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Executive Summary

We present SleepTalk, a device which displays a households live sleep states to aid with everyday scheduling, interaction and communication. Initial investigation highlighted that there was little in the way of sleep interaction research in a social context though this would be an interesting path to follow, especially with the advent of sleep technologies which record live sleep data.

The aim of SleepTalk was to design, develop and use a Sleep Awareness System to answer the research question 'Could awareness technologies designed for sleep affect the behaviours, routines and closeness of a household'.

This was achieved by extensive research into the key areas; sleep, awareness technologies, situated displays and user study techniques. Participatory design was used to create the SleepTalk device and three, month long user studies were completed within cohabiting households of three to four occupants. Using significant data collation techniques to gather a large set of data and thorough analysis utilising qualitative analysis methods enabled the extraction of key correlations and theory proofs.

There are numerous elements to SleepTalk; software development is used to design and develop the SleepTalk device, design of the user study plans and documentation, testing, data collation techniques and data analysis to achieve results. SleepTalk is mostly investigatory with an element of software development.

In addition to the research review the SleepTalk system has been designed and developed it is an integrated system that utilises Zeo™ Sleep Coach Alarm Clocks to transmit live sleep data from a household of users to a central situated display within a communal area. This device was then utilised to complete three, four week studies of cohabiting households to investigate whether SleepTalk could facilitate changes in the household's interactions from the knowledge of participants sleep schedules. The data was collated by using key techniques gleaned from the literature review to harvest a large amount of data, including but not exhaustively surveys, sleep diaries and semi-structured interviews. This data was analysed in several ways, primarily typology and through constant comparison.

Five highlights of the project were:

- The creation of a system that utilised live sleep data to display sleep states to a household. It is a unique system that has not been investigated previously.
- Using participatory design to create the interface developed a simple, effective situated display that could be used by all.
- The research into user studies provided the project with a wide range of techniques that were extremely valuable for collating qualitative data.
- The ability to conduct a large scale user study across households having to install, explain and support was very rewarding.
- The results from the studies showed that SleepTalk is a worthwhile device to aid the sleep scheduling within a household by increasing intimacy, consideration for others and competition whilst maintaining the users privacy at all times.

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1 Introduction

Sleep is a fundamental and necessary part of our everyday life. The nature and quality of sleep affects our physical and mental health and is essential for normal functioning of all processes within our body. On average a human requires about 7 to 8 hours of sleep. Lack of sleep or poor quality of sleep can be lead to a broad range of detrimental outcomes such as reduced cognitive and physical performance, a weakened immune system, weight gain and reduced mental wellbeing.

With our increasingly busy lifestyles and juggling pressures of home and work life, the trends suggest that there is a rise in unhealthy sleeping habits with a growing number of people having reduced average sleep hours. In the US, for example, approximately 65% of the people stated having some kind of sleep problems with 44% reporting sleep problems almost every night resulting in symptoms close to insomnia (Robotham et al., 2011). People's concern with these issues is reflected in an every growing multi-billion dollar pharmacological market for dealing with sleep disorders.

Given these issues, we are also beginning to see a growing interest in exploring how technology can play a role in supporting healthier sleep behaviours. For example, there is a multitude of websites devoted to sleep "hygiene". More recently, various iPhone apps, such as EasyWakeup are appearing, allowing users to monitor and manage their sleep routines to varying degrees. Similarly, more dedicated devices are also coming to market such as the Zeo™ alarm clock. The Zeo allows users to see how long they spent each night in a certain sleep stage and gives users a sleep quality number from 0 to 120. Users can also use a dedicated website to keep track of their progress and receive coaching to maintain a healthy lifestyle through better sleep management. Similarly, the Philips" Wake-up Light©" is aimed at helping people wake-up refreshed in the arctic darkness, while the Zeo is marketed as an easy to use sleep education tool and motivational program created to help one understand how they are sleeping.

Broadly speaking, these technologies have typically focused on sleep as in relation to individuals and take a largely "corrective" approach to our sleep behaviours. In addition, these approaches tend to orient towards sleep as a purely biological and physiological concern. Such biological and physiological issues are undoubtedly important but as is being increasingly documented in the sociology literature, our sleep behaviours are also an inherently social concern. The when, where, how, with whom and why of sleep are intimately bound up with our social circumstances, our age, gender, work patterns, life stage, family relations and so forth. Our routines and rhythms are coordinated, and negotiated and influenced by our particular social relations and our particular roles within the home. This coordination and negotiation of sleep routines can be the source of many human values; intimacy, caring, security, as well as a source of tension and resentment. The politics of sleep within a household are bound up with the everyday management of social relations.

In thinking about sleep related technologies, then, we wanted to move beyond the individual, physiological and corrective concerns to think about how ways that enable people to position these factors within a broader social context. Technological work that orients to the social fabric of sleep behaviours is relatively sparse though some recent exceptions have begun to explore things from this social perspective. A good example, Kim et al. [INSERT ARE YOU SLEEPING] developed a network-enabled alarm clock that enabled distributed people to share their sleeping status within their social network. This work is principally aimed at facilitating intimacy and connectivity across distance and is a useful start in this area. But as the sociological literature has highlighted, there is a

much broader set of concerns that comprise the social nature of sleep behaviours. For example, much of the social of sleep can be found within household settings of families and cohabiters, such as parents coordinating their activities to accommodate their teenagers sleeping habits or young couples coordinating and dealing with sleeping difficulties of their new-born.

In light of the discussion above, we present a device called SleepTalk (see Figure 1).

FIGURE 1 - SLEEPTALK LOGO

SleepTalk is a situated display device that presents data from the respective Zeo™ alarm clocks of household members. The aim here is to provide members of the household with information about each other's sleep behaviour. By presenting it on a situated display in a communal part of the house, the aim is to make the sleep information visibly at-hand as a resource that can be appropriated and mobilised in the context of particular social relations in the household. The concerns here are more than the direct negotiations and coordination that might happen around household sleep patterns. Rather they relate how more general issues around the social configuration of household behaviours and rhythms may be revealed and discussed through the shared sleep data. In order to understand the ways that the device comes to be used, the values and implications of a household sharing their sleep information in this way, we present findings from a field deployment of SleepTalk in 3 households (cohabiters) in the UK.

1.1 Aim & Objectives

The aim of the SleepTalk system is to investigate how households communicate, participate, engage and interact with each other when live sleep data is available to them to assess the usefulness of awareness technologies in conjunction with sleep to support a household in their daily routines.

The focus of the SleepTalk Project split into two distinct areas, SleepTalk Development and SleepTalk Analysis.

1.1.1 SleepTalk Development

The development of SleepTalk was achieved through the following carefully planned objectives:

- **Literature Review** – To conduct a literature review to gain a full understanding of the area and review related work.
- **Prototype** – To develop a prototype of SleepTalk to feed into the main implementation.
- **SleepTalk** – To develop a complete system to aid with sleep interaction within a household.
- **User Participation** – To engage the users of SleepTalk at an early stage to ensure user compatibility.

1.1.2 SleepTalk Analysis

The larger part of SleepTalk was to review the use of the device and evaluate the benefits of such a system.

This was completed through the following objectives:

- **Pilot Study** – To conduct a week long pilot study to analyse SleepTalk, data collection techniques and users expectations.
- **Main Studies** – To conduct various four week studies with cohabiting households to analyse the use of SleepTalk.
- **Data Collection** - To utilise a variety of data collection techniques to ensure rich data.
- **Data Analysis** – To analyse the data to thoroughly understand the implications of SleepTalk within a household.

2 Background

2.1 Understanding Sleep

2.1.1 Introduction

SleepTalk is a device which utilises sleep to initiate interaction within a household, it is therefore important to understand the significance of sleep to a healthy lifestyle. The understanding of sleep stages are central as they will be used to distinguish the data to be displayed within SleepTalk. Sleep measurement must be investigated to ensure the SleepTalk implements measurement which is accurate and non-invasive.

2.1.2 Importance of Sleep

Investigating the effect of sleep will feed into the SleepTalk device and maximise the benefit of the system.

Sleep is vital to a healthy lifestyle and it is thought that good quality sleep is more important than healthy eating and exercise. We sleep for around a third of our lives (Robotham et al., 2011) so it is surprising that it has only recently become the UK Governments priority to campaign for a healthy sleep routine (Sleepio, 2011).

The sleep duration needed to awake refreshed is individual to a person, some people can survive on a very small amount of sleep, Margaret Thatcher stated that she could live on 5 hours, whilst some need as much as 12 hours a night; advice suggests 8 hours sleep is optimal (Council, 2007).

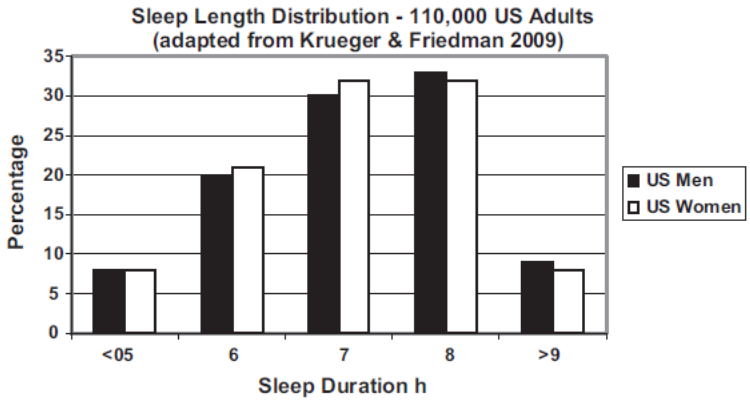

FIGURE 2 - US SLEEP TIME DIRECTLY TAKEN FROM (HORNE, 2010)

Recent research in the US of 110,000 adults found that an average person's nightly sleep duration was between 7 and 8 hours as per Figure 2, our individual research of 61 adults between the ages of 21 - 40, showed that the average sleep duration was between 6 and 7 hours (Figure 3), below the recommended amount, which correlated more closely to Groeger's research (Groeger et al., 2004) which found an average of 7.04 hours per night, it has been suggested that sleep durations are decreasing yearly (Horne, 2010).

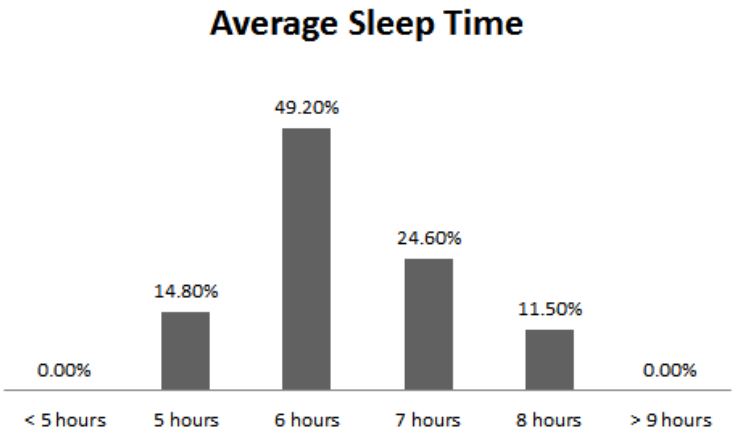

FIGURE 3 - INDIVIDUAL RESEARCH SLEEP TIMES, UK 2011

Sleep routines define two types of people, "larks" who wake up and go to bed early, and "owls" that prefer to sleep late and stay up into the early hours of the morning. Whether you are a lark or an owl is down to an individual's circadian rhythm, which is the body's own cycle which is just over 24 hours in length, this dictates when we feel tired and want to sleep.

The circadian rhythm is heavily influenced by the earth's sun cycle, with light encouraging wakefulness whilst darkness encourages the body to produce melatonin creating a feeling of sleepiness. In modern day, with the advent of shift work, transatlantic flights and erratic sleep patterns the circadian cycle is easily disturbed, or ignored. So strong is the connection that circadian rhythm sleep disorders are treated with light therapy (Mishima et al., 1994). Ubicomp systems are now being used to simulate light, such as Philips Wake-up Light, which uses light which mimics natural light to wake a user slowly and naturally, encouraging a healthier routine.

An extreme case is the 2010 Copiapó mining accident, which left 33 miners trapped for over two months underground; with the absence of light the miner's circadian rhythms would become out of sync. NASA advised that they split the area into daytime and night time areas (Robotham et al., 2011) to create a routine of sorts, with the miner's flashlights illuminating the daytime area.

As sleep is an essential process to repair and restore the body (Robotham et al., 2011) under and oversleeping has been associated with many issues, in the short term it can lead to loss of concentration, disorientation, and memory difficulties. In the long term it has been linked with depression (Riemann et al., 2001), anxiety, mental illness and in extreme cases death. Sleep deprivation has also been linked recently with the onset of cardiovascular disease (Wolk et al., 2005).

It is gradually being recognised that the general population are not fully aware of the importance of good sleep. This has been highlighted within the recent UK government sleep report which advises us on ways to improve our sleep patterns. National Sleep Awareness Week took place on (7 – 13 March 2011) and was devised to heighten awareness and educate people regarding the health benefits of sleep.

The research shows that a device which allows users to monitor sleep would be beneficial as individuals are becoming more aware of the benefits of sleep, and are looking to improve their sleep quality especially with increasingly busy schedules and conflicting routines

2.1.3 Stages of Sleep

An understanding of the stages of sleep is needed to ensure that SleepTalk takes advantage of the stages to highlight good quality sleep.

There are five stages of sleep, four of them are known as Non-REM (NREM) and then the fifth stage is REM (Rapid Eye Movement). Within NREM sleep there are two stages of light sleep and two stages of deep sleep, the brainwaves for these stages can be seen within Figure 4. Before entering any of these stages the brain produces brainwaves named beta waves, which are high in frequency and can be between 12 – 19 Hz and are known to be the brainwaves for wakefulness.

