

A SEMIOTIC ANALYSIS OF PERSUASIVE TECHNOLOGY

An Application to Obesity Management

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Abstract: The semiotic approach to information systems development has proved over the years as a reliable framework for analyses, and it has been mainly focused on the development of organizational information systems. However, the usefulness of the approach extends beyond the organizational context to other areas of systems development. This paper presents a semiotic analysis of persuasive technologies, leading to the design and implementation of a system for obesity management.

1 INTRODUCTION

Persuasive technology (PT) has opened new channels to the contribution and application of technology in the health sector. It is the use of computing technology for persuasive activities, mainly designed for social benefit purposes (Lockton et al., 2008), and its application areas range from healthcare to environmental issues. In healthcare, PT has been applied in areas of teenage pregnancy, STDs, weight management, and general wellbeing among others. Despite growing interests in PT and its potential benefits, it still lacks established methods to systematically analyse and understand the problem domain that leads to its effective and systematic development.

This paper explores the use of methods in organisational semiotics (OS) to design a PT, particularly for combating obesity and overweight conditions and to design a motivation technology to encourage overweight and obese patients on healthy eating and lifestyles.

In the next section, a review of literature on obesity and PTs is presented. This is followed by a descriptive analysis of weight management PT using the semiotic framework. The systems analysis section follows, and it focuses on requirement analysis including the stakeholder analysis and the design of a demonstrator system. Implementation issues were also discussed and finally the system was evaluated, leading to a conclusion.

2 BACKGROUND

Obesity is a condition in which excess body fat negatively affects one's health or wellbeing and it is diagnosed using the Body Mass Index (BMI) or the Quetelex index (WHO, 2000). Figures indicate that, currently 33.3% of the male population and almost 60% of female are unhealthily heavy, and nearly a third of boys and girls under 11 years will be overweight or obese in 2010. This increase is a result of unhealthy lifestyles of families; such as eating of unbalanced diet and engaging in less physical activities (Campbell et al., 2001).

As the years go by, human habits on food has been affected a great deal. This is mostly due to the abundance of food, and also it is available in more varieties than before. Food is cheaper, especially processed ones (Meikle, 2001). Marketing strategies developed by retailers encourage more consumption. In addition, with the increase of knowledge workers, people are made to sit by their desks mostly, resulting in the increased sedative activity.

Genes also plays a major role in obese conditions, as obesity tends to run in families. It is estimated that 19.8% of children living in households where both parents are either overweight or obese were themselves obese compared with 6.7% of children living in households where neither parents were overweight or obese (Jotangia et al., 2005). Obesity related genes affect one's eating habits and food metabolism which results in increased risk of obesity. However, people with

obesity-related genes are not destined to be obese; rather they have a higher risk of becoming obese (Bourn, 2001, WHO, 2000, Jotangia et al., 2005, Campbell et al., 2001, Kumar and Johnson, 2006) and thus needs to increase their activity levels.

Another key cause of the sharp increase in the adulthood obesity population is the increase in the childhood obesity. Research has revealed that most cases of childhood obesity develop to adulthood (Bourn, 2001) and this creates concerns on factors that cause childhood obesity. Parents serve as role models and influence the development of overweight and obesity at different stages of their children’s development; during gestation and infancy, toddlerhood or preschool stages and schooling age or early adolescence (Dietz, 1994). Hence lack of proper parenthood and lifestyle choices makes their wards become obese. As children become obese, they develop to adulthood with obese and overweight conditions in majority of cases. This situation creates a vicious chain and according to studies it is one of the most contributing factors of the increased in obese and overweight conditions (Kumar and Johnson, 2006).

2.1 Persuasive Technology Intervention

As the heat to curtail the menace increases, most interventions are geared towards providing tools, training and support to health professionals, youth institutions, schools and other relevant stakeholders. The focus is on combating the obesogenic environment, making healthier choices the most easy ones, creation of education awareness for all by putting in place practical, ethical and evidence based interventions across board (Jackson, 2006).

