Final Team Report for HC System: Detecting stress during activities

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# CONTENTS

1 Introduction 4

2 Related Work 4
   2.1 Purpose of the HC System ........................................... 5
   2.2 Human Contribution to the System .................................. 6

3 Functionality of a Novel HC System 6
   3.1 Functionality as Seen by a User .................................... 6
   3.2 Functionality as Seen by a Stakeholder ............................. 6
   3.3 Incentivization Concept ............................................. 7

4 System Design and User Interface Elements 7
   4.1 System Architecture .................................................. 7
   4.2 Algorithm for Data Aggregation .................................... 9
   4.3 Technologies Used for the Implementation ......................... 11
   4.4 User Interfaces of the System ..................................... 12

5 System Evaluation and Success Criteria 14
   5.1 Limitation of the System ............................................. 14
   5.2 Evaluation and Success Criteria ................................... 15

6 Future Works 15
   6.1 Possible Extensions of the HC System ............................. 15
   6.2 Thoughts on Interaction With Other HC System .................. 16
ABSTRACT
The effects of stress can be enormous. Starting with sleepless nights and continuing to strokes and heart attacks. As stress is a permanent companion in our today’s society it is a common problem to deal with. Stress can be either negative (distress) or positive (eustress). Although positive stress can be useful in learning situations, both types of stress can cause adverse health outcomes. Therefore, strategies to deal with stress and its consequences are needed.
To reach this, a human computation system can be helpful to detect stress and dealing with it. The idea is a game with a purpose where the users can control their avatar by means of their heart rate, which is tracked by a wristband. At the same time, they can detect their stress level and the reasons for their heart rates, while also having fun playing the game. For controlling their heart rate, users get tips by the HC system. These can be for example exercises for breathing or meditation.
As the system can only be helpful when used by the users, they can give feedback about which exercises were helpful and also give suggestions for tips.
1 Introduction

In today’s society stress is almost a permanent companion. It is a common problem in our contemporary society, especially among students and professionals. The pressure and demand to deliver excellent results in their studies or at their work places is constantly growing. To overcome this pressure, plenty of them are using wearables as smart watches or fitness tracker along with their smartphones to monitor their daily activities and to measure physiological data [5].

Sometimes stress can be a good companion when it is positive stress, or eustress. Eustress can push people to their best e.g. in learning situations.

But unfortunately there is also negative stress. It is also called distress. If this negative stress becomes too much, it can have serious impact on one’s health. To prevent negative consequences of stress it is important to prevent stress or at least to learn how to deal with negative, but also with positive stress.

In this paper a human computation system is presented that helps to deal with negative stress and detect positive stress. For the beginning, learning as an activity during which stress should be detected is chosen. This system is an application that consists of a game with a purpose that shall help people to detect and therefore decrease stress by doing certain exercises and keeping one’s own heart rate in mind. Within this paper the functionality of the app will be presented, as well as the design of the app, the evaluation and success criteria and the future work.

2 Related Work

In many papers and scientific articles, stress has been researched [1] [2]. Firstbeat Technologies says [2] that stress is indicated as a part of normal daily life, and physiologically manifested by increased sympathetic and/or diminished parasympathetic activity of the ANS. From a biological viewpoint stress is an increased activation level of the body when sympathetic activity dominates the ANS and parasympathetic (vagal) activation is low [1]. But stress is not equal stress, negative and positive stress have to be distinguished. Positive as well as negative stress gives energy ”to get the job done”.

But negative stress causes negative emotions and reactions [1]. Thus, especially negative stress, for instance enhanced through the fear of not passing an exam should be preferably avoided.

