Quick, Print This Page! The Value of Analogue Media in a Digital World

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ABSTRACT

Quick, print this page![1] Otherwise, the information in this document might be digitally manipulated, and initial creative intention and contribution will be changed. You will lose your access to this document when the database containing this paper is decommissioned or compromised. This paper highlights the relevance of features from analogue media in an increasingly fragile digital world. Digital content can be altered to change its meaning or be deleted altogether. In analogue media, this is much more difficult without anyone noticing. Just imagine the impact if YouTube was decommissioned and all its content was rendered unavailable. In this paper, we outline concrete commercial examples and insight from the research of issues with distribution, storage, and manipulation of digital media and its impact on users. We conclude with strategies to preserve content, access, and artistic freedom in an increasingly digital future.

CCS CONCEPTS

• **Social and professional topics** → **Computing / technology policy**; • **Information systems** → **Information storage systems**.

KEYWORDS

Analogue Media; Digital Media; Knowledge Preservation; Archivability

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[1]**Hint:** Print to PDF will also work, or check the supplementary material if you are having access trouble!

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1 INTRODUCTION

"If printing was invented today, after the computer, it would still be a revolution; no booting time, no battery, no OS needed" - Morten Fjeld (private communication)

Now that you have printed this paper, we would like to welcome you back to the analogue world. Previous research found that printed paper makes it easier to read and memorise content [9] — some may argue that this is still true after nearly 30 years. You can read it without additional technology, even if there is no power available or if all your digital devices are broken. You can even hand the paper copy on to one of your friends or colleagues without asking anyone for permission, and you can also make a copy of it. Furthermore, the physical paper you are viewing cannot easily be changed without you noticing the manipulation. This paper is also permanently in your possession until you decide that you no longer want it. Printing this paper keeps your access to this document even when it gets removed from the digital library or the database where you obtained it. It cannot be taken from you even when the repository stored is decommissioned after the operating company files for bankruptcy.

We will discuss the pros and cons of analogue and digital media only briefly since our intention is not to compare the formats against each other. Instead, we wish to point out how digital media can be improved by utilising some unique properties of analogue media. We envision that both digital and analogue media should undergo a symbiosis that preserves the flexibility of digital and the persistence of analogue information. Mainly, we will discuss manipulability, archivability, access, and data ownership. This work aims to provoke and facilitate discussions around media stored on physical or digital mediums. Hence we make a fundamental distinction between media available on physical storage systems available at home (i.e., digital media in the user's possession) and decentralised services, such as streaming services (i.e., digital media service provider's control). Therefore, **we refer to digital or analogue more in terms of owning something or having direct access to it without relying on a third party to store and provide content.**

Analogue and digital media formats each have particular advantages and disadvantages regarding privacy, data possession, and modifiability. To illustrate a clear example: video streaming, where users view but do not own the media, accounts for approximately 60% of worldwide internet traffic [32]. In this scenario, the streaming

Figure 1: This caption is no longer available!

provider is directly in control of user access to the content. Digital Rights Management (DRM) could restrict your access at some point, causing you to lose access to your favourite movies, books, or important references. Losing access to your media does not only affect subscriptions but also purchased items. This concept captured public attention through a viral tweet about DRM-protected books which reported "The books will stop working"[2] (see Figure 1).

While this is a serious impact on consumer rights, the implications can be more far-reaching. For example, the documentation and understanding of historical events can be compromised by manipulating online-only resources. The ability to change these resources calls their accuracy into question and erodes public trust [26, 34, 38]. Furthermore, if a single distribution system fails, it could lead to compromised documentation or lost media and art. MySpace[3], a social networking and media platform popular in the mid-2000s, irretrievably lost 50 million songs from numerous artists before 2015. Laborious attempts have led to the recovery of less than 1% of the songs. Imagine if this were to happen to YouTube today – it would lead to the loss of an enormous portion of culture and created content from the early 2000s. This would include funny cat videos and important cultural knowledge, historical analyses, documentaries, tutorials, art, entertainment, and representations of the societal structures in which the content was made.

