Chapter 17
Positive Computing

Tomas Sander

Introduction

In his opening speech at the International Positive Psychology Association (IPPA) Conference in June 2009, Martin Seligman, founder of Positive Psychology, formulated a formidable challenge: By the year 2051, 51% of the world population should be flourishing. This is an ambitious goal given that even in the richer, "happier" Western world only 2 in 10 people are considered to be genuinely psychologically flourishing, according to some studies (e.g., Keyes, 2009; Huppert & So, 2009).

A necessary condition for achieving the 51% goal is that Positive Psychology develops a delivery model for its well-being enhancing interventions that scales up globally. Meeting the 51% goal will require a sea change in how we look at public policy (Diener, Lucas, Schimmack, & Helliwell, 2009) and at national accounts of well-being where raising those accounts is made a major policy goal. Research by positive psychologists, such as Sonja Lyubomirsky and Barbara Fredrickson, focusing on positive interventions, suggests that besides good policies there is also a significant role that individuals can play by changing their attitudes, beliefs, and behaviors (e.g., Lyubomirsky, 2008; Fredrickson, 2009) in order to lastingly raise their level of well-being. But how can these change processes of individuals be supported in a truly scalable fashion?

The main thesis of this position paper is that we should take a radically new look at information technology to uncover the possibilities it can play in contributing to the 51% goal. I will present several arguments for the proposition that information technology is uniquely positioned for assisting individuals with their flourishing in a way that is effective, scalable, and ethically responsible. Following the tradition of successful, galvanizing notions such as Positive Psychology and Positive Health, I propose to call the study of information technology from the perspective of human flourishing Positive Computing.

T. Sander (✉)
HP Labs, Princeton, NJ 08540, USA
e-mail: tomas.sander@hp.com

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The question what "flourishing" or the "good life" is has been around for millennia and different answers have been given within religion, philosophy, and increasingly within psychology. To have a better understanding of the key term of "flourishing," we briefly review some of the contemporary conceptualizations of well-being that have been given within Positive Psychology:

- Diener et al. pioneered the model of subjective well-being (SWB), which is defined as a subjective sense of satisfaction with one's life, the presence of frequent positive affect, and only lower levels of negative affect (e.g., Diener, 1984, 1994). This approach is sometimes called the hedonic approach.
- Ryff's model of psychological well-being is an example of a conceptualization of well-being influenced by the idea of "self-actualization" (Ryff, 1989). Its six dimensions are: autonomy, environmental mastery, personal growth, positive relations with others, purpose in life, and self-acceptance. This model can complement a subjective well-being approach.
- Seligman speaks about "three pillars" of the good life (Seligman, 2002): the pleasant life, characterized through the presence of positive emotions, the engaged life, where one is engaged in satisfying activities and utilizes one's strengths and talents, and the meaningful life, in which one serves a purpose larger than oneself. He recently suggested adding positive relationships to this list.
- Sheldon et al. focus on how pursuing and achieving goals that are aligned with a person's core values and beliefs leads to personal growth (Sheldon & Elliot, 1999; Sheldon & Houser-Marko, 2001).
- Deci and Ryan stress the importance of the fulfillment of the basic psychological needs of autonomy, competence, and relatedness (a sense of belonging) for well-being (Deci & Ryan, 2000).
- Hayes et al. put the focus on actively moving toward one's important life goals and values, independent of whether that makes one feel good or bad in the moment (Hayes, Strosahl, & Wilson, 1999). Thus this approach downplays the role that positive hedonic tone plays for leading a fulfilling life.

Different researchers and individuals assign varying importance to the elements in this admittedly incomplete list. In addition, characterizations of the good life vary considerably across cultures (e.g., Markus & Kitayama, 1991). The first conclusion from this list is that there is no universal notion of what well-being or human flourishing "really" is. Fortunately, for the purpose of coming up with a good working definition for Positive Computing such an agreement is also not necessary. Much more important is that the list of goals is kept open for ongoing revision and is inclusive, so it can reflect and honor people's diverse perspectives. Otherwise a global acceptance and scale cannot be reached. The second conclusion is that the objective of enhancing flourishing provides computer scientists with a rich set of plausible sub-goals that are valuable to pursue and that will require quite different technical approaches. For the remainder of the chapter we use the term "flourishing"

as a family resemblance term for the type of constructs in the list above and can now define:

> Positive Computing is the study and development of information and communication technology that is consciously designed to support people's psychological flourishing in a way that honors individuals' and communities' different ideas about the good life.

