

# Serendipity By Design? An Alternative Framework for Preventing Filter Bubbles and Echo Chambers in Social Media

Urbano Reviglio<sup>1</sup>

<sup>1</sup> PhD Candidate of the LAST-JD International Joint Doctorate in Law, Science and Technology (ERASMUS+) at the University of Bologna

urbanoreviglio@hotmail.com

**Abstract.** Personalization of online content creates filter bubbles and reinforces echo chambers. These are driven not only by natural human behaviors (selective exposure and homophily) but also by design choices and efficiency-driven recommender systems. The traditional media policy goal of exposing citizens to diverse information to protect pluralism has not found its concrete application on social media. This is an urgent issue considering that the usage of social media as a news source is increasing, as well as personalization' sophistication and group polarization. The paper suggests serendipity as a potential design principle and policy goal. Indeed, serendipity – considered both as a capability and a process of seeking and processing unexpected and surprising information – requires novel and diverse information as preconditions as well as it causes cognitive diversity. Serendipity as a design principle might encompass all the phases of production and consumption of information representing a positive freedom valuable from an epistemological, psychological and political perspective. By being both limited and cultivated in the digital environment, the research reveals a theoretical trade-off between serendipity and relevance that might indeed be tackled with serendipity-driven recommender systems and structural and informational nudging.

**Keywords:** Filter bubble, Echo Chamber, Personalization, Media policy, Ethics, Serendipity

## Introduction

Information online is nowadays essential for individuals to plan their lives rationally and to participate fruitfully in public life. In particular, the exposure to challenging or alternative information is fundamental for promoting critical thinking and informed decision-making, and even preventing or correcting inaccurate beliefs or dangerous radicalization. Though Internet gives unprecedented access to information and people of widely varied backgrounds, this increasing availability of diverse information does not guarantee an equally diverse exposure to different perspectives. Selective exposure to

information – the individuals’ tendency to favour consonant information and avoid dissonant information – can indeed negatively affect deliberative discourse. Concerns increase when algorithms filtering provide a highly personalized Internet experience, producing at the individual level *filter bubbles* and at the collective level *echo chambers*. Yet, whether these ultimately lead to collective political action or simply more fragmentation is a question that has been debated by social and political theorists ever since the Internet entered academia. Still, it is not clear whether they should be, or even whether they can be, legally handled.

Media law and ethics discussed this issue in terms of “diversity exposure” without, however, being able to balance different ethical perspectives and offer an encompassing methodological framework. Firstly, because there are not enough scientific evidences of risk assessment. Secondly, because expose individuals to diverse information might even further polarize them, so that it is not clear how much diverse information would be sufficient. At the same time, there are trends about social media’s information production and consumption that are potentially limiting information diversity exposure. It is evident, indeed, a lack of autonomy in de-personalize the recommender systems that users enjoy. Then, social media are often opaque, especially about users’ information consumption. Implicit personalization filtering is also increasing, as well as its accuracy. Further, social media are more and more often designed to subtly affect users’ behaviors in order to increase their engagement, so the profit. Hence, Internet users actually risk to be trapped in a continuous flow of highly personalized information rather than diverse, alternative and more serendipitous one, without clear ways to opt-out, nor motivation, awareness and skills to do that. It is therefore becoming imperative to employ an ethical mediator to influence media users in an appropriate way.

Thus, the article attempts to explore this phenomenon through the lens of serendipity, considered both as a capability and a process of seeking and processing both unexpected and surprising information. In fact, serendipity requires novel and diverse information as preconditions as well as it is a cause of cognitive diversity. Seen as a principle, serendipity provides an alternative perspective that is able to represent a positive freedom for users, as the best conceivable outcome, able to encompass all the phases of production and consumption of information and valuable from an epistemological, ontological and political perspective.

Serendipity is, of course, a complex concept, on which there is no consensus on the meaning. Apparently, it seems impossible both to create it on demand, and to properly assess it. It will be necessary, then, to define what is meant with serendipity, how it expresses in the digital environment, and explore whether it is possible to program it in algorithms, cultivate it by design, and objectively assess it. The major questions that the paper will attempt to answer are the following: Is it possible to design serendipity? Can this be preferred to “diversity exposure” as a desirable media policy goal? Ultimately, can ever be conceived as a useful normative horizon able to foster a healthier *infosphere* ecosystem [1] ? If yes, how would that be possible?

