Gaming Media and Social Effects

Anton Nijholt *Editor*

Playful User Interfaces

Interfaces that Invite Social and Physical Interaction

Springer

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Interfaces that Invite Social and Physical Interaction

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Preface

This book is about user interfaces to applications that can be considered as "playful." The interfaces to such applications should be "playful" as well. The application should be fun, and interacting with such an application should, of course, be fun as well. Maybe more. Why not expect that the interface is persuasive, engaging, challenging, and aims at helping to provide the user with fun, trying to keep the user motivated, not frustrated or bored, or, in terms of "flow theory," in a state where there is a balance between skills and challenges? Obviously, we can introduce playful interfaces to boring tasks and tasks that require efficiency in the first place. Also such tasks can profit from interfaces that introduce playful elements, for example, performance statistics and competition elements, or personalized and motivating conversational agents. But of course, we can expect that most useful applications of "playful interfaces" appear where users have to interact with computers, sensor-equipped environments, social robots, wearables, and mobile devices that are embedded in smart environments that support our general daily-life activities and that are not directly aimed at efficiency. Gamification of society aims at introducing playful elements in our digitally supported daily activities, whether it is about home activities, work activities, public space activities, or recreational activities. Playful interfaces, that is, interfaces that allow playful interactions with such activities, are then required.

Playful interfaces are designed to invite playful, social, and physical interaction. Users should feel challenged and persuaded to engage in the interaction with the particular application and the interaction should be fun. This does not necessarily mean that the application has been designed for providing fun only. Nothing wrong with that, but playful interfaces can also be interfaces to educational material introducing physics, mathematics, and informatics to a student. Or they can be interfaces to simulation environments that are meant to train professionals in decision-making situations or performing tasks in riskful situations. In addition to training and educational applications there can be aims such as playfully supporting rehabilitation activities or activities aimed at improving physical and mental health. Artists interested in digital art and entertainments have introduced—and will continue to do so—art installations with sensors and actuators that invoke playful user participation to experience their art.

Advances in interaction technology have allowed us to talk about ubiquitous and pervasive computing. That is, sensors and actuators embedded in environments, (mobile) objects, and wearables, have made it possible to extend the view of human–computer interaction where the user is attached to mouse, keyboard, and monitor with a graphical user interface to a reactive and proactive environment that surrounds a user and where the computing power is not necessarily addressed in an explicit way by the inhabitants of the environments. Such smart environments allow the sensing of their inhabitants, including the interpretation of their verbal and nonverbal behavior, their bodily behavior, and their physical activities in this sensor-equipped environment. And, of course, they allow the sensing of how inhabitants of these environments interact with each other. Examples of sensors are cameras, microphones, position and proximity sensors, acceleration meters, augmented reality glasses, augmented, and immersive virtual reality headsets, and physiological body sensors, including brain–computer interfaces for monitoring and stimulating brain activity. Smartness embedded in the environment makes it possible to offer playful interaction possibilities to inhabitants of these environments.

These developments allow users to interact with objects and devices that are part of their natural physical environment. Information presentation, information exchange, and information manipulation can be done in a context where the environment knows about the user and its preferences, and its moods and emotions. Digital multimedia can be employed to augment physical reality and what we see, hear, feel, and smell can be manipulated by artificially evoked events. These events can take place in physical, augmented, and virtual reality environments where users can interact with tangible or virtual objects, including social robots in a home environment, embodied agents in conversational environments, or avatars and semi-autonomous actors in video game environments. Clearly, these developments allow a transition from video game environments to game and entertainment applications that are part of a digitally augmented physical world. That is, videogames enter the real world.

In the chapters of this book we discuss playful interfaces. We discuss new interaction technologies and applications that require these new and playful interaction technologies. We survey the present state-of-the-art research and future developments in the area of playful user interfaces. Many chapters in this book discuss designs and applications of playful interfaces that will only become available in commercial applications 5 years or later from now. In this book, we see the introduction of many prototypes of potentially interesting human–computer interfaces and their connection with their applications. Persuasive, social, and tangible interfaces are among the topics discussed in the chapters of this book.