Like human persuaders, PT brings about constructive changes in many domains by designing applications intentionally to change attitudes and behaviours in a predetermined manner (this should not be confused with side effects of the use of technology, which are not usually intended). This is because computers are sometimes considered to be more credible than humans (Fogg, 1997) and hence a better choice for persuasion. They also present two ubiquitous trends which is converging and creating a new opportunity in preventive healthcare (Intille, 2004). The rapid improvements in mobile computing devices and the ability to carry these devices almost everywhere makes it possible for technology to be used for healthcare purposes at places where humans are not welcome (Fogg, 1997, Intille, 2004). The second property which is the ability to give real-time suggestions makes conveying of “just-in-time”

motivational messages possible. As such, the future of PTs in healthcare interventions appears to be bright. However, design issues are limitations to its success. As social animals, human’s attitude and emotion are unpredictable; it may be independent or dependent on a number of factors which are not easily determined. This presents a critical challenge to the development of PTs. To have a better understanding of how they should work, it is envisaged that semiotics can be used to analyse and make explicit some critical factors to be consider during analysis and design.

3 SEMIOTIC ANALYSIS

The application of semiotics presents an informative approach for the descriptive analysis and design of a weight management system. In general, there are three major approaches in the study of semiotics for information systems development, namely, knowledge-oriented, behaviour-oriented, and system-oriented approaches. This paper focuses on the behavioural approach.

Our ability to transfer knowledge depends on the use of signs which affects our behaviour (Andersen, 1990) and attitude directly. However, some research disputes that semiotics should not be considered as part of cognitive psychology and it puts it out of context in the enquiry into the work of the human mind (Jorna and Liu, 2008). That notwithstanding, the issue of persuasion is related to our intention, motive, behaviour and attitude, thus the consideration of signs as artefacts used in the transmission of knowledge and information is critical in the development of PTs and cannot be ignored completely. As such, an analysis based on the semiotic ladder introduced by Stamper (described in (Liu, 2000)) was considered at all levels and the following observations were made.

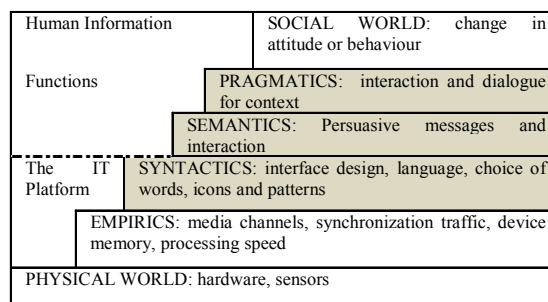


Figure 1: The semiotic framework of PT adopted from (Liu 2000).

3.1 Social, Pragmatic and Semantic

The social world deals with social norms and impacts of signs and their uses. How society accepts the use of a particular sign and its meaning, by considering both the direct and indirect effects. In the development of a PT the ability for the technology to create real effects in the social world, e.g., change of attitude or behaviour, is the primary interest in this level. In the case of obesity, some of the most important issues that affects the persuasiveness can be identified as, privacy, motive of design and legislature surrounding the healthcare industries. Most patients suffering from obesity and overweight conditions prefer to be anonymous due to the stigma attached to this unhealthy condition, thus the need to considered all these issues during the design stage is crucial.

At the pragmatic level, the design intention, and the communication methods is considered. Like human persuaders, a persuasive technology needs to adopt a strategy. It was observed that pragmatics mainly focuses on the primary task support (Oinas-Kukkonen and Harjumaa, 2008) and principles such as reduction, tunnelling, tailoring, personalization are some of the methods that can be applied to achieve the desired intention for the envisaged weight management system. Also, at this level, it seeks to identify whether the intended meanings of messages are understood effectively in the context of users. Different meanings can be given to the same sign depending on its observer. For example, a “do not eat now” message displayed to a user may have variable meanings depending on the time of display, how it is displayed and whom it is displayed to. When this message is displayed to a hungry user, he/she may see it more of a coercive message rather than persuasive, whereas the same user might consider it as a persuasive message if he/she just finished his/her lunch. By concentrating on dialogue support systems (Oinas-Kukkonen and Harjumaa, 2008) a good rapport can be established between the user and the technology which will enable the delivery of messages in the appropriate time to enhance systems credibility.

Whenever credibility is achieved, assurance is created and audience is established. At the semantic level, it is expected that the system conveys the persuasive message in a manner that is seen as the truth to the user. This can be achieved by the demonstration of facts which can also be associated with credibility. More important, is the relationship between the semantic level and the pragmatics level. In the case of the weight management systems, the

ability to establish credibility is crucial in the persuasive approach since users need systems they can trust. The use of convincing logics and demonstration of principles in weight management would enhance the credibility of the system. Design intentions and methods should be explicit and users should be made to understand the rationale behind the task they perform.

