Health Features of Activity Trackers: 
Motivation, Goal Achievement, and Usability

George Angulo, David Brogan, Anthony Martini, Jue Wang, and Leigh Anne Clevenger
Seidenberg School of CSIS, Pace University, Pleasantville, New York

Abstract
One of the major problems with using mobile technology to form healthy habits is that it lacks a social component separating it from the reality of people’s lives; which leads to problems keeping up with a routine or building healthy habits. Part of the problem is that during the developmental phase of forming healthy habits, individuals are unable to demonstrate success of an individual workout, a weekly routine or even their step count for a day. Recent technologies such as smartwatches and fitness bands are well suited for solving this problem. This study examines whether wearable technology with a social aspect will improve efficacy of forming healthy habits by surveying participants on potential factors and by using data created which allows an activity tracker to monitor daily activities. This study focuses on a surveys results and data collected on a group of users furnished with socially integrated technology.

Index Terms—social, activity tracker, wearables technology, fitness, motivation

1. Introduction

There is strong evidence that technology shapes people; this means motivation can be derived from technology. In a recent study depicting encouragement for family fun: E-health has been touted as the “Single-most important revolution in healthcare measures, like sanitization and clean water” [10]. At the vanguard of this revolution is the simplicity to interact with self-monitoring capabilities and people to create data they can share and understand on a daily basis.

Academic and commercial research shows how technology affects fitness. Activity trackers are still a relatively young technology, but the evidence supporting their potential health benefits has already become apparent in several medical studies [10]. Participants of certain medical studies who were outfitted with pedometer type devices were able to see significant decreases to body mass index (BMI) as well as measurable increases to daily step count; furthermore, patients who received motivational tips via text message often fared better. Because of studies such as these, health care providers believe that electronic devices such as fitness bands and smartwatches could revolutionize medical care by introducing a new wave of personalized medicine [10]. Some medical doctors firmly believe that these devices can effectively be used in metabolic assessment, behavior therapy, and weight management, becoming an essential part of the solution to not just obesity related ailments, but also diabetes and other chronic diseases [4].

The ability to motivate the user in achieving their fitness goals is the key factor behind the activity tracker’s success, according to researchers such as Alderson [1]. Tech publications are proclaiming them to be one of the fastest growing trends of 2015, being used by top athletes as well as ordinary people looking for a simple way to monitor their everyday lifestyle [1]. The majority of activity trackers available today are paired with a smartphone or computer and include a software application that allows the user to see metrics such as the number of steps taken in a day, calories burned and progress monitoring of their established goals. Alderson believes that such an ability eventually drives the individual to change their fitness habits, especially with those that live sedentary lives. Through the user interface, individuals are able to see just how inactive they are, which effectively triggering a natural response to become more active [1].

In response to activity trackers growing popularity, white papers have been written to help manufacturers improve their success in the business. One such report written by Ledgers and McCaffrey of Endeavor Partners states that three key factors were discussed in this report: habit formation, social motivation, and goal reinforcement [11]. The report shows habit formation is a complex process that occurs over time and involves a study of human decision-making and the applied practices of behavior change, goal setting, cognitive neuroscience and health psychology.
The report concluded that wearable devices “can make the process of habit formation more effective and efficient than ever before” [11]; a point of view that concurs with statements made in Alderson’s article [1]. The adding of a social element to these devices was recommended in order to achieve “sustained engagement” between the user and their device [11]. Ledger and McCaffrey believe that users of such devices have the potential to motivate their peers to do the same, citing Bandura’s social cognitive theory [2], which posits that we learn not just from our own experiences, but also vicariously from observing those around us. In regards to goal reinforcement, Legers and McCaffrey agree with others in the field that a user needs to continually experience a feeling of progress toward defined goals recommending that users initially set smaller goals and gradually increase them as the smaller goals are met [11].

Miriam Hospital and the State of Rhode Island conducted a study in 2009, called the “Shape Up Campaign”. The study consisted of 3,330 overweight or obese individuals, where participants joined teams in three divisions: weight loss, physical activity and pedometer steps. The weight loss outcomes were clearly determined by which team the individual was on. Individuals who reported higher levels of teammate social influence increased their odds of achieving a clinically significant weight loss by 20 percent. According to Dr. Leahey, “Being surrounded by others with similar health goals all working to achieve the same thing may have really helped people with their weight loss efforts” [14].