In the first chapter ("Playful Interfaces: Introduction and History") of this book, there is a short introduction to the history and the state-of-the-art research in playful interfaces. Introduction and survey are short. After that there are five parts with chapters that introduce state-of-the-art-research on Playful Interfaces.

These five parts are (1) Public and Mobile Entertainment, (2) Indoor and Outdoor Playgrounds, (3) Games for Change, Personalization, and Teaching, (4) Health and Sports, and (5) Learning by Creating. The chapters in these parts provide a state-of-the-art survey of the current research on playful interfaces and provide a look into the future of playful interfaces.

Anton Nijholt

Contents

Playful Interfaces: Introduction and History

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Abstract In this short survey, we have some historical notes about human–computer interface development with an emphasis on interface technology that has allowed us to design playful interactions with applications. The applications do not necessarily have to be entertainment applications. We can have playful interfaces to applications that have educational goals or that aim at behavior change, whether it is about change of attitude or opinion, social behavior change, or physical behavior. For the developer and the designer of these applications and their interfaces, there is no need any more to assume that, in addition to focusing on the application, the user has to pay attention to manipulating a mouse, using the keyboard and monitoring the screen. Smart sensors and actuators embedded in a user's physical environment, objects, wearables, and mobile devices can monitor a user, detect preferences and emotions and can re-actively and proactively adapt the environment and the behavior of its actuators to demands of the user or changing conditions. In this way, interface technology can be employed in such a way that the emphasis is not on offering means to get tasks done in the most efficient way, but on presenting playful interaction opportunities to applications that provide fun, excitement, challenges, and entertainment. Clearly, many applications that have more serious goals than "just" providing fun can profit from this interface technology as well. In this introductory chapter, we shortly survey the chapters in this book that show the many applications of these playful interfaces.

Keywords Playful interfaces · Human–computer interaction · Pervasive computing · Ubiquitous computing · Entertainment computing · Games · User experience · Tangible interfaces · Mobile devices · Persuasion · Behavior change · Exertion interfaces · Whole body interaction · Gesture interfaces

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1 Introduction

This introductory chapter to "Playful User Interfaces: Interfaces that Invite Social and Physical Interaction" is meant to introduce and discuss user interfaces to applications that have been designed to invite users to engage into playful interactions. Obviously, the applications should allow playful interaction. Moreover, the interfaces we want to look at should also allow playful social and physical interaction. The interfaces are "playful," that is, users feel challenged or are otherwise persuaded to engage in social and physical interaction because they expect it to be fun. However, both from the point of view of the users and that of the designers, there can be more than fun that has inspired the design of the application and characteristics of the user interface or that are meant to motivate the user. Users do not necessarily be aware of that. A video game can be fun to play, but maybe it has also been designed to teach mathematics or history, have the user learn about art, or the game was aimed at enhancing cognitive or social capabilities, or at changing an unhealthy life style. Recreational activities can now be digitally supported and enhanced. Solving puzzles, reading books, playing chess, maintaining collections, providing information to social media and consuming information from social media, picture and video processing and collecting and retrieving sports events and results are some examples that come into mind.

Whether it is just about providing, supporting, and enhancing fun activities or whether there are additional educational or change of behavior, attitude, and opinion motives involved, designers can now also use physical, sensor-equipped environments, to design such games and entertainment applications where the user is not condemned to sit on a chair, using keyboard and manipulating mouse or joystick and following actions on a monitor. That is, games, entertainment, and educational applications can be designed where the user, or maybe several users, can be physically engaged in an application, and where, when there are more users, whether they are co-located or distributed, users can compete and collaborate or inform others about their whereabouts and activities. Competition and collaboration can take place in home and office environments, "arcade-like" public spaces, or public spaces in general, for example in the case of urban games. Sensors and actuators in wearables and mobile computing devices will add to the possibility to design a playful interface to the physical world and its inhabitants. These added possibilities to have playful interfaces will extend application areas and approaches to application areas, such as passive and active recreation, education, behavior change, training, and sports.