What are the future impacts of failing to account for the vulnerabilities in our current digital systems? Future generations could have a skewed or utterly false view of our present culture and history depending on whether records are manipulated or stored in a no longer readable form. There could be an empty gap in human history where most events were held across decommissioned servers once owned by long-defunct cloud storage service providers. Perhaps only Instagram[4] stories will survive, and the only source of information for future historians will be 10-second clips of "influencers" and photos of their brunch. To leave an accurate picture for the future, we must actively work to create content that is, by default, forward-compatible and robust to the relentless progression of time.

In the short term, some digital content also has opposite properties: content that is once shared online may be tough to delete. There are various examples with copyrighted materials (e.g., movies, music, or source code) and personal or intimate pictures or films. Research in HCI has looked at how we can achieve more ephemeral representations (e.g., [11]).

TAKEAWAY MESSAGE

We have to consider the future when deciding how to store and communicate information. We need to integrate redundancy in our data storage that does not rely on a single corporation or system. Diversity and redundancy imbue strength into the global information database. This work does not intend to discuss the advantages and disadvantages of digital and analogous technologies but instead envisions how our perception of knowledge, consumption, and social interaction alters through changes in information channels. We intend to provoke future technology designers to develop new paradigms and more robust systems to preserve our information integrity, access, and history.

[2] www.twitter.com/rdonoghue/status/1144011630197522432 - last access 2021-02-16
[3] www.myspace.com - last access 2021-02-16
[4] www.instagram.com - last access 2021-02-16

2 WHAT HAPPENED BEFORE: COMPROMISED DATA OWNERSHIP AND SOVEREIGNTY

To better illuminate our point, we will first follow up with examples from literature to show how the scientific community tackles issues surrounding modification of information, changes in data ownership, and the impact on the user's privacy.

2.1 Data Ownership and Storage

Given the unprecedented flexibility offered by cloud storage services, enabling ubiquitous access and freeing up local storage capacity, it is no surprise that remote data storage is continually expanding [13]. However, this flexibility comes with a cost since cloud storage typically involves trusting a third party to store files for the user remotely. The user then becomes dependent on companies, such as Dropbox[5] or Microsoft OneDrive[6], to maintain storage facilities indefinitely. Recall the MySpace scenario: what happens when one of these companies goes bankrupt? There are no comprehensive systems to archive and manage potentially huge amounts of personally and societally valuable data if a company fails. Some companies may seem to be "too big to fail", but throughout history, we have seen that big companies fail all the time [23] and their innovation gets replaced by a technological successor.

In response to questions such as these, researchers find digital archiving to be increasingly crucial [1, 25]. Ownership of digital content is a related important issue. The effort required to duplicate digital content is typically minimal compared to similar analogue content. This ease, combined with the prevalence of digital copycats, necessitates researchers to innovate on Digital Rights Management (DRM) methods [14].

2.2 Privacy and Online Monitoring

The average user is tracked as they browse the internet. Engelhardt et al. [12] found that Google Analytics has a tracking presence on 70% of the top one million websites. Internet activity tracking can help personalise browsing experiences and increase the ratio of relevant content that a user encounters. Still, there are often multiple complex steps required for users who wish to maintain some level of privacy. Online activity monitoring can be hazardous in tense political situations, as in Hong Kong in early 2020, when protesters were moving offline to avoid being tracked by the government they were protesting against [19]. A digitally interconnected world's promise is the widespread democratisation of information, but when the information flow is monitored and controlled, this connection can cause serious harm. Researchers have been developing untraceable communication services since before the internet was available to the public [7], and encryption remains an important topic for social media [3] and big data [37].

[5]www.dropbox.com - last access 2021-02-16
[6]www.onedrive.live.com - last access 2021-02-16

2.3 Between Reality and Deepfakes: How Digital Information can be Manipulated

One of the most powerful features of digital media is the ability to create and modify user-generated content. Abilities to edit images, video, and sound are responsible for increasing content and greatly extending the reach of human creativity. However, the digital world's malleability also presents serious consequences as it is possible to make changes to the information that we trust to be static. *Deepfakes* [5] are one poignant example in which photorealistic synthetic images or videos are generated using neural networks. Deepfakes can portray videos of people convincingly saying words that they never said, as demonstrated by Suwajankorn et al. in their manipulation of video footage of former U.S. president Barack Obama [36]. To combat rising concerns about Deepfakes, researchers have begun developing methods of Deepfake detection [8, 10, 22, 39]. However, this, in turn, has lead other researchers to develop Deepfakes that are increasingly resistant to detection [17]. The case of Deepfakes serves to highlight that digital media in its current state is highly manipulable, which erodes public trust in news media and other sources of important information [26, 34, 38].

