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Design for Global Challenges: Communicating Emergencies for Behavioral Change Through Disruptive Technologies

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Abstract

The current emergencies such as climate change and sustainable development, are outlining the responsibility we have as researchers and designers to transform disruptive technologies into action/reaction tools able to address and overcome the nowadays challenges.

From this perspective, as designers, we indeed believe that the key to change lies in human behavior, and thus precisely in this direction design can impact using disruptive technologies in raising awareness by resulting into behavioral change.

Specifically, this paper aims to encompass how advanced technologies such as Data Visualization and Immersive Realities can cooperate in order to activate proactive behaviors in contemporary society through a careful analysis of opportunities and limitations.

On the one hand, Data Visualization has always been used as a tool for analyzing and communicating emergencies (Snow, Nightingale, etc.), on the other hand, immersive realities are more recently beginning to explore this field.

It is indeed at the meeting point between technology and Human Interface that the biggest gaps emerge, sometimes making the deployment of these technologies fail, due to sensory, sociological, psychological, and cognitive limitations.

Have we ever wondered, for example, whether the rules of Gestalt and Bertin's theories, belonging to the first half of the 1900s, are sufficient today in making effective Data Visualization?

Are we relying too much on the "astonishing" effect of immersive realities, paying more attention to their use rather than to the conveyance of the content?

This paper attempts to critically analyze – in a multidisciplinary way and through a historical analysis, case studies, and personal experimentation – the use of disruptive technologies, such as XR and Data Visualization, trying to clarify their limits, potentialities, and plausible common application fields.

The objective of the study is related to the determination of possible theoretical and practical approaches for the development of validation tests regarding the use of disruptive technologies and their relationship with the Human Interface.

1. Emergency Communication

In the face of the multiple current and future crises (such as climate, pandemic, and war challenges) a solid critical approach to support innovative social cohesion scenarios needs to be added to the digital transition process, sustainability, and inclusivity to instill a deep understanding of the emergency nature that we are facing. (Lotti et al., 2022)

The contribution derives from the observation of how two technologies and fields - Data Visualization (DV) and Immersive Experiences (IE) - widely used to communicate complex phenomena, have a common problem area: gaps related to the effectiveness of communication due to paying more attention to their use than to the conveyance of the content. (Bateman et al., 2010; Carey et al., 2017; Gaggioli et al., 2019; Licaj, 2018)

Historically, DV has often played the role of a decision-making tool to deal with emergencies and immediate impacts on society. In its long history, the ability to analyze complex phenomena in a short period of time remains constant. This is precisely why are recognized merits in its most famous historical cases, such as the discovery of the source of the cholera epidemic in the city of London in 1854 - *Cholera Map* by John Snow -, or the discovery of the causes of death in the military, during the Crimean War, linked to poor hygienic conditions, rather than to the war itself - Florence Nightingale's *Coxcombs*. A few hundred years later, it proved to be a crucial tool for emergency communication during the COVID-19 pandemic, described as the most data-informed event in history (Columbro, 2021). Strongly emerging from this period, however, the problems of DV: people were subjected to an exorbitant number of DVs, reaching up to 1,700 per week, one every four minutes, (Iaconesi, 2020) generating what could be considered real visual pollution made up of representations of data that were often wrong or misleading (Sbarbati, 2020). A pure infotainment phenomenon (Holmes, 1984) where what mattered was to grab the spectator's attention without actually allowing him to effectively understand what was being described.

In parallel, although the use of IE related to the dissemination and explanation of emergency topics is still a territory yet to be explored due to the recent nature of such advanced technologies, it is possible to recognize in them powerful communicative capacities related to the ability to make complex phenomena comprehensible beyond the limits recognized by DV, which are highlighted in this contribution. The IE are nowadays at the center of many debates. They can open up new and interesting educational possibilities thanks to the provocative and motivating effect that can be instilled if well-designed (Riva et al., 2012). Immersion can transcend the traditional boundaries of reality as well as cultural, social, and geographical limits, allowing us to fully understand the complexity of different social, ecological, economic, and inclusive perspectives, reversing the viewer's point of view. This approach allows to take advantage of the technological potential in an unconventional way allowing users to live situations that are difficult to experience in other ways, thus helping them to put themselves in the shoes of others, stimulating empathy, and activating proactive behaviors in the face of contemporary and future challenges (Tromp et al., 2011).

