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Immersed into our clothes. Are wearable technologies a potential gateway to extra-virtual immersion?

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## ART & MEDIA FILES **Immersed into our clothes. Are wearable technologies a potential gateway to extra-virtual immersion?**

*Is wearable technology set to take over our wardrobe?* titled an article by Suzanne Bearne, which appeared on the Guardian in August 2015.<sup>1</sup> The question of whether interactive technologies embedded in garments are bound to become an integral part of our everyday lives in the next few years, was included in the debate since its early development, at the time where the discussion was mostly focusing on the designing of health monitoring systems as transferred into the daily lives of the patients. These items, such as “Smart Shirts” or “Wearable Motherboard,” were imagined as wearable technologies which would have been able to keep patients’ health under observation in the *least intrusive* way, by including specific monitoring systems into basic pieces of clothing which would have been worn by these individuals in common everyday life circumstances.<sup>2</sup> This first wave of wearable technologies was based on the idea that technologies could be *contiguous* to the body, in order to monitor it and facilitate its functionality, without intruding it. The interaction was conceived as *invisible*, allowing the body to benefit from it without acknowledging any level of interaction with technology.

More recently, devices that are deeply interwoven with our bodies to “blend into our skin”<sup>3</sup> are being developed and will in the near future become part of the Internet of Things, opening an entirely new dimension of the relationship between technology and the body. These new devices, such as the ones developed by fashion design brand Cutecircuit, i.e. the “Twitter dress” or the “Hug Shirt”, are shifting the focus from a mere opposition between a *passive* use of wearable technologies, where the body is being monitored, observed and tracked invisibly, and an *active* use of technology, where the body is provided the agency to operate technology, for example in the way we actively use mobile communication technologies to communicate.

My hypothesis is that this “third wave” of body-technology interaction is opening the way to an *inter-relational exchange* between body and technology, in the context of a multi-layered communication space. From pieces of clothing which can be directly controlled by users, to objects that react to wearers’ emotions in ways that act beyond users’ control, the potential “communication space”<sup>4</sup> created by these new wearable technologies sees technology as being immersed and operating into a multi-media environment, where multiple devices will be used simultaneously and could potentially create a number of unpredictable relationships by recombining messages in unpredictable. For example, these interactions among media embedded in clothes and worn by multiple different users could create a level of interaction with the technology, which goes beyond the interaction between the two users with each other and through their devices. Each one of the users will be rather interacting with their own device, with other users’ devices, with each other as well as with a network of visible and invisible devices already present in the “media-scape.”<sup>5</sup>

What will this new environment imply? Will this new form of body-technology interaction create an *new conception of immersion, which will alter altogether the real/ virtual dichotomy*.<sup>6</sup> Following the “adaptation” paradigm used by Gaudenzi in the analysis of immersive technologies,<sup>7</sup> I explore wearable technologies and question whether their appearance outside of the experimental field and into the mainstream, could be laying the ground for a potential gateway to an entirely new step in the conception revolving around immersive technologies – an *extra-virtual immersive environment* the implications of which we can just start to foresee.

### **Monitoring the body without intruding it**

The idea contained in the development of health-related nanotechnologies contained in garments, was to provide information in order to “prevent” potential problems and monitor patients’ health condition –

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directly or remotely – as a way to *facilitate* and *enhance* the life of potentially vulnerable individuals, such as senior citizens.<sup>8</sup> These technologies, as applied to biology and medicine, were developed in three different directions:

1) the design and implementation of sensors that are *minimally obtrusive* and reliably record movement or physiological signals, 2) the development of systems that *unobtrusively* gather data from multiple wearable sensors and deliver this information to clinicians in the way that is most appropriate for each application, and 3) the design and implementation of algorithms to extract clinically relevant *information from data recorded* using wearable technology.<sup>9</sup>

The aim was that of embedding technology into clothing naturally contiguous to the body, in order to monitor its functionalities- observing the body, without intruding it.

