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ABSTRACT
Personal information can be used to influence better decision making, change behaviour, and create an idealised self. With the rapid advancements of computer technologies, learning about one's self has become easier than ever before. A vast number of systems have appeared in recent years that assist users with collection, analysis, and presentation of personal information; however little work has been done to understand the needs of the users. In this paper, the underlying idea of Personal Informatics is explained, along with a look at some of the problems associated with existing Personal Informatics systems, and proposed design strategies and frameworks for a successful system. These frameworks are based heavily on behavioural and social psychology, with the intention of defining a system that is motivating for the user, easy to use, and easy to understand.

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Documentation, Design

INTRODUCTION
Humankind has a long history of striving to understand oneself. Ancient Greeks, while in search of answers, travelled to the Temple of Apollo, to be greeted by the inscription "Gnothi seauton", which translates to "Know thyself". Benjamin Franklin recorded which days he achieved one of his 13 virtues (temperance, silence, order, resolution, frugality, industry, sincerity, justice, moderation, cleanliness, tranquillity, chastity, and humility) over a 60 year period [5]. This need to understand one's own self exists to this day. Nicholas Felton, at http://feltron.com, has been recording personal information and constructing "Annual Reports" since 2005.

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The most common way to obtain this knowledge is to record information about oneself, including habits, thoughts, and behaviours, and analyse trends. With the advancement in computing, and ubiquitous technology in general, many applications, known as Personal Informatics systems, have appeared, such as Mint: http://mint.com, and DailyBurn: http://dailyburn.com.

Personal Informatics systems are tools used in this pursuit of creating an idealised self. However, current tools were not designed with sufficient understanding of the users' needs in mind [1, 2, 3, 4]. There is no widely regarded list of problems, and related solutions on which to base Personal Informatics systems. In this paper, we discuss a number of attempts at creating such a list and the resulting system frameworks. These frameworks are based on both behavioural and social psychology.

What are Personal Informatics?
Personal Informatics has been defined, in [1], as "an activity where people collect and reflect on personal data to gain a better understanding of their own behaviour". Personal Informatics is also known as "quantified self", "living by numbers", "self tracking and surveillance", and "personal analytics" [6, 7]. This means Personal Informatics systems are those that assist with the collection and self-reflection of this information.

This data can represent information from a vast collection of topics from both behavior (such as frequency of exercise), and physiological (such as blood pressure). Data can include a variety of different types, ranging from a number to indicate heart rate to a word or phrase representing the mood of a user. This data can be either quantitative or qualitative, meaning it may or may not exist in the form of numerical values. Additionally this data may be external information that the user expects to use to analyse personal information, for example the weather.

With such a diverse range of both topics and recordable data as explained above, personal informatics can take an unlimited set of values. This causes a multitude of problems for both recording and analysis systems. This paper will describe some of the fundamental problems with current personal informatics systems, and some of the research into these problems.

PROBLEMS EXISTING SYSTEMS FACE

To gain an understanding of some of the problems associated with personal informatics systems, we must first take a look at some of the current systems. Papers [1-4, 6-8] and [10] all analyse a number of existing Personal Informatics systems, with similar resulting.

With personal informatics spanning such a large variety of different problem spaces, from monitoring health conditions to number of calendar entries, an ever increasing number of these systems are appearing. However the majority of these systems were created with a limited amount of research into the requirement of the user.

One of the most noticeable limitations users face with existing systems is the restrictions placed on information display. For example, a user may be interested in long term trends, though the system may only display recorded data in the form of a spreadsheet, which is not ideal for user analysis. Additional to this is the lack of support current systems have for finding correlations between multiple types of data.

Another major issue that has been documented in [3, 4] and [10] is the lack of availability. Users find themselves having to record data by temporary means, such as writing on paper, or sending an email to one's self. With the advancements of mobile technology, this problem can easily be solved. For ideal ease of use a system should allow a wide range of input, including mobile devices through text messages.

[10] places analysis on information scraps, which are small pieces of information that a user deems to be either outside the scope of their personal informatics system or the scope for their problem space. The former is a well known problem, and is one most developers choose to ignore by creating systems tailored to specific needs. Systems that are designed for a wide range of data are occasionally found to be too cumbersome and confusing. The latter problem is known as the relevance problem and has been more or less solved with the improvements in ambient technology.