2 Exploring Playful Applications: Early History

The assumption that only in recent years or in the last decade ideas about playful applications of computers and computer supported environments emerged is very wrong. Already in the early years of computer science (1950 and 1960s), applications were predicted, and sometimes even designed and implemented that focused on non-scientific, non-administrative and non-industrial use of computers. Alan Turing, Norbert Wiener and later many Artificial Intelligence (AI) researchers considered such applications. However, at that time the focus was mainly on the application, not on how users, that is, the general audience, could interface in a convenient or attractive way interface with the application. Understandable of course, the users were computer scientists and intellectual challenges such as can we make the computer play chess were more important than having a "user-friendly" interface to a chess playing program. And, of course, the general public did not have access to computers. Computers became available for scientific, administrative, and industrial (process control) applications, computer time was expensive and only professionals were able to feed the computers with programs that were executed in "batch processing," without interactivity between computer and professional user. That is, hand over the program and see how it has been processed by the computer the next day. Most probably there was an error message. Having a computer more efficiently running a program was worth the extra human effort. Soon there were attempts to provide users with a language that could be interpreted by the computer and that helped them to control how their programs had to be executed without human intervention.

New applications and more and other groups of users required more direct access to available commercial computer power. It required also more interactivity to control processing of collections of interacting programs and to provide user data. Interactivity in the late 1960s and early 1970s meant having access to a Teletypewriter (TTY) that allowed interactively changing commands in your program, resubmit your program, and evaluate results (and error messages) in real-time. Communicating with computers in real-time and from a distance, rather than offering a pack of punch cards to a receptionist of a computer center, became common practice. Having a "dialogue" with the computer about tasks that had to be processed became a point of view when using computers. Two additional points of view, not really in the main stream of computer science and its applications, came from Artificial Intelligence (AI) research and from artists that explored computer applications from an artistic viewpoint. These views are explained below.

- AI Research: AI researchers explored whether and how computers could perform tasks that required intelligence, that is, when performed by a human being. Early AI research in natural language processing looked at machine translation systems, question-answering systems and database retrieval interfaces. Performance, not efficiency was the issue. And although useful applications could be foreseen, the applications did not necessarily address societal, business or industrial problems. But of course, the political situation in the 1950 and 1960s did steer some of the interests. Eliza, a conversational program developed by Joseph Weizenbaum in the 1960s, allowed users to chat, using natural language, about any topic (Weizenbaum 1966). Although performed in a rather primitive way, this research can be considered as a first attempt to understand the user and to offer feedback based on that understanding. Moreover, the application did not in any way ask for efficiency in the interaction. Users took their time (more than the system) to think about the questions posed by the system and to formulate their answers. In the same period there were other attempts to design natural language interfaces to applications that were meant to amuse the user or to provide information about a user's sports and entertainment interests rather than about his or her computer-supported professional needs for handling information.

- Artistic Research: Artistic applications, starting with drawings of pin-ups (ASCII art) using pen-and-ink plotters and matrix printers, were added to the domain of applications. Other input and output modalities than text were investigated in the interaction between humans and computers. Camera's that provided information about the user's presence, movements and activities, and allowing the computer to manipulate this information before giving feedback, were certainly among the main tools used by many interactive art artists. That is, the user or the audience played an active role in the creation of interactive drawings, paintings or music. Less-known than these applications are the artistic efforts of composers, musicians, brain researchers and computer scientists to use brain activity as input to artistic computer applications. Although in the early years computer science did not yet offer advanced (digital) signal processing, machine learning methods, or even the possibility to store data for future analysis, there nevertheless was much artistic activity to use brain signals in order to create and modify visual, auditory and audiovisual landscapes.