Therefore, in the attempt to use DV and IE in communication, for the purpose of raising awareness, it is essential to bear in mind that digitization must not concern the uncritical use of advanced technologies. It must instead be placed within a broader systemic vision in which these can become the protagonists of new and crucial challenges, opportunities, and impacts on society and the whole system (Gerry, 2020).

2. IE and DV communication limits. A common field

The possible criticalities of immersive experiences are linked not only to the obvious limits of a technology that is still strongly evolving but, above all, to the lack of strategic content that leaves digital tools the important role of the container but never of the essence of the story. The real innovation of immersive experiences does not lie in advanced technology - which must be used only to support it - but in a transdisciplinary design useful for behavioral transformation (Wojdecka et al., 2021), based on the storytelling ability to expose participants to new ideas, alternative views or unknown situations, encouraging critical thinking and open-mindedness, questioning assumptions, beliefs and perspectives of individuals and of society as a whole (Mitra et al., 2022). The main limitation of immersive experiences is that they usually rely on the technology itself to innovate. The potential of these advanced technologies must be exploited as a tool to support the creative, design, or strategic process without becoming the ultimate goal. In light of this, it is therefore important to continue investing in the development of digital technologies, while addressing the challenges they pose to society. By adopting a critical approach, It is possible to take advantage of the opportunities offered by the digital transition by progressing towards a future in which digitalization can complement the concept of Positive Technology, allowing us to fully understand today's complexity (Riva et al., 2012).

What happens in the Data Visualization field is not very different. In the early 1990s, Jacobson (2000) attempted to give DV, at the time incorporated in a broader concept of Information Design, its first label as a recognized discipline by painting a fragmented framework full of internal contradictions. Moreover, in this first framework emerges what twenty years later Bihanic's (2015) text confirms: every big technological revolution drastically influences this discipline, questioning most of its theories and practices. Everything revolves around information: with each technological step, as the type and quantity of information changes, the phenomenon of data boom occurs (Rhodes, 2015). It is observed that as the type of information changes, so do most of its processes, rules, and products, and as Murray (2014) argues, despite its long history, always seems to be trying to understand things for the first time. It can be observed how it has always attempted to explore new ways of doing DV, riding the wave of the latest technological breakthroughs but still hasn't validated previous processes and theories. It can be said that the spread of computers, graphical interfaces, and the birth of the internet, initiated the first data boom; Social Networks and Big Data were the second ones.

About ten years after the framework found in Bihanic's text and thirty years after Jacobson's, it can be observed that many issues remain unresolved. During an event held in Bologna in 2022, entitled *From Knowledge to Wisdom, and back![1]* It has emerged, together with the important guests present, some of the biggest issues related to DV such as those concerning aesthetics and representation, perceptual limits of users, accessibility, bias, and much more. Above all, due to the lack of these, the need emerges for quantitative validation tests that are able to attest, by analyzing cognitive and emotional processes, what today's DV methods are. Thus, one moves from one digital transition to the next gaps that have been carried out for decades. As evidence of this, it can be observed how the first attempts at DV through IE have emerged, such as the project *Cielo, Terra, Mare[2]* by The Visual Agency, a VR platform offering an immersive experience made of orbits and 3D graphics. Although the communication goals are about providing positive messages on environmental sustainability issues, it is described as "An effective tool for communication" where, however, the value of effectiveness, according to the agency's website, is not related to the impact on people but to the number of hits to the site and the boosting SEO.[3]

3. Communication Emergency. Good models

Despite the several problems highlighted so far, there are some case studies that provide insight into what good practices should be taken into account when constructing communication models using Data Visualization and/or immersive experiences in relation to the topic of climate emergency.