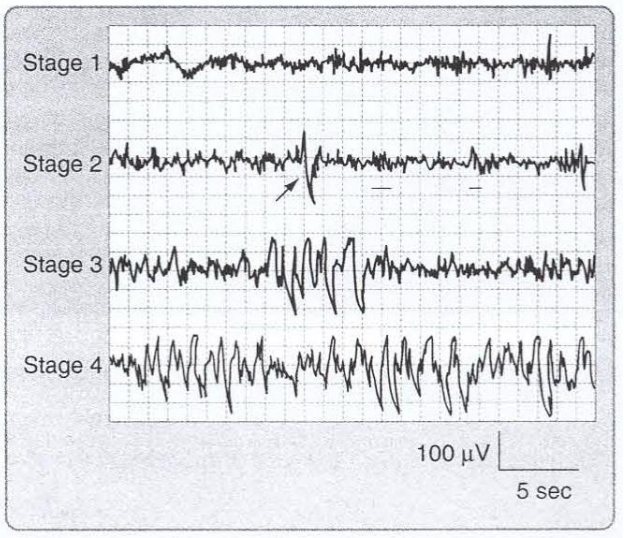

FIGURE 4 – BRAINWAVES OF SLEEP STAGES DIRECTLY TAKEN FROM (CARSKADON AND DEMENT, 2000)

During the night four or five cycles of the five sleep stages will normally be completed with stages 3 and 4 being the most important (deep sleep), as Deep Sleep is when the body restores itself and memories are sorted and stored (Robotham et al., 2011). Without Deep Sleep a person can wake up feeling unrested and tired.

- ***Stage 1 & 2: Light Sleep***
  Light sleep is the stage you enter when first falling asleep, it is not restorative and you can be woken very easily, the majority of a night's sleep is mostly light sleep. Light sleep is also associated with hypnic twitches / jerks which happen and your body feels like your falling (Robotham et al., 2011) then you wake up. Once someone has entered light sleep their

brainwaves adjust to theta waves which are slower than beta at a frequency of around 4-6 Hz.

- ***Stages 3 & 4: Deep Sleep***
  As a person's brain waves start to slow even further into delta waves this becomes deep sleep. This is your restorative sleep; which is needed to function fully in the waking hours. Being deprived of deep sleep can cause illness, and has been linked to depression and mental health (Riemann et al., 2001). The average person has around two or three rounds of deep sleep lasting from 20 – 40 minutes each night (Carskadon and Dement, 2000).

- ***Stage 5: REM***
  REM sleep is also known as dream sleep, or active sleep, it is named Rapid Eye Movement due to the reaction of a person's eyes within the stage. Other bodily reactions within this sleep state are; heightened blood pressure, quickening of breath and your brainwaves move up to alpha waves, which are similar to your brain activity when awake. Your muscles move into a state of paralysis which is due to the production of an amino acid called glycine (Obringer, 2005) this is sometimes why people experience Night Terrors. Individuals with chronic depression (Tsuno et al., 2005) have been shown to have excessive amounts of REM sleep and disproportionate amounts of deep sleep.

Our research has highlighted the importance of SleepTalk to indicate the current sleep stage to make the users aware of this, real-time sleep data has not been used before, so this will be unique to Sleep Talk.

2.1.4 Measuring Sleep

Measuring sleep can be accomplished in various ways; it is typically completed by monitoring a bodily response (biometric data). At the moment a person falls asleep (sleep onset) the body reacts in particular ways, the eyelids close, the eyes become still, the body stops moving (as the sleep becomes deeper), the heart rate slows, as does the breathing rate and brain waves go through four stages (alpha, beta, theta, delta).

These bodily changes could be used, in theory, to detect sleep onset and to monitor a person's sleep within real time. One research paper (Atienza et al., 2004) used the Nightcap® to detect slow eyelid movement which is associated with sleep onset to investigate the likelihood of an accident. Eyelid movement has been used previously within awareness systems such as Aura (Mhóráin, 2005) which utilised a sleep mask to monitor eyelid movement. For SleepTalk this measuring system would be too intrusive for users as they would need the sleep monitor to be placed on the user's eyelids. Also, eyelid movement does not detect a user's sleep stage, it can only detect sleep onset, so the only data we would be able to glean from this method is whether a user is awake or asleep.

Ogilvie (Ogilvie and Wilkinson, 1984) investigated whether respiratory rates could be used to detect sleep onset, this proved to be possible by measuring the rate of breathing, which slows and steadies as sleep onset occurs. Again, this method would be difficult to implement for SleepTalk, the only systems which monitor respiratory rates are sleep apnoea technologies (White et al., 1995) but these are very invasive. Again, this technique would only allow us to monitor whether a user was asleep or awake.

With the popularity of smart phones and their associated applications, there are now many sleep applications which are advertised as being sleep aids. One notable application is the iPhone Sleep Cycle Application (Tahnk, 2010). When placed under a pillow the application uses the pressure on the pillow to detect sleep onset. Movements during the night estimate the sleep stage and this data is recorded and displayed in graph form. Although this is a less invasive technology it is also unreliable as it uses pressure as a measure, pressure could be exerted in other ways, rather than the user actually being asleep.

FIGURE 5 - IPHONE SLEEP CYCLE APPLICATION DIRECTLY TAKEN FROM (TAHNK, 2010)

Extensive research has been completed using EEG (Electroencephalography) which uses sensors to monitor brainwaves by way of the scalp. (Kupfer et al., 1978) uses EEG to prove its reliance on detecting sleep disorders such as depression, whilst (Dement and Kleitman, 1957) uses EEG in conjunction with eyelid movement to detect REM Sleep among adults.

The Sleep Coach Alarm Clock (SCAC) created by Zeo™ uses a headband with EEG sensors to monitor sleep. This relatively new technology records four sleep stages: Awake, Light, Deep and REM and displays this data within a graphical display within the SCAC.

It is clear that EEG technology would be the most appropriate technology to employ for this project, as not only is it accurate, as it monitors brain waves; it can also detect sleep stages.

2.1.5 Conclusion

It has been found that sleep is fundamental to a healthy lifestyle, more so than diet and exercise and that this is something that has been highlighted recently by the UK Government as a priority. We now know that sleep quality can be understood by recording the sleep stages a person cycles through the night and that deep and REM sleep are the stages that correspond closely to sleep quality.

Sleep stages can be monitored using EEG technologies which record brainwaves, one such apparatus which has been created to do just that is the Zeo™ Sleep Coach Alarm Clock (SCAC). Utilising this technology is the most reliable way to measure sleep, it will also allow us to visualise the data.

2.2 Situated Displays

2.2.1 Introduction

Sleep Talk will use a situated display to convey at a glance information to a household, therefore it is important to look at the ways situated displays have been used in the past to influence SleepTalk's design. Situated Displays have become the norm within public areas and workplaces in recent times. Schemes such as the 'Big Screen Initiative' by the BBC, who erected Big Screens in all UK major cities have become commonplace. Workplaces now use situated displays to broadcast latest news and opportunities in shared areas, and doctor's surgeries use interactive displays to aid with their appointment services. We look at some prominent examples of situated displays to explore the techniques that will be harnessed by SleepTalk.

2.2.2 Workplace Displays

Workplace displays are used to convey information and promote collaboration within co-located work environments. SleepTalk is to convey at a-glance information to a household and will promote interaction, so it is important to understand how workplace displays have been used.

FrostWall (Kjeldskov et al., 2009) is a dual-sided frosted window used as a situated display which is sandwiched between a meeting room and a corridor. This wall allows employees to interact with the situated display in the meeting room or the corridor, exchanging notes and updating information. This is an interesting concept which highlights the need for co-located information exchange.

FIGURE 6 - FROSTWALL TAKEN DIRECTLY FROM (KJELDSKOV ET AL., 2009)

RoomWizard (O'Hara et al., 2003) employs a situated display that resides outside a meeting room. It solved an issue with people using meeting rooms ad-hoc, without using the booking system, this is thought to be due to employees observing an empty meeting room and taking this opportunity to occupy it. This was frustrating for employees who may have booked the room, as they found it difficult to move the meeting room opportunists once they were situated within the room.

RoomWizard's situated display allowed employees to see if the room was actually available, or booked at a-glance.

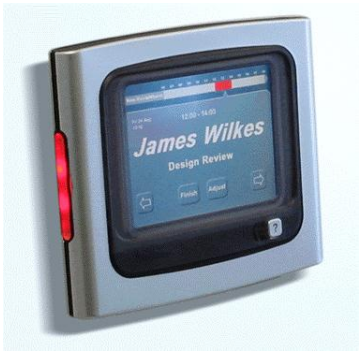

FIGURE 7 - ROOMWIZARD TAKEN DIRECTLY FROM (O'HARA ET AL., 2003)

The field study of the RoomWizard indicated that a situated display was a suitable method to investigate and manipulate individual's behaviours and social situations (O'Hara et al., 2003). As ad-hoc usage was a well-known area for tension within the office, and whilst the usage changed, an interesting outcome was that the users perceived future bookings to be more important than ad-hoc bookings. If a room was occupied after the allocated room time, other users would still be hesitant to book the room and then ask the users to leave.

Another offshoot discovered was that it also highlighted where individuals were within the vicinity if they were not at their desks, this was valuable as it was data that had not been previously available 'at a glance'.

The Newspaper project (Houde et al., 1998) created a newspaper type display which resided around the drinks area of a company, emails were sent to the newspapers email address and then displayed in the style of a newspaper on a situated display to employees. User feedback showed that the front page of the newspaper was regularly viewed rather than the clickable sections, pointing towards the notion of users wanting quick, easy access information, at a glance, rather than in-depth information. It was also noted that users read the front page, but not many employees' submitted stories, so it became more of an informative service than an interactive one.

The above three situated displays highlight the importance of co-located data visualisations, all displays use simple information to communicate and inform an audience and prove that employees value being able to access this data easily. The workplace displays show that SleepTalk should be easy to look at and informative without providing too much detail.

2.2.3 Public Displays

Public Displays have been used in the past to create a sense of community and to promote interaction. It has been proved (Brignull and Rogers, 2003) that users find it difficult to engage with public displays due to feelings of embarrassment, inhibitions, and due to the technologies being relatively new. Public displays are being reviewed to investigate the type of information that is displayed and how the public respond to this, this will support the choice of a situated display to convey the information to our household groups.

In the UK the BBC are making inroads into the acceptance of urban situated displays with their Big Screen Initiative, situating displays in all the major cities of the UK. They display most sporting events, continual news and special televised events. For instance, tea, cucumber sandwiches and cake were served whilst people sat on deckchairs within Millennium Square in Bristol to watch the Royal Wedding on mass.

FIGURE 8 BBC BIG SCREEN TAKEN DIRECTLY FROM (HTTP://ROHANTIME.COM/9267/THE-PROMS-ON-THE-BIG-SCREEN)

The BBC will also be showing the 2012 Olympics and have used the screens to interact with audiences for Comic Relief and Children in Need (Struppek, 2006). The popularity of the big screens within UK cities indicates that people are receptive to screen displays; it also confirms that SleepTalk should utilise a situated display. It also shows that using a screen to convey important information, such as breaking news, for peripheral viewing is highly effective.

The Wray Photo Frame (Taylor et al., 2008) used a situated display to evoke a sense of community as it is realised, whilst people may feel more connected due to the great many interactions within mobile phones and the internet, it does not replace the togetherness of being part of a community. The photo frame content was dictated by the people within the village and displayed in public locations where anyone could see it. The display received a positive reception with users exclaiming that it promotes a sense of community but also informs and welcomes new comers to the village (Taylor et al., 2008).

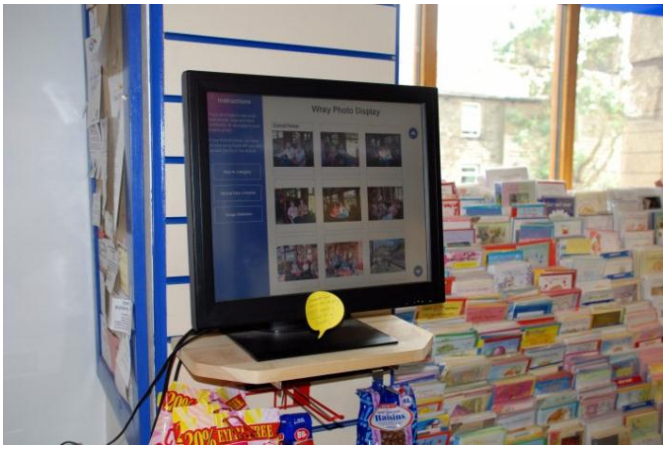

FIGURE 9 - WRAY PHOTO FRAME TAKEN DIRECTLY FROM (TAYLOR ET AL., 2008)

This type of application demonstrates the need for people to be kept informed to promote a sense of community, something that can be lacking within a modern household, especially if the householders are not closely related. This supports the theory that SleepTalk could encourage communication and a feeling of closeness with the participants.

(Odom et al., 2008) used competition within a large visual display to promote conservation of energy. The system used a bar chart to show which dormitory within a university campus was using the least energy, this visualisation encouraged participants to save energy.

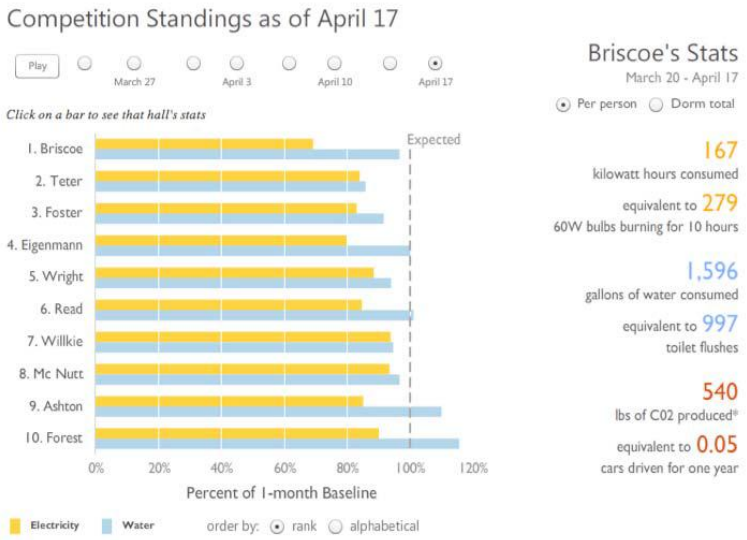

FIGURE 10 - THE DYNAMIC ENERGY CHALLENGE 08 EV DISPLAY TAKEN FROM (ODOM ET AL., 2008)

It was noted through the research that although the competition aspect was encouraging, it needed to be backed up with follow up data. For instance, if the dorm was losing, they would want to conserve more energy, but not know how. Giving the participants details of how they could do that meant they could try the ideas and see the results. Another consideration was that energy consumption is a very slow process so the bar graphs did not change quickly enough to inspire motivation within the participants. The idea of implementing competition within a visual display to bring about viable results, especially within the area of conservation of energy was promising; it is unfortunate that the visualisations were too slow to motivate the users.