The effect of stress on learning also has been investigated. ”While stress around the time of learning is thought to enhance memory formation, thus leading to robust memories, stress markedly impairs memory retrieval, bearing, for instance, the risk of underachieving at exams” [2]. Furthermore, S. Vogel says that being moderately stressed can enhance memory formation for emotional material and information that is related to the stressful context, whereas stress may impair the encoding of stressor-unrelated material. It is also mentioned [2] that considering that stress is ubiquitous in education and even primary school children often report stress symptoms, understanding the effects of stress on memory is very important [2].
There are tools respectively human computation systems that help people to track and analyze their stress during learning situations, such as Stila [5]. "The goal of project Stila is to provide students and professionals with personalized recommendations aiming at improving their learning performances. To achieve this, stress development of students and professionals needs to be monitored during theirs learning activities" [5]. To incentivize users to use such a system, several types of HC system are conceivable. Since at a Game With A Purpose (GWAP)\(^1\) the participants can have fun, at the same time helping to accomplish those tasks that are very demanding for machines, such as image labeling [...] [3], GWAPs are often a well working solution for that kind of tasks. To overcome the issue that pure stress measurement by providing HR data could be annoying for user over time, the type of HC system described in this work is chosen to be a GWAP. "People do not play because they are personally interested in solving an instance of a computational problem but because they wish to be entertained" [4]. Furthermore the user can have feedback about the own stress development during learning within a funny and entertaining method.

2.1 PURPOSE OF THE HC SYSTEM

Since stress can arise either in a positive or in a negative way and one can say that we are permanently experiencing a specific way of stress the HC System described in this work is a possibility to detect and manage effects of stress that can impair memorial functionality. On the one side the Human Computation System should be able to collect heart rate data from the users and analyze it afterwards. It must provide a smart way of collecting data and the further processing of it should be automated. Finally, the system should provide a way to detect stress development by analyzing the given data and furthermore, to detect positive (eustress) and negative stress (distress) within recorded sessions of heart rate data. On the other side the Human Computation System gives feedback about stress development related to specific learning situations such as learning for an exam or attending a course. This helps the user to be aware about his/her stress levels. Thus controlling one's own stress level will be supported by the help of the HC System. Since studies showed that also lower levels of stress (as they may occur more frequently in schools) during or just before learning may strengthen human memory and furthermore being moderately stressed can enhance memory formation [2]. So the function of the HC System supporting to control the own stress level seems to be very useful.

Also since human's health, especially mental health suffers from a permanently high level of stress, the user should be able to decrease it which leads to an overall better health and life quality. Hence, the probability of heart attacks related to permanent high stress levels should be reduced.

The HC System should identify the development of stress, in detail eustress and distress related to specific learning situations. This information will support stress awareness.

\(^1\)https://www.artigo.org
2.2 Human Contribution to the System

The purpose of the Human Computation system has been clarified, but what is the contribution to the system? First of all, the system users have to wear a fitness tracker to collect data which can be used for analytics. This tracker sends continuous heart rate data to the app that is synchronized with an app called "Stila" to get eustress and distress. These are the human data which will be tracked automatically. Furthermore, the user can make some inputs to get more detailed information about his/her current learning state. Especially his activities like "learning for an exam", "taking an exam" or "attending a course". These are very high-level information, but we also need low-level information to get better analytics and improve the learning situation with stress. Low-level data is the kind of workings the human actually does like learning for "mathematics". Moreover, the user has to follow the instructions given from the app to relax, or respectively to control the stress level during learning activities. The last input of the human for the system is to evaluate the instruction and maybe also give examples for further exercises.

3 Functionality of a Novel HC System

3.1 Functionality as Seen by a User

The users could be anyone from pupils to students to employees or professionals. All of them are the target group, because everyone should have a good and smooth stress level.

With the app, the user can control his own stress and get a good awareness of stress. For instance, the quality of human health will be improved, because the user decreases distress and maximizes eustress. So the users are learning much about stress while having fun, and how to handle distress. While learning with eustress, for example for an exam, the brain can store more information in a shorter time. So the achievements in school, university or at work will rise and the human's efficiency increases.

With the rating system of the application, the user can evaluate the exercises they did for getting less distress and more eustress or rather no stress at all. Furthermore, the user can recommend other exercises they made in the app for special learning situations, which were also helpful during their learning situation. So the users learn a lot of practices to control their own stress and improve their efficiency.

3.2 Functionality as Seen by a Stakeholder

A university or a company, for example, are in line for a stakeholder for the app. The university could use the data for research, but also to improve their own lectures. The professors know in which parts of the lecture the distress of the students will rise. So it is possible to handle it.

This can also be applied by teachers in school to handle the stress level of their students. Teachers can react to the distress of their pupils. So the children have less distress and less negative impressions of learning.

