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## Understanding New Emerging Technologies Through Hermeneutics. An Example from mHealth

ZAID ZEKIRIA SAKO, SASAN ADIBI & NILMINI WICKRAMASINGHE

**Abstract** New technologies such as mHealth have entered the health domain as an innovative technology to connect people suffering from a chronic disease with healthcare services to reduce the pressure on healthcare systems. The primary driver for these technologies is data and they contain valuable information. Understanding what the data means and the accuracy of the data can be complex. Hermeneutics has been applied in previous Information Systems studies that interpret data to provide a meaning about unexplored and complex phenomenon. This paper provides background information about Hermeneutics and an example of Hermeneutics applied in a new mHealth study.

**Keywords:** • mHealth • Hermeneutics • Qualitative Study • Information Transformation • Emerging Technologies •

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## 1 Introduction

The Information Technology innovation continuum is creating new and innovative solutions for different industries. Particularly, the healthcare industry is witnessing a new era of innovation (Spanakis et al., 2016) as new emerging technologies such as Mobile Health (mHealth), is being adopted to assist in fighting and managing diseases at both global and individual levels to deliver better health management platforms (Willcox et al., 2015). The technology is delivering innovative solutions through mobile devices that facilitate a number of initiatives that include but not limited to health call centres, treatment compliance, appointment reminders, mobile telemedicine, and patient monitoring (World Health Organization, 2011). These innovative solutions can empower people and patients to be proactive in managing their health through self-management (Guifeng et al., 2015), as self-management can prove critical in reducing healthcare costs while delivering optimal healthcare services (Monsen, Handler, Le, & Riemer, 2014). The empowerment of patients to self-manage is through the delivery of information that allow them to understand their medical conditions (Hayes & Aspray, 2010) and it is through the devices, as the devices act as a gateway for accessing healthcare services through the exchange of data and information. The exchange of data is through secure data transfer mechanisms between patients and healthcare professionals. The data contains valuable information and it is primary driver for the treatment of diseases and empower of individuals to self-manage their health.

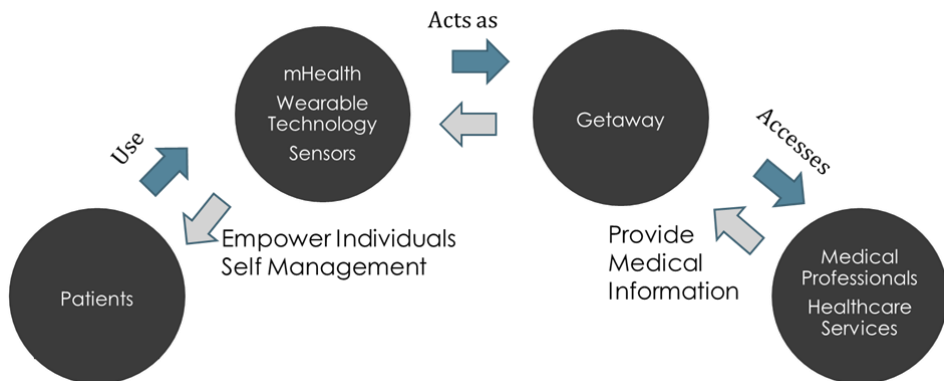


Figure 1: Example of how technologies are becoming a gateway for patients accessing healthcare services

While new technologies are introduced and solutions have been created, how does one interpret the data captured by such devices to learn more about the underlying IT solution that facilitates the transaction between the different stakeholders of an IT healthcare solution? More specifically, from a research perspective, how does accessing secondary data produced by the devices allow the researchers to understand if the technology is delivering the desired outcome? While from the healthcare point of view, how does one evaluate the quality of a solution and whether it is delivering accurate healthcare services?