Among the most famous DV case studies related to climate change communication issues is the animated visualization *The Climate Spiral*[4] by Ed Hawkins (Figure 1). The British scientist posted this visualization on Twitter, reaching 3.4 million views in the first year alone and even being awarded the prestigious *Kantar Information Is Beautiful Award*. This depicted, in just a few seconds, the rise in temperatures from 1850 to 2016 in which, as the years go by, in a concentric motion, a line changes from blue to yellow, showing how temperatures up to that year have risen by an average of 1.5 Celsius degrees. There are many elements that make this visualization effective, but the main one is that of having successfully identified the most correct way to exploit the dynamics of social networks in the communication of the message, which is immediate and impactful, making implicit and explicit meanings permeate. The communication structure is also effective. The development of a GIF, with a square format and therefore adaptable to different screens, just a few seconds long and which reproduces itself in a loop and autonomously upon scrolling, makes it an example replicated in the years to come because it is capable of overcoming the limits of this era where the hunger for information, fast, passive, without the need for too much interaction, clashes with our tired minds overloaded with information (Gazzaley & Rosen, 2016) and with our reduced attention threshold (Gausby, 2015).

On the other hand, although the use of immersive experiences designed to stimulate consciousness is expanding, still a very small number of best practices are present today. This is because using IE for the digital reproduction and

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[1] https://www.youtube.com/watch?v=W0V9pjJqy-c&t=8098s

[2] https://cieloterramare.terna.it/en/

[3] https://thevisualagency.com/works/an-immersive-platform-to-communicate-sustainability/

[4] https://web.archive.org/web/20190816215511/http://www.climate-lab-book.ac.uk/ 2016/spiralling-global-temperatures/

reconstruction of a physical scenario may not be effective. Using a cinematographic language through 360-degree video (VR-3 Degrees of Freedom) although could be considered more simplistic from a technological point of view, exponentially increases the identification in real contexts and people, stimulating reflection and empathy.
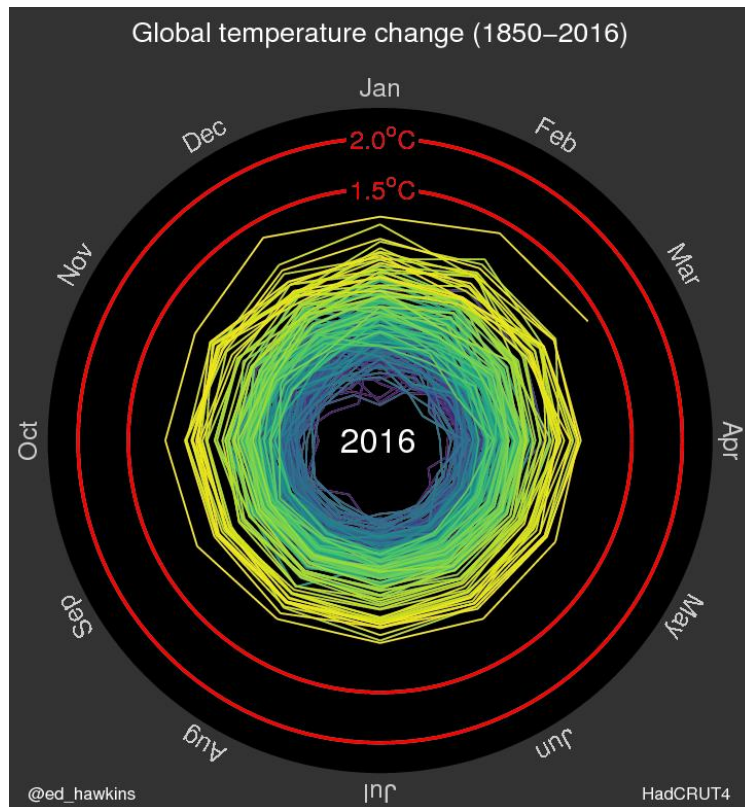