Companies can also be interested in this data, for example, insurance companies can use this
kind of data to prepare personalized contracts. An alternative employment opportunity for companies is to protect employees from getting burned-out, heart attack or any other stress-related diseases. So they can classify work packages with a stress level rating. Furthermore they can give some training with the app in reducing stress and present the most helpful exercise. Health organizations can help people, with stress-related diseases, become healthy with the use of depending on the stress arise and personalized exercise. The stakeholder have many options for the usage of the data, to improve their business or help people to prevent from stress-related diseases.

3.3 Incentivization Concept

Playing has been an activity to fill spare time ever since. While there are a lot of games that are created to make fun while playing it, there are also a lot of games with a purpose. Every game has a different purpose. While some of them are just created for having fun, others shall solve certain problems. The human computation system presented in this paper is a game with a purpose. In this game the users get information about their current heart rate and can control their avatar in the game by trying to achieve a constant healthy heart rate. This means, that in stress situations the user has to use techniques to relax to reduce a high heart rate and therefore preventing their avatar from dying. The suggestions for relaxing are also given by the system and can be expanded by the users. In chapter 4.4 the concept of the system is explained more detailed.

The purpose of the system is to raise awareness for detecting stress during learning situations. The motivation for using this system is having fun playing it, while also getting information about what to do to decrease the heart rate when the stress level is too high or too low and therefore rising awareness for their own stress level. Thanks to this information people can achieve a bigger learning success because they develop an understanding for eustress and distress. This understanding can be used by the people properly in different situations. E.g. people can use eustress for achieving bigger learning success, while in distress situations people can play the game to calm down and e.g. start learning again with a calmer mind.

Becoming more successful at e.g. learning may not be the only reason to use the system. If the game delivers a certain fun factor, people are more likely to play this game to beat the highest score and excel oneself in the game.

4 System Design and User Interface Elements

4.1 System Architecture

The Human Computation System consists of various technical components which are connected through interfaces and interact with each other. Both hardware components and software components take place in the system. All in all the system consists of three main components creating the basic architecture of the HC System. The first to be mentioned is the tracker component implemented through a FitBit wristband (see Figure 4.1).
The wearable device, e.g. FitBit or a Polar wristband measures the heart rate activity of the user and saves the tracked data in their database. The next component of the system which is the frontend (GWAP) realised through a native mobile application for both iOS and Android. The app uses the FitBit developer API to be able to receive the measured data from the tracker respectively from the FitBit database and to get information about the user like the name as well. Like mentioned in the FitBit documentation, after the implemented application has been registered at FitBit, anyone can develop an application to access and modify a Fitbit user’s data on their behalf. Several types of data such as food data, sleep and of course also heart rate data can be fetched from the FitBit database. The fetching is realized via GET requests, in detail https-requests. One receives a json file containing the information. The application forwards the received data automatically to the Stila Portal, which is able to analyse stress out of a given set of heart rate data. This automation of synchronizing data takes over the task of sending the data manually to the Stila portal. Since the goal of project Stila is to provide students and professionals with personalised recommendations aiming at improving their learning performances [...] and for achieving this stress development of students and professionals needs to be monitored during their learning activities [5], the GWAP provided in this work can be seen as an extension of Stila. Summarised, the data analysis takes places inside Stila. More specifically Stila can detect eustress and distress along a sequence of heart rate data (see Figure 4.2). Moreover the frontend uses the Stila API to communicate with the portal. After the data analysis process the information about eustress and distress

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Figure 4.1: System architecture of the Human Computation System with technical components. These are: A wristband (left), the frontend in form of a native mobile app (iOS/Android), the Stila portal and the backend.

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[https://dev.fitbit.com/de](https://dev.fitbit.com/de)
will be requested and read by the frontend. This data is needed in order to bring the GWAP to life. The received data will be then sent to the backend which is reachable via HTTP requests from the frontend. The data containing information about distress and eustress related to specific learning situations will be pushed and stored in a database. Furthermore the stored data will be aggregated according implemented aggregation algorithms within the backend logic which will be described in the following section. Finally, the last component of the system to be mentioned is a web interface where aggregated data can be evaluated. This web interface receives the data also with GET-requests from the backend. Especially universities or teachers as stakeholders can do evaluations which could be interesting for them. For instance, it could be evaluated how the stress level generally looks like during math exams.

Figure 4.2: Visualization of stress in Stila. One can recognize eustress (green) and distress (red) in the diagramm.

