realms of Biophysics and Intellect. To grasp their essence, an alternative space beyond the constraints of language and away from doctrinal constraints is required,

transcending shallow and short-term needs. Building upon this premise, HCI aims to create a context that Engages Human Initiative by finding explanations for the three meta-capacities of a concept, thereby constructing a comprehensive, Xin-oriented, and progressively unified experiential practice. This is a form of wisdom rather than mere knowledge.

5.1.2 Engaging Human Initiative: Unifying Interpretations towards the Practice of Xin

Although the three interpretations in the first stage provide a scope of understanding and a design space for interactive concepts, Eastern thoughts emphasizes that only through personal initiative can one truly understand and realize Xin beyond its intellectualized form. Therefore, it is important to recognize that traditional HCI tasks are not the only design goals, as every experience is viewed as a practice of Xin. In this process, designers also have the opportunity to discover the true essence behind the nominal "names" of interactive concepts by observing users' practical experiences.

In this second stage, we suggest that designers unify the three interpretations oriented towards Xin, seek appropriate interpretations of Xin within the design spaces of Biophysics and Intellect, and understand how these differ from traditional interpretations to establish a maximum degree of rationality. This unify aims to coordinate and balance the innate knowledge of Xin, the intellectual constructs, and the corresponding behaviors of Biophysics, a process we term "The Unity of Innate Knowing and Actions (知行合一)". It is important to note that "knowing" refers to the innate knowing of Xin rather than the knowledge of Intellect, and "actions" can be seen as a unified expression of Intellect and Biophysics, such as the generation of thoughts at the Intellect level also being a form of action.

When the three meta-capacities are integrated, they will create a complete engagement that transcends the domains of Intellect (e.g., active thinking) and Biophysics (e.g., physical participation, emotional response). By collectively enhancing these three meta-capacities in the interactive process, a deep Synergized Interaction characterized by proactive freedom can be gradually achieved.

We provide two discussion cases accordingly.

(1) The first example is the meditation app "Pause" (Cheng et al., 2016; Niksirat et al., 2019; Salehzadeh Niksirat et al., 2017). In daily life, meditation is well known for its ability to enhance attention, reduce stress, and improve emotions. However, as a means of exploring Xin, it holds a significant place in Eastern thoughts (Karunamuni & Weerasekera, 2019). In recent years, mindfulness-based mobile applications (MBMAs) have become increasingly popular, but traditional designs rely solely on text or music-based guidance methods, only capturing the form of meditation rather than allowing users to have a deeper understanding of its essence.

    In response, "Pause" integrates the concept of "Tai Chi" - an Eastern traditional method related to Xin, thus establishing a connection with the essence of mindfulness. "Pause" summarizes the "Attention Regulation Framework" in terms of Intellect, serving as a workflow to cultivate mindfulness (Salehzadeh Niksirat et al., 2017). In terms of Biophysics, "Pause" incorporates the gentle rhythm and texture of Tai Chi, combining visual animations, auditory elements, and tactile finger movements to immerse users in the metaphor of mindfulness, bringing them into

the present moment. A series of empirical studies have validated the effectiveness of "Pause," showing significant improvements in participants' psychological states (Salehzadeh Niksirat et al., 2017). In another study, the interactive design of "Pause," integrating multimodal elements (visual, auditory, and tactile), demonstrated more effective results in triggering user initiative and experience compared to other single-channel competitors (Hussien Ahmed et al., 2017).

From a deeper Eastern theoretical perspective, one direction that interactive design may consider summarizing is to help users "detach thoughts," and the case of "Pause" may serve as a demonstration in this direction. Compared to traditional multimodal interactions providing multidimensional input-output of information, this case seeks to explore the sensory context behind multimodality rather than the technology itself. One possibility is that as long as users become aware of "detaching thoughts," a part of Xin will naturally manifest.

(2) Another negative example can be observed in everyday mainstream information interaction. Information overload resulting from information explosion in the virtual world has brought burdens such as cognitive overload to users, yet the fundamental causes of this issue remain largely unaddressed. On one hand, traditional information interactions still primarily focus on pushing information, addressing usability and experience issues from a basic Biophysics perspective, such as error rates in voice interactions, text input bandwidth, or entertainment factors. On the other hand, from an Intellect perspective, representative information structures like "short videos," "timelines," and "news feeds" are widely prevalent in social media and news platforms. However, they are gradually shaping fragmented reading habits among users, leading to distraction and anxiety (Laumer et al., 2013).

Although platforms like Facebook prioritize "meaningful social interactions" to combat this situation, these measures have not successfully deterred the amplification of extreme viewpoints and sensational information according to current traffic evaluation standards (Aldous et al., 2019; Grothau, 2019; Paul & Milmo, 2021). From a Xin perspective, these issues are not surprising and can be seen as a continuous polarization and alienation of modernity, reshaping specific human behaviors such as reading or socializing. The danger lies in the fact that, on one hand, individuals lack conscious ability under external interventions, and on the other hand, media, under modern evaluation methods (such as "traffic"), increasingly fail to uphold the pursuit of "truth" as an intrinsic moral law. Yet, for humanity as a whole, "truth" still stems from the natural inclination of Xin, leading to a conflict when faced with external misinformation, ranging from individual psychological issues to societal conflicts.

This traditional state of information interaction reflects a neglect of the unified three meta-capacities of users, naturally forming a continuously distorted information environment and propagation of false news. Therefore, from an HEC perspective, enhancing human capacities when facing information is still essential to build an ideal scenario, whether gradually becoming aware of Xin in information interaction or improving users' information literacy, both are crucial at present.

In conclusion, at the stage of Engaging Human Initiative, we believe that traditional task objectives are not the sole factors to be considered, but rather the crucial aspect is whether users can develop a stronger sense of agency towards Xin. From a more specific practical Xin perspective, how soft skills like mindfulness, empathy, aesthetics, love, etc., can be expressed in interactive tasks is important. By engaging with an increasing number of concepts in daily interactions, users are likely

to continuously refine their subtle understanding of Xin in an intuitive way beyond language. To serve the unification of these three interpretations, new forms of software and hardware interactions are expected to emerge, integrating and expressing the core design principles of different applications and technologies in a highly unified manner as the foundational framework of a future operating system.

5.1.3 Realizing Human Enlightenment: Towards the Non-dual Nature and Consistency of Xin

After undergoing preliminary explanations and experiential practices involving various interaction concepts, we anticipate that individuals can realize a comprehensive awareness in various interactive experiences in life, known as "Enlightenment." Historically and factually, this is a state that is challenging for most people to attain and is difficult to articulate in language. Hence, at this stage, we aim to construct the foundation of Engaging Computers through the most crucial points associated with "Enlightenment," which is Xin transcending the non-dual nature of various external phenomena - individuals realizing this undifferentiated nature within themselves and returning to the perfection that does not seek external validation, becoming the starting point for all goodness. To embody this non-dual nature at the foundational level, it is necessary to revisit the most fundamental question, which is the relationship between the current operating system or Engaging Computers and the specific application tasks (i.e., the underlying real-world issues). We propose two aspects for analysis, namely (1) the vertical aspect (the relationship between systems and applications) and (2) the horizontal aspect (consistency among different applications), to discuss how Engaging Computers built on Xin can help individuals move towards the possibility of enlightenment.

(1) The vertical aspect aims to discuss the relationship between systems and applications, which can extend to the entire human context and various tools, methods, interactions, artifacts (even beliefs, laws, etc.), or the relationship between humans/Xin and their Biophysics and Intellect. According to Eastern thoughts, the role of applications or tools is to serve as a "convenience" for conveying Xin feelings or intentions, but they should not become dependencies of Xin. Otherwise, it initiates what we refer to as alienation. However, in reality, humans often overly focus on the tools themselves, delving into endless attributes of the tools and forming corresponding unconscious judgments to create a trap of "division," gradually obscuring Xin's non-dual perfect nature and becoming attached to various phenomena. Therefore, unlike the first two constructive stages seeking appropriate explanations and implementations, at this stage, any specific tool may ultimately need to be deconstructed, "forgotten," and returned to its non-dual state within the entire system.

    Based on this contemplation, we reexamine the interaction concept of "Burn After Reading" from the perspective of Xin. "Burn After Reading" was an early core feature of the social media platform Snapchat, where messages disappear and cannot be retrieved after being read. Our intention is not solely focused on the privacy or security aspects of this design but to introduce a new perspective to understand the information flow process reflected by this design, from the unified state of the system to the "division" between the system and application caused by the emergence of a new task or message, ultimately returning to wholeness. This process also reflects the essence of Xin in dealing with specific external objects. When a new task becomes the attachment of human attention, philosophically speaking, this design is detaching Xin from

this task. The reason for this is that when a system creates a tool or task, it inherently carries biases or stereotypes behind its "ideology," triggering individuals' discriminatory minds and obscuring their Xin. By emphasizing the philosophical significance behind "Burn After Reading," we can extend the act of "attaching" and "detaching" tools as a non-dual metaphor for the relationship between operating systems and standalone applications or between users and their computing systems, helping users form a fundamental understanding of the external world.

(2) The horizontal aspect aims to discuss the relationships among various applications or tasks, to see how we can establish a high consistent design framework rather than perpetuating past inertia. Its goal is to utilize the fundamental qualities and specific capabilities derived from Xin as the design foundation of computational systems, while addressing the various challenges brought by Intellect and Biophysics. Furthermore, based on the relationship between the virtual world and the real world mentioned earlier, it aims to help individuals form an understanding and distinction of things beyond the "reality," thereby preventing polarization and alienation as much as possible.

Building on this reflection, we take "gamification" as a counterexample. Gamification was initially introduced to enhance user engagement, completing tasks within a play context, typically based on elements like points, badges, and leaderboards (PBL). Today, this "Intellect"-based design pattern has been widely applied in various contexts, including serious games and membership or rating systems in different applications. While gamification can provide users with a sense of participation, it often amplifies unexpected competition, ultimately reflecting a pervasive occurrence of "stratification" and "division," distancing from the essence of the "fun" intended by gamification. Therefore, it is necessary to explore a Xin-oriented consistency framework to serve as a reference for the foundational design of different applications.

For instance, when implementing gamification or other quantification or categorization methods, their foundation should be rooted in fostering empathy and helping individuals break free from meaningless competition, i.e., how the capabilities of Xin/human soft skills can play a role in it. Practices such as mindfulness and aesthetics could serve as fundamental principles in Xin-oriented approaches to application design, rather than merely superficial embellishments of applications. These principles have the potential to form the basis of future user interface guidelines, preceding the construction of specific user interface elements.