Drive and motivation is a key area of concern when creating Personal Informatics systems. As a user feels they have the knowledge to continue the processes the system has helped them develop, they use the system less, and often disregard them entirely [1, 4]. This can lead to a relapse to their previous behaviors. Placing a motivator as a pivotal element in a Personal Informatics system, such as a rewards system, encourages continued use and continued behavior change.

UNDERSTANDING WHAT USERS WANT FROM A PERSONAL INFORMATICS SYSTEM

Humans strive to become the best they can be, and we seek to assist this process through the creation of Personal Informatics. Becoming the best one can be requires work in a multitude of areas. Personal Informatics systems are tools used to assist this process. Understanding Personal Informatics is a key step towards perfecting the assistance.

Life Cycle of Personal Informatics

A user of a personal informatics system, electronic or otherwise, can be described as being in one of five stages discussed in [2] as the life cycle of personal informatics. These stages represent the user's correlation with their personal informatics.

The first step towards using personal informatics is having motivation. The preparation stage defines a user that is motivated to collecting data about one's self. This motivation can be influenced by a number of different sources, from self observation to social stimulus to medical advice. The latter is the most common source of stimulus for beginning self analysis and thus a large amount of research has been put into the field of health informatics.

The second stage is the collection stage. This stage involves the user collecting data about one's self. With the introduction of ambient technologies this process can be largely automated, however a sub-set of data, including mood, is either too difficult or too intrusive to extract in this way. As such Personal Informatics systems must be able to accommodate the near limitless set of data as mentioned previously. Users are also turned away from systems that cannot effectively manage the multiple types of information the user requires.

Once data has been collected for a period of time, the user enters the integration stage, where data is combined and graphed. Again, with the advancements in technology, this process can be largely automated, although there are still limitations on this process as some data, particularly qualitative data, can be difficult to analyse without user assistance.

After the data has been combined and/or graphed the user is able to reflect and analyse the data gathered. This stage is known as the reflection phase. Problems associated with the reflection stage are often passed through from the integration stage. For example, survey results from [1] highlight users' frustration with the limited views and outputs for information in current Personal Informatics systems. This can be due to a failure in either the integration stage, where the system abstracts the information too heavily, or in the reflection phase, where the system does not support functionality to display the information as the user requires. An analysis on user requirements for information has been evaluated in a number of papers [1-4], and will be discussed further in this paper.

The final stage is the action stage. In this stage the user chooses how to react to the information and analyse provided in the phase proceeding. This stage is critical for Personal Informatics systems, and in particular health informatics systems, that intend on modifying a users

behavior. From this stage a user can revert back to any of the previous stages and repeat the process.

By understanding each of the life cycle stages, we move closer to a system that is able to support the user's needs throughout the self-surveillance process.

Questions Asked About One's Data

[1] uses meta cognition in an effort to categorise the questions a user asks about their information. The majority of applications do not have sufficient output methods for user requirements, and those that do are considered overly complicated. Knowing the kinds of questions one asks about their data can assist Personal Informatics system by identifying and limiting the required types of output.

The types of questions are split into six categories: Status, History, Goal, Context, Discrepancies, and Factors. These types of questions define which sub-sets of data a user requires; recent or long term, internal or external, and any information to abstract or combine.

As an individual's understanding of the problem space changes, they transition between two phases of reflection, which fit into the reflection and action stages in the Personal Informatics life cycle mentioned above. These are the discovery and the maintenance phases.

The discovery phase describes a user that is unaware of how to accomplish a given goal. When in this phase the user tends to gather an excess amount of information as they are unaware of what they require to solve the problem. This is known as the relevance paradox, and is something ambient computing seeks to assist. To assist a user in this phase a system must be able to collect a multitude of data anywhere, anytime and frequently. Being able to present all types of collected data together will further help the user find the solution to the problem. Once this solution has been found, the user is able to transition to the maintenance phase.

When in the maintenance phase, a user is aware of how to accomplish their goal. This leads to a limited amount of analysis and often a drop in the amount of recorded data. During this time a user is more interested in their current progress towards goals. In the event the user is unable to reach their goal, or by other means, a user may transition back to the maintenance phase. Due to the possible drop in data collection it is important that a system supports continuous data collection regardless of how much is currently relevant to the user.

THEORECTICAL BASIS FOR PERSONAL INFORMATICS SYSTEMS

It is important for the designers of personal informatics systems to understand that behavior change is a long term process that affects multiple areas of a user's life. If done poorly this system and changes are likely to be abandoned; therefore a theoretical basis is required.