If technology can make good on the promise articulated in this chapter to significantly increase well-being in a scalable cost-effective way, this benefits individuals and societies enormously. Evidence to support this claim includes Lyubomirsky, King, and Diener's study that people higher in well-being are more successful in life domains such as health, income, work performance, and social relationships (Lyubomirsky, King, & Diener, 2005). Fredrickson has shown that positive emotions help people build psychological and social resources and enhance resilience (Fredrickson, 2009). Pressman and Cohen have found that higher well-being leads to increased longevity (Pressman & Cohen, 2005). Seligman argues that higher well-being predicts lack of depression and better physical health (Seligman, 2008).

The structure of the chapter is as follows. Section "How Computers Can Help Flourishing on a Global Scale" gives six reasons why information technology is an indispensable aid for flourishing. Section "Technological Capabilities Relevant to Positive Computing" presents key technology enablers for Positive Computing. Section "Dealing with Challenging Situations" looks at how Positive Computing can assist coping with adversities and challenges. Section "Addressing Ethical Concerns and Data Privacy" describes ethical and privacy challenges Positive Computing raises, and how one can approach them. Section "Concluding Remarks" concludes the chapter.

How Computers Can Help Flourishing on a Global Scale

This section describes six reasons for the key thesis of this chapter: Positive Computing can be effective in helping billions of people achieve greater psychological flourishing. Throughout the chapter additional examples and research results in support of these reasons will be mentioned.

1. **Anytime, anywhere access to powerful mobile phones.** What sets smartphones (like the iPhone) apart from anything that existed previously is that they are powerful computing devices *that are always with us*. Thus unlike a human coach to whom one has access for typically 1 hour a week they are able to deliver Positive Psychology applications in any situation and at any time, ideally when they are most beneficial.
2. **Computers can collect and act upon data relevant for flourishing.** These data include information about how we feel (our emotions), what we do (our behaviors), and with whom we do it (our relationships). These data can serve multiple functions. Inspection leads to more *self-awareness and insight* into how we live

our lives and can help us move in deeply valued directions. They can support *contextualization and customization* so that *the right Positive Psychology resource is delivered at the right time*. For example, if the data suggest the user is stressed, the computer can deliver a Positive Psychology resource right then and deliver a specific resource that is *right for the person* (some people prefer to relax by listening to a guided meditation, some by talking to a friend and some by taking a walk).

3. **Computers are persistent and can be highly persuasive.** Fredrickson and Lyubomirsky (e.g., Lyubomirsky, 2008; Fredrickson, 2009) have suggested that raising one's level of happiness is not accomplished by quick fixes but requires motivation, effort, and consistency comparable to an exercise program or diet. In support of ongoing lifestyle changes computers can send motivational information and reminders, track progress, and use many other powerful techniques to persuade users to take positive actions. Computers have already been successfully deployed for lifestyle change programs such as weight-loss and exercise (e.g., Denning et al., 2009; Consolvo et al., 2008b).
4. **Information Technology can create environments and experiences beneficial for flourishing.** Information and communication technology mediates much of what we do. Many people spend more time with their computer or phone than with any one person or other activity in their lives. Reality which is already often computer-mediated can thus be designed and "augmented" with flourishing in mind. Computers can assist in correcting negativity biases through the display of more accurate, balanced information about our day, our life, and our memories. An example from the work place involves the emotionally taxing job of call-center agents where it is common that a whole work day can go sour due to one bad call with a customer (Millard & Hole, 2008). After each call the agents release a token on how the call went and the software displays the aggregated information to them. As there are usually many more good calls than bad ones, this helps to put a bad call into perspective. Some psychologists have argued that in today's society for many (though not for all) situations our evolutionary motivated negativity biases do not serve us anymore. Information technology can extend our memory in a more balanced way and correct this bias where so desired.
5. **Scalability.** Computing technology meets massive scalability requirements. As examples, note that within a few years Facebook gathered more than 400 million users. In 2009 more than half of the world population owns a cell phone and more than three in four adults in the United States own a computer. Hardware prices continue to fall creating inexpensive access for more and more people in the years to come. This trend allows Positive Computing to contribute to the democratization of Positive Psychology in two ways. First, by making the fruits and insights of Positive Psychology available to a wide group of people and, second, by making it easier for people and communities to create and distribute their own version of Positive Psychology which may be different from what is done in its currently most prolific basis of research activities in the United States.