More recently, following the same lines of reasoning – improve health as well as improving in-depth knowledge about societal health<sup>10</sup> - the idea of “wearable, washable, potentially life-saving computers” was developed by a group of researchers working at American academic institution Virginia Tech,<sup>11</sup> who found a way of including a network of wires connecting sensors which could communicate with each other and with a data collection computer into trousers. The trousers would prevent a potentially vulnerable wearer from falling on the ground by alerting him instantaneously in the face of potential danger. The wearer would rely on the technology for his/her safeguard, investing pants with an entire different use to the primary one and squeezing two *different functionalities into one single object*. By combining locomotion research and e-textiles, students and researchers at Virginia Tech developed a prototype called the “Hokie Suit,” which uses a “gait matrix of various sensors — such as accelerometers, which detect changes in speed and direction of motion,” which are embedded into a dress that can be easily worn by a patient in their everyday life. The consequence of this is “the wearer can move around naturally and the wiring and electronics can be woven and fitted so that they seem part of the fabric. The electronics are powered by a regular nine-volt battery carried in the pocket,”<sup>12</sup> which could help doctors monitor heartbeat acceleration, the changing of direction in motion – all elements that could signal the potential danger of falling.

The idea of technology serving the body by tracking its functions, seems to raise enthusiasms as well as concerns<sup>13</sup> in the medical community. The idea that health technologies might increase costs, promoting a “technology for technology sake” approach, or that the inadequate distribution of technologies based on socio-geographical differences might continue the inequitable health distribution and that patients privacy<sup>14</sup> could be abused or used for potentially harmful control systems<sup>15</sup> deals with questions of coordination of information sourced by technology, its costs, fragmentation of technological application and the potential abuses connected to data gathering. This set of questions can be extended also to wearable technologies not dealing with people’s health, but using information collected by and through the body in connection to any form of technologies.

### **Interactions beyond users control: an inter-relational exchange between body and technology**

The question of whether and in what way would wearable technologies be changing our communication systems is crucial to the aforementioned set of questions. As Kùchler noted, as a way of combining a synthesis of opposites – B functionalities embedded into objects with a pre-existing A functionality –

smart fabrics is *serious fun*. Serious, because what it demonstrates is an environment that is both *material* and *informational*, with the environment being internal to the material, and *funny*, because it touches a raw nerve in a society that believes its working relations to be a matter of its own choosing, not least because it is dominant matter through machinery.<sup>16</sup>

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As part of a sort of “techno-oriented” take on society, existing wearable technology, which “refer to electronic technologies or computers that are incorporated into items of clothing and accessories which can be comfortably worn by the body,” can, in fact, perform many of the computing tasks portables devices are designed to act upon, often proving to be more sophisticated by using “sensory and scanning features, not typically seen in mobile and laptop devices, such as biofeedback and tracking of physiological functions.”<sup>17</sup>

Their aforementioned employment in the field of healthcare and medicine precedes by ten years the various experimental uses we are starting to see now and which vary from applications in the field of gaming, fashion, music to uses in the field of audio-visual arts and entertainment. These new interactive applications that are recently flourishing in the arts and which are opening the way to a less utilitarian approach to the technology, are now favouring a more creative and artistic employment, less bound to functionality and closer to multiple and open operational uses. From the idea of “human body as an interface, a sort of second skin, that can connect us to people and places” developed by fashion design company CuteCircuit,<sup>18</sup> which promotes a Human-Human interaction, to new, collaborative “tangible dimensions and possibilities for making meaning” as debated by Auckland-based artist collective Colab in the realm of interactive art,<sup>19</sup> these applications seem to be relying on the technology for recombining open-ended functionalities, in a way similar to early developments of the World Wide Web.<sup>20</sup>

From the point of view of Media Studies, these technologies, all designed as interactive, “experience-centred” items,<sup>21</sup> challenge Jenkins’ paradigm related to new media in regards to the role of the user in its participation/interaction with the technological interface,<sup>22</sup> as an interaction with an interface which is material only insofar as it serves the virtual immersive world it gives access to, as a “socially-networked peer participation”<sup>23</sup> enabled and hosted by technology, among other users. If we think about the paradigm of the *produsage*, as a “a system built on community logics of re-use and permission rather than commercial logics of ownership and restriction,”<sup>24</sup> we are still moving ourselves in the realm of an interaction entirely controlled and facilitated by users. In fact, here, with wearable technologies what is really at stake is a shift towards “a new kind of surface ontology which replaces the opposition of inside and outside, invisible and visible, immaterial and material, with a complementary relation that thrives on *transformation* rather than distinction,”<sup>25</sup> as a way of rebalancing the status of the materially technological interface and transferring its technologically functioning interactions into the world where the materiality is the predominant dimension.