Research into Public Situated Displays has highlighted that people now see public information displays as the norm and this indorses our indications that a situated display within a home environment would be well received. With Odom's (Odom et al., 2008) findings it also brings to light the aspect of competition, which could be integrated into SleepTalk to promote improved sleep routines.

2.2.4 Household Displays

There has been a small amount of research into these applications within a home environment compared to work and public displays.

FIGURE 11 - HOMENOTE SITUATED WITHIN A KITCHEN TAKEN DIRECTLY FROM (HTTP://RESEARCH.MICROSOFT.COM/EN-US/GROUPS/SDS/HOMENOTE.ASPX)

HomeNote (Sellen et al., 2006b) uses a situated display as a remote or co-located messaging system to inform household members of various messages. The display incorporates a mobile phone chip to allow users to text messages to the display, a user can also use an electronic pen to hand write notes onto the display. User testing highlighted seven types of messaging that a household used: Calls for action, Awareness & Reassurance, Social Touch, and Broadcasting Identity, Reminders, Passing on Messages and as an Information Store. The types of messages sent showed important information about the households bond and how the householders, in this case families, communicated, and their place within the household. This information is significant for SleepTalk as it demonstrates that valid data about a household's communication strategies and overall closeness can be alluded to via a situated display.

CommuteBoard (Hindus et al., 2001) is an interactive situated display which has the primary purpose of allowing co-located car share users to distribute their leaving plans. Users in different locations can write on the display and it is displayed in both households (see Figure 12). User testing found that the Commute Board was successful, it was considered useful but users commented about the lack of feedback within the interface, meaning that the users did not know whether a message had been received (Hindus et al., 2001). Also it was noted that the users self-time stamped the messages.

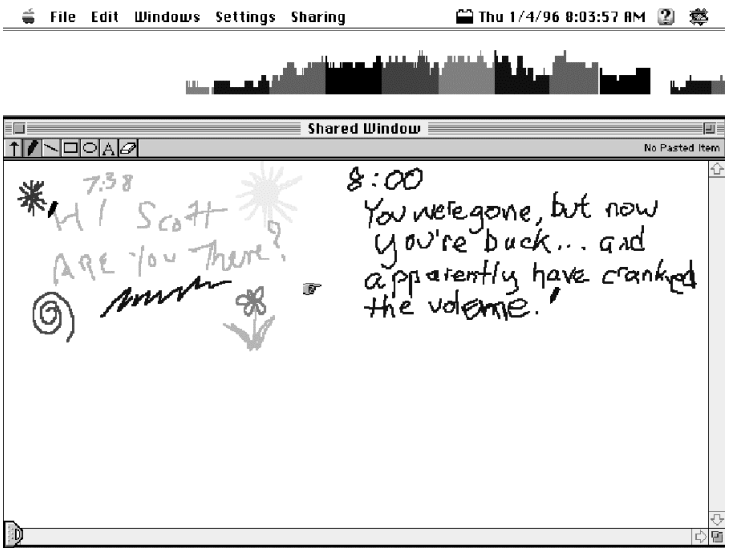

FIGURE 12 - COMMUTE BOARD TAKEN DIRECTLY FROM (HINDUS ET AL., 2001)

This system indicates that users are happy to use situated displays within their daily lives, this is positive affirmation for SleepTalk and indicates that as well as informing householders of the groups sleep data it would be a useful addition to include time data also.

The CareNet display (Consolvo et al., 2004) used a photo frame model to create a display which alerted caregivers to any missed medication, appointment or unusual behaviour that an elder may have experienced that day. This was designed to blend into the background and could be used 'at a glance' to indicate whether something out of the norm had happened as a red icon would show. The user could then get closer to the display to find out exactly what had happened. The users were given no instruction as to how or where to place CareNet and the majority positioned it within a shared, frequently used area of the house, such as the living room or kitchen.

FIGURE 13 - CARENET PHOTO FRAME IN-SITU TAKEN DIRECTLY FROM (CONSOLVO ET AL., 2004)

CareNet highlights another area which is important to our project, 'at a glance' information, whilst users will be informed of the sleep data this would need to be basic and large enough for a user to glance at the screen rather than the user having to give the screen their full sole attention.

It has been shown that the placement of household displays contrast with the placement of work displays. Whilst within a work environment displays need to be within areas with a large amount of thoroughfare, or within a hub like setting, depending on the information they are conveying (O'Hara et al., 2003), the specific placement can have dramatic effects on the usefulness of the information

displayed. For instance, the newspaper display (Houde et al., 1998) was situated in a social area of the workplace to ensure that work productivity was not diminished by the display and that it was viewed when the employee had time to peruse the information.

While a home situation is very different, a home is an individual space that displays the lifestyle of its occupants (Schmidt et al., 2007), this indicates that a home based ubicomp display would need to fit into a variety of homes. This will mean a discussion with each of the households within the testing of the situated display to ensure that the display is within the correct position.

Desirability of a situated display has become a priority with household displays. When situated in a home setting a display would need to integrate into the environment and be pleasing to the eye. The key to a successful device is to blend into the background rather than being the focal point of the room. This would allow us to convey ambient information in a way that does not draw attention to itself (Fogarty et al., 2001), but rather is noted through our peripheral vision.

We have learnt from the investigation of home displays are that they differ greatly from work or public displays in that they need to be useful to be utilised, they need to be placed carefully and they should also blend into the surroundings of the given household.

2.2.5 Conclusion

Using situated displays within a work environment has been shown to be successful as it allows employees to access information that may not have been available to them previously in a way that is quick and easy to understand.

Research into situated displays within public areas has highlighted that the general public are now accustomed to situated displays and use them to inform, and to entertain. They also allow users to congregate for a shared purpose, which seems to build a sense of community.

Whilst situated displays in a home environment are not currently commonplace, it is clear that there is a place for them, and that they offer a valuable service to a household by conveying information, co-location communication, and to provide awareness.

It is evident that SleepTalk would need to be situated within a communal area of a household that is agreed upon by the occupants. It is also noted that the display data will need to be visualised so that a user can gain awareness 'at a glance', rather than providing detailed information. From the research conducted it has been found that SleepTalk should be able to provide valuable information to a household without overloading the user which should promote communication and interaction.

2.3 Examining Awareness Technology

2.3.1 Introduction

SleepTalk would be categorised within a group of technologies known as awareness technologies which provide information and awareness in some way to users.

Awareness technology research has been focused on location awareness which is an area of interest to SleepTalk, as an offshoot of displaying live sleep data to a group will also give users the knowledge of the location of the users.

Another area for exploration is awareness for intimacy as we forecast that SleepTalk will stimulate a feeling of closeness between users. This is examined to indicate how this has been completed in the past and what results were produced.

2.3.2 Location Awareness

Location tracking devices are now within most mobile phones, specifically smart phones. GPS can be used to navigate a user home if they get lost, or they can use location services such as Facebook Check In to let your friends know where you are. Studies into location awareness are now moving towards individual awareness. This awareness encompasses more than a precise location for a person; it promotes a sense of connectedness within the people involved with the device.

One such device which deals with this area is the Whereabouts Clock (WAC) (Brown et al., 2007) which uses a clock type display within a shared area of a household to indicate the location of family members. The clock shows family members location in a broad range of "Home", "School", and "Work" and "Elsewhere", this ensured that the family did not feel that their privacy was being invaded.

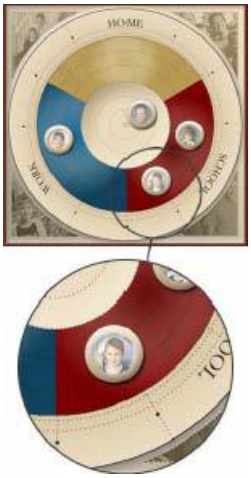

FIGURE 14 - WHEAREABOUTS CLOCK TAKEN DIRECTLY FROM (BROWN ET AL., 2007)

Extensive user testing found that the WAC produced a feeling of connectedness within the families tested (5 families) as they knew when their family members were on their way home they could 'put the kettle on' (Brown et al., 2007) or have dinner ready. These effects allowed family members to be reassured 'at a glance' of the whereabouts of the whole family and be assured that 'all was well'.

This study showed that as ubicomp technologies are evolving, an important area of research is within awareness, the awareness of location, or what an individual is doing, this information, displayed non verbally within a peripheral situation encourages togetherness, closeness and conversation.

2.3.3 Awareness for Intimacy

There has been substantial research into creating a feeling of intimacy within a couple, or group of people when they are co-located in a personal environment. This is an interesting area of research for SleepTalk as one of the outcomes of the data analysis will be whether SleepTalk affects the closeness of the household.

In studies made by (Lottridge et al., 2009) it was found that while there was a gap for technologies that promote closeness among the mundane moments spent on your own, individuals were looking for a presence that reassured them of their close ones while they were going about their everyday activities. Lottridge (Lottridge et al., 2009) used MissU (Mini interactive shared sound Unit) as a technology probe to collect data and inspire ideas about how couples could promote intimacy within the quiet times of their day. MissU uses a tangible interface and a song playlist for each user, when the user wants to feel more connected to their partner they will touch the device and it will play a song from their partner's playlist.

Aura (Mhóráin, 2005) implemented a sleep mask which monitored the users sleep, recording their quality of sleep by way of eye movement; the amount of times the user goes through the REM cycle dictates their quality of sleep. The data collated was then used within a music box to convey to their remote partner the quality of the previous night's sleep. While this is an attempt to think 'out of the box' to the possibilities of awareness technologies Aura does not seem to succeed in its realisation of sleep data and finds that emotions are not as easily conveyed as first thought.

Presence Light (Hindus et al., 2001) is a system of two lights positioned in co-located households to bring together a sense of closeness by illuminating when there is movement or sound in the connected household. Although this seems like a good idea, care is needed when designing the light transitions as this could be quite distracting and could become the focus of the attention instead of staying on the peripheral.

It is clear that there is scope to explore the effect of an awareness system on the closeness of the users of SleepTalk but it is difficult to get the balance right. This data will be taken forward to aid with the development of SleepTalk and supports the theory that a situated display, rather than a tangible object would be the most appropriate approach to display the sleep data.

Research shows that users preferred simple asynchronous systems than multimodal interactions. Key findings are that these household appliances were well received, there were privacy concerns around informing people of real time (live) data at all times (Kim et al., 2008), as this was found to be intrusive to some people. It was also noted that as the information was basic, the users did not feel that it was an evasion of privacy, but that this is a fine line and care needs to be taken when designing social household systems.

2.3.4 Conclusion

Whilst Awareness Technologies are breaking the mould when it comes to unique solutions to awareness issues, it is clear that these techniques are in their infancy and it would be beneficial to this project to take heed of these issues. The research results have confirmed that awareness technologies can promote closeness, community and behavioural changes. It has also been proved that awareness technologies can be used to alter behaviours within a group situation; they can encourage intimacy and communication which is of interest to this project. It encourages the theory that sleep data awareness can have an effect within a household.

2.4 Investigating User Study Techniques

2.4.1 Introduction

One can create a usable visualisation, but this is of no use if the data collected using the system is of no relevance, or is not valuable, therefore it is paramount that the field study techniques employed are valid and of interest. This is difficult due to the nature of the issue, it is not something that can be quantified so qualitative data will need to be gathered and analysed.

User studies are appropriate for investigating SleepTalk and the benefit of its use as they are designed to be used within their usual environment, for instance, a system which supports an employee through their work day needs to be tested in the work environment to gain any valid data.

This was proved by Consolvo who compared traditional HCI (Human Computer Interaction) techniques (Consolvo and Towle, 2005) with what they called an 'in-situ' evaluation (user study). This was completed using the CareNet display (Consolvo et al., 2004) and proved to be a valuable technique to evaluate usage.

2.4.2 User Study Period

The user study period is an important aspect of the design of the application as the duration needs to be long enough to collate the data necessary but not so long as to deter potential users.

Consolvo used the study period of 3 weeks (Consolvo et al., 2004) over four households, whereas Kim (Kim et al., 2008) started their sleep alarm clock study as two weeks and found that was not long enough to collate the amount of data needed to conduct a reasonable analysis, so it was lengthened to three weeks. The Whereabouts Clock (Sellen et al., 2006a) chose to use a six week trial and an eight week trial (Chetty et al., 2010) was used by Chetty, these durations would gather more data but would possibly be infeasible for SleepTalk due to tight timescales.

Kim (Kim et al., 2008) and Sellen (Sellen et al., 2006a) also used a Pilot Study before the actual user studies which proved to be effective at ironing out any issues before the test period.

It was therefore decided that a three week study would be optimal, with allowances being made for the holiday season; this would be lengthened to four weeks.

2.4.3 User Study Plan

A user study plan should be formulated to ensure that the right type of data is collated during the user study period.

An example of a good user study plan can be found within (Chetty et al., 2010) where they used an amalgamation of techniques. The users were taught how to use the software, they were given technical support and troubleshooting guidelines and within the initial visit, the display screen was located in an area chosen by the household.

They used weekly interviews and paper diaries to collate information during the user study process, it was found that this steady contact nurtured good relationships between the testers and the users and allowed for free flowing discussion.

The evaluation of RoomWizard (O'Hara et al., 2003) also conducted a user study, their approach chose to interview employees before the deployment of the system to gage current practices. They

implemented paper journals for the duration of the user study and based weekly interviews on the journal contents.

Within the BuddyClock study (Kim et al., 2008) they used semi structured interviews at the beginning, middle and end of the study period. They also had a setup day and training session as did other studies.