6. **Openness and participation.** Computer systems can be designed as open platforms, e.g., by providing open interfaces. These interfaces can be used by other programmers to build new applications on top of existing ones or to modify existing applications. This allows programmers from diverse backgrounds to participate in creating diverse Positive Computing applications that are appropriate for the communities they serve.

For the above reasons there is a remarkable opportunity for technology to support people in new and innovative ways that are not available in an offline world. In addition the principles of openness and scalability can drive a democratization of Positive Psychology by making its benefits available to more people and by allowing diverse communities to create their own versions of what flourishing means for them and how it should be supported.

There are also obstacles that need to be overcome to realize such a vision. Technologies consciously designed to monitor and influence deeply how we think, feel, and act are still radically novel and will for some trigger fears of a Big Brother and technology abuse. These concerns got to be taken seriously. At least some of them can be mitigated through the proper design of the technology itself, e.g., to protect user privacy. We revisit ethical and privacy concerns in more detail in section "Addressing Ethical Concerns and Data Privacy".

Another objection is that computers are unlikely to fully replace the wise, compassionate counsel of a personal coach, doctor or therapist. There may be some truth to this for a variety of reasons. Perhaps surprisingly, research by Nass et al. (e.g., Reeves & Nass, 1996) has shown that people *do* tend to treat computers as if they were social actors. People respond to computers socially and emotionally while being fully aware that computers are not human. For Positive Computing it would be a remarkable achievement if users justifiably regarded their computer as a resource comparable to a "supportive, caring friend, which acts in their best interests." Users already develop emotional relationships with personal technology a prime example being how many people "love" their smartphone. For helping professionals Positive Computing creates a remarkable opportunity to provide their clients with customized resources outside the weekly therapy session.

Technological Capabilities Relevant to Positive Computing

Collecting Data for Positive Applications

In this section we look at which data can be reasonably collected and utilized by Positive Computing applications.

- Location data: where a person is at a particular time (both from a built-in GPS and collecting data about the nearest cell phone tower)
- Movements, e.g., whether a person is standing or walking can be determined from the accelerometer included in some of today's smartphones.

- Analysis of voice in phone calls for symptoms of depression can be done using speech analysis software by Sung, Marci, and Pentland (2005), which can run on smartphones. It monitors voice for slowed speech and other patterns suggesting depression.
- Analysis of text (e.g., email or online postings) for moods and emotions using linguistic analysis software developed by Pennebaker, Francis, and Booth (2001).
- Collection of physical sensor data such as galvanic skin response (GSR), blood pressure, heart rate, and heart rate variability. These can give insight into levels of emotional arousal.
- Analyzing pressure on a mouse reveals levels of user frustration (Reynolds, 1999).
- The microphone of a phone can be used to detect whether a user is currently engaged in a conversation and might thus be helpful to determine an appropriate time to interrupt the user.
- Analyzing typing behavior for indicators of cognitive and physical stress (Vizer, 2009).
- A user's communication patterns, e.g., whom he calls or emails, for how long and how often.
- Calendar data indicating how a user spends his time.

Based on these data, it is first possible to detect (some) situations when a user is particularly in need of support or a boost in well-being, e.g., when he is stressed or depressed. Second, these data help determine when it is a good time to interrupt the user with by a Positive Computing application. (For example, at work it may not be appropriate, whereas at home it is.) User activity recognition from sensor data is an active area of research.

How to leverage these data in a way that enhances human flourishing is an exciting question for both computer scientists and forward-looking positive psychologists. In an interesting related project Pentland et al. argue enthusiastically for what they call "reality mining" (Pentland, Lazer, Brewer, & Heibeck, 2009): "Reality mining, which pulls together these crumbs using statistical analysis and machine learning methods, offers an increasingly comprehensive picture of our lives, both individually and collectively, with the potential of transforming our understanding of ourselves, our organizations, and our society in a fashion that was barely conceivable just a few years ago. It is for this reason that reality mining was recently identified by Technology Review as one of '10 emerging technologies that could change the world' (Technology Review, April 2008)." Examples for the benefits from reality mining are assessment and improvement in individual and community health, including some mental health applications such as screening for depression based on voice analysis and physical movement patterns (Sung et al., 2005). Pentland et al. take mostly a health-related perspective. Positive psychologists can look at these data afresh from their own novel perspective, i.e., how the data can be put to use to enhance flourishing for individuals and communities.