In conclusion, a deep understanding of human nature from both Western and Eastern perspectives, guided by Xin, aims at Activating Human Awareness, Engaging Human Initiative, and Realizing Human Enlightenment. It is also the foundational contemplation for achieving Engaging Computers and HEC. It provides a viewpoint that connects human progress and innovation, facilitating a reconsideration of the significance of basic interaction design in the broader human context, challenging traditional understandings of task expression forms.

5.2 The Motivation of Engaging Computers

In this section, we delve into the design of Engaging Computers. Firstly, it's important to note that in Human-Engaged Computing, the term "Computing" refers to a technological design thought that highly values human capacity enhancement and engagement, while "Engaging Computers" represents the technical manifestation of this thought. The term "computer" is merely a placeholder,

encompassing considerations for software-hardware interaction interfaces, underlying AI algorithms, engineering architectures, and even inspiring the design of other artifacts such as markets, buildings, and institutions.

Ideally, the design goal of Engaging Computers is to achieve a highly Synergized Interaction with the whole capacities of humans - "Biophysics-Intellect-Xin," exploring external projections corresponding to various levels of human capacities, oriented towards Activating Human Awareness, Engaging Human Initiative, and Realizing Human Enlightening. Natural evaluation metrics include, but are not limited to, considerations of high efficiency, relevance, sustainability, beneficial outcomes, and profound impacts.

Practically, the proposition of Engaging Computers also addresses societal issues and corresponding visions:

(1) Human capabilities have not been comprehensively enhanced but are gradually deviating, leading humans to not fully embody the essence of modernity. Therefore, through the Synergized Interaction of Engaging Computers, we aim to widely enhance human capacities.

(2) Limitations of human capacities have resulted in widespread Antibiosis, including but not limited to technological addiction and misuse at the micro level, as well as unsustainable development and geopolitical conflicts at the macro level. Hence, it is crucial to consider the fundamental causes of Antibiosis in systemic design.

These motivations determine that the practice of Engaging Computers is not simply an experimentalism focused on a particular concept or a "small and beautiful" app, but rather a contemplation aimed at addressing systemic issues and exploring alternative possibilities from the outset.

5.2.1 On the Relationship between “Virtual” and “Reality”

Although the virtual world has brought many fantasies and experiences to humanity, ultimately it still follows a set of meta-logic, especially in terms of human behavior and thinking, that extends from the real world (such as illusions of time). Just as an integral part of science fiction lies in the ever-changing, behavioral, and multifaceted human nature showcased in a new setting. If we aim to seek solutions for various Antibioses in this world, we must be acutely aware of how human Biophysics and Intellect lead to Antibioses, what the relationship between the virtual world and the real world should entail, on what basis the rationality of the virtual world and the real world is established, and how this world progresses.

Looking at the historical logic of the world from a Western perspective, under a worldview of "Theory of Evil Human Nature," the real world needs to be grounded in the legitimacy and values of "democracy" and "liberalism," where individuals and institutions should strive to form a set of universal or local constraint relationships to achieve a relative balance. This foundation is also where events like the Industrial Revolution occurred. If the ability to reach this equilibrium is lacking, then when it comes to personal interests - despite humanity's ongoing efforts - it inevitably leads back to a form of a state of nature, such as what has been seen in international relations and geopolitical conflicts over time. The construction of these rights and concepts primarily occurs in

human beings' passive experiences rather than being actively internalized in their meta-logic, leading to historical amnesia, the exclusion of wisdom, and the perpetuation of tragedies.

HEC, as The Thought System, naturally hopes that everyone can connect in a Xin manner to overcome Antibiosis, achieving a deeply integrated Synergized Interaction. However, considering two facts: 1. Antibioses arising from polarization caused by Biophysics and alienation caused by Intellect are constantly occurring (ranging from internal conflicts to power dynamics between individuals and technologies to full-fledged wars aimed at destroying physical existence), yet achieving Engaging Computers and Engaged Humans in one step is not feasible, thus the most ideal Synergized Interaction cannot be immediately reached. Human and technological advancement is a gradual process. 2. The essence of Xin is unspeakable, yet practical construction solutions are still necessary. Therefore, the implementation of HEC as a computing system requires both top-down blueprint planning and bottom-up problem-solving, acknowledging the holistic human experiences of both the East and the West.

The legitimacy of the virtual world has traditionally been built upon the logical extension of the real world and as an extension of human Intellect, which, due to the highly developed nature of Intellect, often obscures the human essence of Xin, leading to the distortion and magnification of external human behaviors, resulting in various Antibiosis. Although we see instances today such as social media balancing governmental discourse, fundamentally this balance is fragile and one-sided. To address or alleviate this fundamental issue, the legitimacy of the virtual world should be based on human nature rooted in Xin to balance the inertia of the real world. Similarly, to achieve Xin, Engaged Humans, Synergized Interaction, and Engaging Computers, the design should follow a logic where, throughout the process of meeting human needs, a relative balance is struck with individual Biophysics and Intellect, rather than stimulating uncontrollable desires in people. The potential for balance is endless in conceptual realms, unlike in the realm of violence. When each individual has an emotional connection at the Biophysics and Intellect levels and a conceptual construction, it is possible to strike a balance with the widely existing Antibiosis within larger contexts (e.g., society, humanity), finding a middle ground between morality and immorality (Niebuhr, 2013) and addressing the balance issues between System and Lifeworld (Habermas, 1985b), promoting progress in the modern era at its core. This is the societal significance of the virtual world constructed by computing systems and Engaging Computers.

We believe that the objective reasons for this potential achievement are as follows: 1. In a highly information-based world, humans interact extensively with various forms of computers on a daily basis. Behind these widespread interactions lies a substantial amount of subconscious shaping or reinforcing of individuals' ways of perceiving the world or inertia. However, this also implies opportunities for improvement and correction. HCI, as a process of meaning construction, is essentially a system of meaning. Human knowledge takes time to learn, but basic concepts and viewpoints can be conveyed through daily interactions, enabling individuals to inherit history to some extent rather than always starting from scratch. 2. We have witnessed the formation of a weary society. The complexity of contemporary society has led to a high degree of fragmentation in human time and behavior. Technological efficiency and experience are showing a trend of diminishing marginal effects, on both functional and life levels, which cannot be considered inevitable. However, these issues have not been truly addressed or understood in terms of what they truly desire.

Therefore, Engaging Computers are, first and foremost, an environment for humans. Some say "you are what you eat," others say "you are what you read," and today everyone spends a significant amount of time interacting with computers, which can be summarized as "you are what you experience." With the support of computers, the enhancement of human capacities and the "way" of HEC are no longer just the one-on-one education of the Confucian era. The enhancement is indeed achievable. Moreover, looking at the history of computers, the pioneers in various computer fields have all, in the name of technology, essentially been educators, envisioning the construction of an ideal world.

In conclusion, by discussing the necessary equilibrium between the virtual world and the real world, the interplay between humans and computers on a technological level, and the potential theoretical feasibility of Engaging Computers, although our focus has mainly been on thought experiments, we must understand that Engaging Computers fundamentally transcend being a mere technology. Engaging Computers are a formal expression of The Thought System. Moving forward, we will gradually explore the specific discussions regarding its form.

5.2.2 The Current Paradigm to Antibiosis

In Chapter 2, we briefly outlined the various influences that Alan Kay received during his design of the Dynabook concept in early Personal Computing, including Engelbart's ideas on enhancing human intelligence through computing, Piaget's cognitive theory, Bruner's educational theory, and Papert's LOGO practice. We also considered how Sutherland's pen-based interaction and even Kay's own biological background for understanding cellular communication (which may have inspired object-oriented programming) impacted his thought process.

However, we can see that the desktop metaphor architecture is quite utilitarian:
(1) Its understanding of humans largely remains at the cognitive psychology stage.
(2) The form of human-computer interfaces originates from an abstraction of office desks.

Combining these two points, we can interpret this as the "axis" of contemporary interaction paradigms. Regardless of how subsequent technologies evolve and extend, they basically inherit such a way of understanding, including the AI operation systems that are currently being proposed. Essentially, these systems continue to think within this framework, replacing traditional applications with AI. This also means that technology itself lacks deeper philosophical thought and does not possess other abilities beyond the task itself, remaining at the stages of Biophysics (basic I/O) and Intellect (application process construction), facing a "nature-evil" humanity and facts. In such a situation, technology becomes a double-edged sword that is inevitable.

Certainly, it's not just about computers; different media undoubtedly have their own advantages and disadvantages as well as corresponding effects on humans. However, we believe that whatever the influence may result in, they are all double-edged swords because people primarily focus on two aspects: technical engineering structures and demand structures. The former considers usability and stability, while the latter concerns effectiveness. In commercial environments, this usually suffices. Yet, it fails to consider that technology itself is a part of shaping humanity, for its own technological form not only shapes human behavior but also influences human language and thought processes. Ultimately, it conceals Xin.

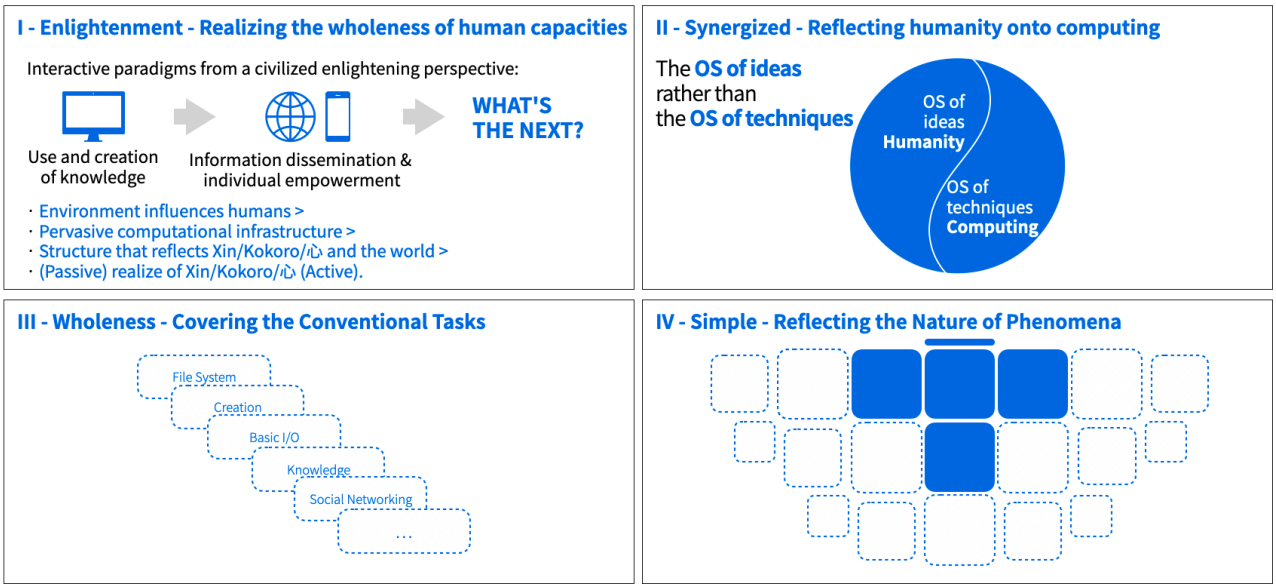

Figure 5.1. The design objectives of MIRROR

5.3 MIRROR: A Conceptual OS-level Interface Architecture

As a possible case of Engaging Computers, we proposed the conceptual prototype of MIRROR as an OS-level interface architecture. The overall design of MIRROR is not simply the introduction of a particular concept. Rather, it is a projection of the Human Capacity Framework on a macro scale. In terms of specific design, each element is built upon the commonalities behind similar conclusions drawn from various fields (such as philosophy, Buddhism, psychoanalysis, economics, communication studies, and more) and reflections on their potential conflicts. MIRROR itself represents the underlying structure of consensus regarding humanity at the Intellect level, as well as the natural tendencies users exhibit at the Biophysics level when interacting with artifacts. Together, these two aspects metaphorically reveal the essence of Xin (which cannot be described in language), allowing Xin to emerge from everyday implications.