It is clear from the research that a variety of techniques need to be employed to gather a large amount of relevant data for data analysis. For this project we will use semi-structured interviews at the beginning, after each week and at the end of the period. The interviews will be semi structured so that any relevant data that comes to light during the interview can be followed up. There will also be a focus group so that the testing group can discuss their findings together as this may bring up areas that individuals had not thought about. Users will also complete paper journals which will contribute to the semi structured interviews and focus groups.

2.4.4 User Input

A central focus of UbiComp applications is the need for user input for the design of a system. As the system is to integrate into their everyday activities it is very important to involve the user from the start.

This approach was taken within (Redhead and Brereton, 2009) an interactive display within an Australian village that the called the Nub (Neighbourhood Hub) which detailed events happening within the community. Upon each new version of the device feedback of the design was given and the new version would reflect this feedback. Not only did this make the display feel like it was owned by the community it also encouraged discussion between the community, which is something that has not been the focus of urban displays previously.

Although this approach is advantageous, it is unfeasible within the projects timescales. User Input has been considered and will be used to help with some design considerations within the early stages of the project.

2.4.5 Conclusion

Research into user study techniques has focused attention on the various ways in which data can be collated, it has also indicated timescales to deploy an effective study. The investigation has been the deciding factor as to how this project will conduct its user studies.

The studies will be of four week durations with one pilot study of one week within the initial user household. The study plan will include an initial survey, interim and final semi structured interviews, a final focus group and daily diaries as through our research it is clear that these are the most effective forms of data collation. A combination of data collation techniques and a reliable test period is vital to the success of the SleepTalk evaluation. Employing the right techniques at the right time ensures valuable data is collated.

3 Related Work

Research into sleep data is limited, though there are some notable examples, they all use user inputted data rather than real-time (live) data. Research is also limited to the use of alarm clocks as the instigator of the data transmission, which has been thought to be the most sensible application to use as a user will normally use an alarm clock in their daily life.

Users were asked (Kim et al., 2008) to use a mobile phone alarm clock named 'Buddy Clock' to notify co-located users (a group of friends) of their sleeping habits. This used perceived data to provide sleep information as it was felt that the user should be able to be in control of the data they transmitted. Users notified friends that they were asleep by setting their alarm.

The alarm clock gave the following three states: Alarm set - user asleep, alarm on snooze – user still asleep and alarm off – user awake. The statuses are conveyed by the use of smiley faces.

FIGURE 15 - BUDDY CLOCK TAKEN DIRECTLY FROM (KIM ET AL., 2008)

The alarm was chosen to alleviate any privacy concerns; a user could decide whether or not he / she wanted to participate.

The study found that knowing friends sleep schedules had many effects on their relationships and behaviour. Users questioned their own sleep patterns (going to bed too late) couples virtually synchronised their sleep times and users noticing a change in sleep patterns felt concern for the user and called them. All participants said that the system effected their decision as to whether to contact the person or not.

This is notable for our project as it suggests that there is the ability to change user's behaviours and communication strategies by conveying other users sleep data.

The Networked Alarm Clock (Schmidt, 2006) used a mobile alarm clock to dictate when a user woke up. Utilising other users sleep patterns to command their own sleep times, this was created by setting an alarm to wake a person at a certain time, such as the same time as their partner, or once 90% of the users were awake. This idea is useful as it investigates the need for users to conform to social norms within their sleep patterns, wanting to wake at the same time as their peers rather than their own selected time.

The connection between sleep data and awareness within groups is a small research area but it is felt that this presents a unique opportunity to take this research further by implementing a system that utilises live sleep data.

4 SleepTalk Design

SleepTalk is a situated display system designed to support awareness and conversation around sleep between members of a household (see Figures 1 and 2). The system consists of a large display placed in a communal space of the house – like the kitchen or living room, and an interface to each user's alarm clock in their respective bedrooms.

The design of the situated display was guided by certain principles derived from the situated display literature and adapted for supporting sleep related context. The primary purpose of the display was to provide awareness of each other's sleep state while at the same time supporting conversations through careful examination of the data streams. So the display was designed to support information at a glance from far and closer examination of specific data streams. The display was always ON but users could only access the display when they were physically in the room. The display could be accessed remotely, but care was taken to ensure that no personal information was included to protect user's privacy. The display was positioned in such a way that it becomes part of the routine life of the family.

SleepTalk was designed by gathering information from a set of users (61 participants) to indicate the sleep data they would most like to see within the display.

Research into how to create a system that is easy to use for all users was conducted at every stage of the development; this led to a design which would be light on the user's involvement. This meant that users were more inclined to use SleepTalk daily as it did not interfere with their daily routine.

4.1 SleepTalk Situated Display

The design of SleepTalk's situated display was developed through three inputs, the initial research into situated displays and awareness technologies, secondly by way of questionnaire asking users opinions and thirdly, the interface was amended during the study to suit the user's needs.

Initial research indicated that situated displays are most appropriately used for peripheral information (Fogarty et al., 2001), this also creates a device that would then be classed as an awareness technology. With this in mind the display was designed to be simple with basic information; real time sleep status, alarm set time and ZQ Sleep Score, and see Figure 16.

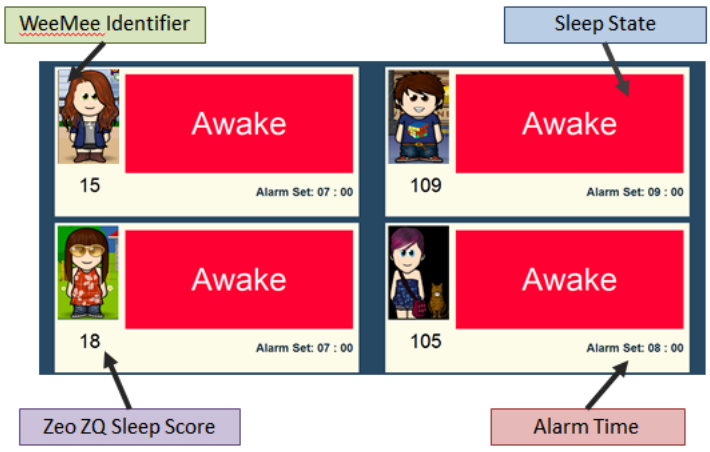

FIGURE 16 SLEEPTALK SITUATED DISPLAY

The initial interface was designed with four distinct areas, as it was known that the interface was to support groups of 3 – 4 people the display was split into four segments.

WeeMee Identifier – The WeeMee identifier, which is an avatar which is created by an individual, was used to ensure anonymity of the users as it was felt that a photo would be too personal whereas a symbolic picture would not identify the user easily enough. With the WeeMee a user could glance at the situated display and see each user clearly.

Sleep State – The sleep state wording was taken directly from the wording within the Zeo Alarm Clock, this ensured that the users would not get confused when using the clock and the situated display. The colour of the sleep state block was taken from the initial questionnaire completed by 61 respondents recruited via Facebook, where they were asked: If you were able to represent the four sleep stages by a colour, please which colour you feel is most appropriate, figure 17 indicates the results.

	Red	Blue	Green	Yellow	Response Count
Awake	**45.9% (28)**	14.8% (9)	19.7% (12)	19.7% (12)	61
Light Sleep	8.2% (5)	24.6% (15)	18.0% (11)	**49.2% (30)**	61
REM Sleep	11.5% (7)	27.9% (17)	**37.7% (23)**	23.0% (14)	61
Deep Sleep	29.5% (18)	**37.7% (23)**	29.5% (18)	3.3% (2)	61

FIGURE 17 SLEEP STATE COLOUR RESULTS

Zeo Sleep Score (ZQ) – The Zeo Sleep Quality Score was included within the interface as from the initial research it was found (Odom et al., 2008) that competition could be used to motivate users. The most optimal data type for this purpose was the ZQ Score.

Alarm Time – The alarm clock time was included in the interface as the initial questionnaire found that this was the most important piece of sleep data for other users within a household with 34 out of 61 respondents requesting this information. It was also seen to be vital for household scheduling.

The initial interface was used for the pilot study and was amended from user feedback within the main user studies.

The first amendment was to the sleep states due to feedback from the users such as; P5 (User Group 2) stated P6 '*always goes to bed quite early and even though he's gone to his room we have no idea if he is trying to sleep or not*' and P4 (User Group 1) said '*it would be nice to know if people are using the device or not as if they are just in their room I might not keep quiet, or might know that they are out of the house.*'

To address this issue a new sleep state was introduced ‘Not In Use’ which indicated that SleepTalk was not being used, the sleep state ‘Awake’ would only display when a user was trying to sleep, but had not yet fallen asleep.

The next improvement to the interface was that of historical data to add depth to the situated display. From initial research it was found that users would like to see their housemates various sleep states, i.e. a graph of their housemates sleep states, but during the first weeks of the user studies this data was contradicted. Users were given access to each other’s sleep data, though through interview and sleep diaries it was found that none of the participants accessed this data. What was clear was that conversations centred on users ZQ Score, so it was decided to include a graph of the historical ZQ Scores within the situated display. Figure 18 shows the final version of the situated display.

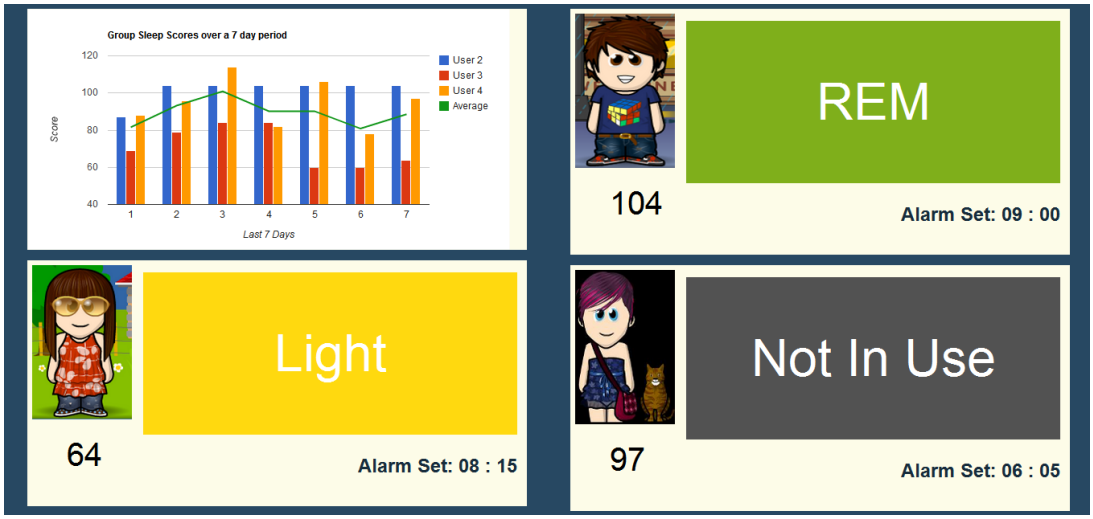

FIGURE 18 COMPLETED SITUATED DISPLAY

The historical graph was for the last seven days and could be hovered on to obtain more detailed data about the ZQ Sleep Scores such as actual sleep score

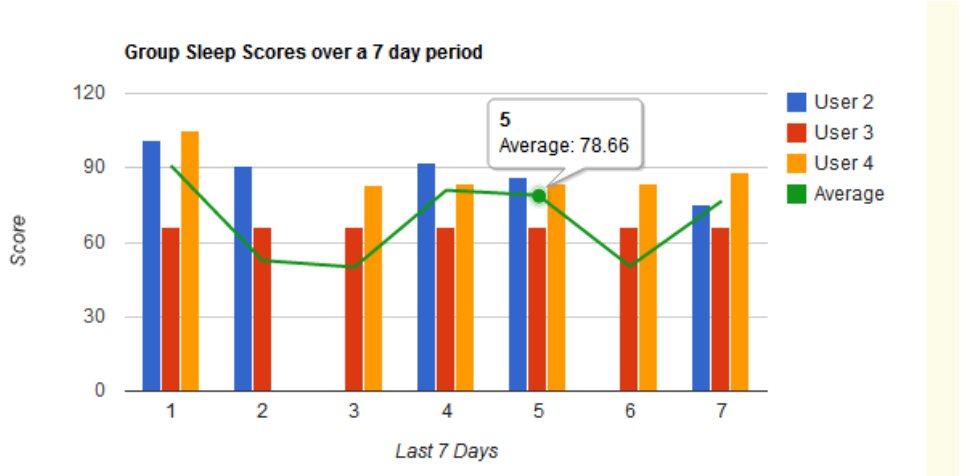

FIGURE 19 SITUATED DISPLAY GRAPH WITH INTERACTIVE DATA

4.2 Interface Positioning

As can be seen from the research the majority of the situated displays used have been monitor size, with exception of the BBC Big Screen Initiative. Whilst a larger display was contemplated for SleepTalk it was realised that as an awareness technology it would be more beneficial to have a smaller screen that could be integrated into the surroundings. A 15 – 17 inch screen would be optimal to blend into the natural surroundings but also to enable users to obtain information 'at a glance'.

4.3 Feeding into the Situated Display

SleepTalk's structure was divided into two key areas, the alarm clock linked with the user's personal interface and the situated display itself. Each component was researched and developed as an integrated system to ensure compatibility and usability.

The overall structure of SleepTalk is detailed within figure 20, where it can be seen that all individual alarm clocks feed into the central situated display.