Affective Computing and the Personal Happiness Assistant (PHA)

Affective Computing is a research area started by Picard (1997), which investigates how computers can recognize, interpret, and express human emotions. Positive Computing can leverage many of these fascinating capabilities. However, Positive Computing does not reduce to Affective Computing as in addition to emotional approaches Positive Computing will also incorporate cognitive approaches (e.g., to enhance cognitive constructs such as optimism, hope, self-efficacy, curiosity) and interpersonal approaches to contribute to forming and maintaining higher quality relationships.

Applications of Affective Computing discussed by Picard include online learning software that recognizes when the student is frustrated and adapts its presentation accordingly, a digital disk jockey that selects songs appropriate to one's moods, giving interactive virtual agents the ability to express emotions and empathy in response to the user's emotions and moods (e.g., through facial expression and word choice), and for creating an "augmented memory system" in which a wearable, always-on camera captures video images of a user's life, and in which those that have been determined to be of emotional significance will automatically be kept while others are deleted.

Let us start with an example. Christian Nold, a British artist, has created "emotion maps" since the year 2000 (Nold, 2009). He provided individuals with a Galvanic Skin Response (GSR) sensor allowing to measure emotional arousal, and a Global Positioning System (GPS) device. Users wear these devices as they walk around their communities and the measured data are recorded. By overlaying the collected date on a geographical map (like Google Earth), Nold created an emotion map of the user's physical environment. Nold writes: "People who actually wore the device and tried it out while going for a walk, and then saw their own personal emotion map visualized afterward, were baffled and amazed." He also used this technique in a communal way where people share and combine their maps to create a joint map of their communal environment.

Popular, empirically validated interventions in Positive Psychology as comprehensive include "Three good things," "Keeping a gratitude journal," and "Savoring of past, present or future experiences" (see, e.g., Lyubomirsky, 2008; Fredrickson, 2009; Seligman, 2002 for an overview). They all point to the happiness increasing value that comes from consciously experiencing, remembering, and re-experiencing one's good moments, presumably by helping to develop a more optimistic outlook, counteracting hedonic adaptation through conscious appreciation, and through experiencing more positive affect when reliving good moments.

Many of today's mobile phones are GPS-enabled, and can connect wirelessly with external devices or sensors, for example, with a GSR sensor worn on the hand. For a discussion of cost-effective GSR sensors that are convenient to wear, have a good battery life see, and can wirelessly connect with a computer (see Fletcher, 2010).

Based on these technical building blocks and the related ideas, we can now envision a first example of what non-trivial Positive Psychology inspired technology might be. A "Personal Happiness Assistant (PHA)" application is part of a mobile phone. Its job is to record data about a person's emotional arousal and locations. The PHA automatically transmits arousal data to the user's PC, so the user can view them on a convenient size monitor. The PHA application displays the time and location for peak arousal situations (good and bad). The user can select and annotate good experiences with a short description of what the experience is about, add a photo or tag them with the positive emotion that was most dominant in that situation (joy, pride, enthusiasm, awe, etc.) Alternatively, he can tag the experience with a personal strength he was using.

The benefit of tagging experiences with positive emotions or strengths present is that they can be searched for later, e.g., with a query "show me all the experiences in the last months where I experienced a sense of pride." This is a convenient way to build up "positivity portfolios," which have been suggested by Pawelski and Fredrickson (Fredrickson, 2009).

The success of Positive Computing will be critically determined by the level of end-user acceptance it achieves. For this positive technology needs to be convenient and pleasurable to use. More automation, rather than manual processes will usually do better. For example data collection should run seamlessly in the background once turned on and the data should be automatically pushed onto a platform where they can be easily manipulated. A user should not have to change sensor batteries every few hours. When presented data should be of high quality with respect to the purpose for which they were collected. For the PHA example sensor data need to be cleaned from motion artifacts as the GSR sensor measures sweating which can also come from the physical exertion. To filter out motion artifacts accelerometer data from the smartphone have been used. Solid engineering is required to get all of this to work well, but there are no insurmountable theoretical limitations.

The PHA example also exemplifies the usefulness of having an open platform. Collecting basic data about emotions, memories, etc. will be a useful building block of many Positive Psychology applications and should thus be reusable. Developers will come up with many innovative ideas, e.g., how to share some of this information with friends or to upload it to a social networking site that computes joint "joy maps" of cities, etc.