The technologies are new to the health domain and require a well-established research method to understand how they operate, specifically the IT solution that is delivering healthcare services to people and patients. Although today's modern data analytics platforms are extracting new insights from such technologies to create business value and answer some of the business questions (Tailor, 2015), yet from a scientific perspective it can be challenging. A way to approach the analysis of secondary data from new, emerging technologies can be accomplished through Hermeneutics. Hermeneutics has long been applied in studies where the texts/artefacts are distant from its original authors. The application of Hermeneutics in new emerging technologies is to gain a window through interpretation, into the phenomena lived by the patients interacting with healthcare professionals for the management of diseases while using any of the technologies. The essence of interpretation in such cases, is to understand how the technology is operating, the quality of the primary driver of the technology being data, and the integrity of the information based on the data.

The purpose of this study is to understand what data accuracy is, discover the sources of data inaccuracy in health data and the impact inaccurate data has on the Integrity of the Information while determining the most appropriate Machine Learning Algorithm that can detect inaccurate data. The accuracy of the data is understood through Interpretation and it is done through Hermeneutics and Thematic Analysis.

## **2 Literature Review**

This section of the paper introduces Hermeneutics with a background around Hermeneutics in the Information Systems (IS) domain and an example from a current research in progress where Hermeneutics is used for analysing secondary data based on an mHealth solution for diabetes.

### **2.1 Hermeneutics**

The term Hermeneutics is a modified transliteration of the Greek verb "hermeneuein", a term that means to express aloud, to explain or interpret and to translate as explained by Kennedy Schmidt (2014) and it is a technique derived from the Interpretive Paradigm (Grbich, 2013). It is also known as the process for making a meaning (Esterberg, 2002). Hermeneutics was thought to have originated as the study of the interpretation of the Bible (Lee & Dennis, 2012) and has been applied in the interpretation of previous work of authors who studied the Bible (Black, 2006).

Historically, in ancient Greek, it was believed that Hermes, the mythological messenger god was equipped with language and understanding that enabled him to interpret the messages from the gods and deliver them to the mortals (Butler, 1998). This mythological example illustrates the process for interpreting messages and communicating them with people. The four key terms of language, understanding, interpretation and communication, from the example, are key to Hermeneutics.

In research, the researcher must be equipped with the language of the subject understudy, understand the messages (data, texts, artefacts), has a method to interpret the texts to effectively communicate the results from the study to the audiences. Although equipped with language and understanding, the interpretation can become an issue. When interpretation becomes an issue, it is an issue of unintelligibility and it occurs when a person does not understand an artefact that he or she came across, and it is known as rebelling against successive smooth understanding (Tkáčik, 2016). In research, unintelligibility can occur when the researcher accesses secondary artefacts that are distant from their original authors and has no access to the language that would enable an understanding of the artefacts.

The objective of using Hermeneutics in research is to interpret texts that would allow an understanding of phenomena, peoples' actions and behaviour to address questions that fall under the interpretive paradigm. IS research can be classified as interpretive if it is assumed that our knowledge of reality is gained only through social constructions such as language, consciousness, shared meanings, documents, tools, and other artefacts (Klein & Myers, 1999). Interpreting texts through Hermeneutics is not an easy task and requires an in-depth understanding of Hermeneutics and the interpretation process.

The problem with interpretation is that it is a two-fold problem. The first problem is avoiding projecting one's own viewpoint on the text (Coelho, 2001) and blur the interpretation of the texts as one's preconceived ideas may influence the interpretation. The second problem is the need to successfully communicate to a variety of audiences (Coelho, 2001). However, ones' own perceptions and experiences in a subjective, cultural, and historical, as referred to as the lifeworld, can be included in the interpretation of the texts (Høiseth & Keitsch, 2015).

In the IS domain, Hermeneutics has had a dominant role in the interpretation of Information Technology (IT)/IS related studies and the results are quite interesting as they provide a fresh view of the IT systems. The widely-known paper of Klein & Myers (1999) set out principles in conducting Hermeneutics in IS, Robert, Wendy and Lucas (2001) for Hermeneutics and meaning making in IS, Boydens and van Hooland (2011) using Hermeneutics in quality of empirical databases and Acker (2015) toward a Hermeneutics of data, are a few examples where Hermeneutics is key ingredient to the study. They all seek to make meaning of the study and providing guidance in finding a meaning to the study (See Table 1).