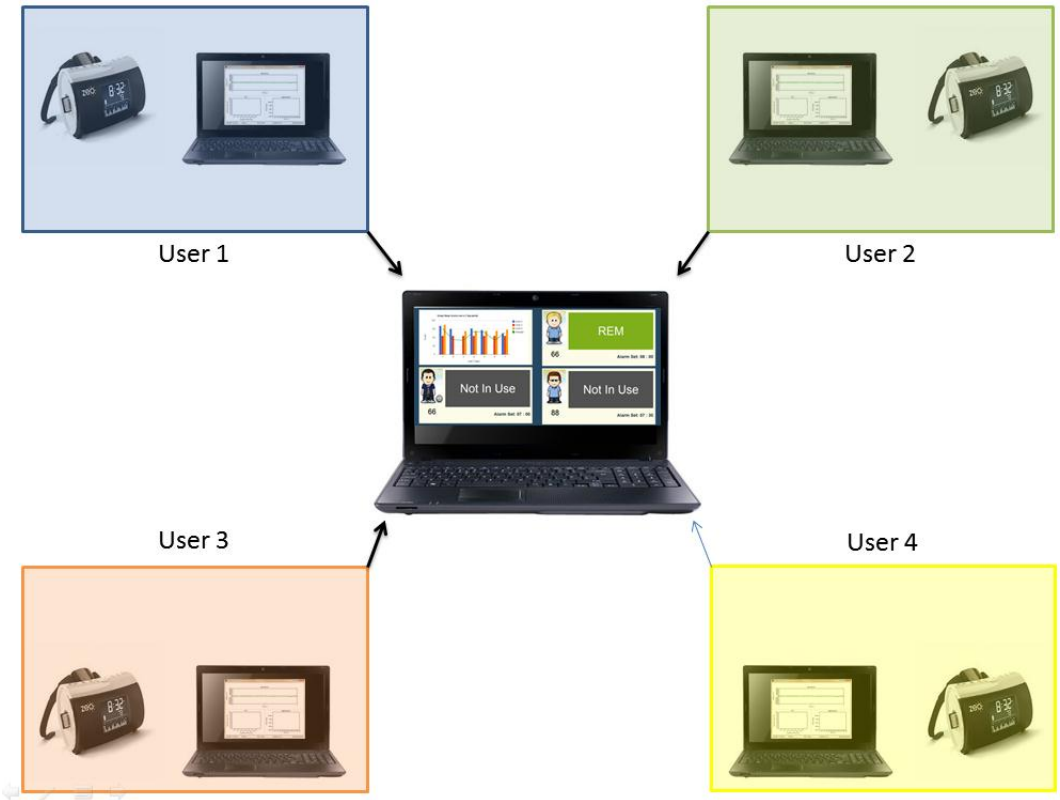

FIGURE 20 - SYSTEM STRUCTURE DIAGRAM

4.4 Alarm Clock

We had access to twelve Zeo™ Sleep Coach Alarm Clocks (SCAC), they read a user's brainwaves by way of a sensor headband which is worn during the night (figure 21).

FIGURE 21 THE ZEO HEADBAND TAKEN DIRECTLY FROM ZEO.COM

Data is taken from the sensors within the headband and transmitted to the clock itself, saved on a SD Card. This data can be viewed on the SCAC interface (figure 22) or the sleep data can be uploaded to Zeo's dedicated website.

FIGURE 22 ZEO ALARM CLOCK INTERFACE (HTTP://WWW.POPSCI.COM/GEAR-AMP-GADGETS/ARTICLE/2009-06/ROUGH-NIGHT-TRY-BEDSIDE-BRAINWAVE-SCANNER)

Research into how to take the data from the SCAC to a central server was conducted to establish how the connections would be made.

We established at an early stage that it was not feasible to take live sleep data and historical sleep data from the SCAC within the same method, and that the data could not be transmitted wirelessly to another device. This led to the exploration of separate methods to extract the sleep data.

4.5 Prototype

Part of the investigation incorporated creating a prototype of SleepTalk to assess the most fitting method.

The live sleep data was taken from the SCAC by utilizing a Zeo Python library, known as the Raw Data Library (RDL) which is in its Alpha (testing) stage. The RDL accesses the clock data by way of a bespoke wire (figure 23) that had to be built to connect to the serial port at the back of the SCAC (figure 24).

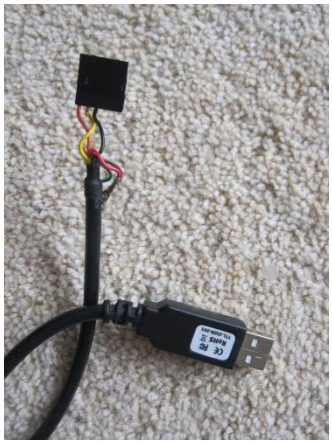

FIGURE 23 BESPOKE SERIAL PORT WIRE

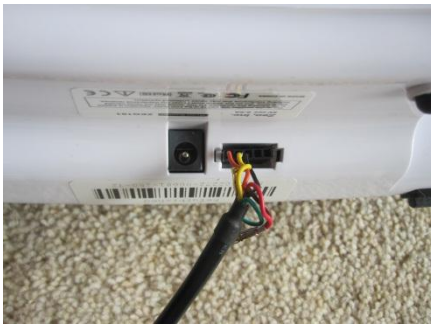

FIGURE 24 WIRE CONNECTED TO THE SCAC SERIAL PORT

The live data that the RDL detects and can transmit are:

- Headband undocked – This event is triggered when a user takes the headband from the charging dock.
- Night start – when a user has been wearing a headband for a certain amount of time the SCAC assumes the user is ready for sleep.
- Sleep Onset – This event is triggered when the user has moved into one of the sleep stages.

Secondly the RDL reads the brainwave type of the user: Delta, Alpha, Beta (three frequency stages), Theta and Gamma. These frequencies are used to establish the stage of sleep the user is at. This is then defined by the alarm clock as the following sleep stages:

- Undefined
- Awake
- Light Sleep
- REM
- Deep Sleep

The SleepTalk prototype used Python to take the live sleep data (time and sleep state) convert it to a readable format, append a file and upload the data every time the state changed to a central web server. This data could then be read from any location.

The historical data; alarm set time and ZQ Score could be accessed using a java alpha library named the Data Decoder Library. This library extracts the encrypted data from the SD Card, decrypts and converts the data to a comma separated file. The prototype used Java to perform the extraction, format and transfer of data to the central server.

4.6 Prototype Testing

On testing of SleepTalk the users found that using the Python implementation and the Java implementation proved confusing. This is due to the fact that the user had to upload the ZEO.DAT (from the SD Card) every day before starting SleepTalk; they also had to ensure the file was saved in the correct place to ensure the Java implementation could find it. This was decided to be unmanageable for the users and work went into finding a method to integrate the two implementations.

After extensive research it was noted that the systems could only be integrated by converting one of the alpha libraries to another language, or by creating a shell script to start one of the implementations automatically. This did not address the issue of uploading the SD Card data every day, and after discussions directly with the Zeo™ it was confirmed that historical data could not be extracted by another means.

Therefore, a new way to collate the historical data was needed.

4.7 Main Implementation

The main implementation of SleepTalk consists of the live sleep data software which includes a GUI (Graphical User Interface) see Figure 25, which gives the user feedback to confirm the software, has started correctly once initiated.

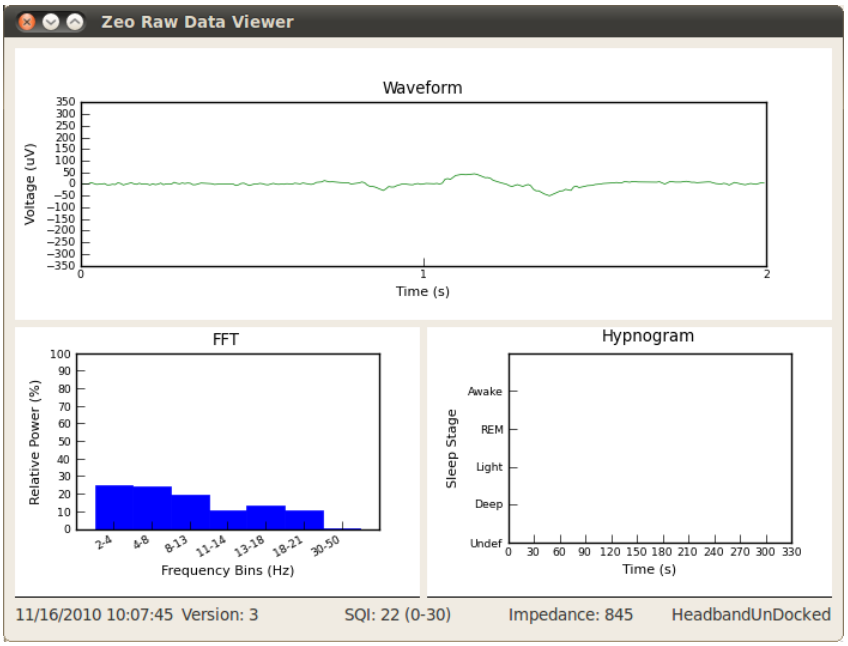

FIGURE 25 ZEO RAW DATA VIEWER

To solve the issue of the historical data a web based update form was created using PHP which the user could complete each day, see figure 26, this form was seen to lighten the load on the user as it was quicker to complete than uploading the data from the SD Card.

FIGURE 26 SLEEPTALK UPDATE INTERFACE

The update form was created to be extremely simple and only hold the data that was needed to feed into the situated display. As can be seen from figure 26 the user selects their user number, which has been given to them within initial instructions, they enter their alarm time and their latest sleep score. The update form also freed the users from using the SCAC as an alarm clock; as it was found that they wanted to use the clock to record their sleep, but found the alarm itself too low to wake them up.

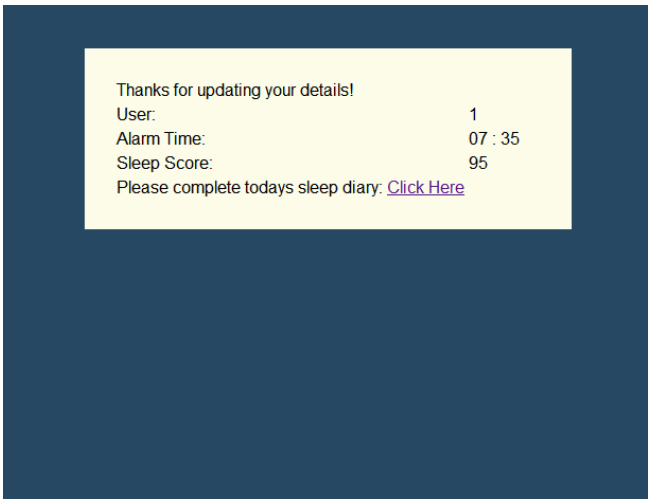

FIGURE 27 SLEEPTALK CONFIRMATION PAGE

Once the update form is completed the user submits and receives a confirmation screen (figure 27) which confirms the data input and also prompts them with a link to the daily diary which adds to the routine and minimises the probability of forgetting to complete the diary.

4.8 Testing

Once SleepTalk had been constructed a 48hr testing period was utilised by one user to ensure that the system ran smoothly through an overnight period and to iron out any issues before using the system with a group.

One issue which was highlighted through this process was that PCs tend to have their power settings set to turn the computer off after a certain period, this needed to be amended for each computer

involved to ensure the computers stayed on all night, and if a laptop was used settings were amended so the users could close the lid after activating the software. This diminished the likelihood of the computer interrupting sleep.

4.9 Documentation

The creation of documentation was important to the smooth running of SleepTalk once within the user studies, this was highlighted by Chetty (Chetty et al., 2010) who proved that good supporting documentation aided the smooth running of a user study. The documentation consisted of instructions for the use of SleepTalk (APPENDIX C), troubleshooting guides and information about the system and how to obtain extra information if user's wanted to obtain more detailed information. This documentation was created to ensure a clear understanding of the system and that a support system was in place should it be needed.

5 Evaluation of SleepTalk

The SleepTalk system is used within households to provoke interactions and conversations.

To test the hypothesis that SleepTalk would have a positive effect on a household it was tested by conducting a series of in-situ user studies. All participants within the SleepTalk study signed ethics forms to confirm they were happy to take part in the study and agreed for data collated to be used for the report.

5.1 User Groups

The groups were chosen through various channels, word of mouth, advertisements and through work colleagues. The user studies were conducted between June 2011 – August 2011.

The groups lived within the Bristol area and all lived within large townhouses. Each household did not know each other before living together and came to share accommodation by answering spare room advertisements on Gumtree.

The ten participants have been split into their groups for ease of reference, see table 1.

TABLE 1 USER GROUPS

User	User Group
P1	1
P2	
P3	
P4	
P5	2
P6	
P7	
P8	3
P9	
P10	

5.1.1 User Group 1

P1 is 30 years old, female and works for the government, she has flexible working hours but likes to stick to a routine. She has a busy social life and is usually out most evenings.

P2 is 26, male and is a mature student; he has no routine as such and enjoys a busy social life which leads to him to late nights and sleeping during the day.

P3 is 31, female and a government worker, she keeps to a steady routine, out most evenings and goes camping most weekends.

P4 is 25, female and works as a nurse; she works three shift patterns, early, late and the night shift. P1 does not stay at home every night as she sometimes sleeps at her boyfriend's house.

The group is quite disjointed without much information about each other's routines, P1 and P3 spend the evenings in the living room watching television, but otherwise the only communication happens within the kitchen whilst cooking food. The group do something as a household around once a month.

5.1.2 User Group 2

P5 is 27, male and a government worker, he likes to go to bed late and sleep in. He is in most weeknight evenings but gets home late due to the gym and has a hectic social life at the weekend.

P6 is 24, male and an electrician, he usually goes to bed early and is awake first in the morning; he keeps himself to himself and spends a lot of time with his girlfriend.

P7 is 26, male and works for a mobile phone company, he is in most weekday evenings and plays football regularly, he enjoys nights out with his housemates at the weekend.

The groups has a solid routine for wake up and bed time routines and often go to the pub together on weeknights and weekends.

5.1.3 User Group 3

P8 is 31, male and works for an insurance company. He is busy most nights of the week but spends a lot of the weekend in the house.

P9 is 30, female and is an engineer, she enjoys scuba diving and spends weekends away following her pursuits, and she also has an interest in her sleep patterns.

P10 is 27, female and works for a bank, she has a steady routine but has to work away from home quite a lot, and she also sleeps at her partner's house every now and again.

This group cooks for each other every couple of weeks and has household events, such as BBQs. They spend time together in the living room but most weekends are spent pursuing individual social activities.

5.2 Study Structure

The user study duration was four weeks, this was deemed to be the optimal time as previous studies for sleep software had found that two weeks were too short to obtain valid data (Kim et al., 2008) and that any duration three weeks or over was optimal as per Consolvo (Consolvo and Towle, 2005). As the studies were to be conducted within the holiday season it was decided to extend an additional week to the studies to allow for any time away users may have.

