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# Challenge of tacit knowledge in acquiring information in cognitive mimetics

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**Abstract.** Intelligent technologies are rising. This is why methods for designing them are important. One approach is to study how people process information in carrying out intelligence demanding tasks and use this information in designing new technology solutions. This approach can be called cognitive mimetics. A problem in mimetics is to explicate tacit or subconscious knowledge. Here, we study a combination of thinking aloud in ship simulator driving and focus group commenting the solutions of subjects. On the ground of these early experiments, a multiple method combination seems to be the best way forward to solve problems of tacit or subconscious knowledge.

**Keywords:** Desing science· HTI · mimetics · AI

## 1 Introduction

Intelligent technologies are in focus. Robotics, Artificial intelligence, cognitive automation or technologies and autonomous systems are under intensive development [1] [2]. The unifying factor of these new technical openings is the systems' capacity to carry out intelligence demanding tasks. Consequently, human technology interaction specialists have to meet the problem of how to design technologies with intelligent capacities.

The first serious example of a machine that could take human role in intelligence requiring task was presumably Turing machine [3]. Of course, computing machines were not new, but it was possible for a universal Turing machine to be programmed to perform very different intelligent processes from mathematics to chess. The Turing machine created a frame which could be applied in very different types of intellectual tasks [3].

The next step forward was invented by Herbert Simon and his colleagues [4]. They understood that Turing's model of the human mind was too intuitive [3]. It was possible, for example, to have unlimited number of machines which could solve some problem. So, it was impossible to tell which one of these processes would be the true model of the human mind. Thus, it was a good idea to study how people really processed information.

It was important to adopt the empirical research methods of modern psychology of thinking and thus study how people process information when they carry out intelligent tasks such as chess playing [4]. The empirical research in human thinking enabled on the one hand researchers to study the best possible models for programming intellectual machines and on the other to think of the limits of computational machines as models of the human mind.

The intimate relations of computational models and human thinking has been problematic and under intensive research for decades [1]. Recent advancement in developing intelligent technologies brings a new aspect to this discussion. Modern intelligent machines are designed to take care of tasks, which have earlier been done by people. Consequently, to improve their design, designers have to understand how people process information in such tasks.

## 2 Multiple realizability and cognitive mimetics

For several thousands of years, people have been able to steer boats and ships from one place to another because of their sufficient cognitive capacities. They have been able to perceive and categorize things, create spatial mental representations, remember these representations, and manipulate mental representations or think. Consequently, ships have found right places, thanks to human information processing capacities.

People have been components in shipping (and also in other machine systems) because of their capacity to process information [4]. No ape, bear, or ant, for example, would be able to steer ships from one port to another. Thus, human information processing has made seafaring possible. However, today, it is possible to construct machines that can take care of many parts of these complex steering tasks with minimum human involvement, and, for this reason, a new goal for designers has emerged, which is to design machines that can replace people in tasks requiring human-like information processing.

A prerequisite for successful replacement of human work in intelligence demanding tasks is that machines can take care of the same things that people do when they take care of these same tasks. Intelligent machines need not do the same thing in the same way as people do. The main thing is to get the same outcome. Chess playing machines do not think like people, but they perform as well as or even better than people do.

Turing machines illustrate quite well that it is possible to carry out same information processing tasks in different ways. Different physical systems can carry out same tasks. People can drive industrial trucks and move goods from one place to another, but this can be done by automatic systems also. Thus, one can carry out intelligence demanding tasks with different types of physical “platforms”. This property of intelligent performance can be called *multiple realizability*.

Originally, multiple realizability referred to fact that human brains need not be in precisely the same physical state to represent something. Different physical states can carry out have same information states. The idea can be generalized over many types of physical objects and information states. Thus, computers can solve the same mathematical problems as people can. Such a general multiple realizability is the ground idea of intelligent technologies.

The generalized multiple realizability has an important consequence. Because people have been able to process information and because information processes can be realized by different physical systems, it is natural to ask if we can use human information processing as a model for designing intelligent machines. In fact, this was what Turing did. He used his intuitive idea about how mathematicians compute to model their minds. Similarly, modern AI and autonomy designers could mimic human information processes in constructing intelligent artifacts. Such approach to intelligence design can be called cognitive mimetics. Here we study how to develop the methods of cognitive mimetics, and for this reason our focus in is methodology of knowledge acquiring rather than results. The latter can be reported separately.

# 3 The acquisition of knowledge

Here, we made a two-stage design simulation experiment to analyze how to collect tacit information. In the first stage, we made a simulator driving experiment with thought aloud protocols. In the latter stage, we asked sea captains as a focus group to comment the presented driving solutions. Thus, we could get additional information about subconscious information processing.

**3.1. Simulation method**

The first part of our study investigated the use of simulator in collecting knowledge about subjects thinking.

*Data collection and analysis:* Our chosen method aims at analyzing how captains think when steering a ship. Simulator setting was applied data collection, because, in contrast to real at-the-sea setting it allows to, controlled collecting data in challenging tasks.

*Subjects:* The study subjects were experienced maritime pilots (highly experienced ship-handlers, former ship captains) (n=6) and other professionals (n=2), all being high-grade licensed mariners. They had on average 20 years of experience (between 4 and 40 years) of ship steering .