Figure 1. Frame from *The Climate Spiral* by Ed Hawkins

One of the most interesting case studies to raise awareness of environmental issues and the consequences of human behavior in the current era is the project *Anthropocene VR-Dandora* (Figure 2), a VR documentary part of the larger *Anthropocene* project that explores the history of human incursions on a global scale. The aim of the project is to explore a critical moment in the history of Earth and humanity and to broaden awareness of the scope and impact of our species. *Anthropocene* was conceived by the award-winning team of Edward Burtynsky, Jennifer Baichwal, and Nicholas de Pencier, produced by Nicholas de Pencier, and Nadia Tavazzani. The project, and here lies its strength, is a multidisciplinary work that combines documentaries, artistic photography, film, virtual reality, augmented reality, and scientific research to investigate the human influence on the state, dynamics, and future of the Earth. More specifically, 360-inch videos and cinematic VR aim to create experiences that bring viewers into the reality of the Anthropocene. The documentary offers a very raw insight into how the inhabitants collect scrap by hand and sell it to recycling plants on site. The hills and canyons of Dandora are symbols of an emerging microeconomy and an entirely human landscape. Waste plastic has become a separate resource that can be extracted and sold as source material. However, a large amount of it cannot be reused and is then dumped in landfills and dumped on courses. The experience is highly exciting and impactful because it conveys, through the sequences plan and the strength of his images, the current emergency condition, the faults of the past and the present, as well as the need to take targeted and sudden actions. Through the targeted use of immersive technologies in a transdisciplinary experience it is therefore possible to sew a deep connection between the community and the ecosystem, trying to stimulate a sense of conscience capable of overcoming personal and limited contingencies in time.

Figure 2. *Anthropocene VR-Dandora* @ Sima Academy

4. Towards validated models

As understood from the previous paragraphs, in both Immersive Experiences and Data Visualization there are gaps regarding the effectiveness of the communicative models. In the sphere of IE, the tests focus more on the technological aspects than on the actual emotional/cognitive impacts. In the area of DV, tests are generally qualitative, with small numbers and limited measurability of the factors analyzed.

In the face of emergency issues, it is therefore important to consider to what extent immersion can actually play a decisive role in stimulating empathy toward current and future critical issues. This is why it is essential to collect qualitative and quantitative data that are able to measure the real impact of IE best practices from the perspective of emotional impact and behavioral change to date, however, there do not currently seem to be any tests capable of fully assessing this scope. The reason lies in both the innovative and recent nature of the topic and the difficulty of measurement itself. At the moment, present tests designed to assess the effectiveness of immersive experiences are mostly focused on the technological aspects rather than the content, to the point of having questionnaires in the literature (which are also dated) related to the user interface, the attractiveness of the technology, the degree of attendance and immersion, and sickness (e.g., nausea, vomiting, dizziness) (Brooke, J. H., 1997; Usoh et al, 2000; Witmer & Singer, 1998) but not on the transformative capacity and empathic stimulation of such experiences (Carey et al., 2017). The use of tools such as questionnaires and interviews although they can outline an initial picture of the effect of such experiences, nevertheless, turns out to be severely limiting in that, given the type of subject matter, it possesses a high risk of not completely truthful responses, even at the unconscious level. This results in a knowledge gap on the potential use of immersive technologies in the above framework.

Useful Junk (Bateman et al., 2010), one of the most famous tests in the DV field, instead precisely analyses the structuring of contents and their permeability in people's memory. A qualitative test with twenty participants explores the issue of embellishment in charts in terms of interpretation accuracy and long-term recall, based on the historical Tufte-versus-Holmes dispute. It was Tufte himself who defined the charts as Holmes chart junk by disdaining the aesthetic approach and promoting a pure and minimalist one. The test was divided into two phases. The first phase consisted of exposing the participants to chart models and a subsequent section of questions, and in the second phase, the participants were asked to recall after two to three weeks to see which charts and which content had stuck in their memories the most. As an additional parameter, an eye-tracking system was used to monitor eye activity when observing the various graphs. What was surprising in the results was that both types of charts had similar interpretation accuracy, and participants recalled the embellished charts better after a two-to-three-week gap. The study also highlighted that both minimalist and embellished charts could introduce bias in their own ways, challenging the assumption of pure objectivity in minimalist charts.