The focus of the just described PHA is on identifying high arousal moments. This is still quite incomplete, given that there are many serene moments in a person's life that might be worth capturing as well. It is an interesting question how to capture serene moments of well-being in a user-friendly way. Computer scientists have investigated a variety of digital approaches for capturing memories that a solution may built upon (e.g., Hodges, 2006; Hoven & Eggen, 2008).

Note that the PHA also captures stressful moments in a person's life. We describe how those can be used to improve well-being in section "Dealing with Challenging Situations".

Persuading People to Take Positive Action

The PHA described above helps people to gain more insight about what they deeply enjoy. And that may naturally lead them to want *to do* more of that. Positive Psychology has assembled a general "catalogue" of activities that have been empirically shown to improve well-being (e.g., Lyubomirsky, 2008; Fredrickson, 2009; Seligman, 2002). This section explores how technology can assist people take "positive actions," such as:

- using one's strengths regularly and in novel ways
- compassionate acts
- writing 20 min about one's best self
- writing a gratitude journal
- active constructive responding to others
- spending more time with other people
- exercise
- savoring experiences
- loving-kindness meditation
- relaxation
- using one's skills
- playing

Successfully motivating positive actions over time helps overcome a major challenge of lifestyle change programs: It is hard to follow through on one's initial intentions on a consistent basis. For example taking an online strengths inventory reveals to an individual a bundle of personal strengths (*Clifton Strengthsfinder*; *VIA Inventory of Strengths*; *CAPP strengths assessment tool*), which is itself considered a helpful intervention. But how long does the effect of this intervention last? More benefit ensues, the strengths inventory manuals advice, if a person cultivates and applies his strengths over time. This of course becomes easy to forget and after a few weeks one may wonder: "What is it exactly that I am supposed to do? And what are my strengths again?"

To support an *ongoing growth process*, the PHA can support, say, working with two strengths a week, by sending in the morning an *SMS reminder* to the user about the currently worked on strength. The SMS message suggests a *concrete action* what the user can do with this strength today and thereby makes it *simple* for the user to take action, e.g.:

> Utilizing your strength "love of learning" helps you be energized and fulfilled. What can you learn more about today?

Later in the day an SMS message is sent requesting the user to text back a word or two what he actually learned something about as well as a rating how much he enjoyed it. These responses are stored in the user's "Strengths Bank" where they can be reviewed periodically and utilized to create further insight. If this messaging

is done with varying, interesting, relevant content this is a major step toward motivating and supporting users who wish to actively cultivate their strengths *over an extended period of time*. See the work by Fogg and Allen (2009) for more suggestions on how to use SMS effectively for persuasive purposes. An additional benefit of using SMS technology is that it is available on almost all mobile phones in the United States.

Fogg and others created the field of "persuasive technology" which he defines as "any interactive computing system designed to change people's attitudes or behaviors" (Fogg, 2003). Coercion and deception are not considered persuasive technologies by Fogg. Persuasive technology researchers have already created a number of impressive applications within health coaching and to promote lifestyle changes such as eating better, boosting physical activity and quitting smoking. Computer simulations have been used to teach about HIV infection risks and computer games to teach young girls about social skills. Fogg and his students at the Stanford University Persuasive Technology Lab have also conducted work on how to create Facebook applications that spread "virally" and how to create persuasive online video (e.g., for YouTube).

A promising experiment for Positive Computing will be to pick target behaviors from the list of positive actions and to investigate if and how persuasion techniques can support their adoption. Many (though not all) positive actions have the attractive feature to be rewarding and enjoyable *at the very time they are performed.* To get a sense of the sophisticated persuasion techniques that have been used in persuasive applications, here is a list of examples (e.g., Fogg, 2003):

- reduction, where a desired action is simplified to make it easy for a user to perform it,
- tunneling, where a user is led through a pre-determined sequence of steps,
- tailoring, where the persuasion techniques are matched to the user, e.g., for education level, the user's interests, etc.
- social comparison: users like to benchmark themselves against others.
- normative influence: leveraging the desire of users to conform, e.g., by sharing a tracked behavior with the user's in-group.
- self-monitoring in a way that is not tedious.
- social learning: learning from how others do certain things.
- praise.
- reminders.
- reciprocity.
- operant conditioning through positive reinforcement: very popular in video games, however needs to be used carefully due its possible abuse for manipulation.
- presentation of information through virtual human actors, which can apply principles of mimicry, empathy and appropriate display of emotional responses to increase rapport with the user (Bailenson & Yee, 2005).