Table 1: Summary of papers where Hermeneutics was applied in the study

| <b>Paper</b>  | <b>Summary</b>   | <b>Author(s)</b>            |
|---|--|-----------------------------|
| A SET OF PRINCIPLES FOR CONDUCTING AND EVALUATING INTERPRETIVE FIELD STUDIES IN INFORMATION SYSTEMS | Use of Hermeneutics to make sense of failed IT implementation  | Klein & Myers, 1999         |
| HERMENEUTICS AND MEANING -MAKING IN INFORMATION SYSTEMS   | Introducing IS Researchers to Hermeneutics, and the concept of Interpretation  | Robert, Wendy, & Lucas      |
| HERMENEUTICS APPLIED TO THE QUALITY OF EMPIRICAL DATABASES  | Present a conceptual framework to analyse and improve the quality of empirical databases to interpret shifts in the quality of databases | Boydens & van Hooland, 2011 |
| TOWARD A HERMENEUTICS OF DATA   | Using Hermeneutics to analyse the traces of data left in a networked computing infrastructures   | Acker, 2015                 |

Hermeneutics can help render the meaningful of a text (object or phenomenon), which has become obscured or ‘distanced’ in some way, thereby making it no longer immediately obvious (Robert, Wendy, & Lucas, 2011). An obvious everyday example that does not interpretation is a STOP sign as it is either understood or not (Kennedy Schmidt, 2014).

When is Hermeneutics needed? Hermeneutics can provide a rich, detailed interpretation of peoples’ experience and texts (Grbich, 2013). Traces of data and metadata left in a network computing infrastructure are becoming computing history where Hermeneutics is needed to provide an interpretation of the data (Acker, 2015). Interpretive research can help IS researchers understand human thoughts and actions in social and organizational contexts; it has the potential to produce deep insights into IS phenomena including managing of IS and IS development (Klein & Myers, 1999). Hermeneutics was also discussed in the development of Information Engineering (Fonseca & Martin, 2005) due to its powerful ability in interpreting users and the system.

With new emerging technologies, human actions can be understood through the interpretation of data produced by the devices as they are used by people and patients for specific needs, specifically in healthcare. The data is becoming an extension of people and patients as traces of interaction between patients and medical professionals are

captured and exchanged to achieve a desired state of well-being. Yet, while the data has served its purpose, it contains valuable information that can help in different scenarios. From the technological side of the solution, it sheds light on how the technology functions, how the underlying data quality help achieve the desired health outcome and what exactly does the data contain that enables this transaction.

While mHealth being a new technology where prototype solutions have been developed and commercially available, studies in the actual quality of data is not looked at thoroughly as the technology is still in its early stages. The following section will elaborate on how Hermeneutics is applied to study the emerging technology of mHealth with specific focus on Data Quality.

## 2.2 Hermeneutics in a Case Study Research of mHealth

The preceding section has defined Hermeneutics and its application in IS studies. This section illustrates with an example, the process of applying Hermeneutics in the study of a new emerging technology used for health and disease management. The illustrated example in this paper is from a current research study. The objective of conducting the study is to evaluate data accuracy and information integrity in mHealth solutions, identify how data inaccuracy can occur, test different Machine Learning Algorithms, and evaluate the accuracy of the algorithms in detecting inaccurate data.

The selected case study is mHealth for diabetes with the case being patients' data. The selection of the case study was based on the research question, in which it posed as following:

‘How can Machine Learning be applied in mHealth Solutions to Address Data Accuracy and Information Integrity?’