In the first chapter the paper aims at analysing through a literary review the main concerns about personalization, and whether one could legitimately argue a policy intervention. In the second chapter, it will be discussed the phenomenon of serendipity in the digital environment, whether this might be considered as an alternative design principle suitable to increase the diversity exposure in social media. It will be argued how this is possible by defining a preliminary framework of “serendipity by design”. Finally, conclusions will be drawn.

## 1. The Risks of Hyper-Personalized Information Filtering

By recommending content according to the inferred preferences of users, personalization performs a fundamental role of knowledge management. In general, it occurs explicitly and implicitly; the first makes use of users’ requests, while the other is mainly based on monitored users’ activity. Both increased dramatically in the last years, though many websites have acted to make passive forms of personalization the fastest growing forms [2]. Many fear that this hidden personalization could close users in a kind of cultural and ideological bubble, in which they continue to see, listen and read only what reinforces their own view of the world [3, 4].

Over-personalization filtering can actually create *filter bubbles* and fuel *echo chambers*, two sides of the same token. The first is a kind of cultural and ideological bubble, in which an individual continues to see, listen and read what reinforces its opinions and interests. The latter, is a group situation where information, ideas, and beliefs are uncritically spread and amplified, while dissenting views are ignored. The major difference between the two is that filter bubble occurs without the autonomy of the user [5]. Echo chambers, instead, pre-existed digital age: people naturally tend to selective exposure and homophily [6].

Yet, there is few and conflicting research about the extent to which personalization is detrimental. This phenomenon, however, raises serious concerns both at the individual and collective level. Individual, because these filters might reduce opportunities for users’ identity to self-determine. Indeed, personalization would reduce opportunities for serendipitous discovery, particularly reducing exposure to alternative points of view [7]. The consequences may be various: from the limitation of personal creativity, “insight and learning” to a reduction in our ability to build productive social capital [4]. Collective, because by fuelling polarization, pluralism may be weakened and make people more vulnerable to censorship and propaganda or, to some extent, to self-propaganda. In fact, the filter bubble thesis is supported particularly in the context of online radicalization [7, 8]. Further, a frequent result is the formation of homogeneous, polarized clusters that are the primary driver of content diffusion, especially misinformation and conspiracy theories [9]. Finally, another prominent risk is growing inequality. Indeed, some privileged group of users, that have enough (digital) literacy, would be able

to reach a good balance between relevance and serendipity, and a larger group of users exposed only to a minimum, qualitatively inferior part of information [10].

The question is not whether filter bubbles and echo chambers exist because there is plenty of evidence of their existence [5, 8, 11, 12, 13]. As O'Hara and Stevens [14] argued, the two key questions are: 1) whether social media's recommender systems are complicit in their growth and, in that case, 2) whether this should be the target of a policy focus and, eventually, of intervention. Actually, it is problematic to answer these questions, since most of research is often inconsistent and rarely conclusive because it is generally survey-based, and thus dependent on self-reporting, or based on a small or unsatisfactory sample. Also, in the light of the rapidly changing media landscape, many studies become rapidly out-dated [15].

Another fundamental issue is whether it is possible to dispel or weaken filter bubbles and echo chambers, and how would that be possible. In fact, some political radical groups have claimed that they use exposure to opposition to strengthen their opinions further [8]. Simply exposing radicalized people to alternative points of view would not undo these phenomena [14]. Quattrocioni and Sunstein [16] recently showed that even debunking is ignored by ~99.98% of conspiracy Facebook users. In fact, for most of what people believe to know, they lack personal or direct information, so that they must rely on what other people think. In some domains, this brings people to suffer from a “crippled epistemology,” in the sense that they know very few things, and what they know is wrong [17]. Thus, extremism stems not from irrationality, but from the fact that they have little (relevant) information. It is a matter of *how* people acquire information. Hopefully, other studies [18, 19, 20] suggest that exposures to opposite views tend to increase political tolerance and awareness of the legitimate arguments underlying opposing perspectives. Indeed, individuals would strengthen their opinions after better understanding the other political side and, in some cases, formulating new opinions on issues that were against their former beliefs.

The possibility to counteract the risks of personalization is, therefore, deeply controversial. Recommender systems and design choices, nonetheless, maintain a large role in preventing it. Hence, to some extent social media are complicit in the growth of filter bubbles. Though there is no empirical evidence that warrants any strong worries at present, in case Artificial Intelligence would enable a sort of “hyper-personalization”, groups polarization would increase and personalised news content would become people’s main information source, problems for democracy could arise. These, actually, represent the current trends.