While the much talked about Google Glasses were withdrawn from the market, due to hard criticism received by experimental wearers which considered them too expensive and not aesthetic enough, pop stars like Lady Gaga, supported by designers, such as Studio Xo and Pauline van Dongen, started using incredibly scenographic wearable technologies to add digital wonder and magic to their multi-platform, futuristic, interactive shows. In November 2013, the designers prototyped the Volantis flying dress, a piece of clothing in the shape of a woman’s body surrounded by flying engines, which made Lady Gaga “levitate in what looked like, and was, an upscaled manned drone.” Even more interestingly, the same London-based company designed “interactive clothes” for the Black Eyed Peas band, a “digital mermaid bra” for Azelia Banks, clothes that blink and flash in controlled sequences, boots with embroidered LED lights and screens, and they are currently developing a ready-to-wear collection which will include a “jacket that can remix content on the body.”<sup>26</sup> These first type of interactive wearable technologies are designed *to be controlled by the users through interfaces*, envisaging future employments in the arena of everyday *explicit* communication exchanges.

A second wave of interactive technologies is, on the opposite side of the spectrum, dealing with the concept of *embedding technology into the body* in an even more radical way. Devices that are so deeply interwoven with our bodies to “blend into our skin,” are being developed and will in the near future become part of the Internet of Things, shifting the attention from pieces of clothing which can be directly

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*controlled* by users, to objects that react to wearers' emotions in ways that act *beyond users' control*. From the "Happiness Blankets" responding to the emotional behaviour of costumers by changing colours as experimented by British Airways, which react to brainwave-measuring headbands connected to light-up blankets,<sup>27</sup> to the sensor sensitive to skin users' goose bumps that is being developed by Korea Advanced Institute of Science and Technology (KAIST), to the digital tattoos able to spell the password of our mobile phone introduced by Motorola,<sup>28</sup> all of these technologies aim at incorporating computing tasks or features into pieces of clothing or objects that could potentially become part of everyone's everyday life and could potentially be enhancing - distorting? - social exchanges by employing previously intimate and concealed reactions in the open. Whether this is directed at enhancing marketing strategies, or employed to empower the user - or the collective communication environment - with the sharing of previously ONLY private emotions, a whole new set of questions related to tech environments needs to be posed.

While in the case of the second wave of interactive technologies, issues of consent and privacy might arise within future communication exchange scenarios involving a *passive* use of technology and a reading of people's emotions through technology users might need to give consent to - in the same direction as the "device fingerprinting" affair had stirred up<sup>29</sup> - in the case of the first group of technologies the issue would arise in the field of acquiring effective skills for an *active* use, involving tasks like instant messaging, audio-visual showcasing or remixing, which addresses the intention of creating an interaction as a *mise-en-scène as part of the users' experience*.

A third type of technologies is, instead, dealing with a combination of user's *active control* and user's *passive affect*, as an *inter-relational exchange in the form of a sensory exchange*. A good example is the "Hug shirt," designed by CuteCircuit, which won Best Invention of the Year in 2006 and which have been developed further since. The interactive shirt allows the receiver to feel the touch of the sender who is transmitting a hug via Bluetooth. The Hug Shirt "records a hug like you would record a movie and delivers the data to your mobile via Bluetooth through the App and then your hug is transmitted over the network to your friend's phone and it is seamlessly transmitted via bluetooth to their Hug shirt."<sup>30</sup> Not only the receiver gets a material hug - a tactile message - remotely, but he or she also receives it with precision in the way of its intensity and the heartbeat rate of the sender, in the means of a sensory translation of the original message sent by someone geographically displaced. These kind of interactive technologies seem to challenge the "division of material and computational that underpinned earlier conceptualisations and technologies of interactivity."<sup>31</sup> As it does, for example, the dress which illuminates itself when the wearer receives a Tweet, designed by CuteCircuit. Is the technological world spelled onto the material one as a way of subverting the value system underpinning the relationship between material and computational? Is the visual embedding of the computational into the material reflecting the equality of its role, if not its predominance, in the operational, as well as aesthetic and functional approach to contemporary communication systems?