4.2 ALGORITHM FOR DATA AGGREGATION

To be able to recognize coherences and get findings about stress development during learning the data containing the information about computed stress needs to be prepared for further aggregations. As described in Fig.4.1 the data collected are aggregated in the backend of the system. Algorithms used by the human computation system of this work is mentioned in the following.

Labeling: One of the algorithms used in this human computation system is to label data sets containing information about stress related to a specific learning situation. Labeling is a tech-
nique also used by several HC systems, especially GWAPs like the ESP Game [4] or Karido \(^3\) which are a Games With A Purpose to label images [4]. Since the main function of the system is to detect stress of a user during learning such as learning for an exam, sitting in a classroom and having lecture or just writing an exam the collected heart rate data has to be assigned to specific learning situations. The user tells the system in which type of learning situation he or she is before recording heart rate data during a learning session. The input about the task or learning session the user is situated comes directly from the user. This is one of the human contributions to the HC system. The tag or also the tags the user provided will be assigned to the data set containing information about distress and eustress during that sequence. Finally the data set measured is labeled. For instance, if the user told the system that he or she took an exam, the data will be then labeled with the tag "writing exam". If e.g. the system detected a high emergence of negative stress during the last tracking and evaluating session, this information can be very interesting for comparing with further similar learning situations. Furthermore the user can also give an input about the subject of the learning situation. For instance “informatics” or “mathematics” would be possible input tags for additional labeling.

Furthermore, the system is able to detect coherences between datasets provided by a certain user. This is possible with the help of the provided tags related to the datasets. So the logic of the system can evaluate stored datasets of a specific user and can detect typical behaviors of stress e.g. attached to particular learning situations. For instance, if a user has many data sets labeled with the tag "mathematics" and "exam" and moreover, if these datasets contain mainly negative stress, the finding that the user does have lots of negative stress during mathematics exams could be a helpful information and feedback. Assumed that the user wants to know more about his or her stress development during exams in general, all records in the database of the corresponding user containing the tag "exam" will be evaluated. The stress of these datasets will be summarized and the emergence of distress and eustress will be compared. Also, the own stress development e.g. during exams could be compared to entirety of the users. This gained information about stress development during specific learning situations in general can be also very helpful for institutions like universities, schools and more.

Another type of dataset which is stored is the advice for the user. Users get advice for achieving better results in terms of stress during learning e.g. in form of popups or similar. The goal is to give the user sensible advice related to a specific learning situation. To evaluate if an advice is useful for specific learning situations users can give their feedback through rating mechanisms. If an advice did receive good feedback from the user side it will be shown to users more often in the future. If an advice is rated bad, the opposite happens. The advice can be rated through a five star rating system like it is used e.g. by Amazon for rating products. In order to search for useful advice which can be given to the user, the system uses an algorithm that identifies good advice for the current learning situation. This is realized through an item-with-item table which contains entries representing each learning situation or subject (first item) combined with every advice (second item). Every entry also consists of a field containing the total rating of the users which is \(R_C\). The whole combination is defined as a \(LAR\) (see Figure 4.3). Besides, it is also stored if a user already rated that combination of

\(^3\)https://www.artigo.org/karido
items. If yes, the corresponding advice won’t be shown again to the user in the appropriate learning situation in case he or she gave a bad rating. The threshold $T$ concerning the rating of an item-with-item entry determines if an advice related to the specific learning situation is good or not. $T$ is has to be chosen but is customizable. Finally, if an entry lies under $T$ it won’t be shown to a user in the corresponding learning situation. A criteria which also has to be noted is the number $n$ of users that have given a rating to a $LAR$. If $n$ is smaller than $m$ (representing the minimum of users that must have rated an advice), the advice will be still shown to users anyway, independent of the rating average. If $n$ is greater or equals $m$, $T$ is the next criteria for the evaluation if an advice will be shown or not.

![Flowchart of the algorithm determining whether an advice is helpful or not in a specific learning situation.](image)

$LAR:= \text{Combination of learning situation, advice and rating}$

$n:= \text{total number of ratings for } LAR$

$m:= \text{minimum number of ratings}$

$R_c := \sum \text{all ratings} / n$

$T:= \text{Threshold defining whether advice is good or not}$

$$\text{IF } n >= m \text{ AND IF } R_c > T \text{ THEN advice is considered to be useful}$$

**Figure 4.3:** Visualization and pseudo code of the algorithm determining whether an advice which is shown to a user is helpful or not in a specific learning situation.