The research question aligns with the study objectives as it is broken into sections. Starting by which type of Machine Learning, how it can be applied in mHealth, what defines Data Accuracy and Information Integrity. The selection of the case study was based on the research question, as it is one that conforms to Yin's (2014) criteria for selecting case study, as the form of question is ‘How’, requires no control of behavioural events and focuses on contemporary events. With using case study, the data is secondary, de-identified data of people with diabetes and there was no control of behaviour when the data was produced and it presented a contemporary event. The two sources of data present both structured and unstructured cases of data. The first dataset is of patients with diabetes who have glucose measured through both a device and recorded on paper. The second dataset is extracted from hospital admission records where diabetes was either a factor in admission or was recorded during the admission. These two datasets assist in addressing the research question by using the interpretive paradigm as it allows for the reconstruction of understanding of the social world (Denzin & Lincoln, 2000). Both

datasets allow a rich experience in exploring how different diabetes data is collected and for what purpose, with the patients' experience captured during both scenario.

The Hermeneutics method used in this study is adapted from Kim (2013) using the 3 layers consisting of Text, Translation and Interpretation layer (See Figure 2). The 3 layers separate the text into layers where each has its own purpose and that allow for the data to be analysed using Hermeneutics. The text layer is all the text/data in the study and it is the first layer of Hermeneutics. The text starts with the actual datasets. The datasets are reviewed to form an understanding of what the datasets contain, the format they're in and all the properties of the data including data dictionaries. Once reviewed, the data is then aligned with codes (extracted from Thematic Analysis) from the Literature review that cover Data Quality (each element of Data Quality, source of Data Inaccuracy), Information Integrity and Machine Learning. To simulate the process of disease management for patients with diabetes, the data is mapped against the Omaha Client Care Plan that segments the data into Problem Classification Scheme, Intervention Scheme and Problem Rating Scale for Outcomes. The simulation helps in understanding the role of each instance of data in disease management. After the data is examined and mapped against Omaha System, the data is then divided into training and testing data, and that is to test different Machine Learning Algorithms. These parts form the text layer as they are mainly text and are yet to bring a meaning that would assist in addressing the research question. The text is translated using Thematic analysis.

The second layer is the Translation Layer where Thematic Analysis is applied to generate themes that can extract meaning from the text. The Thematic analysis is adapted from Braun and Clarke (2006). Boyatzis (1998) explains Thematic Analysis as a process for encoding qualitative information. The text in this study is secondary data, one where there's no access to the patients or the medical professionals and they are open for research. The state of the data does not have a meaning and is therefore stateless data. To understand what the text is, Thematic analysis look for patterns in information that at minimum describe and organize possible observations while at maximum interpret aspect of the phenomenon (Boyatzis, 1998).

The interpretation of the data occurs at the third layer of Kim's (2013) model. The Interpretation Layer is interpreting the themes to form an understanding about the phenomenon. The interpretation method is adapted from Taylor, Francis, and Hegney (2013), and it starts with turning to the nature of the lived experiences, that is accessing people who would tell about the phenomenon understudy. The lived experience comes from investigating the experience as it has been lived rather than conceptualizing it by accessing data or people who have an experience related to the research question, that is real and has occurred.

Combining the three layers with the Thematic and Hermeneutics analysis is to divide the sections with clear and concise objectives that would allow for Hermeneutics technique



to be implemented correctly in the right flow. That is by understanding at what stage occurs the text, the translation and the interpretation of the data.