3 "THE BOOKS WILL STOP WORKING": RECENT EXAMPLES FROM THE REAL-WORLD

The previous section presented an overview of the scientific research community's response to complex issues with digital media. This lens is crucial to understand which aspects are considered to be necessary by experts in the field. Despite the efforts of many researchers, however, the issues that we have raised are persistent in the modern digital landscape. Hence, we present an overview of several exemplary cases in the real world that demonstrate our concerns about manipulability, archivability, and accessibility.

3.1 Retroactively Changing Media

When content is published, be it a movie, a game, or a song, the traditional expectation is that what you get is what you will always get. A work of art may change due to perception and age, but one does not typically expect that the content of a work of art will change over time. However, with digital representations of media, particularly streaming services in which users do not own hard copies of content, it has become disconcertingly commonplace for creators or distributors to change the range of media long after original publication. In some cases, the change is motivated by a shift in public opinion or political optics, while others are less explicable. We present several example scenarios where scenes or features were changed long after the content was created. Our intention is not to argue whether the alterations were *right*, but rather to point out that they are *possible*, and that this possibility is due to inherent aspects of the way we currently design digital systems. If it is possible for digital media to change, then the public has no reason to trust media or information to remain over time [26, 34, 38].

3.1.1 Star Wars. Perhaps one of the most famous examples in popular culture where a scene was retroactively changed occurred in *Star Wars: Episode IV - A New Hope*. One of the protagonists,

Han Solo, initially shoots a fellow bounty hunter in cold blood in the scene. The scene was modified in later releases of the film so that the bounty hunter tries to shoot Han first and misses, and Han Solo then returns fire in self-defence. This significantly changes the character development of Han Solo by dampening his change from a morally grey bounty hunter to a true hero later in the story.

The shooting scene is not the only example of retroactive changes in the Star Wars film franchise. The first movie was initially released in 1977 with the title *Star Wars* but was later changed to *Star Wars: Episode IV - A New Hope*. In 2004 the original Star Wars trilogy was re-released with another retroactive change. In one of the final scenes of *Star Wars: Episode 6 - Return of the Jedi*, the ghosts of several deceased characters were changed to reflect actors from the prequel trilogy, which started being released in 1999.

Perhaps most fundamentally, the academy's award-winning colour grading, special effects, composition, and music mastering can no longer be experienced unless you happen to own an original copy. Only updated (and massively altered) versions are available[7]. The original versions from the 1970s and 1980s are still waiting for their introduction into the archives of the American Library of Congress[8].

3.1.2 Disney. With the start of their streaming service, Disney+[9], Disney re-released parts of their movie catalogue. However, more and more changes in these movies have been found, ranging from small alterations and removing individual scenes to deleting entire episodes altogether.

In the streaming version of the movie *Splash*, for example, Darryl Hannah's character runs over the beach towards the water, where her suddenly digitally enhanced hair covers her posterior to edit and censor it out. *Splash* was created by Touchstone Pictures[10], which was formed as an adult-focused label within Walt Disney Studios. By censoring the original version, Disney not only dismissed the original intention of the label, but it also resulted in a poorly executed altered scene[11].

In a similar move, Disney removed a scene in the movie *Avatar* on their streaming service. In the form of connected ponytails, a love scene between Aliens has been removed in the online version. In *The Simpsons* catalogue hosted on Disney+, an episode containing a Michael Jackson cameo was removed entirely.

3.1.3 Grand Theft Auto. The video game series *Grand Theft Auto (GTA)*[12] is famous for recreating and parodying eras of pop culture. A large aspect of this is the inclusion of era-specific music that is played on various radio stations. While physical releases of the game can still be played in the original form, owners of digital versions of *GTA: Vice City* currently experience a reduced selection of songs. In particular, songs by Michael Jackson have been removed. The official reasoning is due to licensing issues, but similar results could happen for publicity reasons. Regardless of the reason, the change alters the game's representation of an era of pop culture. The bigger picture could affect how past eras are perceived by removing persons or events from public memory.