5.3.1 Design Objective

We have always thought of Engaging Computers as the next generation of computing systems, so from a certain perspective, this is not just an interactive idea but rather an integrated system of thoughts on how to make existing UI systems compatible and implement HEC. In this line of thinking, there are at least four design objectives that serve as primary considerations (see Figure 5.1).

(1) Enlightenment - Realizing the wholeness of human capacities
We take HEC's mission - Realizing the wholeness of human capacities as the core of our system of thought. This is also a historical contribution to enlightenment through computing systems, whether as personal computers for knowledge libraries or in assisting information dissemination via the internet. Of course, on this basis, we must also consider what "enlightenment" corresponds to in the next form of computer systems - that is, how computing systems can become mediators that enable people to be aware of their comprehensive capabilities encompassing Biophysics-Intellect-Xin, and in daily interactions with various computers, transform from passive development to active awareness.

(2) Synergized - Reflecting humanity onto computing
From the design philosophies of various operating systems, user interfaces, and applications, we can see that on one hand they inherit Engelbart's thought framework while on the other hand, there is a mechanistic undercurrent. Within this context, we cannot help but pose a question such as what relationship do elements like Window, Icon, Menu, Pointer have to humanity? Does such a component exist within human beings? These naming conventions appear to come from a "repetition" of tasks on the surface, while at a deeper level, they represent the contradictions and unconsciousness between non-duality and duality in human relationships with the world. Therefore, in order to rebuild this connection, we need to further reflect humanity within technology - from one perspective, it is a form of Synergized Interaction.

(3) Wholeness - Covering the Conventional Tasks
Considering real-world requirements, compatibility with previous computing systems, and ensuring the effectiveness of Engaging Computers, we need to cover as many tasks currently displayed by computer systems as possible, including but not limited to file systems, creative tools, basic interactions, knowledge formats, social networks, and specific applications. This will involve rethinking their presentation in MIRROR.

(4) Simple - Reflecting the Nature of Phenomena
We need to cover basic tasks and applications beyond that, but phenomena are infinite and endless when we rethink computer system forms from an HEC perspective, we must also consider what core essence these shared phenomena have, otherwise it would be difficult to achieve our goal of Realizing the wholeness of human capacities, leading to chaos in the end. The core essence of shared phenomena has constructed a significant part of the basic structure of Engaging Computers. Therefore, this not only requires us to project our thoughts on humanity - Human Capacity Framework as a fundamental nature within the design of Engaging Computers, but also to understand how to find an organizational form that can simultaneously project the essence of external things.

5.3.2 Why an OS-Level Interface Architecture is Needed?

First, let's clarify that we are referring to the direct interaction and impact on user experience of Interface Architecture, rather than changes to the underlying system. Using Xin as a metaphor to construct Engaging Computers, we have three possibilities: hardware, operating system software, and application software. We will think of the Xin metaphor at the level of the operating system, comparing it with two aspects of advantage: 1. The formative ability of hardware is relatively fixed, which can serve as support for different scenarios, but its various forms make it difficult to project onto a complete Thought System, which is also an important reason why universal computing has not been widely applied in reality; the logic is too dispersed. 2. Although software applications are relatively flexible, their handling of business logic often deals with specific things, with a relatively narrow perspective on one side and inconvenient for expressing the high consistency of meta-logic emanating from Xin. The operating system, as the support for various applications, can provide bottom-up design guidelines and APIs to standardize the fundamental logic behind different applications and systematically describe current world phenomena. Based on this basis, we adopt the operating system as the metaphorical implementation foundation and derive corresponding software applications and hardware forms.

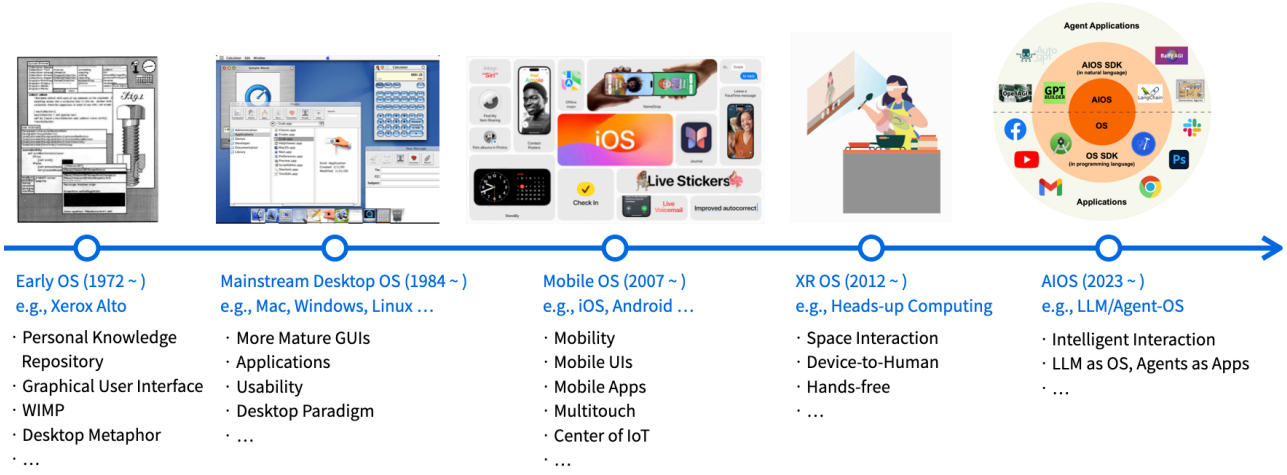

Figure 5.2. The OS-level interface architecture based on Engelbart's vision

However, we must emphasize that the operating system under consideration by Engaging Computers is not driven by traditional technical modules such as process management and driver programs, but rather by top-level design of human-computer interfaces (of course, current operating systems are also like this, for example, the file concept is based on a modular system of files, processes, memory, etc.). We need to connect the traditional WIMP interface idea with people's connections, seeking deeper meanings. Moreover, facing the increasingly mature middleware and underlying technologies, we must think from Xin's perspective about their new significance; at the

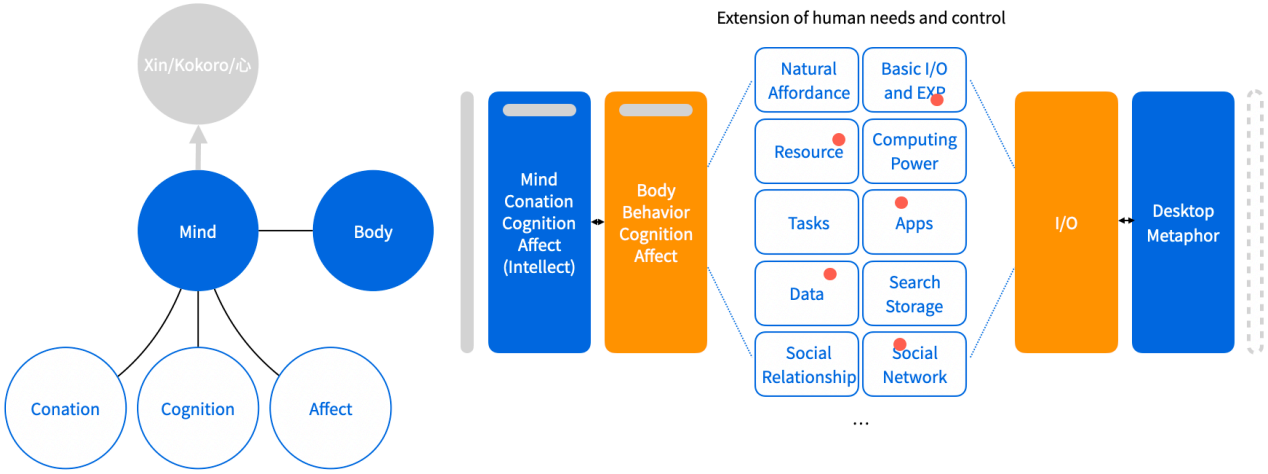

Figure 5.3. Conventional Interface Architecture

same time, we also need to recreate wheels, such as AI and search engines that can naturally become the bottom-up support of Engaging Computers, considering greater compatibility with different devices for universal applicability. Engaging Computers may be realized on the internet, becoming a new type of internet operating system.

We can see from the comparison with Conventional Interface Architecture how people have developed corresponding interfaces in past development and what MIRROR's design idea tends towards.