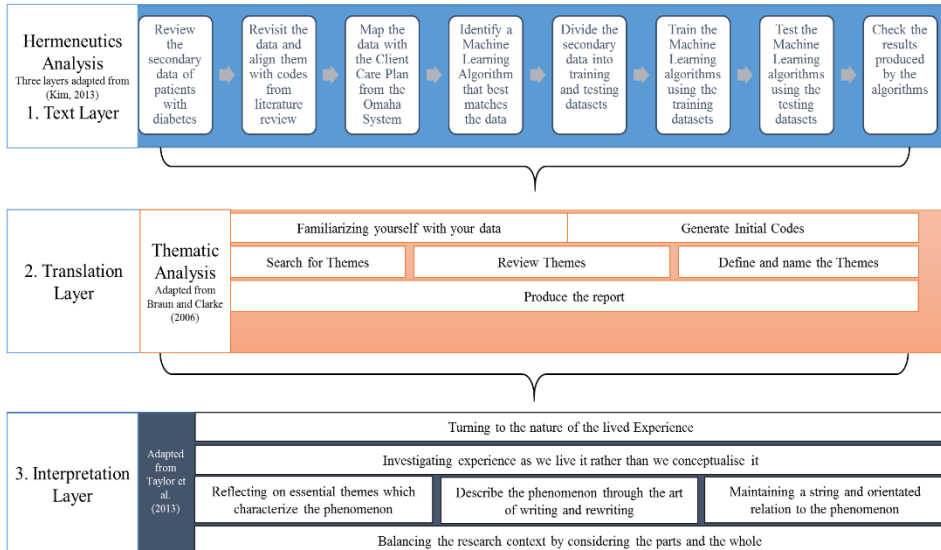


Figure 2: Hermeneutics in studying new emerging technologies

### 3 Findings

The purpose of Hermeneutics is to derive understanding from the text under study as explained by Phyl & Carol (2006). The adoption of Hermeneutics in this research has moved the study from analysing electronic data to understanding the meaning of accuracy and how it occurs in a technology based solution such as mHealth. The data was first measured and evaluated against a set of criteria derived from the definitions of Data Quality that were based on World Health Organization (WHO) data quality standards and definitions of Information Integrity from the literature review.

To date, the study has found that accuracy occurs at multiple levels with each instance of accuracy intended for specific use (See Figure 3). The first level of accuracy occurs at the validation layer where data is simply validated as either accurate or inaccurate based on the input. The model of this validation measures the input against type of data (text, integer, float, date) and whether they fit the range. This form of validation ensure that the data passes its basic test of meeting the minimum level of accuracy before it is passed on to the next level of validation. This made the Classification Algorithm an appropriate Machine Learning Algorithm that could be applied to filter through the data and test the validity of the data before it is processed. Modern electronic forms apply a simple ‘rule based validation’ where data is tested at the time it is entered and no learning is taken into consideration when the next set of data is entered. Machine Learning powerful capability

of learning and predicting data makes it a more suitable technique that would enhance the data quality at the very basic level.

The second level of data accuracy examines the properties of the data. Although the data might have passed its first instance of validation, yet the properties might still not be appropriate for its intended purpose such as timely medical reminders, currency and completeness of readings of a patient or symptoms. Achieving this level of accuracy can be accomplished through the Prediction Algorithm that can predict future datasets based on the existing and historical data. This allows for the current values to be cross-examined against what the algorithm have predicted and raise an alert if major discrepancies in the data is detected through the algorithm.