In conclusion persuasive technology will provide Positive Computing with a valuable set of capabilities to effectively influence users to change their behaviors.

Will all of Positive Computing be "persuasive"? That is unlikely given for example that flourishing comprises goals related to self-actualization, closer to insight, autonomous choices, and value congruent living. Technologies to support these processes will help us gain greater insight into ourselves and how we live our lives but are not "persuasive" per se.

Computers and Purpose in Life

Computer technology has traditionally been optimized for getting tasks done. Recently, Human Computer Interaction (HCI) researchers have started to take a much broader perspective by exploring how computers can support people in living congruently with their values and what is important to them (Karat, Karat, & Vergo, 2004). This thread of HCI research is highly relevant for Positive Computing. Arguably, if computer applications can be successfully designed to help people pursue their deepest values then computers do actively contribute to a value-congruent, maybe even purposeful life.

The HCI researcher Zimmerman wishes to design technology that helps people "to be who they want to be" (Zimmerman, 2009). For computer scientists and positive psychologists interested in flourishing this makes an excellent starting point. As one example, it led Zimmerman to a mobile application which supports busy Zen Buddhists in their spiritual practice. The application enables them to participate meaningfully at the meditation sessions of their Zen centers even when they cannot physically be present. The system provides a live audio connection, so the sound of the gong beginning and ending the meditation session is transmitted in real time. In addition, remote participants are visually represented at the Zen Center itself. This creates a sense of communal presence and practice. The application also allows practitioners to create shared experiences. Sangha members can take and post photos with their mobile phone related to a communally explored theme that then appear as wallpapers on other Sangha members' phones.

Hassenzahl is another HCI researcher (e.g., Hassenzahl & Tractinsky, 2006; Hassenzahl, 2008 who began to ask how technology can fulfill the three basic human needs of autonomy, competence, and relatedness formulated in Self-Determination Theory (Deci & Ryan, 2000). Hassenzahl did a study which showed that users already perceive that computers support autonomy and competence but do not significantly support relatedness.

It is plausible that computers can support the need for relatedness in substantial ways. The huge success of social networking sites that allows friends to stay in touch more easily is an obvious example. Less known, yet powerful and innovative technologies that can have an impact on relatedness have been created in the HCI research community, e.g., technologies for communicating presence. An example is a picture frame that lightens up when a remote lover touches her own version of the frame communicating that she is thinking of her partner at home (Chang, Resner, Koerner, Wang, & Ishii, 2001). Which forms of technology support for relatedness will turn out to be genuinely nourishing and fulfilling is an interesting open question.

The work of Zimmermann, Hassenzahl, and other innovative HCI researchers suggests a meaningful and promising inquiry for Positive Computing that is much broader than just building "well-being gadgets," like the Personal Happiness Assistant discussed earlier:

1. What are important candidates for values, human needs, goals, or activities relevant to flourishing?
2. Which of these candidates are already served well through technology and which ones are not?
3. How can existing computing technology that is used every day be improved to serve those needs better?
4. What novel technologies can be created to support underserved needs?

Dealing with Challenging Situations

Although the majority of Positive Psychology research focuses on strengthening positive aspects in people's lives, there are also benefits if computers can help people to deal better with the negative events, moods or thoughts in their life. From the perspective of Positive Psychology it improves important Positive Psychology constructs such as a person's positivity ratio, i.e., the ratio from positive to negative emotions (Lyubomirsky, 2008) as well as a person's resilience in the presence of adversity, which also provides some protection from depression (Martin, 1998; Reivich & Shatté, 2003). To make dealing with negative challenges an explicit part of Positive Computing broadens the appeal of Positive Computing to a much wider audience by extending it from those motivated by personal growth to those primarily interested in dealing better with their problems.