### **1.1 Techno-regulation of Filter Bubbles by Design?**

Internet constituted a significant challenge to established media policies and the role of public service media. With large media providers no longer serving a gatekeeping function, the diversity of individual exposure turned on the choices of individual users and

algorithms. As a reaction to the new media environment, the notion of “diversity exposure” and potential alternatives like “diversity by design” framework increasingly gained attention as both a media policy objective and a challenge to the legitimacy of public service media [21]. This assumes that pluralism is achieved when users actually enjoy a diverse media diet. Mere exposure to various sources and content, however, is not sufficient for ensuring actual users' experience of media diversity. A thorough analysis of media diversity in the digital age, therefore, should consider not only diversity supply and diversity exposure, but the cognitive and affective factors that drive Internet use, and ultimately actual “diversity experience”. Though most of the studies focused on policy implications at the macro level, the debate on pluralism must employ a user-centric perspective and thereby extend beyond the assumption that supply diversity equals diversity exposure [22].

The normative evaluation of such “diversity experience” is a lot more complex than for the traditional diversity of supply. Diversity experience is far more nuanced and complex than “the more [sources, views etc.] the better”, and it is not sufficient as a policy goal [23]. Thus, fundamental questions for media ethicists and policy-makers arise: how to turn from diversity exposure to diversity experience? How can we conceptualize them as a possible policy goal? What are the values and goals that media diversity serves? And then: how much exposure to how many different contents and sources is considered sufficient? Is it possible to nudge users towards an enriching experience of diversity? These questions have hardly been discussed seriously in Europe's media law and policy, even though filter bubbles are considered problematic for particular different reasons for all the models of democracy [13]. For Helberger [21] this can be partly explained by the uncertainty of policymakers about the permissibility of interference in an area that is as politically and legally sensitive as is individual information consumption. Certainly, users cannot be forced to choose diversely, and governments need to balance the fundamental freedoms of users and media outlets.

Yet, the emergence of such “ambient intelligence” [24], in which automatic smart online and offline environments interact and take an unprecedented number of decisions for us and about us, in order to cater to our inferred preferences, represents a new paradigm in the construction of knowledge. Instead of merely pre-empting a user and providing her with what she is inferred to prefer, there should be a sustained interaction that engages a person as co-creator of a shared environment. Hence, lawyers and legislators should learn to articulate legal protection into the digitally enhanced environment, because human rights lack effective remedies if they are only articulated as written law [25]. What could be, then, a possible role for government design such techno-regulation and eventually nudging people at least indirectly to expose and experience diverse information? Various techno-regulative approach to such issues have been discussed, like Value-sensitive design (VSD) or Pro-ethical design [26, 27]. It is possible, indeed, to nudge users to rely on ‘empowerment nudges, which promote decision-making in the interests of citizens, as judged by themselves, without introducing further

regulation or incentives’ or using any manipulative measures [23, 28]. A similar approach is embraced by Floridi [27], which suggests what he calls “tolerant paternalism” that, in short, aims to modify the level of abstraction of the choice architecture, by educating users to make their own critical choices and to assume explicit responsibilities.

The main rationale of any policy proposal that deals with the risks of hyper-personalization is that development of accurate beliefs requires diversity experience. On the one hand, in fact, partisan selective exposure correlates with higher levels of attitudinal polarization and greater fragmentation in issue priorities while, on the other hand, overcome the “majority illusion effect” [29], as the wrong perception of the popularity of certain belief or behaviors, may lead people to accept the legitimacy of disagreeable outcomes in the political sphere. Nonetheless, it persists a trade-off that raises doubts on the effectiveness of such policy intervention; firstly, that likeminded media use can inspire greater rates of political participation. Yet, one may also argue that participation is not always good while it does not come from well-informed participants. And secondly, in some cases counter-attitudinal information can even amplify attitudinal polarization, though in limited social groups. Complete solutions, therefore, must involve something more than exposure to alternative views.