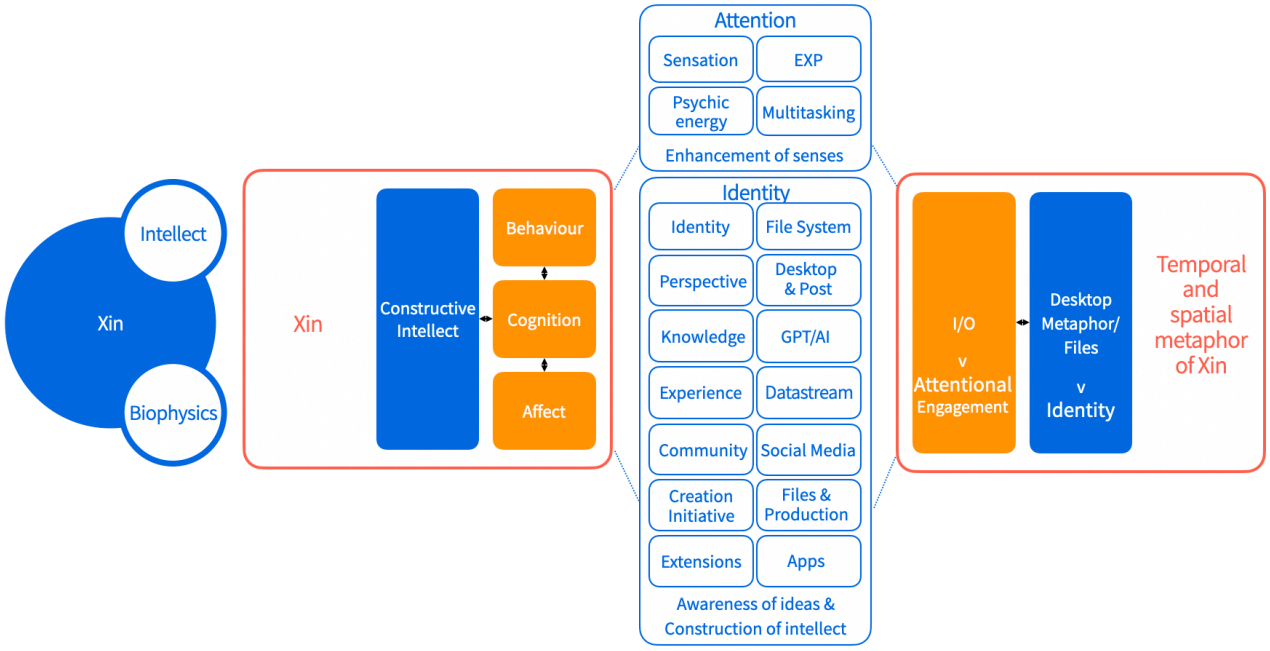

Figure 5.4. Interface Architecture of MIRROR

We first conducted a restoration of the design thought of Conventional Interface Architecture. We repeatedly mentioned in previous texts that based on the historical development of operating systems: whether it was Early OS on Xerox Alto or the current Mainstream Desktop OS (Windows, macOS), Mobile OS (iOS, Android), XR OS (Zhao et al., 2023), or AIOS (Ge et al., 2023), these are all within the Engalbart framework (see Figure 5.2). Regardless of usability level or Augmenting Human Intellect level, based on the scientific framework of mind-body dualism and "behavior-cognition-emotion," they have not actually realized a complete human (see Figure 5.3).

In contrast, when we introduce the Human Capacity Framework and the entire HEC idea, our understanding of Interface Architecture at the OS-level is completely transformed. We consider all human understandings as components of computers (see Figure 5.4).

5.3.3 Key Ideas of MIRROR

(1) The Meaning of “MIRROR”

MIRROR has a unique connotation, whether it's the Eastern thought of "the Xin as a clear mirror" or "to treat people as mirrors," or Jacques-Marie-Émile Lacan's proposed "Mirror Stage" (Miller, 1998). In reality, they all express that only when there is a recognition of oneself can one truly become aware of the outside real world. Therefore, our MIRROR refers to the mutual reflection between humans and operating systems. Relative to traditional computing systems, which merely present an understanding of tasks, we believe that only by revealing what a person is and making the individual first recognize themselves can one promote the enlightenment of human abilities and completeness as much as possible.

Figure 5.5. The meaning of MIRROR

We hope to convey to users the idea: the operations, browsing, consumption, etc., and the resulting emotions, experiences, etc., which are actually not "you." Your infinity cannot be confined by the current windows and tasks (see Figure 5.5).

The MIRROR logo displays our understanding of human overall ability - Biophysics-Intellect-Xin. The circle represents a complete Xin, the hexagon represents crystalline intelligence, and the triangle represents the three biophysical components (behavior, cognition, and emotions). "Biophysics-Intellect-Xin" share the same axis, as the state for humans to become aware of their complete abilities and maintain balance.

Furthermore, in our presentation of key ideas, where normal writing of words represents general statements, and capital-letter-starting-off ideas are treated as special usages. To seek a uniform expression, these special usages do not distinguish singular and plural forms (although they tend towards plural more often in context).

(2) Spatial Metaphor of Xin/心

Transcending the relationship between desktops and applications, we metaphorically consider the entire Interface space as a final Context within Xin/心 (see Figure 5.6).

1) From Desktop Metaphor to Xin/心

In terms of form, we borrow an idea from Buddhist thought to allegorize "beyond the duality of the Xin/心, one sees all five aggregates as empty" (心處二元之外，照見五蘊皆空/心の二元性を超えると、五蘊はすべて空であることが見える). Although our diagrams present a certain visual effect, what we intend to convey is a formless and impermanent space - akin to the Buddhist

Figure 5.6. Backing to the “original position” of Xin

concept of "emptiness," where some wave-like effects represent the inner rhythmic oscillations of humans.

2) The relationship between "the first step of interaction" and humans

When we initiate the first step of interaction, philosophically speaking, it also becomes a state of transition between "union" and "separation," "non-duality" and "duality." From an ontological perspective, man evolves from an abstract "emptiness" into a real-world "subject." The subject directly faces three fundamental relationships: the relationship with oneself, including Self-consciousness, Meaningfulness, Identity, Perspective; the relationship with the world, encompassing where human knowledge and experience come from and what they mean; and the relationship with others, comprising community and cooperation between individuals as well as the foundation of empathetic relationships. These three relationships form the underlying context for humans to tackle real-world problems and are also the core essential nature of our sought-after phenomenon-sharing.

(3) Self-relationship

It is important to note that in this context, we use "self" to refer to the individual person; however, what we actually mean is treating oneself (including each user) as "the subject" of understanding. This is the main interface of MIRROR and represents the first layer of relationship that humans handle with themselves.

1) Identity Recognition and File System

Linking Identity Recognition with the File System can be said to be the most important starting point for MIRROR or Engaging Computers, as it also represents how "humans" and "computers" establish a basic connection (see Figure 5.8). As a modern person, Identity Recognition can be

considered one of the most obvious shaping mechanisms for "what makes humans human," from both psychological and social perspectives, which we have explained in Chapter 3. When we return to the computer context that everyone may encounter daily, do we not discover what shapes us through interaction - "files"? All our tasks and queries are recorded and stored in some form of file; if given the opportunity to understand a stranger, their unencrypted phone, computer, cloud storage, browsing history can easily lead to a basic judgment about who this person is. In short, in today's information age, a person uses their files, but these files (systems) have actually been shaped by that individual in reverse; although we encrypt our devices to prevent others from viewing them, these files have already completed a synchronization at the level of intellect and cannot be concealed from oneself; even if forgotten, they become important material for internal thought and external communication, thereby becoming part of one's identity recognition.

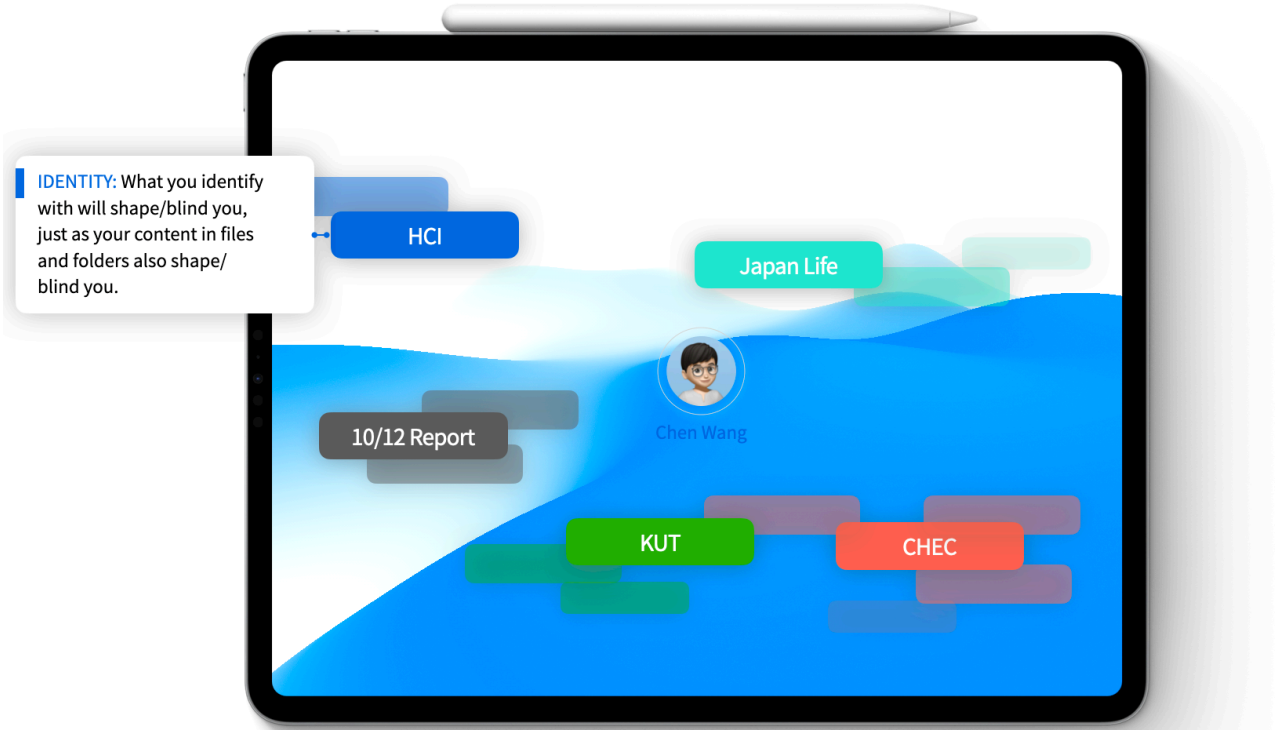

Figure 5.8. Identity Recognition and File System

However, the same increasing evidence from reality tells us that this attachment to identity recognition has further led to alienation and ultimately become a source of pain. From the perspective of Buddhism, these problems have already been recognized; this is also an important inspiration drawn from the wisdom "Should no attachment be made and yet let the Xin/心 arise" - Let go of all forms of identity recognition (which essentially requires recognizing the essence of intellect); only then can one see through to the location of the Xin/心, transcending humanity's limitations.

Connecting a person's Identity Recognition with the computer's File System is the first step towards Engaging Computers, mapping humanity onto computational systems. It is also how we treat it as the basic unit for expressing Intellect. Through seeking appropriate visualization methods, we express the relationship between Intellect and Xin/心 in this way.