From Data to Stories (Licaj, 2018) also explores the issue of impacts and attempts to answer, through qualitative testing, the question: can stories (narratives) be a tool to make the user more permeable to the message brought by data? To do this, datasets were structured on a theme that was very important in that period, i.e. that of Mediterranean migratory flows, and with the same datasets two distinct models were elaborated: an infographic model – model A – and a narrative model – model B. Comparing and testing the two communicative models made it possible to understand the strengths and weaknesses of both to grasp new key elements in the design of DV, in the context of social networks - a relationship that is still little explored today (Licaj, 2018). Specifically, model A (Figure 3) is an animated GIF infographic designed to strike a balance between static infographics and dynamic information visualizations. It aims to gradually reveal its contents through animated elements while presenting a complex overview of the data in a single image. Data were divided into three groups based on reading levels and each group is designed to be experienced in about three seconds, for a total duration of ten seconds, respecting the limits of browsing and the attention threshold on social (Giovanetti, 2020). Model B instead contains the same messages as the data but in the form of a written narrative. The dataset used to construct the infographics becomes the set of information on which to structure the narrative content of model B, and consequently, the message. In the test phase, six people were given the infographics of model A and six others the stories of model B. After three seconds, then ten, and then thirty, they were interrupted and asked questions about their understanding of the messages and their permeability of them. The usability and permeability test results reveal that users feel overwhelmed by information and bombarded with such content on social media. For model A, the test shows that highly aggregated data is perceived as complex or unclear on social media, while less aggregated data is immediately clear and memorable. Users also tend to have a superficial perception of the amount of information presented, as the gradual disclosure of complexity may lead to quick assumptions without deeper understanding. The GIF format proves suitable for passive engagement, and users feel comfortable as mere spectators, aligning with typical social media browsing behavior. However, initially, users of model B find the textual content unattractive. Forward users perceive the stories and information as authentic, despite their reservations about information credibility on social media. Overall, model B demands higher concentration for comprehension.
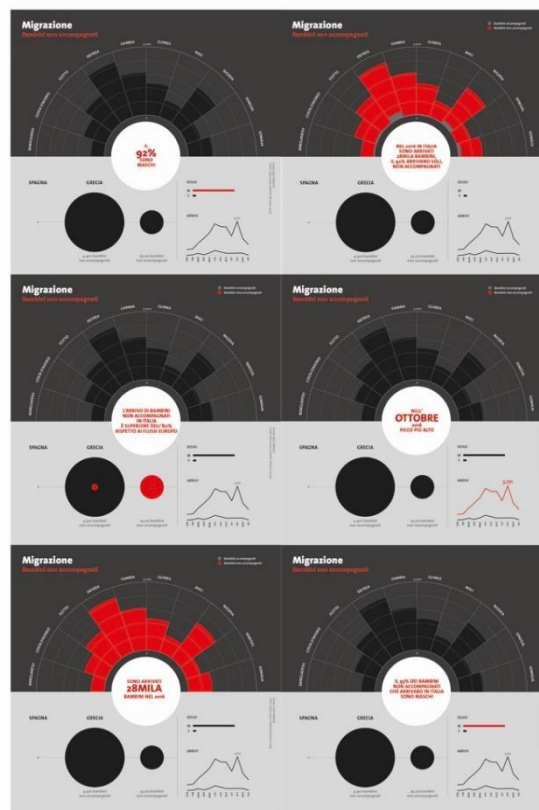

Figure 3. Model A of Experimentation *From Data to Stories*

5. Beyond the limits

The contribution aims to highlight what are the four key steps to structure validation tests that allow us to overcome what are the current limits of communication through IE and DV.

- Union of qualitative and quantitative approaches: the dual scale is fundamental, and there is an urgent need to attempt to understand through a quantitative approach what has already been explored qualitatively. The large scale of the quantitative compared to the qualitative makes it possible to benchmark results and have a complete, and no longer partial, view of the phenomenon. The effectiveness of conducting tests on small samples, with whom one has an in-depth dialogue, must be combined with the effectiveness of sensor monitoring and testing large numbers of people.

- Bias: although the collection of qualitative and quantitative data from interviews and questionnaires is of paramount importance as an integral part of the process of awareness by respondents, it also has innumerable disadvantages, such as unanswered questions, unconscious responses, and bias. Among others, the limitation of questionnaires to assess the effectiveness of DV and IE could be traced to socially accepted or desirable answers, misinterpretation of questions, limited context, and ill-posed questions. On the other hand, bias could play a fundamental role by leading to conservation bias, cultural bias, inaccuracy, and, consequently, incorrect results.