## 2. Serendipity as a Design Principle

In the past, any procedure of selection of information recognized and seek to solve in a beneficial manner the ideal tension between *relevance* – what a reader wants – and *serendipity* – what a reader may want. In the digital environment, this balance inevitably shifted from serendipity to relevance [2]. Serendipitous information, indeed, represents any information that both users and algorithms still ignore that it is actually relevant. Is it ever possible, then, to find out a balance in this potentially emerging trade-off, and to prospect a normative horizon able to cultivate a digital environment that can be freed from algorithms biases? Many scholars, indeed, argued that in an age of user-driven pluralism, media policy goals and public service media could find new legitimacy in facilitating user experiences of diversity by creating encounters with surprising, challenging and, ultimately, serendipitous content [30, 31, 32, 33, 34]. This is possible, for instance, by designing recommender systems that filter content that *intersect* user interests, or by nudging users with visualization tools and design choices in order to better manage their information diet – what I will refer to as “meta-personalization”. Preliminary proposal to the design of such prospective design principle are presented in this chapter by analyzing the most promising software, research and visualization tools. Before that, it is fundamental to look deeper into the nature and the dynamics of serendipity. By doing this, it will first analyzed the main characteristics of such phenomenon. Then, it will be introduced a brief debate about serendipity in the digital environment and, finally, a preliminary framework to “serendipity by design”, its expected outcomes and unintended consequences will be briefly presented.

## 2.1 Origins and Outcomes of Serendipity

The fascinating concept of serendipity originated from the Persian fairy tale “The Three Princes of Serendip”, which narrates how these traveling princes were “always making discoveries, by accidents and sagacity, of things which they were not in quest of” [35]. Serendipity, indeed, is the art of discovering new things by observing, and learning from unexpected situations. It can be broadly defined as “an unexpected experience prompted by an individual’s valuable interaction with ideas, information, objects, or phenomena” [36]. Another useful definition for the purposes of this research comes from Boden [37] which considers serendipity as “the finding of something valuable without its being specifically sought” (p. 234). This definition, indeed, encapsulates serendipity in the act of finding, while at the same time denoting the necessity of value, distinguishing itself from coincidence, luck and randomness. In fact, the discovery can be perceived as accidental but not necessarily unplanned or the result of fortuity. More often serendipity is the result of a lot of groundwork, observation, and knowledge. As Louis Pasteur once famously said [35]: “in the field of observation, chance favours only the prepared mind.” (p.163). Thus, serendipity is also a capability [38]. It has a dual nature [39], as it is “neither only a process nor only a perception, but rather has a paradoxical nature dependent on conditions and context” (p.608). It is true, indeed, that serendipity has different dimensions, environmental factors and components, not well explainable here.

Serendipity plays a relevant role in our everyday life. Yet, the ability to extract knowledge from an unexpected event covers all areas of human activity, including business, law, politics and, particularly, science. According to the sociologist Robert K. Merton [35] serendipity is the “happy accident” inherent in scientific research, one of the main forces that has steered the progress of science. It has been estimated that over 50% of scientific discovery were unintended and it is full of notorious examples [40].<sup>1</sup> Hence, its role on epistemology of science is well established, even though there is a lack of advancement in this field. Campanario [41] suggests the reason for this in the mythization of scientific research. Science indeed is supposed to be something that is totally under control, so that scientists may be reluctant to admit that the discoveries for which they are honoured were accidental. To some extent this conjecture can be advanced for our own illusion to have full control our lives. Though relatively less momentous, in fact, serendipitous insights follow also in our everyday lives, and they can change our day, or even our life. Indeed, serendipity helps us to innovate and to be creative, leading us to the emergence of a theory, a law or perhaps simply revise an opinion, which had never been planned and therefore not intentionally sought for [42]. In fact, while not every creative moment is necessarily serendipitous, all serendipitous moments are creative ones [43]. In fact, serendipity has been considered as a fundamental experience to maintain creativity in the computer era [44].

In the discussion about Internet developments there have been concerns about the loss of serendipity as well as the acknowledgment of its fundamental value [32]. In *Being Digital* [45] Nicholas Negroponte already anticipated the possibility to crank personalization up or down. He claimed that “depending on time available, time of day, and our mood, we will want lesser or greater degrees of personalization” having “a slider that moves both literally and politically from left to right to modify stories about public affairs” because “we may wish to experience the news with much more serendipity” (p.49). Then, in 1997 Ted Gup [46] argued “*The End of Serendipity*”, warning that the tools of efficiency-quick retrieval were helping us to better find information we need but hindering us accidentally discovering information we need, but did not realize we needed. Eventually, recommender systems improved, as well as the recognition of the need for serendipity and its preconditions.

Sociologist Andrew Abbott [47] provided a theoretical basis for such concerns arguing the necessity to defend randomness from processes for search and discovery. Miriam Meckel [48] even made an appeal to literally “save serendipity”, a fundamental experience for our identities undermined by profiling algorithms that “are forever stuck in the past, as they base their calculations on our actions in times foregone” so that they may “force us into a never-ending time-warp, dwelling forever in the status quo of our own preferences and desires.” Further, the value of serendipity has been stressed also in more specific contexts. MIT Media Lab director Ethan Zuckerman is a well-known exponent of serendipity, in particular concerning the development of a cosmopolitan culture and how its development is limited due to georeferenced algorithms [49, 50]. Also, the legal scholar Cass Sunstein [51], a leading expert in polarization, proposed that Facebook could create a “serendipitous news and opinions button, allowing people to opt in”. Thus, it is already a widespread opinion that serendipity is a fundamental experience in the digital environment, especially given its technical volatility.