*Equipment:* the simulator features a 180-degree view from the bridge, playing a 3D simulation of the environment. Other sources of information were a simulated radar, an electronic chart display system (ECDIS), and a screen displaying information of the ship, such as speed, rudder angle, bearing, etc. The ship was controlled by a console which had a mouse operated (heading) autopilot, manual rudder, throttle, and front propeller. The console also held a conference telephone used for simulating radio communications. The experiments were recorded using two video cameras, one placed behind the subject and the other to his or her left. The audio recordings collected by the cameras were transcribed into text.

Figure 1: Simulation environment

*Tasks:* After an introduction to the system and a chance to rehearse for a while in the simulator, the participants were instructed to navigate the ship to the harbor (and back during the second run) and informed that VTS (vessel traffic service) would be (unrealistically) quiet but would answer when asked. The participants were asked to voice their thoughts as they observed their environment and navigated the ship and were reminded to do so during the experiment if they forgot to speak (Ericsson and Simon 1984).

The data collection and the simulator scenarios were designed by a multidisciplinary team consisting of engineers, maritime professionals (including a maritime pilot), and behavioral experts (with background in social psychology and cognitive sciences). The main idea was to simulate a challenging but not unrealistically difficult journey. The setting chosen was a specific real-life Finnish harbor (that of Vuosaari). The simulations took 20-30 minutes one way.

The white circle marks the ship of the participant, which is in this image in the middle of crossing the regatta which can be seen around the ship to the front, back, and right and left (six in total). The route of the sailing boats can be seen circling the island, and was designed to re-cross the path of the participants' vessel again from the right.

### 3.1.1 Results – the ontology of steering

Description of human thinking is normally qualitative (Newell and Simon 1972). Time and other numerical parameters do not normally give a clear idea about what people think and, for this reason, the most natural way of investigating thinking is to concentrate on the information contents of the thoughts. A good way of expressing is to use ontologies [5], [6]. Ontologies provide frameworks in which not only the contents of a particular domain of knowledge but also the conceptual lenses for exploration and research can be expressed. Thus, the main outcome of our empirical work here is ontology for describing thinking of steering captains. This ontology contains:

1) situational information; 2) chosen action; and 3) why the action was chosen. The last component was called explanation.

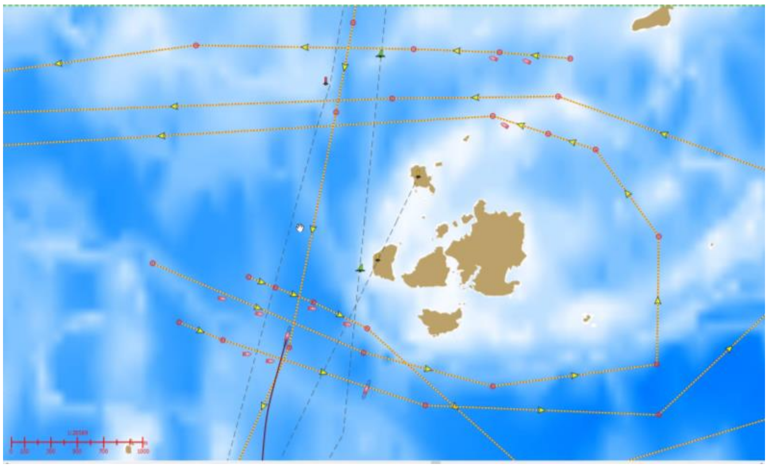

Figure: 2: Regatta problem

On the ground of protocol analysis, we abstracted an ontological schema which gives an idea about the content structure of steering a ship through a regatta.

On the ground of protocols we suggested an ontology of three categories.

| INFORMATION ACQUISITION | ACTION | EXPLANATION |
|---|---|---|

Figure 3. Ontology of steering

The analysis of protocols lead to a three component model of steering activity: 1) Information acquisition 2) The actual steering actions. 3) Finally, the explanations i.e., the reasons and justification subjects can give to the ir actions.

### 3.2 Focus group method

In the second part, we asked five experienced sea farers to tell by means of forms with the given ontology how they would operate in the task situation. One of them was a pilot, one was engineer, three were captains or co-pilots. All of them had over 10 years of professional experience. Our main methodical problem was, if the presented ontology can be used in collecting additional knowledge.

#### 3.2.1. Results:

The main additional information with focus groups was explication of reasons. As they were specifically asked in the form subjects were explicit with them. All the presented actions were motivated. Reasons mostly concerned the control of the ships, but there were also a number of ethical and economic reasons such as avoidance of lost life or damage, or avoidance of breaking the ship engine. Clearly, it makes sense to ask explicitly people for reasons for their actions.

# 4 General discussion

Our example illustrates how designers must meet the problem of tacit or subconscious or tacit information. Subconscious processes are everyday life in clinical counseling. People are not aware of what happens in their mind. For this reason, clinical processes often take long times. Logically, one would think that applying multiple methods in combination and thus investigating human information processing in several ways and from several points of view could be used to get a clearer picture. Consequently, we decided to pilot a multimethod approach to improve human information processing. The target information process is autonomous shipping.

Our pilot study focusses on only one problem in designing intelligent technologies, which is the problem of tacit or tacit or subconscious knowledge. In any case, it is vital to use multiple information collection methods in order to get a complete picture of how people process information. Here, we used a focus group to get extra information, but it is not the only method. The main goal is to get as complete a picture of information as is possible and the reasons why people act as they do.

In sum: The investigation of human information processing and thinking provides an important source of knowledge for developing intelligent technical systems. A problem in this research is tacit or subconscious knowledge, which is not available to experts themselves though it affects their thinking. One can explicate tacit or subconscious knowledge by means of a multimethod approach and present the results by means of action ontologies [6]. They can be used to collect and communicate results.

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