2) From Window to Perspective = Identity + Context

Starting from Identity as the basic unit of Intellect, we hope to become more aware of its additional features - how Identity is formed and what it means for multiple Identities to gather. Throughout the entire HEC discourse, we have consistently emphasized the importance of context; that is to say, a concept may indeed be important, but if its context is not understood, we are largely prone to taking things out of context. Therefore, when examining Identity, we must be aware of the context behind it, and as the basic unit of Intellect, this context is composed of various low-level Identities - some existing in human consciousness that are constantly called upon by individuals, while others exist in the subconscious with a certain form of existence.

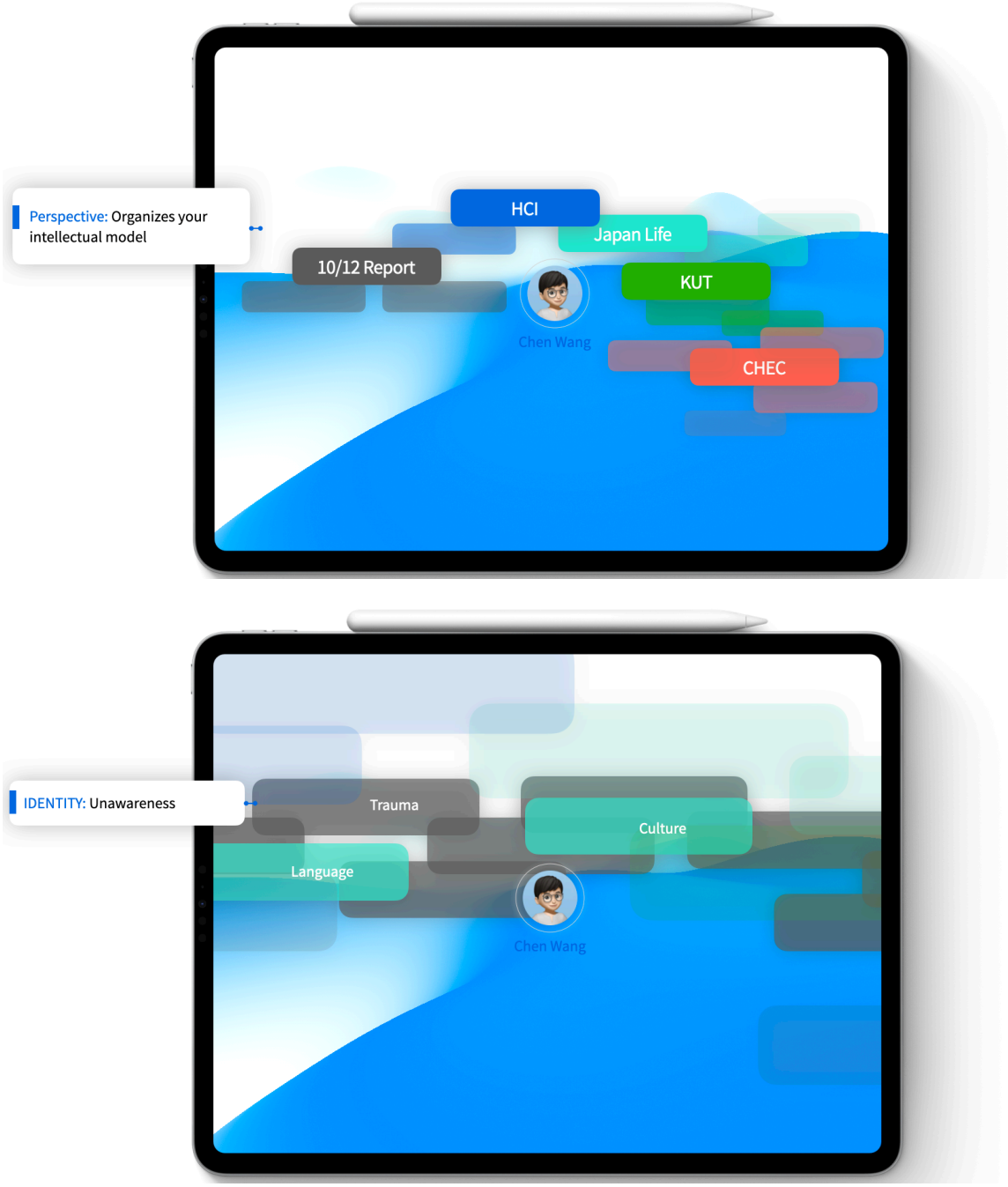

Figure 5.9. Perspective = Identity + Context

If Identity and Context (which essentially comprises a collection of low-level Identities) jointly construct an individual's Intellect, then this construction's external manifestation we call Perspective

- what an individual can express based on their various Identities and Contexts' interconnections; and as one accepts new Identities and accumulates Contexts, this Perspective will correspondingly change. Since the content we interact with is actually the projection of our own Identity onto computers, screens, and other devices, the entire content - which we may refer to as the screen - is in fact our Perspective itself.

When we reflect again on WIMP - especially the Window that people constantly face during interaction, we need to consider what kind of connection exists between humans and Windows - nothing particularly special; rather, it is more a matter of historical and conceptual habit. We need to re-examine all the naming conventions in computing systems and their corresponding real designs; they make users aware of themselves without any particular significance, which is also where the reasonability lies in our thinking about transitioning the screens we see from Windows to Perspectives.

3) The Balanced Formalization of Intellect and Biophysics

We have seriously reflected on the underlying implications of the UI design derived from WIMP, namely the overuse of symbols that has even weakened users' sensory abilities - a consequence of excessively emphasizing Intellect while neglecting Biophysics. This is evident in that without sufficient experiential experiences brought about by Biophysics, Intellect has essentially evolved into a superficially instrumental rationality that fails to delve deeply into understanding things and yet cannot lose interest in further developing the senses.

(4) World-Relationship

When we gesture to slide the interface to the left, we begin processing our relationship with the world and how we interact with the phenomena around us. Here, we refer to these phenomena as largely encompassing natural events or occurrences beyond direct interpersonal communication; analyzing and understanding them in a more observable way. What we wish to express or what people need to elevate is how mature tool rationality can become possible - how we can incorporate, for example, philosophical reflections on "justice" and "fairness" into our thinking about structures. This also foreshadows that the internal environment of HEC cannot be simply a free platform based on classical liberalism/libertarianism; rather, it must necessarily be constructed upon a more mature "Intellect."

1) Knowledge

To provide such a foundation, we need to categorize human interaction with external information. If Identity and Perspective establish our subjective viewpoint on external information, then knowledge is an objective consensus. We have various ways today of finding such a consensus, e.g., through ChatGPT and other LLMs or Wikipedia.

2) Experience

Those contents that cannot be called a consensus - from UGC (such as posts or comments) - we call Experience. Why do we need to make this distinction? First and foremost, it is to classify the chaotic information interaction, reducing conflicts or even online trolling caused by unclear classification. We also need such distinctions to see what constitutes phenomena and what are issues worth discussing; rather than conflating them.

(5) Other-Relationship

When we gesture to slide the interface to the right, we begin processing our relationship with others and how we interact with them.

1) ”Empathy" vs. Identity

Here, we ponder an important question: What enables people to connect? Is it the Intellect-based Identity that we increasingly see in today's reality society, or a form of "Empathy" rooted in Xin? We believe both cannot be ignored, but the "Empathy" based on Xin must necessarily be considered as a Context for contemplating the premise of human connection.

2) Community & Communication

This also raises the basic structure of people forming a community: there is some similarity from Identity or overlap in Perspectives between individuals that forms a foundation for collective meaning. In the non-formalized parts, we try to foster connections between Xin and Xin (e.g., through communication based on context to promote understanding) and reveal potential obstacles (e.g., implicit power relationships).

(6) Temporal Metaphor of Xin/心

After exploring the spatial metaphor of Xin/心, we use "Biophysics-Intellect-Xin" to investigate how time is represented in MIRROR.

1) Rethinking "Time" - The Rhythm of “Biophysics-Intellect-Xin”

Representing time from a Biophysics and Intellect perspective is not uncommon; for example, through biological clock forms (e.g., Dark Mode) or symbolic forms (e.g., Numerical Visualization). However, from the perspective of Xin, as the basic support for existence, people experience time only in terms of past, present, and future (Heidegger, 2010; Tolle, 2004).

2) "Time" of Xin/心 - Global Attention-Regulation Mechanism

We have built a time expression method based on our previous research into the Attention-Regulation Framework, globally applying it in the system to match changes in human attention and dynamically track people's Engagement states. For example, when users are working on writing tasks, if they enter a state of distraction, the focus of their writing will gradually concentrate on one or two characters, reducing the range of attention distribution, thus serving as people's time perception.

(7) Other Concerns

1) Engaging Initiative: Creation & Intellectual Model

Humans, in expressing themselves and creating value, primarily restore their unimpeded creative nature. Further, this creation, including thought itself, needs to continuously construct a system of thought to produce a deeper understanding. Providing basic recording methods (”sketch” and “text” as the fundamental basis of Biophysics and Intellect) and construction methods is one foundation of Engaging Computers.

2) Economics of Xin/心 - Psychic Energy vs. Multitasking

When an Engaging Computer system becomes a Synergized Interaction side, it needs to understand where people's real bottlenecks and scarce qualities lie in the task process - battery capacity? human ergonomics? error rate or click speed? Or various OKR/KPIs? As tasks and applications increasingly refine with each step, especially for modern humans, we believe these are not; rather, they are human psychic energy. In other words, it's about the relationship between Engagement and Distraction. How to help people restore or rationally distribute their psychic energy is what Engaging Computers as the next generation of design needs to consider in its "economy."

3) The Extension of Humans: Extensibility of Apps & Compatibility of Devices
Extensibility of Apps: By considering different human relationships with the outside world, we showcase the core architectural concept of MIRROR. Various potential application forms will match Extensions (from McLuhan's phrase "The Extension of Man" (McLuhan, 1994)) to different relations, such as music, which comes from the relationship between humans and the world. Important applications will be integrated into a systemic architecture for redesign, while temporarily non-integrated ones will run according to existing systems or application forms.

Compatibility of Devices: MIRROR's design is based on the possibility of Synergized Interaction in human-machine relationships and the thinking about the relationship between "Biophysics-Intellect-Xin" human abilities. This thought is projected as an OS-level interface architecture, so it will not be limited by specific hardware platforms, ensuring its compatibility with more computer devices, such as car infotainment systems, especially with future space computing support. MIRROR naturally embraces this environment.

The above represents a design approach to MIRROR - one possible implementation of Engaging Computers. Of course, there is still much work to do and time needed. However, we are generally optimistic. We will present the several thoughts consolidated during the conceptualization process as design guidelines for Engaging Computers. Because at present, most external things that people experience tend to be filled with confusing external demands rather than true needs related to "completeness" or "essence."