3.2 Syntactic, Empirics and Physical

As a persuasive system, the approach used may vary for each individual. As such, extra care must be considered in the selection of “language” and structure used. A clear and well organized formal language structure will enable the user to acquire and understand the persuasive message. However, the system should take into account all categories of users. The interface design for variable age groups must be considered, choice of words, icons and the way they are presented in order not to create ambiguity and distortion of intent, is very crucial. The interface structure, ease of navigation through the system and complexity of icons used are some of the few things which need attention at the design stage. Familiarity enhances motivation (Nass et al., 1995) since users will not need to study new task and activities in order to follow a PT System.

Empirics deal with the study of the quantitative and statistical properties of signs in the physical media. What is analysed in this level is how the data and information on which the persuasive messages are created are effectively transmitted to the interface. In this case of a weight management system, consideration should be given to the various media channels. For example, since it would be expected that users can access the system readily, internet and synchronization traffic should be considered if the system will operate over the internet. Also, mobile device have relatively less memory and slower processing clocks, thus the need to consider these factors at the analysis stage, as users will not be considerate and enthused with PT systems when they are uncomfortable to use.

The physical world concentrates on the physics of the envisaged system. In this case, our consideration is focused on the hardware that users interact with, which also processes and manages data. A critical attention is needed on the types of hardware which is to be used for the design and implementation. PTs are purposefully designed to motivate and persuade for attitude and behavioural change as such familiarity with the hardware is a key factor to the success of persuasion. As much as

possible, the use of a new hardware should be avoided unless it is essential. Also, since in some cases the ubiquitous nature of the system might have enormous effects on its use and success, there might be instances where there will be the need to introduce new hardware and this should be carefully thought through.

4 OBIMO PET DESIGN

The approach used for the requirement analysis process was a standard specification approach which elicits the requirements of all stakeholders involved (Shvaiko et al., 2005) in the development and usage of a weight management system. In this, a thorough review of literature on some existing systems, enabled the identification of relevant stakeholders and a familiarization process helped in the identification of key stakeholders whose interests are to be met, leading to the identification of relevant events and determination of inputs and outputs necessary for accomplishing those events. For simplicity, the activities were categorized into:

- Stakeholder identification, their roles and interest
- Elicitation and definition of software requirements

Stakeholders are individuals, organizations or group of people actively involved in a project and their interest can be positive or negative (Start and Hovland, 2004). Due to constraints on time and resources, it was not made possible to have formal interviews with stakeholders in order to identify their needs. However, extensive review on literature, case studies and casual interviews were used and the stakeholders were categorized based on the roles they play in the project. Figure 2 is a representation of stakeholder categorization.

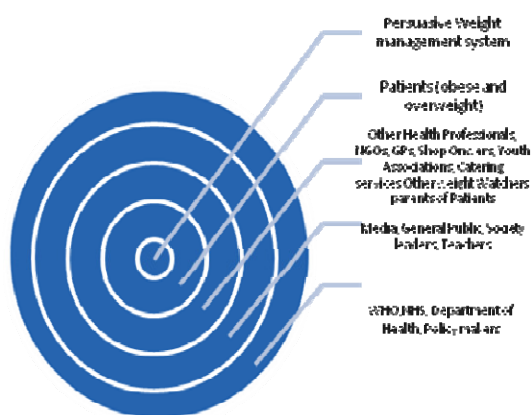


Figure 2: Stakeholder onion.

4.1 Stakeholders' Needs

Our study established that though there are various weight management systems in operation, they are not effectively utilized. This is because weight control issues are behaviour - oriented (Kumar and Johnson, 2006), however, most existing systems are not designed to motivate or persuade whereas stakeholders require an effective system with a persuasive functionality which shall able to:

- provide health status in terms of weight
- provide information on healthy food recipes
- be able to suggest healthy menus
- provide assistance to workout activities
- be easily accessible and readily available
- provide information on their performance
- motivate to control weight
- respect their privacy
- be easy to use

4.2 The ObiMo Pet Solution

In line with the need of stakeholders, a weight management system was designed to include motivational functionalities as required. The solution system was named ObiMo Pet, because it combines the catering of a Pet with an obesity control system. ObiMo Pet is a PT interface developed for PCs and Mobile devices to motivate and encourage individuals to follow and monitor their eating and physical activity. Figure 3 is an overview of the design concept. It comprises a virtual pet and the traditional weight management system. In the system, users are made to set their own goals and each time a user accomplishes a goal, points are allocated for the goal. The points can be energy points or reward points. Reward points are allocated for accomplishing food menu goals (calorie intake) and energy points are allocated for exercise and workout goals (calories burned). The user uses the accumulated points to cater for their virtual pet and the status of the pet in the ObiMo Pet Community (virtual community) is directly proportional to their performance in terms of weight management.