From a sample of 85 internet-based health informatics systems, and 43,236 participants, on average, those with a theoretical basis showed a significant effect on behavior change [8]. Theoretical basis refers to the theory on which a system is based. These theories are used to inform the developer about the constructs to target (motivation, self belief, etc.), the techniques for changing behavior (associative learning, conditioning techniques, etc.) and/or which participants will likely benefit from the system (those with negative attitudes, etc.).

Changing Our Behavior

Cognitive Dissonance Theory explains what happens when an individual realises their attitudes and behaviors opposes their self actualisation. As this dissonance is unpleasant, the user is motivated to reduce or eliminate the dissonance and therefore the adverse attitudes and behaviors [4].

[8] has concluded from meta analysis of multiple studies that of the theories in use, trans-theoretical model, social cognitive theory, and reasoned action/planned behavior are the three most commonly used, all of which and more are described in detail in [2] and [4].

The Trans-theoretical Model describes the five stages of change as pre-contemplation, contemplation, preparation, action and maintenance [2, 4]. These stages have been used in the development and understanding of the life cycle of personal informatics. Additionally the model describes which motives a system for target for a user in a given stage. For example a user in the pre-contemplation stage will favour a system providing education on the problem space, where as a user in the preparation stage will be more interested in barriers and pattern analysis [4].

The Social Cognitive Theory has been used for understanding long term changes to behavior with the fundamental principal being that behavior is determined through expectations and incentives [2]. An individual analyses the expectations of the environment (belief about connected events, and cause and effect), outcomes (how the behavior will affect others), and self-efficacy (competence), and weighs the results against the perceived value of the behavior (incentive).

The Theory of Reasoned/Planned Action has been applied to consumer behavior as it models the determinants of thought out actions. The theory uses three key elements to define these determinants of reasoned action; attitudes (what one believes about the behavior), subjective norms (the influence of others within ones environment with regards to the intended behavior), and behavioral intentions (a function of both attitude and subjective norms which predict the resulting behavior) [2]. This theory highlights the importance of others opinions in one's own decision making, and uses a weighting system to rank importance that final results in an expected bahvior.

While all the above mentioned behavior change theories have shown to have a correlation to effective health informatics systems [8], the theory of reasoned action/planned behavior has the highest correlation. As these theories are not required to be used in disjunction, it is often the case an intersection is used for the theoretical basis of a system, as was the case in both [2, 3] and [4].

Goals and Action Plans

Papers [1, 3] and [4] discuss the benefits of goal setting and in particular action plans to encourage corrective behavior change. In particular, with reference to health behaviors affecting health related issues. "By focusing on problem-solving and goal-setting, successful health self-management programs enable individuals living with chronic illness to identify and correct behaviors and habits which they judge to be inconsistent with their life and health ambitions" [3].

Goals are created by the individual, often with the guidance of a health professional. To be effective motivators, these goals need to fit what is known as the SMART criteria [9]. To fit this criteria a goal must be specific, measurable, accomplishable yet challenging, relevant, and timely. Once the overall goals have been set the individual then creates an action plan to help realise the goal.

An action plan is essentially a short term achievable goal used to help the user make informed decisions about their life style. Using these action plans as small progress markers is an effective motivational method. The concept of goals and action plans are often balanced with a rewards system to further promote its use, as well as providing an additional incentive to follow and achieve the goals and action plans.

FUTURE WORK

Of the referenced papers a number of them [1- 4] and [10] propose a framework or set of guidelines for building a Personal Informatics system. Each system draws on aspects from a wide range of social psychology models and theories. While the frameworks differ between the papers, the underlying goals are the same; increasing users' involvement, motivation, and various methods to maintain interest in the solution.

While [10] provides a definitive analysis on which theories have had the greatest impact in creating successful systems, it is not clear whether the implementation details are consistent enough to support the claims. Further research will need to look at the implementation details of these systems as many social psychology theories overlap and share fundamental values.

CONCLUSION

This paper defines Personal Informatics as personal information one uses to further understanding about one's attitudes and behaviors. Included is also a description of how a user interacts with their Personal Informatics and what questions they ask of them.

With the key to successful Personal Informatics systems lying within social psychology, outlines of the most widely noted social psychology theories, within the given references are provided; Trans-Theoretical Model, Social Cognitive Theory, and Theory of Reasoned Action. And a description their usefulness in relation to Personal Informatics systems is noted.

Additionally, the importance of motivation is included with the explanation of goal setting and action plans. With motivational elements coupled with social psychology, and knowledge of what users want and need, we have a successful basis for the creation of a Personal Informatics system.

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