- Measurability of physiological parameters: Identifying methodologies and tools currently used in medicine to analyze the efficiency of EI and DV based on the study of physiological responses could be crucial (skin conductivity, heart rate variability, pupil dilation). The lack of a quantitative approach in the field of EI and DV apt to assess their effectiveness could be in fact filled by the ability to adapt medical or psychological technologies in digital storytelling.

- Quantitative analysis through the modification of time and space variables: one of the main problems is the way in which many DV and IE models are replicated on different formats and media without re-adaptability to the new medium and thus not taking into account the change of use context. The issue of the environment here is fundamental. Depending on where it is placed and the type of device, there are different conditions that drastically affect the experience such as noise level, movement or stillness of the body, indoor or outdoor environment, etc.. All this affects the main factor of communication, i.e. the level of people's attention and the comprehension and permeability of the message. There is therefore a need for tests that verify these thresholds by monitoring them in different environmental situations, with different devices, and with re-adapted fruition timing.

Advanced research and intervention are clearly needed to thoroughly investigate the relationship between IE, DV, and end-user impact. Currently, however, the use of bio-parameters in the digital world is limited to a few experimental studies mainly related to marketing, sometimes with not entirely ethical purposes, and not yet validated and introduced into design practice as a method of validation and quality assessment with a view to raising awareness and behavioral change. For this reason, a holistic and interdisciplinary approach could be widely adopted, opening the door to the fruitful cross-pollination of different research fields with a clear objective: design transformative experiences with great emotional impact that can instill behavioral change for end users.

6. Conclusions

Surely the meeting and union of DV and IE is imminent. But this research takes a very definite stance on the matter: without taking into account the issues addressed in the contribution and without overcoming the limitations of DV and IE communication by means of validation tests as described, it may not be conceivable to develop effective Immersive Data Visualization projects.

In the face of current and future crises, like climate change, pandemics, and warfare, it is essential to approach the digital transition critically, as this research is trying to do. Data Visualization and Immersive Experiences offer innovative ways to communicate complex issues, but their effectiveness is hindered by focusing on technology over

content. However successful case studies show that effective storytelling and context adaptation can make complex information memorable and impactful.

The research, funded within the NRRP project "Circular and Sustainable Made in Italy", foresees in the next steps the realization of validation tests in order to build, among the various final outputs of the project, a series of IEs experimenting with new communication languages. The main goal is to validate the effectiveness of communication through the adoption of a transdisciplinary approach, which is largely essential for the current research and significantly feasible for the next upcoming developments. The methodology will indeed encompass a spectrum of data collection techniques, including both qualitative elements such as in-depth interviews, and quantitative components involving surveys and the measurement of biometric parameters, readily measurable like heart rate variability (HRV). These meticulously selected tools will be specifically tailored to assess factors such as arousal, attention, and the overall efficacy of communication, essential to determine the level of effectiveness. Through the use of this methodology, our primary objective is to ensure that the combination of Data Visualization (DV) and Immersive Experiences (IE) results in communication that not only leaves a deep impact but also brings, above all, about meaningful change of the complex challenges the society currently faces.

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References

Aime, M., Favole, A., & Remotti, F. (2020). *Il mondo che avrete. Virus, antropocene, rivoluzione*, UTET, Milano.

Bateman, S., Mandryk, R. L., Gutwin, C., Genest, A., McDine, D., & Brooks, C. (2010). Useful junk?. In *CHI '10: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 2573–2582). Association for Computing MachineryNew YorkNYUnited States. https://doi.org/10.1145/1753326.1753716

Bihanic, D. (2015). New challenges for data design. In *Springer eBooks*. https://doi.org/10.1007/978-1-4471-6596-5

Brooke, J. H. (1996). SUS: A "Quick and Dirty" Usability Scale. In CRC *Press eBooks* (pp. 207–212). https://doi.org/10.1201/9781498710411-35

Carey, K. B., Saltz, E., Rosenbloom, J., Micheli, M., Choi, J. O., & Hammer, J. (2017*). Toward Measuring Empathy in Virtual Reality*. https://doi.org/10.1145/3130859.3131325

Columbro, D. (2021). *Ti spiego il dato*. Quinto Quarto Editore, Faenza.