The theoretical implications of technology incorporating audio-visual features into wearable portable garments worn by users, or even part of their second-skin, therefore transforming their bodies into walking screens, remote control and mixing stations and pushing to the extreme the 'post-cinematic' experience, are, as we can all imagine, potentially extraordinary. At the same time, methodological precautions in approaching the subject are necessary not to fall into essentialist views of technology as intrinsic drivers of change. While the time has come for this topic to be extensively studied by Media Studies, it is also true that the question of whether these technologies attached to clothing will play a big role in revolutionising communication systems, cannot be posed yet without incurring into a strongly "techno-oriented" misconception of the functioning of new media. This methodological preoccupation, which has been extensively addressed in current discussions which sprung out since the early 2011 social media debate sparked by the Arab Spring,<sup>32</sup> is based on the observation that the impact of a technology the development of which is constant, fast-running and of unpredictable use, is particularly

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difficult to measure and requires a large number of hands-on data to be analysed, question which also implies a specific concern related to the means of technological experience data gathering.

The shift in the current relationship to the *mobility* and *portability* of the device (i.e. smart phones, iPhones, iPads etc...), in the sense indicated by Roger Odin,<sup>33</sup> towards a more *embedded* use of mobile technology, a revolution of which wearable technologies like e-textiles and smart fabrics, are potential carriers, is entirely dependent on the *actual* active employment of the technologies by the wearers/users of the near future. These implications are almost impossible to foresee at present and can rely only on our own imagination. Moreover, despite the optimism of interactive tech developers and tech companies managers that are interjecting existing desires - as well as injecting new ones - based on the alleged need of people to access "personal data in the format people are starting to become accustomed to,"<sup>34</sup> it is very difficult to predict whether these technologies will be used extensively and will prove successful in a wider communication context. In a similar way, the potential repurposing the role of clothes and objects in their fundamental relationship to the body of the wearer or user and to the eye of the viewer, as proposed by e-textiles and other interactive wearable technologies, will depend on their impact on the society at large. It will, hopefully, be material of future studies based on the study of applied uses made by real agents within the specific context of a larger "communication space" these technologies will be immersed in. In this respect, Odin's semio-pragmatical approach<sup>35</sup> will prove useful to map the interplay of the actants which will be putting the communication in place, drawing a context in which the users' role in creating and spectator's role in decoding the communication will be understood.<sup>36</sup>

### **Wearable technologies and extra-virtual immersive environment**

At present, e-textiles, wearable and second-skin technologies have been employed only in highly technological contexts as *haute couture* fashion, show business or high-profile corporate contexts, where the deployment of a number of interactive media in inter-connection was possible. So far, the display of e-textiles garments in the public sphere has mostly been featuring in the form of a *media event*, built in interplay with a cross media environment which would intervene in the interaction with its own indigenous audience and following a *one-to-many* communication structure which doesn't reflect the possibility of the *peer-to-peer* digital culture to create multiple interactions (Jenkins, ...) (i.e. the media spectacle created around the aforementioned Volantis flying dress developed by technology company Studio XO for Lady Gaga, or the glamorous show-business oriented appearance of the CuteCircuit LED dress worn by Katy Perry, but also the experimental use of the light-up blankets made by British Airways ).<sup>37</sup> The big change will be visible, instead, when the *prêt-à-porter* collections will be made available to a larger spectrum of users and the visuals created - actively or passively - by those pieces of clothing will be projecting themselves into a wider media-sphere, increasing the potential for casual, multiple, variable and inter-relational interaction.

In fact, few things can already be noted in the use of wearable technology so far - and it possible to imagine that these features will become more and more crucial to its future uses. These technologies rely on the pre-existing relationship to the evolution of the digital context as "transformative, adaptive and responsive ecosystem"<sup>38</sup> as a whole, which seems to become an engrained element of *non-linear narrative features creating an exchange between the user and the digital platform*.<sup>39</sup> Moreover, they seem to subvert the relationship between material and computational as developed in the history of innovation,<sup>40</sup> by involving the users in *an interaction with an interface which displays its action in a dimension which is tangible, material and extra-virtual* - but crossed by computational streams which create the infrastructure of the communication. It would be a step forward in the direction, already displayed by interactive platforms, in addressing "life beyond the screen, as it were, entering the hybrid space between life 'offline' and 'online'".<sup>41</sup>

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In the time where we are struggling to understand the motivation behind the development of a specific technology over another one, a certain amount of theoretical precaution seems to be necessary when approaching the subject. As a matter of methodology, I would like to mention Gaudenzi's approach<sup>42</sup> to the development of immersive technologies in the way of a sudden development of a technology over another one. Gaudenzi mentions the cases of Virtual Reality and Personalisation-based projects, which both proved to be extremely successful in the year 2015,<sup>43</sup> as case-studies which represent a shift in the technology which reflects the way of *adaptation* to the technology itself as a process. Why is Virtual Reality suddenly being employed so widely even if we have been hearing about it for the last thirty years? Why do VR-based projects seem to be more successful in capturing audiences' imagination and in channeling film-related funding than, for instance, AR-based projects? And why have so many projects related to personalised stories been coming out in the last couple of years? Why *now*?