There are at least five things that computers can do to support users when negative events happen:

1. Provide *better insight into negative events and patterns* through the abilities of the computer to record them. The PHA we discussed can be such a tool to create more insight. As the PHA measures arousal it also captures negative situations. A user can use this data about negative events as basis for an analysis and decide if something needs to be changed.
2. *Alert users to the presence of stressful situations* in the moment they are occurring and thereby giving them the ability to respond immediately. An example is a GSR mouse (possibly enhanced with pressure sensors (Reynolds, 1999)) that can alert users if they are highly stressed at work.
3. *Make adequate resources available* to the user on demand. The term "resources" should be seen in its broadest sense. The resource library can include audio with guided meditations and calming music for an anxious user and helpful, targeted information for users facing common difficult situations, like an upcoming public speech and much more.

4. In case a stressful event is foreseeable, a user can be *primed with appropriate resources* upfront, for example, by reminding him of his list of strengths or inviting him to do a meditation 15 min before a challenging situation.
5. Assist users *to cope in real time when a challenging situation is happening*.

As an example for the ambitious 5th point a real breakthrough were achieved if a future PHA can successfully assist a user to dispute negative (automatic, or irrational) thoughts as pioneered in Cognitive Behavioral Therapy (CBT). The first generation online CBT systems are not yet able to enter into an intelligent dialog with the user. Indeed general language understanding and reasoning about complex or unexpected everyday events is currently out of reach for computers. Yet there are also promising developments such as work by Daily (2005) on creating natural affective dialogs with users that can potentially be leveraged for meaningful dialogs about emotionally difficult situations. Even in the absence of the ability of intelligent dialogs solving the much easier problem of displaying on demand targeted information to the user for countering maladaptive beliefs in common difficult situations would already be a major progress about what is available today.

A PHA which has recorded our best moments annotated with emotions, strengths, and other metadata can assist users directly in the disputation of common "cognitive distortions" such as "I am a failure." or "I am undesirable." A prominent CBT technique is to collect contrary evidence. In our case the PHA likely already has a collection of contrary evidence on file. Digital memories of situations annotated with the emotion "pride" can be presented to the user for review if they provide counterevidence to the thought of being a failure. Situations that have been annotated with emotions such as "love" and generally positive social situations likely contain counterevidence for self-labeling of the user as undesirable. Thus the PHA offers unique new possibilities, not possible in the offline world, to enter into a dialog with the user by identifying the user's issue and guiding him toward appropriate counterevidence from the PHA's knowledge base. This knowledge base ideally contains both user-generated and expert-generated content. In addition to challenging negative thoughts, a similar technical approach might be usable to develop other cognitive resources such as optimism and hope.

Addressing Ethical Concerns and Data Privacy

In this section we discuss privacy and ethical concerns that arise when designing Positive Computing technology. The simple Personal Happiness Assistant described above already demonstrates significant privacy challenges. Little is considered as sensitive and personal as our emotions. The ability to manage and control the impression we give to others is basic to our lives. Unintended disclosure of this information can have disastrous consequences for its owner. An additional adversarial use of this sort of technology is hinted at by the fact that GSR sensors are used in lie detectors (besides sensors measuring heart rate, blood pressure, and

breathing rate). Picard discusses the lie detector concern (Picard, 1997) concluding that it is very hard to use this technology *against* the user's will. Users can fool these systems with some effort or training which gives reassurance. Nevertheless, disclosure of data that has been "objectively" collected about intimate details of our lives can greatly contradict our interests, e.g., when abused by the government, marketers, or our spouse. It is thus of utmost importance to put the data subject in full control of his own data, to educate him about risks and how to protect against them, and also to apply strong technical privacy and security protection measures (see, e.g., Spiekermann & Cranor, 2009, for background on how to engineer systems in a privacy protecting manner). These protection measures include the use of default encryption of collected records so that lost or stolen devices do not compromise a user's privacy, and the ability for users to entirely rewrite and "fake" their own records to give some protection in the presence of coercion to disclose them. Another applicable good privacy practice is to put policies in place that service providers keep user data only for a relatively short time and to have mechanisms to enforce this (e.g., by external audits). Otherwise the data are at risk of being subpoenaed in criminal or civil cases (e.g., divorce) or could be broken into. Typically, in the United States, legal protections for data kept on personal devices are higher than for data residing on the servers of some third-party providers. Another relevant privacy practice to reduce the risk from sharing of information is *minimization* of the information flow to what is needed for the task at hand, rather than sharing everything by default. For example uploading a daily emotional "average" to a social networking site is less risky then sharing detailed emotion maps and whereabouts. The latter data could be abused by marketers and stalkers. Even if obvious identifiers are removed from such data they may still remain unique and thereby remain at least in principle linkable to an individual (e.g., Narayanan & Shmatikov, 2008). Nevertheless, good techniques for pseudonymizing and aggregating data prior to sharing them with other parties or applications are necessary for good privacy. Another important protection mechanism will be the design of reasonable default and easily customizable policies for whom data are shared with (coach/therapist, friends, the public, Positive Psychology researchers, etc.)