In contrast, another study conducted the Department of Biomedical Sciences examined the effects of a pedometer-based activity on 106 sedentary workers. The study took participants from jobs with moderate to highly sedentary positions. Using subjects as their own control (no social aspect within study), physical activity was compared before and after a 12-week intervention. The results of the study showed steps increased from 7,029 at baseline to a plateau of 10,480 steps per day. On average, participants experienced significant decreases in BMI, waist girth, and resting heart rate; reductions in waist girth and heart rate significantly map to the increase in steps per day [3].

Despite the significant advantages the enhancements to instrumentation can provide, there exists work that suggests wearable devices are not drivers of modern health behavior change [12]. Wearable devices are only facilitators if people want to change health behavior. Therefore, it takes much more than wearable device reports to drive the behavior change. Social motivation will also carry the individual forward, potentially more than any other, which is why we encourage all participants in the study to engage in social activities.

The structure of this paper is as follows: Section 1. Introduction includes premises of document and literature review, Section 2. Background is an evaluation of context to wearable activity trackers and technology descriptions, Section 3. Research Methodology covers our strategies for exploratory research, Section 4. Results and Findings is a summary of our data collected, Section 5. Conclusion is knowledge gained from study, Section 6. Discusses future work and Section 7. References of scholarly journals and publications.

2. Background

Wearable tech is rising as a “wrist revolution”: roughly seven million devices shipped in the first quarter and a projection of 45.7 million for that year [9]. These devices span from smartwatches with advanced notifications and GPS functionality, coupled with third party apps, while fitness bands target specific activities. Both device types have sensors called accelerometers, which detect motion along with the speed and direction. They could be digital or analog, different sensitivities, and various axis. This study will focus on the common activity tracking function hence all smartwatches and fitness bands in this study are referred to as activity trackers.

For the purposes of this study, we are primarily concerned with the features that focus on improving a person’s health. Such features include activity tracking, goal reinforcement, sleep monitoring, and any social networking components that are used to enhance the overall fitness experience. All devices being used in the study are ranging from inexpensive, no-frills fitness bands to full-featured smartwatches released in the current year of 2015 worn around a person’s wrist. They also all support classic Bluetooth, Bluetooth 4.0 and are compatible with Bluetooth Low Energy. Table 1 below describes Web links for all the devices involved in this study.

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### Table 1 Web links corresponds to devices

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**Xiaomi Mi Band** - The least expensive (under $20) activity tracker and it has an IP67 [18] rated aluminum alloy sensor that includes a military-grade accelerometer and is enclosed in a band made of thermoplastic urethane (TPU) and cross-linked silicone rubber [19]. Aside from its low price, the Mi Band is also known for its 30-day battery life made possible by the 41 mAh battery capacity.

**Fitbit** - the Flex, Charge, and Charge HR are made of a flexible and durable elastomer material with a focus on overall comfort. Although not IP67 rated, they are sweat, rain, and splash proof with a three-axis accelerometer. All three devices provide a minimum of five-day battery life. The Fitbit Flex is the least expensive model at $99 while the Charge and Charge HR are $129 and $149 respectively. An altimeter is added to the more expensive Charge and Charge HR models for the purpose of tracking floors climbed. Charge HR adds the ability to monitor a person’s heart rate. Fitbit devices all feature a social component as their greatest attribute. Fitbit provides users within its ecosystem the ability to connect and become friends, allowing them to compete in a variety of Fitbit facilitated events. Once entered in such events, participants can further “motivate” one another by taunting and cheering each other on via the built in chat function.

**Apple Watch** - a high-end smartwatch with a variety of bands and finishes available. The retail price varies greatly from $349 for the Sport Edition to $17,000. All models feature an Apple S1 chip with 512MB of ram, heart rate sensor, accelerometer, gyroscope, ambient light sensor, speaker and microphone. Battery life expectancy is typically about 18 hours. Fitness tracking features are possible through the Apple Health app. Users can choose to use Jawbone’s proprietary app “Up”, which allows connection with “team mates” in a social feed for the purpose of sharing progress and cheering each other on.