Figure 3: Overview of design concept.

Reward points are earned as a user set targets on calorie intake reduction, by consuming healthy but low calorie food. It is computed as follows:

$$\text{Reward Points} = ((\text{Target calorie intake} - \text{recommended calorie intake})/10) + (\text{target calorie intake}/\text{actual calorie intake}) \times 100$$

$$\text{Cash Amount} = ((\text{Target calorie intake} - \text{Recommended calorie intake})/10) + (\text{Target calorie intake}/\text{Actual Calorie intake}) \times 100$$

Where

$$(\text{Target calorie intake} - \text{recommended calorie intake}) \geq 0$$

This is because, users are not expected to set targets below the recommended calorie intake in order to lose weight, and since rapid weight loss has serious health consequences. Dieticians recommend that, calorie intake is based on the type of occupation and daily activity level and these values would be computed accordingly as a hidden feature in the system. This means that in an ideal situation, a user will earn 100 points for accomplishing his target as,

$$(\text{Target calorie intake} - \text{recommended calorie intake}) = 0,$$

and

$$(\text{Target calorie intake}/\text{actual calorie intake}) = 1.$$

Also, energy points are equivalent to the total energy burned, hence

$$\text{Energy points} = \text{total energy burned}$$

The reward and energy points are used for various activities in the ObiMo community and this enables the pet to gain higher status in the virtual community. There are 3 main factors which contribute to the status (rank) of a user's pet. These are the level of strength, happiness and health. The sum of the 3 factors compared to other pets is the rank of a user's pet. In each activity (e.g. play, bath, dance, shop, etc) some amount of energy is lost, and converted to points gained for performance (happiness, strength and health) summing up to indicate the status of the user's pet. In the real world, users save real cash when they eat less food and gain muscle strength when they engage in physical activities. This has been replicated as reward and energy points respectively in ObiMo.

ObiMo Pet is designed to operate on two different devices (PC and mobile devices). However, it is not necessary to own both devices in order to use the system, though a combination of the two devices is highly encouraged as it adds value to the persuasiveness and motivational nature of the system. The architecture of the system is illustrated

in Figure 4. The main database resides on a server which connects to users over the internet.

Users have client databases on their devices so as to enable them to use the system when it is offline. The system automatically synchronizes with the remote database whenever it connects to the internet. In addition, the mobile device can be synchronized with the PC to enable the user have full access to the system even without internet, though some functionalities such as "status in virtual community" is only active when there is internet connectivity.

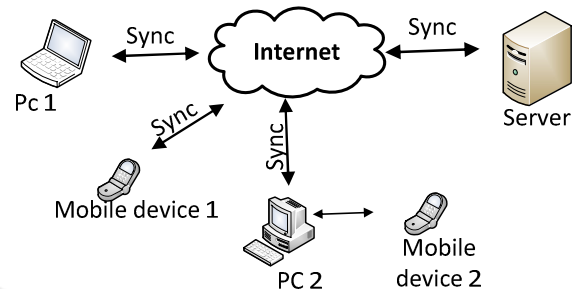


Figure 4: Architecture of ObiMo pet.

5 IMPLEMENTATION

The software was developed in a Visual Studio environment and the codes were written in Visual Basic. The rapid prototyping model was used and it involved the development and construction of prototypes, by merging various structured techniques to accelerate the software development (Whitten et al., 2000).

5.1 Hardware Components

The system was implemented on two devices; PC and mobile handset. The PC interface was installed on a system with, Windows Vista Home premium, Intel core Duo T8100 @ 2.1GHz, 2046MB of RAM and 250 GB HDD, WLAN. The mobile interface was installed on a Sony Ericson Xperia X1 with, Built-in GPS, USB support, WLAN, Microsoft Office Mobile, Internet Explorer, Windows Media, Exchange ActiveSync, Voice control and Utility Applications.

5.2 Software Components and GUI

As a PT, the interface is expected to be interactive, since it is to perform activities of a human persuader, there is a need for a high level of human-computer interaction. As such, the interface was

designed to be simple but interactive. For demonstration purposes, this paper presents a selection of screenshots for the mobile interface.



Figure 5: My Pet.

The system has features such as profile management, tools, pet selection, and activity predictions among others. For instance, the profile manager enables the system to capture useful vital statistics such as name of the user, address, type of occupation, gender, date of birth, vital statistics, among others. The system uses this information to create an account for the user. Most of the information provided is also used for accessing the user and calculating vital information which the system uses for its weight management approach. For instance, the type of occupation of the user enables the system to determine one's recommended calorie intake per day which is very essential for rewarding the person.