AI research, interest of artists, and interest of computer scientists that came with ideas to use the computer for recreational purposes and to support their own daily activities (including their recreational activities) with this new technology helped to draw attention from the general audience (starting with amateur engineers and computer hobbyists) to the use of computers for tasks that were in the interest of a particular user in his or her home and interest environment rather than in his or her task-oriented office or industrial environment. However, many investigations and developments in computer science research labs and institutes remained unknown for the general audience until their results became part of a wide-scale employment in the context of the advent of the personal computer. Long before the introduction of the personal computer we see research institutions experimenting with graphical user interfaces (GUIs), with devices (indeed, the mouse) to interact with such interfaces, and with devices that allow users to use input devices for the computer to compose drawings and sketches, that is, presenting the computer with non-textual and non-command-like information that has to be processed and transformed. Workstations with GUIs appeared in the early 1970s at Xerox's Palo Alto Research Center, commercial workstations with GUIs followed and Apple introduced the GUI in the personal computer in the 1980s. In the same period, that is, before the introduction of the personal computers, we see the introduction of virtual reality environments and devices (head-mounted displays) that provide access to these environments, including the possibility that the environment adapts to the user's view.

3 Arcade Systems, Home Consoles, and Personal Computers

When the first personal computers were introduced in the 1970s by computer hobbyists, it was often the case that the abilities of these hobby and "garage" computers were shown with simple games or other properties that showed how simple software could perform on this simple hardware. But already in these and later years we see that small commercial companies developed playful applications. An interesting view on the development of the early personal computers can be found in (Markoff 2005). Companies developed software and hardware, for hobby and personal computers that was meant to attract users, other than hobbyists and (very) early "professional" personal computer users, to buy and use software and special-purpose hardware that allowed them to play games. An independent development was the advent of text-based adventure games, often made in the spare time of computer science researchers and distributed through the ARPAnet (early 1980s). Multiuser games (for example, MUD: Multi-User Dungeon), first available on local computer networks of universities and research institutes, became also accessible for external users through the ARPAnet.

First home console and entertainment systems (Atari, Nintendo) appeared at the end of the 1970s and early 1980s (Wolf 2008). At the same time small companies took the initiative to develop playful applications, applications that allowed users to consider his or her "hobby computer" as a device that was there to have fun with. Examples could also be drawn from arcade video and electro-mechanical games. The interfaces to arcade games such as Pac-Man and Space Invaders were extremely playful, persuasive, sometimes humoristic, providing sounds, animations, and force feedback and doing this in such a way that not only the gamer, but also his or her friends and possibly other audience could become engaged in this social activity (Smith 2006). Human–computer interaction researchers took notice of this development (Malone 1982). Simple keyboard and mouse controlled graphical user interfaces appeared. But other devices, allowing speech or pen input were developed as well.

Interestingly, during the 1980s we see the development of software and hardware for game computers that allow the design of games and input modalities that make use information obtained from measuring physical movements or changes in physiological information from the user. Arcade games moved to the personal computer, even when the graphics, the sounds, and the animations were not or hardly comparable with what could be experienced in arcade environments. In the 1980s and early 1990s of the previous century we can see applications that were designed from the point of view from bodily interaction (gestures, movements) and a point of view that involved physiological information to control an application or, but certainly less obvious at that time, adapt an application to a particular user. This burst of creativity and interest in bodily interaction did not remain. Many of the ideas disappeared until they reappeared some decades later in the twenty first century when cheap sensor technology to measure physical and physiological user information became available.

4 From ARPAnet to the Worldwide Web

Already in the 1960s it became possible to offer programs to a mainframe computer for execution or communicate with a distant computer using telephone lines. ARPAnet made it possible to make the transition from distributed input devices connected to mainframe computers to the possibility to access a network of worldwide connected computers. Messages between computer users could be exchanged and documents and programs could be transferred from one user to the other. Internet, as it existed since its early exploitation in the late sixties and early seventies, remained the domain of scientists at research institutes and universities for some decades. Internet facilities such as file transfer, electronic mail and, later, news and discussion groups only slowly entered the world of personal computer users during the 1990s of the previous century.

Standards to format documents for standardized exchange, editing and retrieval using distributed databases and computers connected together through the Internet were also first developed in a scientific environment and for scientific purposes. Tim Berners-Lee at the CERN laboratory in Geneva developed the technologies that made World Wide Web possible between 1989 and 1991 (Berners-Lee and Fischetti 1999). This technology was made publicly available some years later and made attractive for a broader audience with graphical browsers. They allowed ubiquitous use and commercialization through an increase in start-up companies in the late nineties and early 2000s. Web research and new web technologies that included the use of audio, pictures, video and animations made it possible to have entertaining and playful web applications. Users extended their presence on the Internet from a linear address to personal webpages and by becoming present in social media displaying personal information, preferences, opinions, and daily activities.