### 4.3 Technologies Used for the Implementation

To implement the human computation system described in this work, several technologies such as third party libraries and platforms with which it should be developed have been chosen. As shown in Figure 4.1, the system includes a FitBit wristband as a tracker of heart rate data. To be able to receive the data the FitBit measures, the FitBit Developer API is needed and will be included in the mobile application. The mobile application is a native mobile app, both implemented for the two most common OS for smartphones on the market, iOS and Android. Information from FitBit will be requested and pulled from the corresponding mobile app. Also, the mobile app communicates with Stila. Stila is the part that detects distress and eustress out of the measured heart rate data. The result will be pulled by the mobile application.

Furthermore the gained data will be pushed to a database as part of the infrastructure of the
system. For that the system uses REST technology to realize uploading data to the backend as well for fetching data. In order to get feedback about user behavior and how the users accept the system, fabric[^4] is integrated into the system as tool for analyzing. Information such as daily or weekly active users as well as the user retention will be recorded and saved. This will give feedback about the quality of the HC system on the one side and the usability on the other side. Furthermore the tool Google Analytics is also integrated into the system and is used as another tracking tool for user behavior. With the help of Google Analytics, specific screens of the app, especially levels of the game can be evaluated. Screens of the app can be tagged with a name within the implementation. Every time a user opens a screen, the information about that hit will be sent to Google Analytics. With the help of that information one can evaluate e.g. how often several levels of the implemented game are played and in general, which parts of the app are used mostly and more. This feedback can be used well for further success evaluations of the system.

For implementing the graphics component of the frontend, it is used the OpenGL library[^5]. Since the game does have graphics implementation challenges, the OpenGL library supports implementing this part. Furthermore, adding new game levels and also 3D graphics can be done with the help of this library.

### 4.4 User Interfaces of the System

The app consists of a loading screen, and a main menu. Within the main menu the user can select what kind of activity he is currently doing and what game with a purpose he wants to play. Examples for the activities are "taking an exam", "learning" or "attending a course". In the level section the user can select the type of game he wants to play. Examples for the levels are the balloon game, the balancing game, or the frustration eater so far. (see Figure 4.4)

The task in each level stays the same: trying to decrease stress detected by the app. The current heart rate is shown in each type of game and tips are given to achieve and keep up a good heart rate. When the heart rate reaches a healthy level and stays there for a severe time, the game is won.

In the balloon game the user can see his avatar holding a balloon and walking around. At the top of the screen there are clouds which shape a stress-level curve and show the current heart rate. If the heart rate is on a good level the avatar can hold the balloon easily. As soon as the heart rate rises, the avatar gets difficulties in holding the balloon until it flies away when the heart rate is too high. If the user reaches a good heart rate and manages to keep this rate for several minutes, the avatar gives the balloon to a little child to makes it happy and the game is won. (see Figure 4.5)

The balancing game is another level within the app. As well as in the balloon game the heart rate is also displayed and tips for reaching a good heart rate are given. In this level the avatar is balancing on a slack line over the mountains. The summits and valleys of the mountains are also showing the increasing and decreasing heart rates. As the heart rate increases, the avatar becomes restless and shaky until he falls off of the slack line and crashes into the mountains. If the user reaches a good heart rate and manages to keep this rate for several minutes, the

[^4]: https://fabric.io/home
[^5]: https://www.opengl.org
avatar balances on the slack line with ease and reaches a platform where he can stay safely. After that the game is won. (see Figure 4.5)

In the level with the frustration eater the avatar jogs around. With an increasing heart rate the avatar becomes slower and frustrated. He then sits down at a table and starts to eat fast food until he gets fat. When the heart rate level becomes too high the avatar dies from a heart attack. In this level the current heart rate is shown as well as tips to decrease the heart rate and therefore motivating the avatar to stop eating and start jogging again. When the user reaches a good heart rate level and holds it for several minutes the frustration eater starts jogging again until he reaches the finish line and the user wins the game.

The following pictures show what the interface of the menus in the app could look like:

![User interfaces of the menu structure](image)

**Figure 4.4: User interfaces of the menu structure**

The menus consist of buttons where several options can be selected. The following pictures show examples of what the interface of the games in the app could look like:
At the end of the game the users can rate the app and give feedback about which tips were helpful. They can also make suggestions for tips which helped them to relax and which were not given in the app. These suggestions can then fill the database and other users can get those tips to relax.