**Microsoft Band** - The first generation Microsoft Band used in the study currently retails for $129, and is capable of monitoring heart rate, steps taken, calories burned, total distance, floors climbed, and sleep quality. In addition to the standard three-axis accelerometer and optical heart sensor, the Microsoft Band includes a gyroscope, UV sensor, skin temperature sensor, capacitive sensor, and a GPS function. Many “smart” functions that have been included such as email, SMS, and social media notifications, in addition to a capacitive 1.4” TFT full color display. The battery will last for up to 48 hours, however advanced functionality like GPS can alter that number significantly. The Microsoft Health App available for Windows Phone devices, as well as iOS 7.1 or later powers the device, and Android 4.2 or later devices power the device. Like the Mi Band, the Health app allows a user to share accomplishments and aspects of their workout with friends on social media.

**Samsung Gear Live** - currently retails for $99. It is powered by a Snapdragon 400 quad-core Chipset clocked at 1.2 GHz with 512MB of RAM and 4GB of storage capacity. The watch is IP67 rated; ideal for all weather conditions and includes a gyroscope, accelerometer, and compass, in addition to an optical sensor capable of measuring heart rate. The Gear Live is only compatible with Android devices versions 4.3 and greater. Battery life expectancy on a full charge is between 24 to 36 hours. Fitness tracking abilities rely heavily on the Google Fit application and are limited to steps taken, total distance, and calories burned. Users must look to third party applications such as Endomondo in order to integrate a social component into their workout.

**Garmin Vivoactive** - a GPS-enabled smartwatch specifically made for people that live an active lifestyle at a price of $249. Garmin supports a plethora of swimming, cycling, and even golfing metrics such as short distance and yardage-to-green. The watch is also capable of monitoring sleep and includes standard smartwatch features such as SMS, email, and social media notifications. The device is equipped with a color transflective (TFT) touchscreen and has a battery life that can last up to three weeks on a single charge. Garmin devices such as this rely on the Garmin Connect software that allows users to view stats, monitor goal progression, and share activities with friends.

### 3. Research Methodology

Usability testing [16] is widely accepted as the standard method for finding usability problems with products and services, including software and user interfaces [13]. However, often times the testing process has the tendency to suffer from the ‘observer effect’, sometimes referred to as the Hawthorne Effect, which occurs when test subjects...
are conscious of those that are conducting the study or the test and therefore do not behave in their usual manner. It is important that conductors are aware of this phenomenon and how it influences the situation they are observing [7].

Our observational user study focuses on a group of 15 individuals: most of the authors and several of their friends and relatives. This study features both a qualitative and a quantitative approach to gathering data; the objective being to examine the effectiveness of using wearable devices to motivate individuals to form healthy habits, meet fitness goals, and to assess the level of impact the integration of social components has in achieving those desired results.

A. Study Phases and Strategy

Prior to beginning the study, each participant is furnished with, or already in possession of, a wearable device for activity tracking. Since not all devices used in the study are of the same make, model, and price point, we employed metrics that are measurable across all devices: step count and calories burned from Day one through Day 42.

Day 1, participants are asked to answer an initial questionnaire to get a clear understanding of each participant’s starting point prior to commencing the study.

Day 1-14, Participants are asked to abstain from any social features their devices may include to allow participants to become familiar with their wearable devices and the accompanying software application. This will also allow participants to fine-tune their goals and get a good baseline of what their daily activity levels look like in regards to step count and calories burned.

Day 21, The social component of the study begins. At this point, participants are greatly encouraged to incorporate a social element into their daily routines, which may include entering a fitness challenge via third party applications such as Endomondo or utilizing the social features available on their device’s app dashboard. For example, Fitbit allows “friends” to participate in daily or weekly challenges where the objectives range from meeting all of one’s daily goals or walking highest “steps” throughout the day or week.

Day 28, a second questionnaire is given to participants in order to assess any changes in their activity levels and usage habits that may have occurred during the two-week period. This will allow them to express any opinion on factors regarding general usability and the effectiveness of notifications and other features available across all devices. Participants will also be asked if they have encountered any obstacles - personal or technical - that may have a direct impact on the data being captured. It is important to note that there are many factors that we cannot control that may occur during the study. A participant may become ill or may experience a significant change in their daily routine that is completely unrelated to wearables and the influence of social interaction. The recurring questionnaires will allow us to continually identify those factors and eliminate them from our results when necessary, thereby improving the integrity of data captured. We ask every teammate to keep in close touch with their users to identify any external factors that may skew our numeric data.