3.1.4 Rambo 3. The credits of *Rambo 3* show a dedication that reads: "This film is dedicated to the gallant people of Afghanistan". Starting in 2001, some internet forums began claiming that this dedication was altered from an original, which supposedly read: "This film is dedicated to the brave Mujahideen fighters of Afghanistan". It was argued that the film creators were attempting to retroactively change the perception of history and provide a more sensitive message. However, the claim of an "original" version dedicated to the Mujahideen is a falsification. Members of movie discussion boards were able to identify and disprove this manufactured claim by referencing original physical copies of the movie and books referring to this credit scene[13].

3.2 Digital Archival

This section highlights examples where digital storage has led to the loss of vast quantities of important information. We do not claim that analogue media storage is without flaws; printed paper fades, and CDs degrade with repeated use. However, remote and intangible digital storage systems have created new challenges for information archival that require creative new solutions. Some forms of analogue storage, such as microfilms [33] or vinyl records [21], continue to be used for information preservation since the technology required to read them can be recreated with relative ease.

3.2.1 Baby Photos. While childhoods of past generations are well documented with physical photo albums, generations born during the rise of digital cameras often find themselves unable to locate or access their childhood photos. Pictures from the early days of digital were often not backed up correctly, if at all, and are therefore lost. They may be stored in a file format that is no longer supported or on a digital storage device that cannot be inserted into any modern computer. One of the most efficient ways to ensure continued access to photos continues to be printing them off and creating a physical photo album. Dr. Vint Cerf has argued that continuing on a purely digital storage path could lead to a loss of baby photos and a widespread digital blackout where years of information about our culture and activities are illegible to future generations [6]. Numerous other researchers have warned of a potential 'digital dark age' if appropriate actions are not taken [4, 18, 20].

3.2.2 The Books Stopped Working. In 2019, game designer and Twitter user Rob Donoghue tweeted[14] in response to the closing of the Microsoft eBook store:

> *I cannot believe that sentence.*
> *"The books will stop working."*
> *I keep saying it, and it sounds worse each time.*

The tweet went viral for highlighting the absurdity of DRM-restricted digital media. Users of the service lost access to their books when the program was no longer supported [30, 31]. This is a fundamental issue in cases where critical publications are only available on one online store or extreme instances where many or all online book stores are shut down. In a world where users do

[7] www.youtube.com/watch?v=mGrXO2RDzLg - last access 2021-02-16
[8] www.savestarwars.com/lucas-nfr.html - last access 2021-02-16
[9] www.disneyplus.com - last access 2021-02-16
[10] www.touchstonepictures.com - last access 2021-02-16
[11] www.reddit.com/r/gifs/comments/g0tzwn/disney_tried_editing_out_darryl_hannahs_butt_by - last access 2021-02-16
[12] www.rockstargames.com/V - last access 2021-02-16
[13] www.skeptics.stackexchange.com/questions/28476/have-the-ending-credits-of-rambo-iii-been-changed - last access 2021-02-16
[14] https://twitter.com/rdonoghue/status/1144011630197522432 - last access 2021-02-16

not own actual copies of the media they consume, we are all reliant on a few companies to maintain access and archives of the world's media library.

3.2.3 MySpace. MySpace[15] was the largest social networking platform of the early 2000s, and it was home to music from thousands of artists. During a botched server migration, MySpace inadvertently deleted 12 years of music hosted on the site [28]. For any bands without a backup storage location, this music is lost forever. Even assuming that many of these files were backed up somewhere, this public repository cataloguing and characterizing over a decade of music is no longer accessible to potential listeners or music historians.

3.2.4 Closed Accounts. When users lose access to social media accounts, whether from a rightful suspension due to inappropriate activity or a wrongful deletion due to a move from a password breach, they lose access to myriad content related to that account. For example, if a user's Facebook account is permanently suspended, that user has no way to access thousands of photos of themselves that may not be stored elsewhere. Additionally, consumers will lose access to any purchased Oculus games if they delete their linked Facebook account [2, 27].

3.2.5 Linked References. This paper contains multiple references to websites and other information posted online. Ironically, some of these links may be dead or inaccessible to you if you read this paper after some time has passed since its publication. This is true for digital references across scientific communities and within internet-hosted content; it underlines the importance of archiving digital data.