According to Sandra Gaudenzi:

VR and Personalisation are both speaking about *immersion*. VR is about our body being immersed in a digital world that recomposes itself every single moment you are turning your head, effectively it is the representation of the fact that we are becoming more hybrid, we have a digital personality and we need to learn to deal with the idea that between body and world – the world could be a digital one – these things could work together. We are training to get used to these hybrid worlds. (...). Personalisation instead is about using data about you to make the story personal to you (...) Is the story that is being immersed in my world. While VR is about me being immersed in the digital world, personalisation is about the digital world being immersed in my world.<sup>44</sup>

Both VR-and-personalisation-based projects, according to Gaudenzi, are addressing issues to do with the understanding of the world we are in. In the sense that users move in these worlds and are challenged in ways that are similar to what happens to them in dealing with technology at large. As a mean of analogy, I would to apply Gaudenzi's paradigm to wearable technology and question whether their appearance outside of the experimental field and into the mainstream, could be laying the ground for a *potential gateway to an entirely new step in the conception revolving around immersive technologies*. I suggest an hypothesis that follows a potential strand which is here used as heuristic tool to identify the changing relationship to immersion altogether. I suggest that, in connection to the changing relationship between material and computational mentioned before, as a display of computational functionalities into an extra-virtual environment, this option entails the relationship between the position of the user in the space where the interaction occurs.

Following the aforementioned hypothesis, this shift would imply the *repositioning of the concept of the screen as containing the moving image and the spectator being immobile*. If we follow Leo Manovich's analysis in his *The Language of New Media*, "the cinema screen enabled audiences to take a journey through different spaces without leaving their seats;" in the words of film historian Anne Friedberg:

[It created] a mobilized virtual gaze (...) instead, (in the VR experience) it is the virtual space as a whole that changes its position with each shot. Using the contemporary vocabulary of computer graphics, we can say that this virtual space is rotated, scaled and zoomed to always give the spectator the best viewpoint. Like a striptease, the space slowly disrobes itself, turning, presenting itself from different sides, teasing, stepping forward and retracting, always leaving something covered, so the spectator will wait for the next shot...the seductive dance which begins all over with the new scene. All spectator has to do is remain immobile.<sup>45</sup>

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Here we read about the comparison between cinema experience, where immobile spectators relate to a screen located in space containing moving image, and the VR experience, where the spectator is immobile but immersed into a tri-dimensional space which rotates around him/her in the virtual world. Instead, in the environment generated by wearable technologies, with multiple users carrying their own messages and moving image contents on their body, we don't encounter anymore neither the 'fixed' screen nor the "fixed" spectator, in order to experience a shift towards a new *relationship between mobility of the spectator and the movement of the visual space*. The spectator is no longer immobile nor the visual space is bi-dimensional, as it was in the cinema. But it is not even the case of what happens in VR, with the spectator being almost entirely immobile, exploring a tri-dimensional virtual dimension by rotating the head or the eyes. We are here, instead, projected into a *mediascape* which implies the real world as being the platform where all interactions -the user- device, the user-user and device-device interaction - take place. Both the spectator/user and the space where the visual experience takes place, are in movement. Mobile users who are carrying mobile devices embedded on portable clothes which are sharing their messages, move in the open in a moving, variable space. In this context my hypothesis is, therefore, based on the idea that the new space of interaction wearable technologies could contribute in creating is similar to the one *simulated* by pervasive games.