5 Ambient, Ubiquitous, and Pervasive

During the early years of computing, in parallel with the more mainstream developments that focused on improving efficiency of hardware, software, and interface technology in general, there were experiments in research laboratories that aimed at introducing special purpose hardware, software and interaction technologies. We already mentioned AI applications, mainly software-oriented (with the exception of special symbol processing machines) and game hardware, software and interaction devices, allowing players to have more natural interaction, based on the game-activity provided by the application, than made possible by keyboard, mouse, windows and menus. Distributed collaboration issues had already gotten early attention (Hiltz and Turoff 1978), just as virtual and augmented reality, and haptic applications with new interaction possibilities (data gloves, headsets, haptic devices). A well know example from the early haptics history is the Tactile Vision Substitution System (TVSS) (Bach-y-Rita et al. 1969). Images of a television camera were converted in vibrations with different frequencies of 400 pens that were put in the back of a chair. A person, for example a blind person, could then experience (or "see") the image while sitting in this chair.

In the early 1990s, Mark Weiser introduced his vision of ubiquitous computing (Weiser 1991). Weiser based his views on three forms of ubiquitous devices that became available in research laboratories: tabs (wearable centimetre sized devices), pads (hand-held decimetre-sized devices), and boards (metre sized interactive display devices). In the years that followed interconnectivity and the use of Internet became more visible. This led to similar concepts, sometimes emphasizing the role of the environment (ambient intelligence), the use of small sensors (pervasive computing) or the interconnectivity of devices (Internet of Things). Presently it is difficult to distinguish these "different" views.

Although there was quite some of interest in the ubiquitous computing view and similar views but with different names, most research efforts related to Human–Computer Interaction, went to Internet, the World Wide Web, Multimedia, Computer-Supported Collaborative Work, and Information Retrieval. There were certainly great, useful, and successful attempts to lay the foundations of the field by developing methods and methodology for interaction design, for requirements engineering, for usability research, user experience design (Hassenzahl and Tractinsky 2006), and persuasive technologies (Fogg 2003). The foundations were also laid for interaction research based on virtual and augmented reality and, starting with speech, natural language, and pointing gestures, multimodal interaction research. Again, as always, once there is a clearly visible new development, it is always possible to trace it back to some ideas that were introduced some decades before. Successful development of new interaction technology very much depends on the possibility to have it integrated with existing technology and to being able to develop an infrastructure that helps to make this technology attractive and affordable. The latter obviously depends on mass production or massive use of a new technology.

6 Tangibles, Smart Materials, and Wearables

In Weiser's view the tabs, pads and boards were assumed to be wirelessly connected; devices such as tabs (and pads) can move around and proximity can be detected. But there is still lot of attention for large, medium, and small-sized displays on these devices to present information. A more rigorous break with the tradition of graphical user interfaces appeared in the work of Hiroshi Ishii in the

MIT Media Lab (Ishii and Ulmer 1997). The emphasis in this work is on physical objects that have sensors and actuators and that invite physical interaction with digital content represented by the object. This view does not exclude interconnectivity between objects as we discussed in the previous section. Neither does it exclude the ambient intelligence view where it may be the case that although the user focuses on the interaction with a physical object, ambient media are there at the periphery of human perception to shift a user's attention. But certainly, in this view the focus is on objects in the physical world that can be grasped and spatially manipulated. These Tangible User Interfaces (TUIs) can be seen as a way to implement Weiser's view of computers that disappear in the environment by coupling digital information and information processing capability to everyday physical objects. This view was illustrated with a physical implementation of a GUI that included the possibility to move physical objects (phicons) on a desk surface to control the computation.