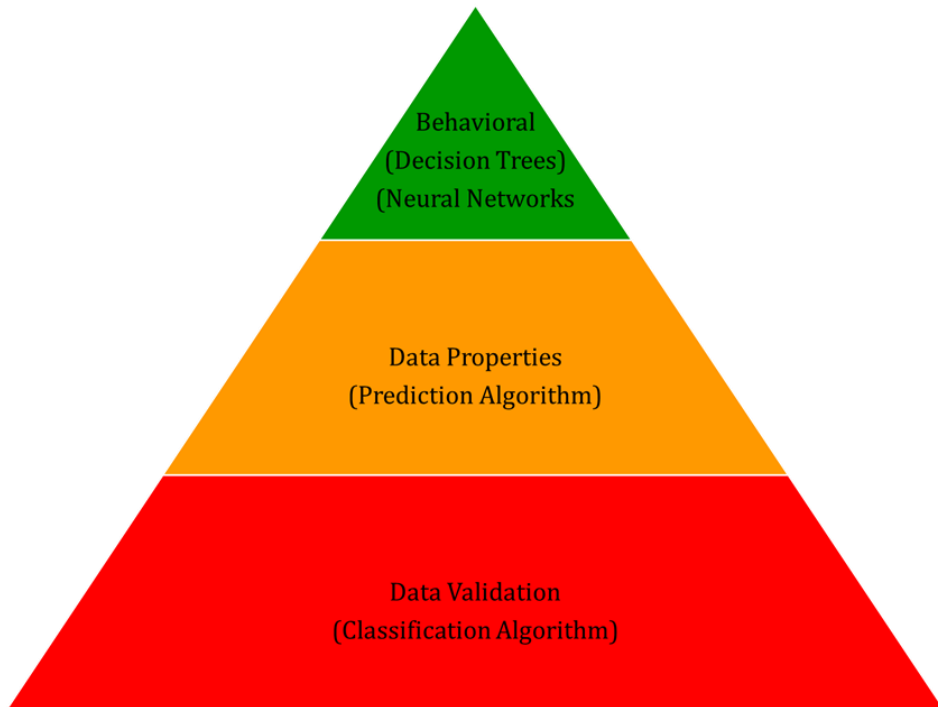


Figure 3: Levels of data accuracy in a digital health context

The third level of accuracy occurs at the behavioural level where the human behaviour, based on the data, is analysed to understand the meaningfulness or the usefulness of the data and its intended use. This includes decision based behaviour or health outcomes that can detect if a treatment is being adhered to as planned or if there's a gap in the intervention program for the specific disease. Behavioural accuracy is reflected through the decisions that are being made which can be mapped through Decision Trees or Neural Network algorithms that can simulate a person's decision making process that would

allow the medical professional to understand the thinking behind patients' decisions. This satisfies the collection of the data in an mHealth scenario and in the absence of a medical professional when the data is entered by the patients.

While still at an early stage of analysis, these findings are a result of Hermeneutics where the technique has shifted the focus from simply cross-examining the data against certain definitions, to understanding the meaning of accuracy in an mHealth context.

#### **4 Limitations**

A key drawback for this study is the datasets. The data was not obtained from an actual mHealth solution as the mHealth solutions are still in early development stages. However, the use of the algorithms against data like the ones produced by mHealth solution, particularly one designed for chronic diseases such as diabetes, make the results more appealing and relevant to technologies. The results do not only consider the accuracy of the data but highlight some key areas of where data accuracy might be influenced by behaviour of patients and users of mHealth technologies.

#### **5 Discussion and Conclusion**

Emerging technologies can hold valuable data that require beyond traditional analytics platforms for the analysis of data from a scientific perspective. Hermeneutics has had a role in previous IS studies and has provide to provide a fresh perspective of IS systems. The new technologies are changing the way patients seek advice from medical professionals, manage their disease, and delivering healthcare services through the platform. This change can have many undiscovered, unexplored phenomenon attached to the technologies that are yet to be studied. The role of Hermeneutics in this study is to assist in the interpretation of the data through a well-designed process that extracts meaningful information from the themes generated by the data.

The study is of qualitative nature and not quantitative as it seeks to understand the data, and particularly application of Machine Learning in mHealth. To understand what the data means, and how Machine Learning can be applied, Thematic analysis and Hermeneutics provide rich and detailed coded information with techniques to extract information that provide insights about data and how information is produced.

The data is of quantitative nature and the study focuses on understanding a single instance of mhealth designed to assist in a case of chronic disease. It does not aim to statistically evaluate the instances of accurate or inaccurate datasets in a mHealth transaction but instead its objective is understanding in detail the cause of inaccurate data.

IS studies have become richer in information, and Hermeneutics has found its place in IS domain as an interpretive technique that seek and explore a deep, powerful meaning of a phenomena. The mHealth technology is capturing peoples' actions and health

information that is becoming an extension of them that requires a technique, like Hermeneutics, to be applied to understand the underlining messages hidden in the data. Similar future studies may incorporate mixed methods approach to strengthen the findings through triangulation of methods that would provide two different perspectives on data.

## 6 Future Research Directions

This research sets the foundation for examining the quality of health data in digital context. There are several areas that will require research to be done to continue delivering high quality healthcare services through mHealth technologies. One key area is the human behaviour when using the technology, especially when entering and transmitting the data. Whilst the human behaviour is understood, another key area is the accuracy of other mHealth technologies when used for the treatment or management of other diseases.

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