Pervasive games are in general described as inducing a mixture of the real and the virtual, in particular creating virtual worlds of play in everyday environments through the use of different ubiquitous applications of technologies (media). In a temporal, spatial and social sense, the game world encompasses everyday physical environments, which the player can interact with in real time through multiple media platforms.<sup>46</sup>

Let's imagine future scenarios: the potential "communication space" created by wearable technologies sees technology as being immersed into a multi-media environment – where multiple devices will be used at the same time. These interactions among media, worn or brought by two different users, for example, can create a level of interaction with the technology which goes beyond the interaction between the two users with each other and through their devices. Each one of them will be interacting with their own device, with the other users' device, with each other, as well as with a network of other devices – visible and invisible - already present in the *mediascape*. For example, what would happen if a Tweet appearing on the Twitter dress gets re-tweeted and appears by chance on the dress of another unknown user in the same room, causing them to recognize each other in person through a message which was launched in the web? The user/spectator would be carrying the audio-visual experience on their body and would share it with others in a multi-media, layered, mobile, extra-virtual environment. Is this an entire new conception of immersion which gets rid altogether of the real/ virtual dichotomy? These are only hypothesis which will be subject to future scrutiny in the years to come.

Ludovica Fales

### Note

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2. Sungmee Park and Sundaresan Jayaraman, "Smart textiles: wearable electronic systems," *MRS Bulletin*, Volume 28, Issue 08, August 2003, pp.586-591.
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5. Arjun Appadurai, "Disjuncture and Difference in the Global Cultural Economy," *Theory, Culture & Society*, vol. 7, no. 2, June 1990, pp. 295-310.

6. Henry Jenkins, *Convergence Culture. Where Old and New Media Collide*, New York, New York, University, 2006

7. During the roundtable on "Media, Interactivity and Immersiveness" which took place at Filmforum 2015, in Gorizia, on the 23<sup>rd</sup> of March 2015, Sandra Gaudenzi made an intervention on Skype where she stated: "What I am noticing is that this year has definitely been the year where a lot of projects using Virtual Reality have emerged, especially in interactive narrative and I think the next trend, which is going to happen very soon, because there are three projects coming out as we speak, will be personalisation. (...) This is what I am trying to focus my research on at the moment, to question 'Why is this happening now?', while we have been hearing about Virtual Reality for the last 30 years, and how is that repositioning *being in this world* and our actual *understanding of being in this world through the technology*'.

8. See Note 2

9. Paolo Bonato, "Advances in wearable technology and applications in physical medicine and rehabilitation," *Journal of NeuroEngineering and Rehabilitation*, February 2005, p. 2.

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12. *Ibidem*

13. See Note 10.

14. See Note 10.

15. See Note 10.

16. Susanne K uchler, "Technological Materiality: Beyond the Dualist Paradigm," *Theory Culture Society*, 25, N.1, 2008, pp.101-120.

17. Kiana Tehrani and Michael Andrew, "Wearable Technology and Wearable Devices: Everything You Need to Know," *Wearable Devices Magazine, Wearables.com*, March 2014, available on the web at [www.wearables.com/what-is-a-wearable-device/](http://www.wearables.com/what-is-a-wearable-device/), last access 30 November 2015.

18. <http://cutecircuit.com>, last access 30 November 2015.

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20. Tim Berners-Lee, "The World Wide Web: Past, Present and Future," August 1996, available on the web [www.W3.org/People/Berners-Lee/1996/ppf](http://www.W3.org/People/Berners-Lee/1996/ppf) "Any attempt to constrain the mental model users have of data into a given pattern was always doomed to failure." Last access 30 November 2015.

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23. Paul Ducum, "Youth on YouTube: Prosumers in a Peer-to-Peer Participatory Culture," available on the web on [http://ed.arte.gov.tw/uploadfile/periodical/3052\\_9-2-p.24-39.pdf](http://ed.arte.gov.tw/uploadfile/periodical/3052_9-2-p.24-39.pdf), last access 30 November 2015.

24. See Henry Jenkins, "The Moral Economy of Web 2.0 (Part Two)," 2008, available on the web at [http://henryjenkins.org/2008/03/the\\_moral\\_economy\\_of\\_web\\_20\\_pa\\_1.html#sthash.NAv4WD9s.pdf](http://henryjenkins.org/2008/03/the_moral_economy_of_web_20_pa_1.html#sthash.NAv4WD9s.pdf), last access 30 November 2015.

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25. See Note 16.
26. Nick Compton, "Studio XO, the 'fashion laboratory' adding digital light and magic to what we wear," *The Guardian*, 22 September 2014, available on <http://www.theguardian.com/technology/2014/sep/22/sp-wearable-technology-clothes-that-let-you-download-the-latest-look>, last access 30 November 2015.
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