Gaggioli, A., Villani, D., Serino, S., Baños, R., & Botella, C. (2019). Editorial: Positive Technology: Designing e-experiences for Positive Change. *Frontiers in Psychology*, *10*. https://doi.org/10.3389/fpsyg.2019.01571

Gausby E.: *Attention Span: Consumer Insights.* Microsoft Canada (2015). dl.motamem.org/microsoft-attention-spans-research-report.pdf

Gazzaley, A., & Rosen, L. D. (2016). *The Distracted Mind: Ancient Brains in a High-Tech world*. https://muse.jhu.edu/book/65912/

Giovanetti, F. (2020). How to Stand Out Online in a 3-Second World, *BetterMarketing*. bettermarketing.pub/how-to-stand-out-online-in-a-3-second-world-a533bd7bd84

Holmes, N. (1984). Designer's guide to creating charts and diagrams. Watson Guptill.

Iaconesi, S. (2020, March 31) *Come la 'spettacolarizzazione dei dati' cambia la nostra percezione della realtà.* CheFare. https://che-fare.com/almanacco/societa/corpi/iaconesi-dati-societa-covid-19/?fbclid=IwAR25BZz3mUVb-IOO-yrooK5oPgcTvBRo9ikpHMQxgvmbnRMLCcX31GlpCoo

Jacobson, R. (2000). *Information design*. MIT Press.

Licaj, A. (2018). *Information Visualization. Disciplina liquida intersoggettiva* [Doctoral dissertation]. University of Genoa. doi:10.15167/licaj-ami_phd2018-05-09

Lotti, G., Marseglia, M., Vacca, M., & Sottani, M. (2022). *Designing Futuring beyond the emergency scenario.* Altralinea Edizioni.

Mitra, S., & Sameer, A. (2022). Storytelling for Behavior Change: Use of Folktales for Promoting Sustainable Behaviors. In *Problemy Ekorozwoju* (Vol. 17, Issue 2, pp. 243–247). Politechnika Lubelska. https://doi.org/10.35784/pe.2022.2.26

Murray, S. A. (2014). Changing minds to changing the world. In *Springer eBooks* (pp. 293–312). https://doi.org/10.1007/978-1-4471-6596-5_16

Riva, G., Baños, R. M., Botella, C., Wiederhold, B. K., & Gaggioli, A. (2012). Positive Technology: Using Interactive Technologies to Promote Positive Functioning. *Cyberpsychology, Behavior and Social Networking*, 15(2), 69–77.

Rhodes, M. (2015, October 8). What infographics looked like before computers. *WIRED*. https://www.wired.com/2015/10/infographics-looked-like-computers/

Sbarbati, S. (2020, March 30). CoviDash: la nuova dashboard con i dati della diffusione del virus, sviluppata da Sheldon Studio. *Frizzifrizzi*. https://www.frizzifrizzi.it/2020/03/30/covidash-la-nuova-dashboard-con-i-dati-della-diffusione-del-virus-sviluppata-da-sheldon-studio/

Tromp, N., Hekkert, P., & Verbeek, P. P. (2011). Design for Socially Responsible Behavior: A Classification of Influence Based on Intended User Experience. *Design Issues*, 27(3), 3–19. https://doi.org/10.1162/desi_a_00087

Usoh, M., Catena, E., Arman, S., & Slater, M. (2000). Using Presence Questionnaires in Reality. *Presence: Teleoperators & Virtual Environments,* 9(5), 497–503. https://doi.org/10.1162/105474600566989

Witmer, B. G., & Singer, M. B. (1998). Measuring Presence in Virtual Environments: A Presence Questionnaire. *Presence: Teleoperators & Virtual Environments*, 7(3), 225–240. https://doi.org/10.1162/105474698565686

Wojdecka, A., Hall, A., & Judah, G. (2021). Transdisciplinary behaviour change: a burst mode approach to healthcare design education. In DS 110: *Proceedings of the 23rd International Conference on Engineering and Product Design Education* (EPDE 2021). 23rd International Conference on Engineering and Product Design Education. The Design Society. https://doi.org/10.35199/epde.2021.62