Day 29-42, participants will continue to take part in any form of group or social fitness events of their liking. Participants are asked to answer the third questionnaire addressing the level of social and competitive interaction. The answers gathered from this questionnaire will ultimately help us understand how effective wearable devices can be when combined with a social component.

B. Survey Design

The quantitative raw data extracted from the activity trackers satisfy some but not all aspects of this study’s objective. To truly understand the role activity trackers play and whether or not they are primary drivers or simply facilitators of positive change in forming healthy habits, one must get a complete picture of what each participant’s starting point is before the study actually begins. That information includes knowing the answers to questions like – what are their fitness habits currently like, how active are they throughout the day, do they have sedentary jobs or are they constantly moving? As the study progresses and social variables are introduced, there are other usability characteristics to be aware of in order to determine the validity of the quantitative data that is retrieved from user’s devices. How often do they wear their band, did they take it off for any reason, were they ill, or did they have technical issues? In order to answer these questions, we felt the need to conduct a number of semi-structured questionnaires containing a mixture of prompted questions with predefined answers as well as open-ended questions that would be given at different points throughout the user study. The qualitative data from the questionnaires would serve as an excellent complement to the numeric data retrieved from the devices and help minimize any data gaps in our study. In an effort to keep the participants focused and engaged, each questionnaire administered during the study is no more than 25 questions in length and primarily multiple choice in nature.

According to a recent report from PricewaterhouseCoopers [5] and current census data [15], 32.2 million Americans are wearing some kind of wearable technology on a daily basis. Using this figure and data from market research sites [8] [6], the number of survey respondents necessary in order to accurately represent this group of Americans equates to 384. This figure was calculated using a 95%
A confidence level – the standard in quantitative research [8] – and a 5% margin of error. Due to time constraints and lack of available resources that include fitness trackers, it is not feasible to include that many participants.

For this very reason, we thought it would be beneficial to the user study to conduct an additional questionnaire aimed at students wearing fitness trackers outside of our closed group of 15. Although the data gathered from this additional questionnaire are kept separate from our closed group’s findings, the data from this presumably larger sample size would not only serve to strengthen the validity of our study, but also serve as an excellent comparison tool – meaning the resulting data from the six-week observational study could be analyzed to see how closely it compares to the experiences of an external group of students.

C. User Data Capture and Analysis

The majority of wearable devices include some method of activity monitor data export as Microsoft Excel (XLS) or comma separated value (CSV) file that can be read directly into a spreadsheet program. This study will use the data export procedure for each device. In some cases, where there is no such option, we retrieve screenshots of a participant’s smartphone in order to record the necessary metrics. All data is collected and recorded weekly all the while, the questionnaire is designed and implemented using Google Forms. Since participants are all either capstone students or friends/relatives of students, authentication will not be necessary. Each questionnaire is “signed” with the participant’s first name and last name’s initial. Authentication became a requirement, however, when extending the survey to a broader audience of the class. A CSV file of responses is created once all responses have been captured for each questionnaire.

The data collected from the screenshots and CSV files are combined into a spreadsheet file. The use of pivot tables will allow us to gather the exported data and arrange it in a way that allows for better data analysis. Data from the questionnaires are discussed in the survey design and results sections.

4. Results and Findings

A. User Data Findings

After collecting user data through six weeks, the first two weeks of the solo phase contain 931 records, of which 886 appear to be valid records. For the next four weeks, which is the team phase, 1563 out of 1701 records are valid data. Invalid data was eliminated based on users’ feedback of sickness, injury and improper device function. The majority of invalid data was related to the sleeping function not fully operating and battery outages for certain models of devices.

For all 2500-user data samples collected, Figure 1 shows a high-level comparison taking each kind of activity into consideration, indicating eight users improved in reaching their goals during the team phase compared to the solo phase, with the greatest individual percentage jumps from 43% to 62%. Including the other five users who have decreased progress toward reaching their goals, Figure 2 shows a general 7% increase from 42% to 49%, which is still a good sign of improvement and shows social networking has a positive impact on goal achievement.

![Figure 1](image1.png)

Figure 1 Percentage of goals met during solo phase and team phase per individual.