Within the study there was an interim interview with each of the participants and a final interview. There was also a focus group at the end of each study where issues could be discussed as a group.

The studies were staggered by roughly five days between each User Group. This ensured that the first few days of the study were free to address any initial issues should there have been any.

The spacing prevented clashes in installations and interviews; it also allowed a more flexible approach to interviews as they could be arranged over a period suitable to each of the users.

5.3 Pilot Study

An initial week long pilot study was conducted before the user studies, as per Sellen (Sellen et al., 2006a) this allowed for any initial issues with the SleepTalk system to be dealt with before the rollout of the system to the additional households.

The pilot worked as a mini user study where the system was fully deployed, the pilot was conducted using User Group 1. A presentation was conducted to demonstrate the system and initial surveys were completed. For the duration of the pilot help was on hand to help with any technical issues, this ensured that any unforeseen issues were highlighted at this stage rather than within the actual studies. The users completed the daily online diary and a semi-structured interview at the end of the week pilot was conducted with each user separately.

5.4 User Study Deployment

An appointment was made with each user group convenient with the household, to install the SleepTalk software onto the individual computers, to demonstrate the use of SleepTalk and to discuss the situated display positioning.

5.5 Situated Display Positioning

The users were asked where they would like the situated display to be in a place where it could easily be seen by the whole house, but that was not inconvenient.

FIGURE 28 USER GROUP 1 SITUATED DISPLAY

Figure 28 shows the positioning of User Group 1's situated display. It was positioned on the piano in the household dining room. All users would pass by the screen at least 2 or 3 times a day as the dining room was a thoroughfare for the kitchen. It was thought that this place would be best as all users would pass it both morning and night.

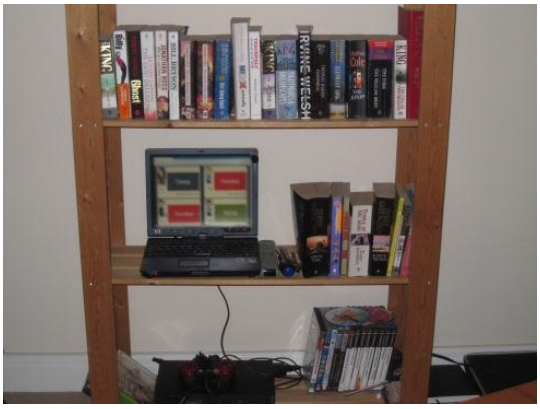

FIGURE 29 USER GROUP 2 SITUATED DISPLAY

The second User Group placed the situated display within the living room as shown within Figure 29, as this was the area that all the participants congregated.

User Group 3 had the situated display within the hallway as the display could then be seen as the users came into the house and when they walked up the stairs or through to the kitchen.

5.6 User Software Setup

The Raw Data Reader is the library that allows a developer access to the live data within the SCAC. Figure 30 shows the connection of the user's computer and the SCAC.

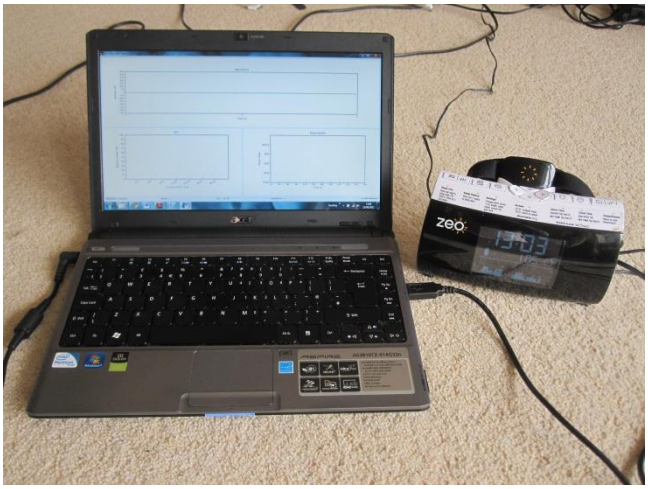

FIGURE 30 USER'S LAPTOP AND SCAC

The length of the wire means that the computer needs to be close to the SCAC. As SleepTalk utilises Python, this along with other libraries needed to be installed onto the user's computer so this was all held on an external hard drive with packs for each user so that the software could be installed in a timely manner.

The software was tested with the user and a demonstration of the nightly routine they would be expected to follow was completed.

5.6.1 Nightly Routine

- Complete online Update Form with Alarm Time and latest Sleep Score.
- Plug in SCAC and open SleepTalk.
- Put the SCAC headband on and check that the software has registered this.
- Close computer lid and carry out normal sleep routine.

This routine was seen to be simple enough to complete at the end of the evening and quick enough to not effect a user's natural sleep routine.

5.6.2 Information Pack

Each User Group were given electronic and hard copy instructions which detailed a step by step guide of what needed to be completed for the study, and also added benefits, such as the Zeo Website itself which could also be accessed. It also contained a troubleshooting guide which included any issues that had arisen during testing and the pilot study along with steps to resolve them, see Appendix C.

5.7 Data Collation

Survey data, interviews and focus groups were used to collate a large bank of data for SleepTalk. The participants were also contacted on a regular basis by mobile phone and email to check progress and to arrange interviews. Staying connected to the participants nurtured a good relationship which in turn allowed participants to be free in their exchanges.

5.7.1 Initial Survey

An initial survey was created to ensure a baseline of the users sleep routines, habits and understanding of the households scheduling was understood. This was found to be good practice within O'Hara (O'Hara et al., 2003) which gave the testers a good baseline to work from.

The data collated was used to define the households and to analyse the specific household's routines, this gave an indication before the study of any routine issues that may emerge.

5.7.2 Daily Diaries

It was seen from previous literature (Lottridge et al., 2009) that daily diaries provided a valid insight into the users activities. It was decided that a blank diary would not be useful as the users would not know what information to detail, so a structured design was created using ten open questions to encourage detail.

An example question: *Did you discuss sleep with someone today? If you answered yes, where did the discussion happen, who was it with and what did you talk / email / text about?*

The daily diaries were held online so that the user could access anywhere and complete them in their own time. And the user details were included so a profile of each user could be accumulated. APPENDIX B holds the Sleep Diary Questions.

The profile then formed the basis of the semi-structured interviews, where the information was used to create initial questions, and once the interviews were in flow the interview took a free form where areas that were talked about were explored in more detail.

5.7.3 Interim Interviews

The interim interviews were conducted midway through, this ensured the data collated from the sleep diaries was sufficient to feed into the semi-structured interviews as participants did not use the system every night due to holidays, nights away and tiredness.

The interviews were conducted on an individual basis to extract as much information as possible as it was felt that participants would be more open if they were talking on a one on one basis. They were conducted face to face, as this helped indicate when to follow up a question, as body language and facial expressions leak information, so an improved overall picture was obtained.

The information gathered within the interviews was collected in a variety of ways, by note taking, memory and photographic. To ensure flow of conversation, the notes taken whilst within the interview were minimal and more a reminder of key ideas than coherent notes which were then written shortly after the interview itself.

5.7.4 Final Interviews

There was a final interview at the end of the four week study, again on an individual basis and building on the interim interview and consequent diary entries.

5.7.5 Focus Groups

Focus groups were used at the end of the study to briefly chat with the participants as a group. It was a chance for the users to discuss together their findings throughout the study as it was found that each household could be reminded of conversations by each other that otherwise may have been forgotten.

5.7.6 Social Media

Permission was given by the participants to monitor any public messages displayed through Facebook as we became 'friends'; mobile communications were also used.

5.7.7 Enforcement

As SleepTalk was installed within numerous households, techniques were needed to ensure the system was being used.

The users were asked to detail any absences and holidays they would have during the study, this helped keep track of participant's whereabouts.

If it became apparent a participant had not been completing diaries then the first step was to text the user to ask if everything was okay. This worked as a rule as the user would start to complete the diaries again. If it did not then the second stage was to email them reminding them of the importance of the sleep diaries. If that did not work I would pop round to the house to see them and have a chat about it. I only had to take this action with one particular user (P7) who hardly completed any diaries. I texted him every time he stopped and he apologised and explained he had been too tired, hadn't used SleepTalk or had been away with work, but consistently did not complete them. After a chat with him face to face it was found that he had sometimes been inputting the wrong user group so some of his diaries were being classed as other participants. Meeting the user in person also enabled me to explain fully the importance of the diaries.

SleepTalk could also be monitored by checking the central server. Each user had separate files upon the server with holding their live sleep data. By checking the date the file had last been amended the time of last use could be determined, if this had been more than a day or two without a note of an absence the same procedure as the sleep diary prompts was used.

5.8 Data Analysis

The data analysis was completed using techniques to analyse qualitative data. The methods of data collation produced a large amount of data; 10 initial surveys, 170 sleep diaries, 18 interviews and 3 focus groups.

The initial surveys were used to develop a profile for each of the users; generally their sleep patterns, details of their morning and evening routine and how much they knew about their housemates routines.

The sleep diaries were reviewed on a daily / bi-daily basis to keep fresh in the mind each participant and how they were using SleepTalk, it highlighted any issues early so that they could be addressed. Each diary was segregated into participants and households, this meant that they could be reviewed participant by participant or as a household to analyse the data in different ways.

The diaries fed into the semi-structured interviews by noting specific events. For example P3 had mentioned an issue of the bathroom door being noisy. This was noted and discussed further within the interviews; this led to the venting of other issues with household chores and habits that P3 found frustrating with the housemates.

P8 made little effort in completing the sleep diaries; this information was used within the interviews to probe into the reasons for the lack of information as this could provide us with interesting data.

The interview notes were written up as a household to obtain a full picture of each user group. This aided with the analysis as interrelated issues could easily be viewed from each perspective. Social Media was also used, as this was to a lesser extent than the other areas a note of any text / email or Facebook status which meant checking online resources on a daily basis.

Constant comparison was used to review the diaries and interview notes regularly with all the data feeding into follow on interviews. Topology was used to categorise areas of behaviour to look into further. Using categories helped to focus the data analysis. After categorisation analytic induction was used to confirm and clarify any theories.

In detail key points were highlighted through an initial read, and then these points were used to look for other examples. Once the essential areas of interest had been highlighted more defined categories for the results were determined so that the findings could be reported. Once the main ideas had been collated the data was then reviewed more accurately to extract quotes and correlations that could be used as proof of theory.

6 Results

In this section we will discuss the results of the data collated throughout the pilot and three, four week user studies of SleepTalk.

6.1 Pre User Study

From the initial studies and discussions whilst installing the software it was clear that two out of the three households already had a good idea of their housemates routines. It was also indicated that each household had a 'best sleeper'. It seemed that the households all had an expectation of the sleep data before they had started the study and were confident of their initial conceptions.

The initial survey also highlighted that only 5 out of the 10 participants thought that SleepTalk would benefit their household.

6.2 Interaction Locations

Each household had a different flow of movement and interaction within the shared spaces; this was proved through the interviews and diaries by indicating where conversations took place. The following three diagrams (figures 31 - 33) show the key areas that conversations took place in and around the households; the arrows show specific interactions between the participants.

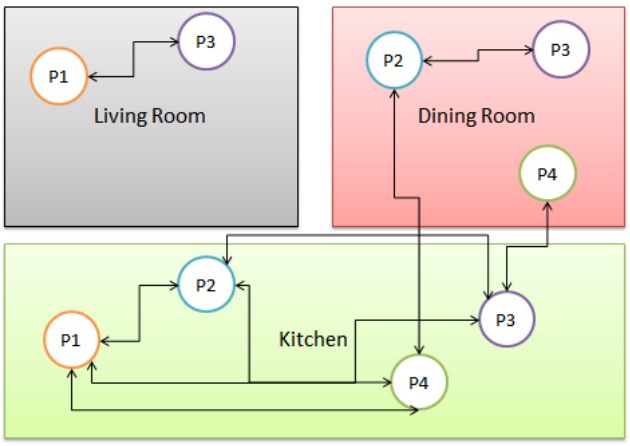

FIGURE 31 USER GROUP 1'S INTERACTION DIAGRAM

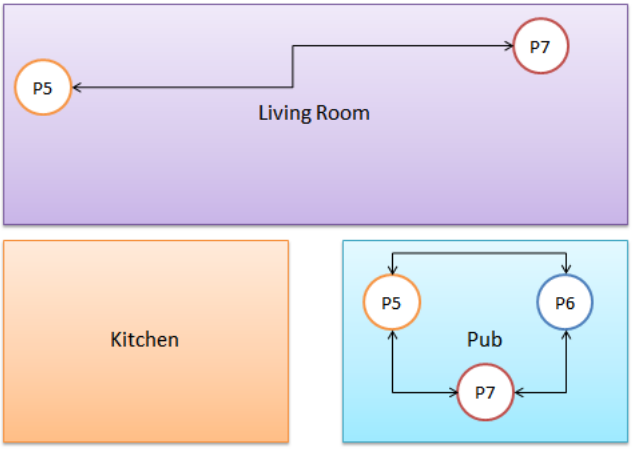

FIGURE 32 USER GROUP 2'S INTERACTION DIAGRAM

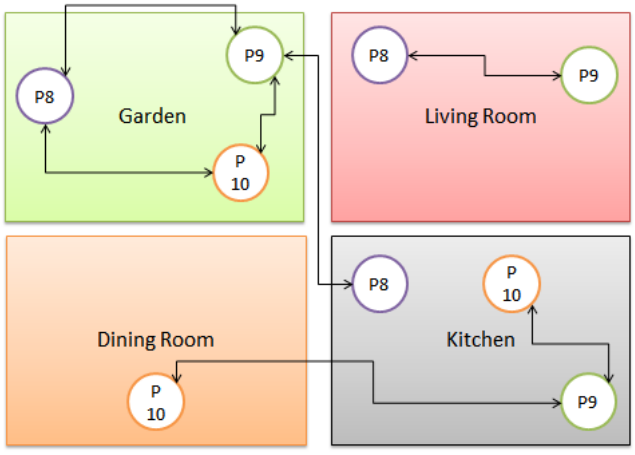

FIGURE 33 USER GROUP 3'S INTERACTION DIAGRAM

It is interesting to find that SleepTalk enabled us to look at the interspatial relationships within the households to show how different each household is.