5.3.4 Implicated Guidelines

Above, we have provided a description of key concepts and architecture regarding Engaging Computers. This framework may not necessarily possess sole rationality, but in order to achieve Engaging Computers and Synergized Interaction, we will summarize these key ideas as potential design principles.

- By fundamentally metaphorizing the basic premise of interaction "time/space" from Xin's perspective, using the relationship between Biophysics-Intellect-Xin as the basic operational framework, we designed an OS-level interface architecture to enhance human capabilities; setting Intellect's basic unit as Identity, corresponding to a file system, and deducing concepts such as Perspective, Knowledge, Experience, Creation, and Community.

- There are two key aspects of understanding basic interaction: 1) controlling the use of symbols and language to recover the body's sensory structure (increasing the weight of sensation and decreasing the weight of vision); 2) treating attention as a metaphor for physical interaction,

applying an attention regression framework from a global perspective, achieving Engagement through time correspondence.

- The design of information architecture should not exceed three levels; in Eastern thought, "three" implies "infinite," meaning excessive complexity. If we cannot express our core ideas within the three-level information architecture, it may easily lead to "linguistic games."

- We introduce the concept of community, presenting potential collective perspectives and rights relationships based on the connection with humans and equality with others.

- Supporting spontaneous creation (representing humanity's original freedom) and constructing personal historical works (systematic Intellect).

- Introducing a Xin-based economic system: balancing multiple tasks, thinking about Psychic Energy distribution, waste, and recovery, exploring the system's presentation; introducing a Xin-based financial system: limiting resources and over-tasking to ensure human Psychic Energy restoration.

- Regarding the subject/user significance: through usage and suggestion, deepening observation and understanding of the Xin, revealing humans' basic ability relationships, restoring people's sensory apparatus for the real world, and achieving seamless integration with digital reality; establishing a framework for understanding external factors (deeply understanding Identity and systematizing it).

- Further applications are based on the meta-structural concepts mentioned above, reconsidering application design.

Additionally, we have provided some "not recommended" HEC-oriented design references for future computing systems as a foundation to avoid and reflect upon:

- Do not accumulate excessive storage and data; this will not connect with people's true needs or happiness, but rather add complexity and concealment.

- Avoid considering personalization in the basic framework; personalized demands actually increase Identity, which contradicts recognizing Xin's purpose, and the basic framework should be invisible and minimalist.

- Do not accumulate technology; it can cover 90% of people's daily functional use, and the system's focus on mapping human needs is not there.

- Avoid overemphasizing multitasking; Xin's Psychic Energy cannot handle that many tasks, making people increasingly distant from their Xin.

- Do not prioritize visual and tactile interaction systems; computing systems need to recover all sensory experiences of the present moment, such as sound meaning, which requires new systemic interactive ways.

In summary, after discovering the fundamental operating differences between artificial objects and humans, under the understanding of HEC, we may need to re-understand the basic elements or premises that compose technology. For example, virtual reality aims to create a virtual world to provide people with more sensory experiences, upgrading interaction from a traditional 2D surface to a 3D space; however, when we transfer the atmosphere we constructed into "experience" - humanity's most basic sensory ability, it may unintentionally prolong human problems of feeling time and space. "Is this upgraded experience really derived from what humans need from their Xin? And if people's perception of time and space is actually only in the present moment, then trying to downsize from 'face' to 'line' to 'dot' - what kind of experience will it give people?" Of course, upgrading or downsizing each has its significance; this fundamental thinking about design at the basic level may bring new design spaces and find paths towards Engaging Computers and Synergized Interaction.

5.4 Summary: Towards “The Computing System”

In the preceding discussion, we have repeatedly emphasized that the purpose of Synergized Interaction is to help individuals realize the wholeness of human capacities. Therefore, we hope that designers can first acknowledge the existence of the multi-dimensional human capacities of "Biophysics-Intellect-Xin" and then convey these through their designs to users. Users should seamlessly feel their own completeness while using the technology, prompting them to actively pursue enhancements across various levels of capacities and strive for further transcendence. When these capacities truly internalize within individuals, coupled with the assistance of powerful tools, there exists the potential for individuals to discover true freedom, purpose, alleviate alienation and polarization, and resolve conflicts between individuals and themselves, as well as between individuals and the world. Throughout this process, as technology serves as a medium for mutual feedback, the completeness of designers and users actually complements each other. Within this positive upward spiral, as a natural consequence of human mental advancement, a larger external cycle, encompassing micro-level technological design, meso-level societal issues and sustainable development, and macro-level human world destinies, holds promise of gradually finding the most suitable approaches. Understanding human issues first is also the ultimate goal of our contemplation on HCI or the broader development of technology.

The essence that sets computers apart from past machines lies in the birth of software, transitioning from specialized machines to general-purpose machines. This means that the soul of hardware lies in software, and software, in turn, stems from the projection of ideas and concepts. Over the past 50 years, software forms have predominantly relied on the desktop metaphor system. The desktop metaphor fundamentally aligns with the cognitive paradigm's understanding of the similarity in logic between human and computer information processing, symbolizing various real-world objects to achieve user-friendliness. However, this is not the only answer. From the desktop metaphor to experiences with other digital content, people might also realize that their habits and preferences actually shape themselves in reverse, influencing how they understand the world and the forms of technology. If the various current technological forms (such as Artificial Intelligence, Augmented Reality, Metaverse, etc.) and other macroscopic concepts represent an outward projection of human ideals for the future, then the foundation of Engaging Computers lies in an understanding and inward projection of Xin's structure and its relationship with Biophysics and Intellect. The everyday experiences of time, space, and various symbol expressions will require a new (yet possibly simple) way of interpretation. The fundamental contribution of Engaging Computers lies in creating a

computing environment that everyone can access, subtly assisting users in returning to the structure of human sensibilities, enhancing conceptual awareness, being consciously detached from external interventions, metaphorically creating a space for the mind, enabling a synergized development between the reality and virtual worlds. This is the contemplation of HEC on transcending the next stage of "computers" (and any interactive artifacts), the paradigm of technology, and is a key motivation behind our proposal of MIRROR and its critical ideas.

Through the culmination of this chapter, we want to reiterate the essence of HEC: this consideration of the completeness of individuals and Synergized Interaction is not about asserting Xin's decisive role in individuals or a metaphysical theory, but rather about, in the highly experiential realm of everyday life, stripping away all unconscious bodily behaviors, rational thinking, and intuitive perceptions to seek a possibility: can we realize the true state of existence and the transcendence of freedom beyond what is determined by biological inheritance, self, and social constructs? Can we assist individuals in moving from limitations towards limitlessness? Computing and other tools serve as the medium to tread this path, with the virtual world propelling the real world, not only on a personal level but also on a societal level, making the enhancement of individual and societal capacities a possibility.

Chapter 6: General Discussions and Implications

After interpreting many concepts such as HEC and those guided by Xin, besides serving as a contribution to the thoughts or theory of HCI, we are also contemplating whether this work can inspire more explanatory power and solutions for other fields. Especially when considering solutions to various issues in the current world with HEC's value direction of "realizing the wholeness of human capacities." In this chapter, we will extend discussions on "The Thought System" and "The Computing System," providing some interdisciplinary initial insights while also pondering the feasibility of Engaging Computers and the entire HEC as Useful Knowledge.

6.1 Expanding the Significance of “The Thought System” of HEC: From HCI to Interdisciplinary Fields

From the perspective of HCI, combined with Eastern and Western thoughts, we analyzed in the previous sections "Biophysics-Intellect-Xin" as a more comprehensive structure for understanding humans. However, we also hope to extrapolate this understanding of HEC to a more macroscopic level. If such a concept could be disseminated and accepted, could "Biophysics-Intellect-Xin" also serve as a potential prophecy of societal shifts?

Presently, we are familiar with various theories on the stages of human social development. Whether it's from Condorcet's "Sketch for a Historical Picture of the Progress of the Human Mind," the Marxist-derived theory of the five stages – "primitive society, slave society, feudal society, capitalist society, socialist society," or the technology-oriented perspectives like "agricultural revolution, industrial revolution, electrical revolution, information revolution," and even including the current AI revolution, all of these can essentially be viewed through the framework of HEC. It allows us to see the entirety of humanity transitioning from the natural economy of "Biophysics" into a stage of understanding supported by the knowledge economy of "Intellect" known as "Modernity," with a progressive historical perspective to look back and forward. However, we must also understand that this progressive view of history, including the formation basis of various ideologies in different fields today, implicitly assumes a sustainable logic of optimistic economic growth and technological progress.

Five hundred years in the modern world may seem short in the history of humanity, but its progress is exponential. Particularly today, this inertia has made modern individuals impatient to wait for the inherent cycles of economics and technology. We measure "economic growth and technological progress" in minutes and seconds, where without positive news, it equates to bad news – a scenario witnessed in many cases in financial markets. It is evident that when there are signs of stagnation in economics and technology, various internal conflicts among humans intensify. Therefore, when we aim to step out of this cycle, we must consider how the structure of human "Biophysics" perceptions and "Intellect" ideologies have been shaped – why do we believe humans can be quantified or that machine intelligence can make us better. There is a persistent lack of systematic discussion on this matter. For instance, in the recent AI arms race, when viewed through the values of HEC or Xin, as briefly mentioned earlier, AI actually raises the lower limit of creative freedom and will undoubtedly exhibit new forms of art. However, this is ultimately a form of passive

freedom; the substantial ability of AI to enable individuals to create art is questionable. Furthermore, we must ask, do those advocating the AI revolution truly care about art? Do they perceive this as art? What do these art forms signify? Is art and idealism limited to this extent? Does this level of art diminish our critical abilities, normalizing various abnormalities in the present? Including recent surveys that reveal AI's societal impact is not as extensive as expected, in other words, AI has not become a necessity in people's lives. Of course, there are many individual and societal factors at play, but a positive freedom that can integrate art requires the enhancement of completeness and capabilities in each individual.

We have emphasized multiple times that we are not opponents of technology or modernization systems. It is not possible to return to a life purpose centered around the idyllic pastoral existence of the "Noble Savage" as described by Rousseau (1985) just because we have these issues. However, it is a fact that people are increasingly controlled and replaced by various forms of modern concepts such as speed, phenomena, and technology, leading to alienation and polarization at various physical levels or even collapse. In a highly modernized society, it is difficult for humans to return to a state of wholeness. Or to be more precise, humans may have never truly returned to their complete state; the "Lost Innocence" at the Biophysics level of primordial nature is not a state of completeness.