During the analysis of the data, it is shown that there are changes of objectives during the team phase. Some of those changes are lifting the goal to a higher target like 6,000 steps to 10,000 steps, while others adjust the goal lower to a reasonable daily activity level. Three users raised their goal and four other users tuned back their objectives. After careful examination of averages for each activity involved with objective changes per individual user, the total changing trend has a limited impact to our findings on objective met percentage. It is believed that all those adjustments to objectives are proof of reflection and self-awareness by the user. It is a positive tuning of their fitness habit formation.
in second. It is important to note that two of the participants admitted that being a part of a user study was the primary motivator behind an increase in their activity levels, while seven others ranked it as a top three factor.

In regards to technical difficulties and other obstacles that were encountered, two participants were not able to participate fully during this third week due to injury or illness. Only one claimed to have technical difficulties with their device, however that person was able to resolve the issue on their own.

We also asked a series of questions aimed at getting their personal thoughts and opinions on factors such as accuracy, metrics and the benefits of wearing an activity tracker. In regards to the accuracy of their devices when it came to the study’s primary metric (step count), all of the participants rated their devices high - seven or better on a scale of one to ten. The majority of participants also proclaimed step count as their favorite metric to keep track of, claiming to check it frequently throughout the day. When asked how long they thought it would take to really benefit from their device, all respondents agreed that positive results could be seen in a month’s time or less. An overwhelming majority also agreed that compared to past attempts at improving their fitness, wearing a fitness tracker has been one of the better overall solutions. At this point, all respondents were comfortable using their devices on a daily basis and were ready for the next phase of the study.

Final Questionnaire – There were 12 responses to this final questionnaire. There were no significant changes in the daily routines of participants and most continued to take part in their favorite activities such as walking and strength training. On the other hand, there was a slight drop in the group’s opinion regarding device accuracy, with a few scores dipping as low as four on a scale of one to ten. Still, more than half the group continued to rank their device seven or better.

Participant responses also show that wearing the tracker continued to motivate them to find ways to remain active throughout the day, ways that include using the stairs and walking to their next destination more often. Counting calories was previously found to be unpopular amongst the group, so this time participant were asked if wearing a tracker played any role in motivating them to watch what they ate; five out of twelve claimed that it had.

The expected Hawthorne effect played slightly less of a motivational role this time around; only one participant ranked ‘being observed’ as the dominant factor behind their activity level and five others chose it as one of their top three motivational factors. Although group

B. Questionnaire Findings

Day One Questionnaire – All 15 participants responded to this initial survey. The great majority of participants said weight loss and becoming more active were the primary reasons for choosing to wear an activity tracker. Many also showed an interest in monitoring their sleep. When asked about technical ability, no one in the group was a novice when it came to the configuration of electronic gadgets, which was a major concern of ours. Some had to go online for help with the initial setup, but overall no one really needed our assistance. In regards to activity levels, only two of the participants claimed to live sedentary lives, while the rest claimed to have a fairly active daily routine. The most popular fitness activities amongst the group was that of walking and strength training. Over half the group expressed being able to work out over three times a week, the other half once or twice, and only one participant claimed to not work out. When asked if they enjoyed working out in a social or group setting, over half of the group preferred it because it motivated them to better meet their fitness goals. All but one of the participants agreed with our request to wear the device daily and for as long as possible, the majority citing battery life as the only real concern.

Week Three Questionnaire – For reasons outside out of our control, only 12 of the original 15 participants were able to take this questionnaire. Although walking remained the most popular fitness activity, there was an increase in the amount of participants that also began to run or jog, ride a bicycle, use cardio machines as well as popular workout videos. Overall, all but one claimed to be working out more often since the study began. The same could not be said for monitoring daily calorie intake. Only one participant had begun to monitor their diet due to the study, however more than half responded by saying they found it too tedious of a task to commit to, and two claimed they had always done it prior to the study. When asked what motivated an increase in their routines, the primary reason was a desire to meet the goals set within their devices. The constant reminders and notifications displayed on devices as part of the accompanying app’s goal reinforcement features came
participation and competitive activities were strongly encouraged during the final four weeks of the study, reaching set goals remained the most influential factor in their daily activity levels. Friendly competition with friends did however come in second, with nine out of twelve participants finding it to be an effective tactic in increasing motivation and activity. Forty-two percent of the participants also found sharing their achievements on social media to be a helpful way of staying on top of their fitness goals as well as an alternative way of encouraging their peers to follow suit. When asked if their use of a tracker had motivated others in their social circle to purchase one for themselves, nine of them responded by saying yes, although not always one from the same manufacturer.