Cloud service providers that are entrusted with Positive Computing related data have to make themselves accountable for implementing best security, privacy and data handling practices and provide tangible proof that demonstrates they are doing the right thing? Another key question is whether the legal regimes in various parts of the world adequately protect these data. Privacy laws in EU countries treat privacy as a human right and put strict limitations on how sensitive data (which include in the EU definition data about health, sexual orientation, union membership, etc) can be used. In other jurisdictions this is less clear.

Another type of a very practical privacy issue that arises when designing Positive Computing technologies is how to give users real-time feedback or alerts. Users may not wish this to be obvious to other people they are with. SMS messages can be a

private channel to alert users. For an application in which a user tracks his exercise goals Consolvo et al. (2008a) created an aesthetically pleasing cell phone screen display based on the metaphor of a garden. The closer the user comes to reaching his goals, the more the garden is populated with flowers, bees, etc. Providing users access to an interface that tracks a variety of goals without revealing to outsiders what exactly is being tracked might provide an acceptable privacy compromise for only moderately concerned users.

There are other ethical concerns beyond privacy that designers need to be aware of. A technology that is meant to assist people in enhancing their autonomy has an extra responsibility to honor user autonomy and related ethical principles in its own interactions with the user. There has been a rich discussion on ethics in the persuasive technology community (Fogg, 2003; Berdichevsky & Neuenschwander, 1999; Atkinson, 2006; Davis, 2009) and many of the insights carry over to Positive Computing. First, a user needs to be made fully made aware of how the technology is intended to influence him and how it is working. This way he can make an informed decision whether he wants to use it. Second, the technology should not misinform about the data collected, results of an analysis and other information. We already mentioned the principle that technology which deeply interacts with how people live their lives needs to be carefully designed not to push values or behaviors on people that are not their own. Fogg recommends to conduct a "stakeholder analysis" as part of an ethically aware design process. Such an analysis should involve all the direct and sometimes also indirect users of the technology and consider their respective needs, benefits, and losses. (Indirect users of the PHA include other people, e.g., a partner, who might be affected by the use of the technology.)

Another ethical issue to look out for is whether technology introduces biases against certain groups of people. As a cartoonish example of an ethically questionable Positive Computing technology imagine, an application that advises people to surround themselves only with upbeat people on the theory that happiness has been shown to be "contagious." Then after a user has rated her acquaintances with respect to their perceived levels of happiness the application tracks and monitors whom the user calls, sends emails to and allocates calendar time with and attempts to influence the user to spend more time with the "happy" people and less time with the "unhappy" people. This application increases discrimination rather than reducing it and is at best a zero-sum game as it arguably reduces the happiness of the already unhappy group even further. A more "compassionate" win–win application would keep track that users on a regular basis share at least some of their time with people who are less fortunate then they are. (Positive Psychology has validated the many benefits that come from "giving" as well.)

In conclusion I believe that through a combination of technical and policy measures privacy and security concerns can be sufficiently addressed possibly at the cost of limiting excessive data sharing. A design process which pays sufficient attention to the benefits for individual stakeholders and groups is likely to lead to Positive Computing applications that are useful to its primary users without harming or unduly disadvantaging others.

Concluding Remarks

This chapter suggests to study systematically how computing can assist human flourishing, i.e., Positive Computing. Clearly, the ideas are at an early stage, but as this chapter demonstrates there is already plenty of existing technology that can be adapted for raising psychological well-being. The overall goal of bringing about flourishing through technology provides an intriguing new perspective for looking at technology and its uses. It provides novel sub-goals to design for (say to raise a user's positivity ratio above a 3:1 threshold (Fredrickson, 2009) or to help correct negativity biases). For Positive Psychology researchers and computer scientists this creates exciting opportunities for collaboration. By combining their respective strengths, namely, the grounding of Positive Psychology in scientific methods and the ability of computer scientists to create powerful technologies, this will surely produce results that would not be possible by either group acting alone. If Positive Computing technology is made fun, exciting and engaging I have no doubt that this will be successful with consumers as well.

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