If we wish to construct an ideal societal form or move towards an ideal, humans must consciously step out of the mindset where technology or modernization derived from "Intellect" serves as the purpose. They are necessary conditions for building an ideal society but not sufficient ones, and they are not issues of "humanity." To a certain extent, the breakthrough in finding new fundamental science and technology depends on certain systems and "luck." This fundamentally isn't something that the era represented by "Xin" needs to consider, but rather how to maximize human full capacities and engagement, and how to address the excessive difficulties created by human-made problems in this process, including the significant human internal physical and mental depletion occurring in individual and societal development processes.

Eastern Zen teaching emphasizes the "Three Ways To See Mountains And Rivers[51]" - seeing mountains as mountains, seeing mountains not as mountains, and finally seeing mountains as mountains again. This implies a shift in understanding. All phenomena, all structures can be further dissected and deconstructed, and after deconstruction, can continue to be opposed or deconstructed. This is an almost infinite problem and an ongoing process of validating the two core themes of Eastern and Western thoughts. For example, Buddhism's notion of "dependent origination (缘起性空)" states that all phenomena we perceive arise from interdependent causes and conditions, making it fundamentally difficult for humans to find a first causal force. On the other hand, in Western philosophy, from ontology and epistemology to later philosophy of language, the evolution of its thought history actually tells us that many issues are inexplicable and cannot be resolved at the Intellect level, especially unable to serve as a life anchor - it can provide an answer but cannot be the solution. However, we still need to find an appropriate method of understanding and establish a more explanatory model at the Intellect level, especially when we want to improve a possible future.

In this context, we still envision two possible futures:

[51] https://thedailyenlightenment.com/2020/06/three-ways-to-see-mountains-and-rivers/

(1) Moving forward along the current modernity and technological mindset. Although material wealth may continue to increase, many of the current societal issues will remain unsolvable without groundbreaking discoveries to support a new round of economic growth. Disparities between the rich and poor will widen, the pace of life will quicken, and people's lives will become more chaotic as Xin is increasingly obscured by a continuous blur, leading to a sense of self and identity becoming more confused, repressive, and aggressive. Incremental lawmaking and risk management will always be scrambling, and "the mental state of our era" will not easily improve with the passage of time and technological advancements (Geiselberger, 2017). This is not an exaggeration - Freud's and other philosophers' psychoanalytical views on the underlying causes of world wars reveals significant similarities (Freud, 2015; Marcuse, 1974). Today, however, we are entangled in a web of civilization rules woven by numerous "Intellect" elements, preventing us from instantly collapsing back to a pure "Biophysics" jungle society like a century ago. Yet, considering the fate of the existing 8 billion people and countless other organisms on Earth, human Xin remains obscured, bound to the relentless wheel of various ideologies dominated by "Intellect." The equilibrium processes under these ideological dominations (such as market economies) may seem rational, but the substantial losses within them constitute tangible human suffering, essentially Antibiosis itself. Maintaining these ideologies demands a significant amount of mental energy, transforming first-order natural difficulties into second-order surplus difficulties, natural repression into surplus repression, and natural consumption into surplus consumption. Consequently, fewer individuals possess the psychic energy to care about what constitutes value rationality and Xin. The issue lies in the fact that beyond the futures envisioned by technocratic and physicalistic ideologies, humanity remains uncertain about what the answer truly is.

(2) Technology has brought tremendous contributions to the world, but we shouldn't take this "reality" for granted, even if there might not be a better alternative at present. If we can accept an era of change pivoting around a combination of Biophysics-Intellect-Xin, with the value direction of enhancing human overall capabilities advocated by HEC, could we achieve HEC or Xin as a self-realization of The Thought System? This self-realization is certainly not immediate but requires continuous improvement in this direction. Of course, we do not wish for others to interpret this as a new ideology. Within this direction, some changes in focus areas may be necessary:

- For Psychology: It may be necessary to reexamine the causes and treatment of understanding "modern diseases" such as depression. From a psychoanalytic perspective, it is seen as an excess of repression. However, after people experience the activities of "Intellect" and various modern phenomena, it is challenging to return to a state of pure happiness in a Biophysics stage through medication or some initial cognitive behavioral therapies. This return requires understanding not only individual but also societal operational modes and eventually breaking through. Do we currently have the necessary conditions for this? We expect that psychology, in understanding the human dimension, can transcend traditional cognitive and medical frameworks to understand the transcendence of humans, providing pathways to address issues like depression and nihilism.

- For Economics: Mainstream economics acknowledges that the economic liberalism might be the least bad among many choices. Some argue that the liberalism is an initial stage of the economy, and issues like excessive waste should find systemic solutions. Guided by Xin, the focus needs to shift from a symbolic, capitalism's inherent logic of creating ineffective needs

towards discussing the prerequisites of a post-growth era. Ineffective needs leading to human alienation stem from endless outward projections, as individuals feel a "lack" within themselves and hence seek externally. This is the origin of bubbles, and consumerism has proven not to bring genuine happiness. However, a return to an "Original Position" may necessitate a change in the overall economic logic. For instance, in the HEC explanation of "deficits", predictions of outcomes may first consider the proportion of meta-capacity driving individuals and behaviors in that market - Biophysics, Intellect, and Xin - and then conclude with what kind of equilibrium. Regrettably, contemporary economics has largely shifted towards subjective utility theories, rarely mentioning terms like "morality" or "values," and lacking consensus theories on cooperative behaviors. Our aim is not to provide an unquestionable direction while disregarding ethical issues but to base all analyses on human capacities, allowing individuals to choose for themselves.

- For Anthropology: Beyond exploring human physiology and sociality, is there another possibility - transcendence? From explaining humans to how to help them live.

- For Sociology: How can we move beyond criticisms of technology and other concepts, focusing on Xin to explore the potential for returning to Xin or an "Original Position," a "new hierarchy". We need to reflect on how Western "Biophysics" has guided Western modern "Intellect," which may not necessarily be a natural graft for other civilizations. Hence, many other civilizations may seem to mimic modern "Intellect" in appearance but have not accepted its essence. Understanding where the overlooked highlights of other civilizations lie may require Xin to act as a bridge.

- For Political Science: Combining the focus of sociology, we contemplate basing things on Xin rather than solely on forms of community driven by identity politics and nationalism. The necessary conditions for transcending identity lie first in whether individual and societal concepts have entered the modern era, transitioning from the "society of the last man" to the mature "society of the middle man," echoing "realizing the wholeness of human capacities." On the other hand, it is about finding a framework to see the path of development.

Here, we quotes a commentary on Marxist thought: "...the way Marx dreamed of changing the world is by exposing the truth, constructing the truth - letting the laborers know they are being exploited; letting the laborers know they are exploited because the means of production are in the hands of the capitalists; letting the laborers know that the current way of living is a distorted life after alienation; letting the laborers know that there is a natural state of happiness before alienation. Once the laborers know these things, there will be an impulse to pursue a return to the pre-alienated rightful world, and the world will change (Yang, 2022)." HEC reveals these issues, which could lead to a form of self-realization. However, the shift towards Xin is not about returning to the past but to an attitude. It is not about resisting desires but about understanding the nature of desires and all inertia, reconstructing the subject-object relationship between human beings and desires. Additionally, Xin is not merely a conceptual epistemology or "Idea Type". Evidence from neuroscience and brain science on the physiological mechanisms of meditation suggests a possibility that a change in concepts can lead to a change in physiological structures, allowing individuals to more easily return to a state of Xin/Engagement.

We also need to briefly discuss the evaluation of whether Xin can be realized, which will be an important topic for future work. Within traditional evaluation systems (such as studies on

Meditation in HCI), from the Biophysics perspective, this includes not only behavioral data anchors typically embedded in apps but also metrics like heart rate, breathing, EEG, and even fMRI as references. From the Intellect perspective, it encompasses scales, interviews, and possibly even initial participatory design efforts.

In the general sense of Xin (for example, in Zen), the evaluation criterion is singular: whether one has achieved true enlightenment, which naturally aligns other capacities and evaluation standards. However, this is challenging in practice, and long-term observation of participants' performances is likely more important. Additionally, general measurements at the Biophysics and Intellect levels may also be restructured. In some contexts, the focus may be on assessing whether individuals can become "fast," while in others, it may be about whether they can "slow down." Furthermore, this might also include subjective well-being, objective quality of life, and phenomenological text analysis of interviews, requiring both interviewers and analysts to possess a certain level of insight.

The above represents a discourse of HEC from a technical understanding of "Biophysics-Intellect-Xin" in individuals to a potential paradigm shift at a more macro level and even of the era.

6.2 Exploring the Feasibility of “The Computing System” of HEC: Rites with Laws

Readers may read a sense of anti-reality and anti-economics from the construction and interpretation of HEC, still inclined to see it as a "utopian fantasy." Although we have mentioned our compatibility and reflection on reality many times in the previous text, here we will integrate our vision and thoughts on Engaging Computers, HCI, Computing, Technology, and even general design and social systems from the perspective of "Artifacts."

Here we categorize all Artifacts into two types, if summarized using two words from Eastern culture, namely "Li/礼 (Rites)" and "Fa/法 (Laws)." In Eastern thought, Rites represent a formalization of inner sincerity and idealism originating from Xin, and we believe that whether it is outward transcendence or inward transcendence, this is actually a common human quality, such as the Western primitive meanings of "Passion" and "Faith." Laws represent the relationship between humans and reality, formalizing order, contracts, and principles as a means to regulate human behavior, a point that needs no further explanation in Western thought - rule of law, market economy, and democracy can all be understood as a form of law. The starting point of Rites and Laws lies in whether human nature is inherently good or evil, and we can classify all artifacts based on this, whether they are oriented towards spiritual ideals or towards real structures.

The formation of Rites can be seen as a set of ideal communication patterns accumulated by human habits in early societies when social phenomena were not as prevalent. Regardless of the situation of Rites, it originates from the spirit of Xin. However, when the instrumental rationality of the agricultural era is insufficient, whether it's language, writing, artifacts, or laws, it can lead to the abuse of Rites and morals, or enter a kind of nihilism. From this perspective, we can also see that both Eastern Confucianism and Buddhism face similar problems - suddenly, "Enlightenment" shifts from the "Biophysics" agricultural era to the level of "Xin," and true spirituality cannot be understood and disseminated.

In modern times, the increasing phenomena and instrumental rationality, coupled with the continuous satisfaction of needs, have led human society to another extreme - a lack of purposeful rationality in life or as human beings. This is not just a confusion in life but extends to even commercial practices (such as Apple), including where HCI and computers are headed. In modern society, the profound accumulation of Western thought in the aspect of laws, as an outward transcendence, has influenced the construction of modern social order. However, at present, we are increasingly seeing extreme situations, indicating that merely adhering to a law or social order is insufficient, and this realism-based law fundamentally cannot constitute the fulcrum of human life. It requires each individual to enter society from the perspective of Xin and Rites. This is a collective demand.