Commercial interactive surfaces (tabletops, multitouch tables) became available in later years and found their use in collaborative work and entertainment applications. Tangible tabletops allow the movement and manipulation of tangible objects on their surface and therefore also the manipulation of digital content as it is projected on the surface. But many other tangible user interfaces appeared. A tangible tabletop is about objects that can be moved and manipulated on a fixed surface with a graphical and touch interface and a perceptual coupling between these physical objects and the dynamic representation of content on the surface. But, to mention another extreme, tangible user interfaces can also be about interconnected physical objects with sensors and actuators that can be thrown from one player to another player, keeping track of speed, position, and individual or team player activity. Players can be informed of the play or interaction knowledge collected, integrated and interpreted by the tangibles. Players can change their behavior based on such information, the play, as it is implemented in the tangibles and the environment where the play takes place, can adapt its parameters to the players and the progress of the play. Again, we see a close, synchronous and real-time coupling of real-world activity involving physical objects and a digital model of a play and players' activities. Educational and entertainment applications appeared and domestic applications have been investigated. In the next section, rather than exploiting a user's or player's activity from the point of view of interacting with tangibles, we will look at measuring human activity, behavior and bodily expressions with multiple sensors embedded in the environment, including sensors embedded in physical objects, to better understand the actions and intentions of a user (the human computing view).

In a next edition of the view on tangible user interfaces it was observed, for example in (Ishii et al. 2012), that the tangibles, that is, the objects that invite physical interaction and their physical manipulation represents manipulation of digital content, despite actuators that provide sound and light effects or information on an embedded display, do not really change their (natural) physical appearance. Is it possible to have tangibles that dynamically change their appearance and behavior in sync with changes in digital content? We can, for example, think of objects that have motors and gears and investigate them in order to make a transition from, as mentioned in (Ishii et al. 2012), the transition from static/passive to kinetic/active tangibles. This view assumes a bidirectional coupling between dynamically controllable deformable and reconfigurable physical objects or physical material and an underlying computational model. In particular nanoscience research on material property changes has made it possible to introduce smart material interfaces that change their appearance because of changes in underlying digital content based on changes induced by interacting users (Vyas et al. 2012).

Other views on tangible user interfaces take into account "wearables." That is, devices that are integrated in our clothes, or, dependent on the definition of wearables, devices that we wear on our body, and in our pockets (Mann 2013). These devices know about our activities, and they can also inform others about our activities. A similar observation can be made about devices that measure physiological information, including information about brain activity. Such kind of information provides knowledge about the emotional and cognitive state of a user and how he or she wants to provide input to the system. That is, if there is involuntary input, based on monitoring a user's mental state or a user's reaction on externally evoked feedback, or voluntary provided input, such as motor imaginary input.

7 The Human Computing View

Weiser's view did not include, at least not explicitly, the measurement and interpretation of human behavior and human activity. Neither does the work of Ishii. Obviously, humans are part of the physical worlds that are accommodated with embedded sensors, actuators and intelligence. There are traditional displays, but also tangibles and smart material interfaces as explained in the previous section. In these digitally supported physical worlds, new interaction modalities or new integrations of interaction modalities have to be investigated. This can be done from the point of view of the characteristics of a particular device or tangible that allows other than remote control input devices such as mouse and keyboard, but it can also be done from the point of view of being able to sense human activity, human behavior, human (body) movements, and to sense (neuro-) physiological information when performing tasks or otherwise being active in such an environment.

Although it is not impossible to detect some aspects of a user's mental state from his or her mouse and keyboard use, in particular when the mouse has some physiological sensors, more information related to natural human activity, behavior, and movements need to be extracted and interpreted in order to provide satisfactory reactive and pro-active support by an environment. For specific applications, including games that require bodily activity, other interaction devices are of course available. Haptic devices, devices that capture movements, eye trackers and other, now sometimes considered to be exotic interaction devices such as thread mills to experience virtual reality, were already introduced decades ago, but usually in a context of a human-device interaction (one human, one device, one particular application). These devices capture one particular natural human physical activity and transform it into the control of an application. Cameras to capture human behavior did not yet connect to computers to analyze this behavior. Applications based on measurement and analysis of human vocal sounds (speech processing) got more attention.