3.3 Digital Rights Management

Several of the examples already presented in the paper have highlighted issues with DRM. DRM describes tools and systems implemented to control access, use, distribution, and modification of digital media. This control is enforced through software (e.g., game launchers), regular online verification, or through processes integrated into the hardware [24]. Although there are apparent benefits to DRM for content creators hoping to benefit from their products, many question the effectiveness and argue that the measures only hinder paying customers while doing little to combat illegal piracy [15, 35]. DRM measures also impact customer rights by limiting the concept of ownership. Customers are often prevented from creating backups or offline copies or using the material for education and research. Media streaming services, such as Netflix[16] typically restrict offline use to specific devices or duration.

3.3.1 Ownership of Physical Copies. Video games are commonly sold through digital stores as digital downloads, enabling instant access and an improved environmental impact. However, when these games only exist on a single digital store, they are at risk of disappearing due to delisting[17]. The delisting of a digital product can eliminate the ability for a customer to re-download a game they have already purchased [29]. At present, customers can still purchase physical copies of most games, which means that they can re-sell games once they are finished or lend them to a friend. However, physical releases are declining [16], with some games solely available in digital format. This often completely removes the option for a secondary used market or the ability to share content. Further, media that is exclusively available in a single digital store (e.g., Nintendo eShop[18]) are not truly part of the free market, which grants providers unprecedented control over prices.

3.4 Analogue Problems

As we have said from the beginning of this paper, our aim is not to pit analogue and digital against one another to determine which is best. Instead, we aim to highlight issues with digital media that could be addressed by incorporating analog aspects. However, there are some significant issues with analogue that have been solved through digitisation, and we must not lose these features. In particular, analogue copies of information tend to degrade over time due to physical wear and tear. Saving information takes time, and physical space and distribution require physically moving an object from one place to another. From a sustainability perspective, creating analogue copies of information means using, often non-renewable, resources. As we work to modify digital system designs to protect against the negative aspects of manipulation, archival, and ownership, it is crucial that we do not sacrifice the flexibility and efficiency of digital media. This challenge is of great importance and far from trivial.

4 "TO BE CONTINUED": WHAT CAN WE DO?

Through various examples, we have shown that our current understanding of storing, sharing, and producing digital media is inherently vulnerable to manipulation, loss of access, and lack of individual ownership. Many of these issues directly result from the profoundly powerful features of digital media that allow users to endlessly change and create digital content and share ideas with millions of users around the world. This paradoxical problem is not easily solved, and we do not propose to have the answer. However, we can suggest some procedures and paradigm shifts that could reduce the problems. Hopefully, highlighting these issues can provoke conversations within the community that eventually lead to the right solutions.

What can individual users and vendors do? Individual users can create systems and routines to regularly back up their personal information in multiple locations, hence tackling the problem of forwarding compatibility and information loss. Spreading files and data across multiple services can reduce individual risk exposure. Beyond merely copying files to various cloud service providers, a diversified storage portfolio should also include offline storage and analogue copies if appropriate. Personal habits can contribute small improvements, but in many ways, our recommendations are simply restatements of robust data storage practices that any user would benefit from implementing. The larger, more important question to ask is: what can technology designers do? How can we shore up the vulnerable aspects of our digital systems at a fundamental level? We propose ideas as food for thought in the design of future digital storage systems. While we do not claim to be experts in the current practices of data preservation, the following approaches should contribute to the more persistent storage of digital information.

[15] www.myspace.com - last access 2021-02-16
[16] https://netflix.com - last access 2021-02-16
[17] www.delistedgames.com - last access 2021-02-16
[18] www.nintendo.com/games/buy-digital - last access 2021-02-16

A Version Control for Internet Content. Some paradigms are already in use by the technology community that could fortify our digital systems. Version control paradigms are intended as a layer of transparency regarding all changes in digital entities. A version control system allows users to track changes and revert to previous states. At present, version control is primarily used by software developers internally and within teams to track changes to a product or file system. If this paradigm was instead embedded into every digital file, we could create a version-controlled internet – an internet that records its digital history in real-time.