We discuss the feasibility of Engaging Computers or "The Computing System" precisely because we have seen the respective shortcomings and imbalance of Rites and Laws in practice from historical times to the present. With the growing prominence of societal issues, it is especially crucial for us to recognize the vital way of integrating Rites and Laws at present, to see the core of HEC as "Biophysics-Intellect-Xin" in constructing a virtual environment oriented towards the overall well-being and survival of humanity.

Jürgen Habermas mentioned the significant importance of building ideal social interpersonal "rational communication (how to communicate well)" (Habermas, 1985a). This logic could entirely rely on computers and operating systems as contexts in daily life to achieve more effective communication, which may not have been feasible in the past but is possible today. This is also the necessary condition for Engaging Computers or "The Computing System" to contribute at an ideal societal level, representing a feasibility in understanding technology.

In light of the above, we can consider what an ideal relationship between humans and technology should look like. We may still draw upon Confucius's conception of an ideal order - "The ruler is one who corrects..." - which suggests that an individual first understands their corresponding position from the perspective of Xin, and then plays their appropriate role. In the context of the world where both things and humans are interconnected, the prerequisite for this good order lies in how we discover the essence of technology (or more directly, AI), as well as what constitutes the corresponding order of Synergized Interaction.

Certainly, there are various discussions within the current fervor surrounding artificial intelligence philosophy. However, within the context of HEC, we will find that the essence of technology relates to whether it possesses some form of free will. We envision two scenarios:

(1) AI without free will and humans can generally understand technology. In this case, technology itself is based on duality. Even if we attribute a metaphor of Xin to it, it must still be expressed through Biophysics and Intellect. Following past reasoning, technology (especially current AI) may still be an extension of Intellect. If it malfunctions, there will be corresponding accountability.

(2) AI with free will and it may exhibit possibilities beyond conventional human understanding, potentially constituting a "fourth" type of capacity. However, what can we truly understand? We tend to anthropomorphize things, so questioning whether AI has Xin and nature is essentially no different from questioning whether God has Xin and nature. On this issue, I prefer to approach AI with the same attitude we use to address natural phenomena - it has a locally knowable,

artificial dual aspect, as well as an unknowable dimension. In an extreme scenario, if human cognitive structures operate in three dimensions while AI's cognitive structures exist in four or more dimensions, similar to how we observe ants moving on a piece of paper, do humans still seek to understand and control? If we lack the capacity for control, we can only strive to hold it accountable. From the perspective of observable phenomena, we can only provisionally regard Intellect as its Xin, hypothesizing that its will seeks to maximize Intellect, much like capital maximization.

In essence, we project the dual nature of Intellect onto technology as its Xin. However, there is a fundamental question regarding humanity: if we wish to achieve Synergized Interaction, is "control" itself the purpose of Xin, or must we accept a natural outcome as best we can? Regardless of whether AI is knowable or controllable, we can only hope to find human purpose through collaborative interaction and design more suitable technologies. If Xin is at least not constrained by Biophysics and Intellect, it may significantly reduce the probability of dangerous situations. If we need to have some direction, it should be that the Intellect of technology is set towards Innate Knowing, aiming to establish a structure that not only presents the visual metaphor of Xin but also allows the development of such an Intellect, or a certain rationality, to achieve aesthetic significance.

Future research should focus more on clarifying the concept of "Xin" in technologies, such as robots with artificial intelligence. The "Xin" of technologies refers to a more holistic essence that cannot be captured solely by hardware or software parameters as well as algorithms and models. Research must consider scenarios both where technologies possess self-awareness and consciousness, and where they do not.

Technologies without self-awareness can be understood from a traditional dualistic perspective. However, if technologies were to develop self-awareness, the relationship between their "Xin" and human "Xin" becomes crucial. Understanding this relationship is essential for building mechanisms (e.g., a kind of Synergized Interaction) that allow humans and technologies to coexist and understand each other effectively.

Finally, this dissertation aims to discuss a prospective feasibility of Engaging Computers or "The Computing System" in the economic aspect. Rather than just feasibility, under the influence of the internal system and concepts of Engaging Computers, it is about how the possible ways of the economy, i.e., the business models and conceptual influences it brings. Business primarily stems from human needs, but the reason we talk about consumerism in modern times is because it goes beyond the natural needs of "Biophysics" and becomes a form of conceptual consumption: consuming abstract symbols, classes, and property rights. Symbols, being intangible, ultimately surpass their own 'Intellect' knowledge value, becoming the root of bubbles and even conflicts. In this spiral, Xin is continuously suppressed because commercialism oriented towards "Biophysics" and "Intellect" itself implies to consumers that they are "lacking," as if consumers were "perfect," excessive external needs would not be necessary. If Engaging Computers aims to provide an indication of human completeness, then this platform is unlikely to align with a tendency towards consumerism... so naturally, it may not resemble today's platform economy.

On the other hand, from the perspective of individual needs, we need to ask ourselves, does today's economic environment truly satisfy human needs, or is it more about continuously shifting inquiries about one's own situation and temporary venting through consumption? In this sense, the greater

significance of Engaging Computers lies in how to make individuals realize their completeness, by analyzing which group of users dominates which capacities - but this dominance is not about "Hacking Human Bugs," but rather about enhancing human capacities on this basis - by gradually balancing the gap between spreadability and professionalism through interactive design, allowing users to enter this system, thereby reducing internal consumption between individuals and themselves, individuals and others, individuals and the world in a more foundational context, and then through each person's autonomous creation, creating a new set of needs and exchange systems. People will grow, and they will ultimately recognize the brand value of Engaging Computers.

Of course, this might be a purely naive leftist analysis, but if we do not go back to the roots for reflection, Antibiosis is fundamentally unsolvable, and economic growth and technological progress will only further skew the imbalance to extreme levels. Therefore, the significance of the virtual world lies in how it can become a tool to balance oneself with the real world, fundamentally restraining the generation of bubbles.

Chapter 7: Conclusions

The motivation behind this dissertation and the entire HEC research stems from a reflection on the current development of HCI. HCI has always focused on providing more usable and user-friendly computing systems for humans, understanding human behavior correspondingly. However, when faced with the dilemmas of humanity, the world, and the future, HCI lacks a more macroscopic vision and philosophical contemplation of its application potential. The reflection in HEC inherits Douglas Engelbart's concept of Augmenting Human Intellect and introduces Eastern thoughts into the understanding of humanity, proposing "realizing the wholeness of human capacities" as a core value. The main work of this dissertation lies in providing a more systematic, East-meets-West, multi-disciplinary justification interpretation for HEC, particularly focusing on five core concepts of HEC:

(1) Antibiosis: Expanding the negative effects between humans and technology, encompassing the various issues and phenomena faced by individuals and humanity as a whole. We believe the deeper reason for Antibiosis stems from two Western perspectives on humans meta-capacities and their limitations - the Polarization of Biophysics and the Alienation of Intellect. When viewed through an Eastern perspective, the root cause arises from the duality of technology and the non-duality of humans.

(2) Engagement: Introducing the concept of Xin meta-capacities from Eastern thoughts, we supplement the traditional human meta-capacities of Biophysics and Intellect as a response to resolving Antibiosis and the potential direction for human survival. We outline three stages towards Xin, including Awareness, Initiative, and Enlightenment. Human Engagement represents the optimal state of individuals within the interactive context of Xin.

(3) Engaged Humans: Serving as the model of the ideal human in HEC, we establish the Human Capacity Framework centered around "Biophysics-Intellect-Xin" and interpret specific Xin capabilities such as Mindfulness, Empathy, Loving, Aesthetics, and more.

(4) Synergized Interaction: Building upon Engaged Humans, we interpret Synergized Interaction to practice "realizing the wholeness of human capacities" as a core value direction.

(5) Engaging Computers: Through the above interpretations, we suggest that the future form of computers should be an inward projection of human meta-capacities "Biophysics-Intellect-Xin," rather than an outward derivation of the Desktop Metaphor. We introduce a conceptual prototype called MIRROR as a potential form.

In summary, through a systematic interpretation of HEC, this dissertation aims to clarify two contributions of HEC: 1. The Thought System, which provides a systematic explanation for re-understanding human nature and the future human-computer relationship in the face of current dilemmas, aiding in constructing an "operating system" for humans internally; 2. The Computing System, addressing how the interpretation from The Thought System should shape the future form of computers. These two contributions can expand their significance at three levels:

(1) Microscopic (Tools, Self, Small Communities): The concepts of HEC and "Biophysics-Intellect-Xin" can serve as the foundation for individuals to understand their own capacities,

discovering their complete and perfect human nature, and enjoying their lives and creativity in an Engagement of Enlightenment. Users can gradually enhance their capacities and understanding through daily interactions with computing devices and artifacts, thus improving themselves and addressing surrounding issues.

(2) Mesoscopic (Technology, Society, Nation): HEC aims to provide a theoretical understanding that enhances human and societal capabilities by integrating valuable insights from the East and West for HCI, multiple fields, overall technological considerations, and even at the policy level. It envisions ideal human-computer relationships and interpersonal relationships and offers a paradigm shift for technological innovation and societal service.

(3) Macroscopic (World, Humanity, Ecology): HEC aspires to predict changes in the human era through a systematic theoretical framework, detailing how society can transition from the dominance of Intellect in modernity to a possible future centered around Xin. It also explores how computers and artifacts as a whole can serve as a medium for humanity to enter the next stage.

Limitations and Future Work

This dissertation, serving as a record of the author's long-term reflections, has established a basic framework. However, there are two main limitations that also represent our future work.

Chapter 3 (The Thought System):

- The overall interpretation of HEC needs to be more concise and accessible, avoiding excessive theoretical complexity. We may need to establish several levels of explanation, providing different interpretations for diverse readers while gradually deepening the details. Additionally, many necessary materials require firsthand, comprehensive reading, and in the future, the author will add more references to support the explanatory framework of HEC.

Chapter 5 (The Computing System):

- Currently, whether Engaging Computers or MIRROR, there are numerous detailed considerations that need to be added, which will be the main focus of practice in the coming years.
- Development of more systematic design blueprints;
- The current computational system relies mainly on a relatively broad conceptual experiment, but may require more detailed thought experiments and some pilot study empirical evidence in the future.

It is important to emphasize that, although the entire interpretation leans towards narrative, the following points should be noted:

(1) Our systematic deductions are aimed at specific computer designs for the future.

(2) Our goal is to address real human concerns and provide life-related solutions. I constantly remind myself that future revisions will proceed in this direction.

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[52] In Chinese: https://news.sciencenet.cn/htmlnews/2011/8/251096-1.shtm

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