6.3 Reflection

Eight out of ten participants used SleepTalk to reflect on their own sleep routines. They found SleepTalk useful to view their housemates sleep behaviour to enable them to judge their own routine. This is something that occurred on a daily basis when users used the situated display to view ZQ Scores and whether housemates were asleep.

P3 was a significant case, she found that her ZQ Score was lower than the rest of the house and would monitor the ZQ Score on a daily basis to keep track of her sleep comparisons. She felt that SleepTalk confirmed her initial suspicions that she did not achieve a restful night's sleep compared to others. This aspect would be discussed quite often in the household, mostly in the evening when members of the house were cooking food. This kind of conversation was part of a general conversation about the day's events, but P3 feels that she would not have had the courage to bring up her sleep issues without SleepTalk to instigate the conversation.

P2 took note of the sleep routines of his fellow housemates had and reflected on the amount of his sleep in comparison as he felt that, not only did he get a lot more sleep than anyone else, he also napped more often. This initially made him feel guilty about his sleep routine, and upon initial interviews he stated that he might try and sleep less, but as the study progressed he came to the conclusion that he naturally needed more sleep than his housemates. He felt that he wouldn't have thought about how much he slept if it was not for SleepTalk and he was happy that he had been able to have access the data as it reassured him that he was healthy.

One of the areas discussed was the percentage of the sleep types the users experienced during the night. For example, as P3 was experiencing low ZQ Scores she was also interested in finding out from her housemates how much deep sleep they were achieving as she felt this was contributing to her low score. One conversation with P1 found her asking about deep sleep:

'Immediately (P3) started to discuss the amount of deep sleep she had with me, she was worried about the amount of deep sleep she got and wanted to know what other users had, I said I usually get around 15% (10 mins to an hour) but I stressed that I was sure it was different for everyone so not to worry.'(P1)

P3 also reflected on this within her sleep diaries:

'I looked at the breakdown on the alarm clock: best 6.35hr time to z 41 mins times woken 1 wake = 1%, Rem 53%, light 42% deep 3% Best time in Rem = 3.33hr light = 2.49hr Deep = 14mins'

P5 reflected on his sleep routine with P7 to find out the percentage of deep sleep he had, to indicate whether the amount of deep sleep was reflected in the ZQ Score or if the score was based on the length of sleep only. He was interested in this data as P7 mostly achieved a higher score even though P5 thought he slept for longer.

These reflections show that once sleep data is presented to a group they start to analyse their own behaviours, improving their understanding which leads to the increased likelihood of improved sleep behaviours.

It was interesting to note that even though there was access to comprehensive information with regards to their housemates sleep data, via the Zeo website; they did not access it, and would rather

speak to housemates directly. All sleep diaries that answered the question: *'Did you look at the detailed sleep data for yourself or your housemates via the Zeo website today?'* as Yes, only viewed their own data and stated it was easier to enquire directly with their housemate as to their routines.

'I uploaded my 7 nights of sleep data onto the Zeo website today. I looked at my sleep scores for the past week and how much time I was spending in deep and REM sleep and how many times I was waking each night. I didn't look at my housemate's data.' (P4)

P10 said she looked at the website for the *'Amount of each type of sleep, to see what contributed to my 105 score.'*

'I wanted to see my percentage of rem/deep/light sleep over the past few days.' (P2)

On why the participants were using the clock data rather than the Zeo Website, P5 stated: *'I looked at the clock info and felt satisfied with that alone.'*

'I would rather just ask (P5 and P6) *about their sleep than faff about with looking at their data on the website.'* (P7)

SleepTalk facilitated the chance to think about sleep and routines and therefore made participants reflect on their routines and make an effort to rectify any low quality sleep.

When participants were asked, what do you think contributed to last night's sleep? Some sample answers were:

'Went to sleep pretty quick but woke up very tired still, only got 5.52 hours sleep so need an early night tonight to make up for it i think.' (P6)

'Worrying about exams, need to stop working at least an hour before bed so that I can switch off.' (P1)

'I did a lot of exercise during the day and was sufficiently tired, although i didn't get quite enough sleep.' (P9)

'I had a better sleep score on Thursday night, probably due to drinking. My other friends, who I was with last night, were feeling more tired than me by what they were saying.' (P2)

These answers showed that the participants were actively thinking about their sleep, whereas before SleepTalk they would have retired for the evening and not thought about what was contributing to their sleep habits.

Overall it is evident that SleepTalk aided participants with reviewing their own sleep routines more so than with the SCAC alone as they were able to compare their sleep to others and discuss freely their sleep routines. SleepTalk also encouraged participants to discuss sleep in a way that wouldn't have been open to them without SleepTalk.

6.4 Competition

A large part of the interactions instigated by SleepTalk were competitive in nature. This was apparent in all the households to a degree but specifically within the household of males.

While within the mixed households there was a healthy amount of teasing focused on the ZQ Score, within the male only household this was taken a step further.

'The first rule of sleep club is that you don't talk about sleep club.' *(P5)*

User Group 2's primary objective was to achieve a high ZQ Score. If a participant achieved a high score they would initiate a conversation to vocalize their score rather than updating the interface immediately. They liked to slip the ZQ Score randomly into conversation to surprise fellow housemates.

For example, throughout the first two weeks of the sleep study P7 was consistently achieving high ZQ Scores, P5 explains *'he was kicking everyone's a** with the sleep scores'.* When P5 achieved a score of 101 and felt sure he would have beaten his housemate. In the evening he mentioned the score in conversation, only to be told that his housemate achieved a score of 107 that night, *'I smashed your score sucker!'* (P5) This escalated the completion further.

'I got bantered for my pathetic sleep score; I'm going to show them how it's done tonight'. *(P6)*

'Mega sleep off on Friday to get 120.' *(P7)*

Participants started to try to disrupt each other's sleep with the aid of the situated display. User Group 2's situated display was located within the living room, if a housemate went to bed, the others would watch the situated display until they could see that the housemate had fallen asleep, and then they would make noise. They would turn the television up, slam doors and generally attempt to disturb the sleeping housemate.

Within the interim interview P5 started with a complaint about P6. He stated that the housemate concerned had found a way to cheat the system. He was sleeping as normal, but when he woke with a score under 100 he would hit the snooze button a few times to add a few points to his sleep score. He was frustrated as he had thought he would achieve the highest score consistently as he was known within the household for sleeping the most.

The same participant requested that I extend the experiment for an extra weekend so that he could *'put in a good sleep'* as he felt that within the four week period he hadn't had a sufficient weekend where he could have the kind of sleep that achieved a high score as he had been busy and consistently had late nights. His wish was granted and the study was extended to the following Monday, where the results of the sleep completion were released. The participant who wanted the weekend to beat his housemate's score failed.

P5: *'Unfortunately I couldn't compete with (P7) score of 124!'*

Researcher: *'I don't know how he managed that; the scale only goes to 120!'*

P5*: 'I saw it with my own eyes. He's broken it with the power of sleep.'*

The Zeo Alarm Clock system has a ZQ Score rating system of 0 – 120 so one participant actually beat the clock itself.

It is evident that within a competitive household SleepTalk instigates competition. Though this could be seen as detrimental in some areas as the housemates were making extra noise, it could also be seen as a positive. This is because the house was bonding and becoming more open with each other due to SleepTalk and the competition. As (Odom et al., 2008) attempted to prove with his Eco-System, competition can be used to improve behaviours, User Group 2 whilst competing against each other were unwittingly achieving better sleep as they were making an effort to obtain good quality sleep, to enable them to beat their housemates, all housemates within User Group 2 improved their sleep to ensure they achieved scores between 90 – 120, which is top quality sleep.

6.5 Consideration

An extensive area of SleepTalk use was to enable participants to be more considerate of each other. Within a shared household there is a politeness that is not present within other households that means that being considerate is a large part of creating a happy house share.

Consideration presented itself predominately with participants being quieter when they were aware a housemate was asleep, with 6 out of the 10 participants over the four week period using SleepTalk for this purpose. It was interesting to find that whilst all 5 of the female participants used SleepTalk to be more considerate only 1 of the male participants used it for this purpose.

An example of this change in behaviour was when P2 came home in the afternoon and from viewing the situated display sleep states found that a housemate was asleep. He explained that normally he would have gone straight upstairs and put his music on quite loud, presuming that he was the only person within the house, as this is the norm on a weekday afternoon. But, as he knew someone was asleep he did not do this: *'There was one occasion that I returned to the house in the afternoon and saw that (P4) was on nights so decided not to put music on as my bedroom is right next to (P4).'*

' I found the system useful for knowing when to be quiet or not, because I have an erratic schedule I could enter the house at odd times of the day and it was good to know if someone was in the house or not and I found this reassuring late at night.' (P4)

One interesting aspect was that issues were raised which might not have come to the fore without SleepTalk. One of the participants found that she had an issue with the bathroom door stopping her from getting a restful night's sleep.

'It did not help that my housemate(s) were not being quiet when opening the bathroom door. The bathroom is right next to my room and when the house is quiet the noise of opening the bathroom door echoes in my room. The bathroom acts as a cave and noise is emphasised, which then makes it harder to sleep.' (P3)

This was an issue that she brought up in conversation with one of her housemates during a kitchen conversation about how they felt they slept *'I spoke to (P2) about having a terrible night's sleep and thinking the loudness of the bathroom door had contributed to me not getting to sleep the night before'*.

What was interesting was that P4, who did not have a conversation about this, also noticed the noise the bathroom door made *'when going through my bedtime routine I noticed that the bathroom door had started to make a loud noise'* and decided to make a conscious effort to close the door as quietly as possible in the evenings.

This situation was raised and resolved through SleepTalk, P3 said that she would not have been aware this was an issue, so would not have discussed this with the household and that she would still be having a restless night's sleep if it was not for the system.

Another situation arose when P10 described how she woke up in the morning, and as she is quite a late riser, would have presumed everyone was awake and was going to start cleaning *'I decided that the house needed a bit of a tidy, so I was going to start to hoover, but I noticed from the situated display that (P8) was still asleep, I decided to wash up and tidy the kitchen instead as this would be less noisy.'*

P4 commented that the dining room situated display may be better situated over the living room, as her bedroom was above the living room and she found that the sound carried easily when housemates were in there. She thought that if the display was within the living room and her housemates could see she was trying to sleep they would make an effort to be quiet. It is evident from this discussion that P4 had faith in SleepTalk to aid the house with their sound levels.

User Group 3 discussed that they found that since SleepTalk had been installed there had been less noise disturbances than usual and contributed this to SleepTalk and being aware of sleep.

It is clear from conversations with the participants that they found SleepTalk useful in being more considerate within the household, this was especially important as the participants would have no access to this information otherwise. Particularly within shared houses, where there are more communication boundaries than within a family situation it is beneficial to have a system that can aid with consideration.

6.6 Routine

Participant's use of SleepTalk integrated quickly into their routine. Due to the placement of the situated display participants checked the display once or twice a day:

'I checked the display in the evening while I was relaxing in the living room to see when housemate's went to bed.' (P5)

'I found it handy that the screen was facing the door as it meant I could check it when I was walking up to my room.' (P8)

Participants found the alarm clock time a useful part of the situated display to help understand others routines and aid their own.

P2 used the alarm time to understand when his housemate was working nights, *'I looked at the display but only to check alarm clocks to see if (P4) was on nights'.* This at glance information provided an essential service to the participants who would not have been able to access this kind of information without SleepTalk.

While P1 found the alarm useful to help with her own routine, *'I knew that (P2) never got up early, but (P3) and (P4) are usually early risers and both have showers before they leave for the day, so if User 3 was getting up at 8 and User 4 at 7.30 I knew I should get up at 7 or 8.30 to be able to pop straight into the shower.'*

And another time: *'I was able to look at the screen and notice that even though her alarm was set for 7.30 I noticed (P3) was still in light sleep, so took this opportunity to pop in the shower as she must have decided to use the snooze button and get a slightly longer sleep.'*

The only way P1 would have been able to get this data otherwise would be to go upstairs and check whether the bathroom was empty, this negated this need as a quick glance at the situated display gave her the answer she needed.

Some participants found it difficult to integrate SleepTalk into their routine as they found it a chore, with the majority of participants admitting to not using the system when they could have, with P7 having the worst record, admitting that he only used the system 50% of the time. There were various reasons for this, privacy, laziness, being too tired and also being intoxicated being the most common.

The participants who used the system the most were the participants who were most interested in their own sleep routines and used the data for personal benefit. This being said all participants thought that the situated display was beneficial to the household as it was unobtrusive, easy to use and worked well within the households, with eight out of ten participants stating they would use the system if it were available.

6.7 Privacy

Privacy came to the fore in different ways through the utilisation of SleepTalk. Throughout the study the diaries and interviews were used as an outlet for frustrations, they were a mechanism that was not usually available and participants took advantage of having this private outlet.

P3 brought up household issues *'when I thought about the bathroom door it led me onto issues such as (P2) not hanging the bathmat back up after his shower and housemates not doing all the washing up'.*

'I wish we had the system all the time as it would give us an excuse to bring issues up.'

Within the design phase of SleepTalk an assumption was that it would be used extensively when participants napped as this is the most likely time that someone could be disturbed, this was not the case. Within the one week pilot and three four week household studies, not one of the participants used SleepTalk while they were napping.

Upon investigation it was found that the participants did not want their napping habits known, by other housemates, but felt free to discuss it in their private diaries and interviews:

'(P7) and I spent the entire day hungover in the front room, afternoon nappage was essential for survival.' (P5)

'I tend to nap in the living room anyway, so my housemates would be able to see me sleeping.' (P9)

From discussions with the participants it is clear that napping was sleep data that participants wanted to keep private.

Curiosity was provoked by SleepTalk when users did not use the system, P2 observed *'I checked it to see of anyone was asleep when going down stairs at 3am, i didn't show anyone asleep so i assumed they were not at home or perhaps their headbands not on'.*

P5 asked about his housemate's routine *'I noticed last night that even though (P6) had gone to bed about an hour before me the display said he was still awake. I asked him what time he went to sleep and he said about 0030.'*

P10 also considered her housemates routines *'Checked to see if they were awake when I was downstairs out of interest - both said awake but I'm fairly sure they were asleep so perhaps they had taken their headbands off in the night.'*

It was clear from the use of SleepTalk that though a household is happy to share the majority of their sleep data there are still areas where they wish to have some privacy. It can also been seen from the study that participants are inquisitive of their housemates routines and wonder why the system is not being used if the housemate is in the house, this shows that there is a heightened awareness of users privacy.