Figure 5 is a screen shot of the "My Pet" window for the mobile device. It can be observed that the system displays the status of the pet by showing the progress for the happiness, health, strength and the overall rank. In addition to this, a text to speech function recites to the user, the performance of his pet compared to other users. Users can also click to feed, shower or play with their pets. As mentioned earlier at the design stage, respective points are accumulated as the user interacts with their pets.



Figure 6: My Tools.

The tools window (figure 6) provides the user with a set of useful tools necessary in weight management activities. These functions includes, BMI calculator, BMR calculator, Performance charts, Calorie burned calculator, Personal calendar, and recipe manage, among other. For example, the recipe manager displays a list of meals and their corresponding recipes, hence users are provided with guidelines for preparing new meals whenever they are introduced.

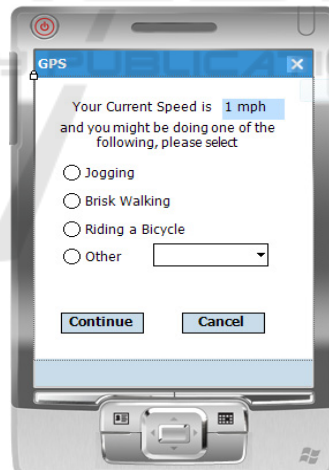


Figure 7: GPS System.

The mobile device interface also has an activity inference feature. This tracks a user's speed with the help of an in built GPS receiver and infers the possible current activity. When an activity is inferred, the user is made to confirm or select one of the possible activities (see figure 7). After which the user needs to input the expected duration of his selected activity. The system then displays his

expected calorie consumption. This facility serves as a self-monitoring system for the user.

6 DISCUSSIONS

As part of the objectives of the research, the proposed solution was evaluated. In the case of a persuasive technology, the appropriate method of evaluation should be to make the system accessible to a number of randomly selected people over a defined period of time. This will enable the identification of the efficiency and effectiveness of the system. However, due to limitations and constraints on resources and time, this activity could not be performed. Instead, the approach used was to assess the method of design and reflect on how it addressed the intended persuasion. One key characteristic of a persuasive technology is the ability to measure progress.

6.1 Intentions and Methods of PT

PTs should be assessed by their intention and methods and from a deontological viewpoint, the intended persuasions and methods need to be in accordance with moral principles by considering whether the technology or the methods used are harmful, discriminative or lead to the infringement on privacy. Also, during the analysis stage, at the semantic level, it was established that the intended meaning of a persuasive system should be made explicit.

The intention of ObiMo Pet was to motivate its users to control their weight by following through activities which are designed for weight management. It is clear that there is no hidden agenda and users of the system have full control of their lives. However, there might be the possibility that other unintended behaviours of a user may change as a result of using the system (microsuasion). For example, a user may start keeping pets or improve upon the way he interacts with his pet. Another aspect examined was system abuse. The interactive and gaming nature of the system might make a user be addictive to the system. This might end up in two possibilities:

- The user may learn to cheat the system in order to gain more point for the pet interaction. This will lead to the user not achieving his goals but rather using the system for a different interest
- The user may attempt to set unreasonable goals which might put his health in danger.

6.2 Privacy

Privacy is a delicate issue and it does not occur only in areas of persuasive technology. As identified at the social level, a persuasive technology should fit into social norms and ethics. Accordingly, the status and competitiveness of a user is transferred to a virtual pet and by this, the user remains anonymous to other users. In addition, users need to log into the system each time they use the system by entering a user name and password and this create restriction to accounts.

For the mobile device, due to convenience and screen size limitations, the login function was not implemented, however it is expected that users have full control of their mobile phones than they do for their PCs.

6.3 Implications of Semiotic Analysis

The semiotic analysis described in Section 3 highlights the issues that should be considered in the design of PT. In particular, since the purpose of PT is to create positive effects in terms of changes in attitude and/or behaviour, the analysis at the Social World level is crucial in achieving or evaluating the effectiveness of PT. While there are a wide range of systems and tools for PT developed and propose so far, these are often developed without any systematic approach. The semiotic analysis enables the designers to consider how the implementation of PT would lead to the intended effect through the analyses at each level of semiotic framework.

In the design of ObiMo Pet, the semiotic analysis was useful in considering design features. However, this was still implicit. There is a potential in the development of a PT design framework based on semiotic analysis to provide a more systematic approach to the design of PT.