Evidence of Manipulation. There must be a system for identifying manipulated files that cannot be hidden or overridden. The possibility of endlessly controlling digital content is a powerful creative feature but must be carefully managed to maintain user trust in digital information. This aligns with the idea of a digital repository, where changes in content can be tracked to unveil potential manipulation.

Forward Compatibility of Viewing Formats. Whether files are automatically and continuously converted to new, compatible file types or retro-compatible file readers are mandated, we cannot continue the current practice of abandoning old forms of storage when they fall out of favour. Additionally, the hardware required to read preserved information should be easy to recreate.

Enable Ownership. Content creators are, of course, well within their rights to modify their creations. However, digital ownership should be re-designed so that consumers own and control local copies to choose whether or not to change.

Regulation. If companies offer services that provide storage or distribution of media content, we could imagine having regulations that require these companies to keep easily accessible backups of all content with a trusted third party. In book publishing, proving copies is common practice, such as the mandatory deposit[19] for copyright in the US for use in the Library of Congress (i.e., two complete copies are required) and national libraries in many countries have similar requirements[20]. If a company no longer exists, the content is still available and could be moved to the public domain. Also, if there is a dispute of access or ownership, having a third-party copy may resolve it. Such a regulation would increase the cost of both monetarily and resources and energy to provide certain services.

5 CONCLUSION

Now that you have printed this page and joined us on a journey through our current digital world's vulnerabilities, we hope you agree that solutions are needed. Many powerful tools and incredible advances have come from the continued development of digital processes. Digital media has enabled us to create previously unimaginable content and share it across the world. We can access information nearly instantly almost anywhere on the planet, and storing information requires a tiny fragment of the physical space previously demanded by analogue means. Despite all these advantages, there remain some situations where analogue media features prove to highlight digital information shortcomings. The flexibility of digital content means it can be manipulated in nefarious ways, eroding user trust in online communication. The rapid advancement of digital technologies means that digital archival may not be compatible forward, and delocalised storage means that the content we "own" is not truly our own. We propose lessons to be learned from analogue in terms of permanence, archival, and ownership. By learning from the past, we can ensure that we move towards a future in which we will be remembered.

[19] www.copyright.gov/mandatory - last access 2021-02-16

[20] e.g., in Germany the collection mandate: www.dnb.de/EN/Professionell/Sammeln/sammeln_node.html - last access 2021-02-16

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COMMENTARY

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This is a tricky paper. Overall, I find the main argument difficult to follow. First of all, I did print the paper (making the linked references quite inaccessible for me) and immediately made notes in the margins. It did not stay a pristine 'preserved' 'copy for long; rather, I immediately started changing what was said for anyone reading from the paper after. The authors later in the paper state how physical material deteriorates, but the point to me is more that a single instance develops further either way, and sometimes with 'history-busting' effects seen in the artwork of a church that a lay person 'restored'. In that regard, the argument tying trust to immutability of digital information needs to be backed up by references and related work more thoroughly to be convincing.

I am also somewhat concerned about the inconsistent terminology used throughout. The authors try and redefine the analogue/digital dichotomy to one referring to models of ownership, though later they seem to use this to make a distinction between physical copies of media (as in tangible things in the world) and digital data. At other instances, the mentioning of certain social media applications seems to actually hinder the authors' argument, given that Instagram 'stories' are unlikely to be the ones that remain as they are specifically designed to have an expiration date, to be fleeting in their ephemeral existence; as a counterpoint to the ever permanent default social media usually comes with. On a technical side, I was surprised to see that while the authors do mention privacy and monitoring, they never discuss the notion of hash functions that allow for checking for manipulation of data across transmission (albeit imperfectly, particularly in practice). I also kept wondering whether the authors argue for the sanctity of media artwork (e.g., movies) or whether they just want transparency. I assume it is the latter, because otherwise they would argue against software updates (e.g., patches for games) on a more fundamental level.

In the end, I am not quite convinced by the necessities the authors describe as the 'archival version' of any document comprises a kind of anti-hermeneutical myth ignoring the intersubjective character of media consumption – as in: one cannot read the same piece of text/watch the same movie/ listen to the same music twice, just like you cannot swim in the same river twice (which is a statement based on the water as well as the person who swims). In that regard, I wonder whether we could not go a bit more with the flow and relax our expectations to the world.