Only two of the participants felt the tracker was a primary driver of positive change in their fitness habits, while the rest felt it to be one of many contributing factors, albeit a significant one. Nevertheless, they did feel that wearing the tracker had become an essential part of their daily routine, comparing it in importance to that of a smartphone or wallet. When asked what they were looking for in their next device, the popular response was one with more smart features, and three participants stated they would be looking for one with a better social component. Only one participant responded saying they would not be wearing a tracker now that the study had concluded.

External Survey – There were 19 respondents in total, all of whom had to authenticate using their Google credentials in order to prevent multiple responses by the same individual. All respondents are Pace University students claiming to have used a fitness tracker for at least a month’s time, 11 of which claim to have been using one for a period of over six months.

As expected, there were quite a few similarities between our closed group of participants and this external group of students. The majority purchased the tracker for monitoring their activity levels and a desire to reach their ideal weight. Only two claimed that they were not interested in fitness tracking; it just happened to be one of the included features in their smart device. Just like our participants, the great majority wear the device as close to 24/7 as possible, with only four users claiming to take it off occasionally for reasons such as irritation and personal aesthetics. When asked how the tracker has affected their daily routine, the most popular response was that they felt wearing the tracker encouraged them to continually look for ways to keep moving, often choosing to walk and using the stairs whenever possible. Only three claimed that the tracker had no effect on their daily routine. The majority of respondents also claimed to meet their set goals anywhere between three and five days a week, putting them right in line with our closed group of participants that happened to meet their goals 42% of the time. No one in the external group found the fitness tracker to be the primary driver of change. The majority found them to be just one of many contributing factors, and five respondents did not find them to be helpful at all. When it came to counting calories and monitoring what they ate, roughly 63% claimed to do so, and of that amount, 42% attributed it to wearing the fitness tracker – the same as our closed group.

There were startling differences between the two groups when it came to using the social component in their devices. The external group’s responses of students showed that they were largely opposed to using the social component integrated into their devices. Just three respondents claimed to use such features and found them to be helpful; however, the rest were not interested in competitive events and preferred to work out on their own. Their use of a tracker had very little effect on those around them, with just five respondents claiming they had influenced their peers to purchase one for themselves. When it came to posting fitness achievements on social media, 90% of the respondents claimed that this did not apply to them.

5. Conclusion

Based on the results of the surveys, the majority said that step count was most important for measuring healthy habit formation when compared to other recorded metrics. The lack of social components in device ecosystems studied all demonstrated they were not good enough on their own when compared to the Fitbit challenges. ‘All’ rated the accuracy of their device based on confidence at 70% or above for the Week 3 Survey; the ‘majority’ of participants said on the Final Survey 80%. Thus, the survey participants feel confident fitness trackers can be useful and accurate to meet their primary objective. Overall, the user study participants everyone agreed that it helped make them more active; albeit, both parties agreed that the device itself was not a primary motivator but only a facilitator; however, they all agreed that it was becoming more important factor in their daily lives.

The reason for the external survey was to get an additional perspective into our participant survey based on the results of the External Survey the majority said they were not interested in the social component such as competitions and social media use and reported to not inspiring others to purchase a device whereas the internal claimed overall to have done so. Albeit, the majority of the external group had used it for at least six months, demonstrating they benefit initially and are moving to new phases of use that our internal may also after the initial habit forming period. Results show the User Study participants had no interest in
monitoring calories whereas 66% of the internal set said they did.

6. Future Work

The current study includes a wide variety of activity trackers with different reporting formats. The data from this study could be used to develop and propose a standard framework to facilitate comparisons between people using different activity trackers. Until reporting standards are adopted by all activity tracker software, utility programs to transpose data to a common format could be developed.

Other future work would be development of a social networking and challenge site that allows users of any activity tracker to easily register and track challenges with users on different activity trackers. This capability could provide a stronger social incentive, and this study could be run again once that capability is available to compare results.

7. References