7 CONCLUSIONS

This research has presented a conceptual design for persuasive weight management system (ObiMo Pet) to motivate users who are suffering from overweight and obesity to follow a weight management plan. It explained the significance of the semiotic approach in the analysis of the state and problem of obese and overweight conditions, and how it can be applied in the design of persuasive technologies.

During the requirement analysis relevant stakeholders were identified and their roles and impact in connection with the new system was

established. Though the system was partially implemented, it managed to explain the appropriateness of the conceptual design.

It can be recalled that during evaluation, it was established that users may be addicted to the interactive Pet and this may tempt to the user abusing or cheating the system. It will be of great interest if a function can be incorporated into the system to cater for this happening, i.e., to *dissuade* this behaviour. Also, the activity prediction feature of the system on the mobile device was limited, since GPS receivers are limited in terms of reception (cannot receive signals in rooms and buildings). However, different hardware can be used to detect movement or activities and this can be incorporated into the system to enhance self-monitoring.

Finally, there is a potential in developing a more systematic approach to persuasive technology design and development based on semiotic analysis. Such an approach would be necessary for further research into persuasive technologies.

REFERENCES

- Andersen, P. 1990. A theory of computer semiotics: semiotic approaches to construction and assessment of computer systems. *Computational Linguistics*, 18, 555-562.
- Bourn, J. 2001. Tackling Obesity in England. Report by the Comptroller and Auditor General. *House of Commons*, 220, 2000-2001.
- Campbell, K., Waters, E., O'meara, S. & Summerbell, C. 2001. Interventions for preventing obesity in childhood. A systematic review. *Obesity Reviews*, 2, 149-157.
- Dietz, W. H. 1994. Critical periods in childhood for the development of obesity. *Am J Clin Nutr*, 59, 955-9.
- Fogg, B. J. 1997. *Captology: the study of computers as persuasive technologies*, New York, ACM New York.
- Intille, S. S. 2004. A new research challenge: persuasive technology to motivate healthy aging. *IEEE Transactions on information technology in Biomedicine*, 8, 235-237.
- Jackson, A. 2006. Combating the obesogenic environment. London: Weight Management Centre.
- Jorna, R. & Liu, K. 2008. ORGANIZATIONAL SEMIOTICS Round Table Workshop 'An organizational semiotic view on interculturality and globalization' at the IASS 2004 Conference. *Relation*, 10, 7692.
- Jotangia, D., Moody, A., Stamatakis, E. & Wardle, H. 2005. Obesity among children under 11. London: National Centre for Social Research, Department of Epidemiology and Public Health at the Royal Free and University College Medical School.
- Kumar, H. & Johnson, P. 2006. *The causes of obesity - genes, behaviour and the environment* [Online]. London: Cancer Research UK. Available: <http://info.cancerresearchuk.org/healthyliving/obesityandweight/whatcausesobesity/> [Accessed May 15 2009].
- Liu, K. 2000. *Semiotics in information systems engineering*, Cambridge Univ Pr.
- Lockton, D., Harrison, D. & Stanton, N. 2008. Design with intent: Persuasive technology in a wider context. *Lecture Notes in Computer Science*, 5033, 274.
- Meikle, J. 2001. Action urged to cut the fat of the land. *The Guardian* [Online]. Available: <http://www.guardian.co.uk/society/2001/feb/15/publichealth.uknews> [Accessed February 15, 2009].
- Nass, C., Moon, Y., Fogg, B. J., Reeves, B. & Dryer, C. Year. Can computer personalities be human personalities? In, 1995. ACM New York, NY, USA, 228-229.
- Oinas-Kukkonen, H. & Harjuma, M. 2008. A Systematic Framework for Designing and Evaluating Persuasive Systems. *Lecture Notes in Computer Science*, 5033, 164-176.
- Shvaiko, P., Léger, A., Paulus, F., Rocuet, L., Nixon, L., Mochol, M., Kompatsiaris, Y., Papastathis, V. & Dasiopoulou, S. 2005. Knowledge Processing Requirements Analysis. *KnowledgeWeb*.
- Start, D. & Hovland, I. 2004. *Tools for policy impact: a handbook for researchers*, Overseas Development Institute.
- Whitten, J. L., Bentley, L. D. & Dittman, K. C. 2000. *Systems Analysis and Design Methods 5e*, McGraw-Hill Higher Education.
- Who 2000. Obesity: preventing and managing the global epidemic. *World Health Organization Technical Report Series*.