5 System Evaluation and Success Criteria

5.1 Limitation of the System

Like almost every system, this GWAP human computation system has its limitations too. One of them is receiving data in real-time. Stila needs a certain dataset to analyze eustress and distress. This requires a selection of data up to 30 minutes. Therefore displaying heart rates in real-time is not possible. Another limitation is the success of the tips in the beginning. The given hints during the games can be rated at the end of a game. People can evaluate which tips are rather helpful and which are not. With the help of the evaluation, hints that are useful will be given more often to leading to a better control over oneself’s stress. Therefore the hints that are shown in the games become only helpful after a several time, i.e. after evaluating the hints.
5.2 Evaluation and Success Criteria

The success of the app depends on the amount of the people using the system. The more people using the system, the more successful the game. This information can be tracked with the help of analytics tools like e.g. Google Analytics which has been mentioned in the earlier section. But not only the amount of people is important for the success criteria. Evaluating the success of the app is also important.

This could be done e.g. by evaluation the people's opinion about the app. If the app gives suggestions about what to do to calm down and if these hints are actually helpful, people will give a good feedback when rating the app. The evaluation of the app could be done by asking the users to rate the hints after a game. In a free text field people can also give feedback about things that were not asked to rate. But the text field can also be used to suggest specific exercises e.g. that can help to calm down, that have not been shown before. These suggested exercises can be shown to other users by the system, which then again can be rated by those other users. The rating system could be a five star rating system, where the users can evaluate certain things in the app with one star, if something is not satisfying or even five stars if something is very satisfying.

6 Future Works

6.1 Possible Extensions of the HC System

There are some options to extend the Human Computation system. At first the application gets more level with new different animations. Another extension for the user functionality is to get more useful exercises to retain the health and reduce the distress. It is also possible to add an statistic to see what the graph of eustress/distress is like. But a lot of more profitably statistics can be added there.

It can also be used in other areas and not only in learning situation. For example the user entered as activity shopping and the app detect the stress-level during shopping. If there is too much distress, the app will notify the user and give him some instructions to reduce it. There are so many activities which can be detected and synchronized with the app. In sports or driving a car it is also necessary. This app can be easily extended with new activities because in every situation the fitness tracker synchronizes the heart rate data with the app and handle it in the same way. But for analyzes it is important to know the activity, because in this case the system can recommend personalized exercise. Maybe a web application can be also useful, where the user can have a closer look on his data and can make some reports. Furthermore there could be some more statistic views on the health data, like the heart rate, distress and eustress.

Another possible extension is to connect the application with physical fitness equipment. To reduce stress the user has to do some exercises on the workout equipment and the app tracks the sport practices too. So the app will not only improve the stress level, but rather get a healthy application with stress detection.

In addition to the FitBit, there are more options to track health data. For example, sensors for tracking the health data can be sewn into clothes. Similar to the wearable jacket from Levis
and Google, which "allows you to stay connected without reaching for your phone"[7].

6.2 Thoughts on Interaction with Other HC System

As in the previous chapter described, it is conceivable to combine the application with a fitness equipment. So if it is a smart fitness equipment which also tracks human information, for example a rowing ergometer, it is also a human computer system. In this case, it is possible to combine sport activities and stress detection to reduce distress. One more way is to connect the app with a shopping website, like Amazon. People could then recommend which fitness equipment they get the best results with. The app will then make some purchase suggestions to other users, for example to buy a meditation cushion.

It can be also used for music platforms, e.g. Spotify. Based on an algorithm the user gets a recommendation for a special song to reduce his stress level. But therefore the users have to track also the music that they are listening to or to enter it in the feedback.

An other point is connecting the application with different social media platforms to show the statistics of stress or other reports which show the people the awareness of stress. It is possible that people try to be better than the other and get better results of the stress level. This means the eustress will be raised and the distress will be decreased. Last but not least, it could be connected to other GWAP to reduce the stress level. For example, if somebody is playing the game "ARTigo" (www.artigo.org), and getting relaxed, so the app will recommend these games to the other users as well.

All in all human computation systems could be used to reduce the distress and are therefore good for humans to live a healthier life.
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