In contrast, intelligence embedded in environments and in physical and virtual objects is meant to allow interaction with users in pro-active and reactive ways and therefore requires more knowledge about their users and their activities. With the exception of the just mentioned input devices, in the past, knowledge about the user had to be collected from keystrokes and mouse movements and the tasks and contents that were accessed. Current sensor technology and the embedding of intelligence in environments, physical objects and clothes and devices on our body allows other and more comprehensive ways of knowing about the user, including his or her preferences, abilities, and emotions. There are many ways to have sensors track human behavior and have this information integrated in order to allow such information to be used in a playful way. Gestures, body poses, body movements, and moving around in an environment or in front of an application can be thought of as explicit commands, or as ways to provide information (produced voluntarily or involuntarily) to the environment and its objects, just as we do in interaction with our human partners. Clearly, microphones and cameras are among the sensors that are embedded in environments and objects and that can measure such behavior. Eye movements and facial expressions provide information about interest or boredom or about focus of attention. And, obviously, when interacting with a social robot or virtual (embodied) agent, our verbal and nonverbal behavior should have meaning to them in order to make interaction more natural. In addition there are applications where an environment or its objects is required to know about and understand the interaction between its human inhabitants. Human computing (Pantic et al. 2008) and social signal processing (Vinciarelli et al. 2009) are research areas that have emerged to serve such applications. Computer-supported play, games and sports in the physical world with two or more players can be designed in which such information is exploited, whether it is for making interactions more natural or for making interactions more challenging, and whether it is for competition or for cooperation (Nijholt et al. 2012).

Physiological sensors, including sensors that measure brain activity, can complement the information generated from other sensors, or, depending on the application, be used separately to feed an application with information about the physical or mental state of a user. It can be used to inform the user about this physiological state, asking or persuading him or her to change current activities or long-term behavior, for example for health or fitness reasons. Based on physiological information from the user an application can also adapt to the user, asking for more or less effort, asking for other input modalities, or providing different feedback. In particular games that require physical effort can profit from such information, but also videogames can use it to adapt the level of the game to measured frustration, interest or boredom. There are also playful applications where the user is asked to manipulate aspects of his (neuro-) physiological state. This is in particular true for brain-computer interfacing, where human—computer interaction researchers are now experimenting with interfaces that expect, maybe in addition with other modalities, brain activity input that is evoked by external stimuli or by voluntary mental activity that is transformed to a command to a computer or other device in the environment (Nijholt et al. 2008).

8 Design Your Own Playful Interfaces for Your Entertainment

Logo (Papert 1980) was a child-friendly programming language that was based on Piaget's constructivist educational philosophy. It allowed children to construct their knowledge through experience. "Turtle graphics," that is, simple animations could be programmed by children. There were also possibilities to "program" physical objects. Logo programming environments for teaching purposes were developed, including programming the control of sensors, motors, and lights in physical objects ("Programmable Bricks," later called LEGO Mindstorms). Teaching and learning was also the objective of the Alice environment developed by Randy Pausch and colleagues. "Drag and drop" enabled students to create programs and get familiar with programming constructs (Cooper et al. 2000). Programming environments for children and students have been further developed into environments that allow designing, in a playful way, interactive stories, animations, music and art applications. Environments can provide examples that can be "remixed" to introduce other characters, animations and storylines. An example of such a visual programming environment is Scratch (http://scratch.mit.edu/).

We already mentioned the programming of physical objects. Nowadays, commercially available micro-controller boards such as Arduino allow the reading of sensors, the control of motors and the behavior of actuators. Microcontrollers, sensors (location, proximity, and movement) and actuators (changes of appearance, location, or movement) are becoming affordable and can be used to design playful tangibles, including the control of natural objects in an educational or home environment. Simple tools such as Makey MaKey make it possible to construct tangible interfaces. Hence, in addition to creating possibilities for constructivist learning for educational purposes, interactive entertainment can be constructed using commercial off the shelf technology (cheap sensors, Kinect, Arduino, Makey Makey, etc.). And, creating entertainment and playful interfaces, especially when done with others, can be as much fun or even more than playing a commercial videogame.