6.8 Intimacy

User Group 1 and 3 both thought about their fellow housemates when looking at the situated display. It was found that if a participant had experienced a particularly low ZQ Score their fellow housemates would ask how they were and if they slept ok. This promoted a feeling of being cared for within the household and made communication more open between the participants.

'I'd ask how an housemate was if she had had a low sleep score (compared to their usual score) and to chat about why they thought the bad sleep score might have been. I would be more mindful around the housemate and it also made me more tolerant if the housemate was short tempered with me that day.' (P2)

Knowing that the housemate had not had a good night's sleep gave him an explanation as to housemate's reactions which in turn made him more understanding.

SleepTalk encouraged participants to talk about their sleep as they had an outlet to do so. They found SleepTalk enabled them to bring up sleep more often, whereas before, if they had spoken about their sleep it was more to discuss that they were tired, and they would have felt uncomfortable about randomly talking about their sleep.

Conversations of the participants sleep led to conversations in the pub, so it seems that SleepTalk became a social conversation point, with participants specifically discussing sleep scores within evenings out with their housemates and with external friends:

'I discussed the sleep study on my camping trip as my friends were really interested in the system and what it was finding out.' (P9)

'Me and (P6) would chat about it regularly when we were having a pint in the Wellington.' (P7)

This led them to talk about sleep with people external to the household so also gave an avenue to discuss sleep with closer friends, who could discuss more personally sleep routines.

One household found that they started sharing cigarette breaks when at home (P8) *'we'd have a catch up when we stood in the garden, it was an excuse to discuss sleep and how the day had been'* (their household is non-smoking, so they smoke in the garden) to create the chance to catch up about the sleep study and to stay informed.

The user study showed that the use of SleepTalk made participants more aware of each other's moods and emotions, promoting conversation and hence achieving a higher level of intimacy within the groups.

6.9 Experimentation

An unusual offshoot of SleepTalk was the participant's individual experiments with the system, specifically with the client side software. The connection between the SCAC and the participant's computer showed the user their brainwaves when they had the SCAC headband on.

'Ridiculously excited about EEG sleep clock thing to analyse my sleep patterns. Get ready for the results of some crazy sleep experiments!' (P2)

P2 specifically monitored their dream sleep to see if it correlated with the times he woke up and the type of sleep the SCAC had recorded for him. This is because he realized that he only remembered his dreams if he woke up whilst having a dream.

Experimentation seemed to be part of the fun of the system, allowing users to not only be more aware of peoples sleep, but also to experiment with their sleep routines and hopefully improve their sleep health.

6.10 Interpretation

Participants reviewed the sleep data displayed within the situated display in different ways. While P3 used the historical data within the situated display to confirm that she had a low quality sleep as she was always scored the lowest within the graph, P2 saw this as her average score, therefore even though it was lower, it was just that she needed less sleep than the others, rather than taking this as a low quality sleep.

P4 would see that SleepTalk told her she had good quality sleep but she felt tired, so would ignore SleepTalk's interpretation of her sleep and use her own body to tell her if she needed more sleep.

This indicated that whilst participants used the SleepTalk data in their day to day routines they still used their own judgment with regards to their sleep routines.

6.11 Overall Success

Eight out of the ten participants found the system useful and, if the opportunity presented itself, would like to have the system installed in their house fulltime, which is more positive than the original count of six out of ten that thought it would be useful before the study. Out of the eight participants only three of these were male. It seemed that the female participants felt that the system benefit them more than the male participants who were more relaxed about the system and could take it or leave it.

This could be because females can be more empathetic than males, so felt the benefits more strongly. It would be interesting to trial SleepTalk within different types of households such as families and cohabiting friends to confirm these findings further.

7 Implications & Discussion

The design and study of SleepTalk has implications within several areas of research; awareness technologies, competition promote improvement, sleep behavioural research and using technologies to support interaction. It has been shown that sleep is not only a physical need it is also has a social aspect which SleepTalk and associated technologies provide the avenue to explore this further.

7.1 Sleep Scheduling Promotes Intimacy

It is clear from SleepTalk that access to simple sleep data gave households an opportunity to communicate and bond as a group; giving participants the opportunity to see when their housemates have had a bad night's sleep and to take an interest in their wellbeing, this is especially prevalent for strangers sharing accommodation as they may not normally be very close. This research is similar to the findings of (Kim et al., 2008) who found that co-located individuals felt closer to their group when they were aware of their sleep status.

7.2 Awareness Improves Performance

SleepTalk has demonstrated that introducing a competitive element to a routine can encourage participants to improve which has a knock on effect of improving sleep quality. It has also shown through the availability of sleep data that awareness of a groups sleep routines instigates reflection on personal routines and focuses the issue of sleep.

7.3 Personal Lives Dictate Routine

Whilst SleepTalk facilitated awareness it was thought that this would promote a change of schedules and routines, this was not seen due to busy work and social lives, though they reflected whether their routine should be similar their housemates this correlates with Schmidt's (Schmidt et al., 2007) finding that people want to conform to society norms. The participants found it difficult to change their routines drastically and instead tried to improve sleep routines by taking small steps such as getting extra sleep the day after a big night out.

7.4 Technology Facilitates Understanding

Utilising a new breed of technology to inform households of live sleep data has proved beneficial to the scheduling and general day to day routine of a household, sleep can be used in a social context to aid scheduling of a group of people and should be investigated further to fully understand the implications.

8 Conclusions & Future Work

This report presented SleepTalk, an awareness system situated in a household's communal area to aid with everyday scheduling and interaction. SleepTalk used a simple visualization to convey live and historical sleep data which was implemented using participatory design and through comprehensive research into awareness technologies and situated displays.

SleepTalk investigated the social interactions, communication and routines within a household when access to 'at a glance' sleep data was made available. This was accomplished by conducting three, four week studies within cohabiting households, recording the interactions and conversations by way of daily sleep diaries and interviews.

The studies showed that awareness of sleep data and sleep routines can indeed change behaviours and instigate interactions within a household. This has been shown in six key areas: reflection, competition, consideration, routine, privacy and intimacy. With participants feeling more connected with their housemates through using the SleepTalk system. The results confirm the theory that sleep has a social context and can be utilised to improve interactions and routine scheduling within a household.

Future work should focus on research into contrasting household types as our research with cohabiting households looks specifically at the routines of shared housing, where social boundaries define the group. A step further would be to test SleepTalk within family units, cohabiting friends, co-located groups and couples as these groups may accumulate contrasting results to this initial research.

Improvements to the SleepTalk system could be included, a notepad facility so users could add a note to their area of the display would allow users to communicate to the household through the display. Additional data that could be viewed from interacting with the situated display would also advance the system.

This project has found, through development and testing of SleepTalk that a simple pervasive computing device can be used, with sleep data, to demonstrate sleeps social context. Such technologies can be utilised to promote intimacy, aid routine and stimulate conversation within a household, which in turn improves the everyday life of the occupants.

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10 Appendix A: Initial Survey

1. **Please confirm your user details**

	Group 1	Group 2	Group 3
User 1			
User 2			
User 3			
User 4			

*2. **Please indicate your age?** 10-15, 16-20, 21-25, 26-30, 31-35, 36-40, 41-45, 46-50, 51-55

3. **Please indicate your gender.** Male / Female

*4. **How many hours sleep do you usually get a night?** Less Than 5, 5, 6, 7, 8, 9, Over 9

*5. **Please detail your usual bedtime routine, if you do not have one, please just roughly detail an average bedtime for you.**

An example could be: I usually go to the bathroom, then get into my pyjamas, then watch TV for around 30 mins before turning the light out to go to sleep.

Please detail your usual bedtime routine, if you do not have one, please just roughly detail an average bedtime for you. An example could be: I usually go to the bathroom, then get into my pyjamas, then watch TV for around 30 mins before turning the light out to go to sleep.

*6. **Please detail your usual morning routine.**

An example could be: I press snooze around three times before getting up, go to the kitchen to make a coffee, and then shower. I get dressed and check my email before leaving the house to go to work.

Please detail your usual morning routine. An example could be: I press snooze around three times before getting up, go to the kitchen to make a coffee, and then shower. I get dressed and check my email before leaving the house to go to work.

*7. **Are you aware of your households sleep routines?** Yes / No

If yes, please indicate what information you know about other people's sleep routines.

*8. **Do you ever speak to anyone about your sleep (verbally or in writing)?** Yes / No

If you answered yes, who do you speak to, and what do you speak about?

*9. **Do you currently have any sleep issues?** Yes / No

If yes, please detail the issues do you currently have?

*10. **Do you feel that this sleep study will benefit you, or your household?** Yes / No

If yes, please detail how you feel it may benefit you or your household and what you would like to get out of the study.

11 Appendix B: Sleep Diary

*1. **Please confirm your user details.**

	Group 1	Group 2	Group 3
User 1			
User 2			
User 3			
User 4			

*2. **How would you rate last night's sleep?**

	Terrible e	Bad	Not Great	OK	Good	Fantastic
Sleep Quality						
Sleep Routine						
Sleep Habits						

*3. **Did you use your Zeo Alarm Clock last night?** Yes / No

If you did not use the alarm clock, please could you detail the reasons behind this

*4. **Please indicate last night's Zeo Sleep Score, if you didn't use the clock last night please enter 0.**

*5. **Please detail what you feel contributed to last night's sleep?**

For example good or bad habits, other people's routines, time to bed etc.

*6. **Was there a change in your or your housemate's routines?** Yes / No

If you answered yes, please give details of the changes that occurred and why you feel this change happened?

*7. **Did you discuss sleep with someone today?** Yes / No

If you answered yes, where did the discussion happen, who was it with and what did you talk / email / text about?

*8. **Did you look at or use in anyway the situated display in your shared area today?** Yes / No

If you did, why did you use it and how? What was the result of the interaction?

*9. **Did you experience any situations where having access to each other's sleep data had a positive or negative effect on you today?** Yes / No

If you answered yes, please detail what happened and how this affected you.

*10. **Did you look at the detailed sleep data for yourself or your housemates via the Zeo website today?** Yes / No

If you did, please could you detail the information you looked at and why.

12 Appendix C: User Instruction Pack

You are GROUP 1

User 1	[redacted]
User 2	
User 3	
User 4	

Timings

The study will start on 06 July 2011 and complete on 26 July 2011. Do not worry if you are away for a period during the study as I understand for a three week period most people will have time away from their household.

Initial Questionnaire

I would like you to complete an initial Questionnaire as soon as you can so that I have a baseline for my results. Please complete this at the start of the sleep study.

The link to the questionnaire is here: http://www.surveymonkey.com/s/6DZTVY5

Sleep Diary

Once the pilot has started then I would also like you to complete a Sleep Diary every night which can be found here: http://www.surveymonkey.com/s/6DQ9GJY

Please note that the Sleep Diary is the most important part **of the study, so please e**nsure, even if you didn't use the alarm clock one night, that you still complete the diary.

Your Nightly Routine

For the duration of the study you should complete the following tasks in the evening before bed (it doesn't have to be right before bed, just sometime in the evening).

1. Access the Update Page and enter your latest Alarm time and Zeo Sleep Quality Score, the update page can be found here:
http://www.georginamackender.webspace.virginmedia.com/group1/update.html
2. Complete and submit your Sleep Diary.
3. Attach your alarm clock to your PC and start up the GUI to record your sleep.

Creating a MyZeo Account

The group details are important for completing the sleep diary and updating your details. Everyone can then access each other's sleep data by way of the Zeo Website www.myzeo.com

To set up your account, register your details (the serial number needed are is on the base of the alarm clock) all accounts need to have the same password so that each user can access the data. The password you are to use is: georgie2

You can upload your detailed sleep data by inserting the SD Card (found in the side of the alarm clock) into your computer, if you do not have a SD Card slot within your computer; you can use the USB adaptor (found within the alarm clock box). There is an area within your myzeo account which will allow you to upload the data and then view the results in various different chart forms and by reviewing specific elements of your or your housemates sleep.

Using the Alarm Clock

There are detailed instructions within the Alarm Clock box as to how to set up the alarm clock. I will highlight some key points that may be useful.

Headband

The headband needs to be worn to record your brainwaves and sleep data. The headband needs to be secure enough as if it is too lose you may experience periods of non-recording during the night or the headband may fall off. It is adjustable so please adjust the tightness of the headband until you achieve a comfortable position.

If you do experience any problems with the headband, please do not worry, just record the details within your sleep diary so that I am aware of the issues and your thoughts on it.

Sleep Score

The Zeo Sleep Score is an overall score as to your sleep quality and is important to the study as it indicates your overall sleep quality, good sleep quality is something we are looking to achieve. The sleep score is between 0 – 120, the higher the score the better your sleep quality. This is displayed on the face of your clock every day and I would also like you to input your sleep score into the update interface, so that your fellow householders can see this information.

Troubleshooting

The interface is displaying incorrect information

There may have been a disconnection of the internet during the night for some reason. If this issue doesn't resolve itself the next night, please contact me.

When I open the Sleep GUI it doesn't find a COM Port

Is the alarm clock switched on?

If so, it is probably the connection between the clock and your PC. Disconnect from the back of the clock and reconnect as one of the pins may not be attached correctly.

I can open the GUI but it is not showing any brainwaves when I put the headband on

Again, this could be a problem with the connection of the wire from the clock to the PC, but it may also be a problem with the drivers installed on your PC.

I cannot complete the sleep diary online

Please use a paper copy and notify me so I can fix the issue.

I did not wear the headband last night

Do not worry, please just detail in your sleep diary why this was and try to wear the headband the next night if possible.

Issues

If there are any issues with the hardware, software or the study itself, please let me know as soon as possible and I should be able to rectify any issues. Email: gogogadgetgeorgie@gmail.com , Telephone: 07885 456 322, I am available 24/7 so please do not hesitate to contact me.