Actually, relatively little research has been undertaken to assess how well existing and novel approaches to information interaction support serendipity [36]. Most of the studies on serendipity are indeed conducted perforce retrospectively [52]. However, new promising experimentations are digging the ground [32]. The study of serendipity in information studies and computer science is an emerging research area, in particular for Human Computer Interaction (HCI) [53]. Of course, one may argue that Internet is already very serendipitous. Internet is considered as a “serendipity machine” [54]. Hyperlinked digital environments are indeed a fertile ground for serendipity [35], providing a diversity of resources to which users may not have otherwise been exposed [55]. Also, social media are a powerful source of coming across information serendipitously [56]. Indeed, it is often a tacit design goal to surprise and engage users.

At first sight, therefore, a loss of serendipity in the digital environment could seem only a mere philosophical speculation. However, serendipity in the digital environment is very different from the “offline serendipity”, as it can be effectively both cultivated and limited not only by recommender systems’ algorithms, but also by increasing or



decreasing users' affordances through software, visualization tools and design choices (as it will be explored in the next chapter). It is, therefore, a matter of degree, and how information societies will be able to reach such desirable informational balance.

Also, the value of serendipity must be considered on the light of current political landscape and potential technological developments. On the one hand, as populisms are currently growing across both Europe and the United States in a period of perpetual crisis, there are concerns that more and more people who were never confident enough to voice their beliefs openly, thanks to social media they connect to like-minded others and become more confident and vigorous. On the other hand, future advances in artificial intelligence, machine learning, and the semantic web have the potential to enable algorithms to make ever more sophisticated recommendations, while virtual reality, augmented reality and the Internet of things will definitely blur the distinction between online and offline. As Pedro Domingos [59] argued, tomorrow's cyberspace will be a vast parallel world that selects only the most promising things to try out in the real one and it will be like "a new, global subconscious, the collective id of the human race" (p.270). Yet, a design principle for serendipity might become valuable in other emerging contexts as well. As in the near future more and more increasingly accurate decisions will be delegated to algorithms, serendipity by design might be a way to opt-out, even from the most efficient automated decision, and to autonomously seek the unexpected.

To conclude, media and information ethicists and policy makers need to ask not only whether and how Internet users need to be sustained to seek new, diverse, challenging and, ultimately, serendipitous information, but, more importantly, also how to translate abstract theoretical concepts in a concrete methodological framework. In other words, how to avoid that such potential principle would remain only an utopian one?

## **2.2 "Serendipity By Design"**

Programming for serendipity sounds like an oxymoron. In fact, how can a subjective process that is only discernible in hindsight and for which the unexpected plays such an important role in its perception be supported? Indeed, serendipity cannot be created on demand. Nonetheless, it can be cultivated by creating opportunities for it through the design of physical, digital, and learning environments [32]. Broadly speaking, from a user-perspective there are two information behaviour for seeking serendipity: non-purposive or passive (browsing and recommender systems) and purposive or active (affordances like visualization tools and design' choices) [33]. Similarly to other proposals to expose users to different media, like "diversity by design" [21], serendipity by design is the idea that it is possible to create an architecture that helps people to make diverse choices and gives the incentives for seeking alternative information and, ultimately, having more serendipitous insights, which represent the best conceivable outcome from a user perspective.

In the following chapter, it will be briefly presented how serendipity might indeed be designed and cultivated. First, it will be assessed the algorithmic metrics underpinning digital serendipity in recommender systems (even though it is not the specific expertise of the author). Secondly, it is explored how users might personalize their personalized experience. Finally, limitations and unintended consequences will be briefly discussed.

### 2.2.1 Serendipitous Recommender Systems

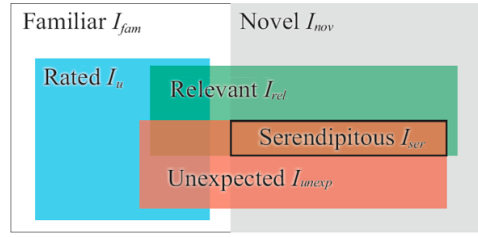
The primary goal of recommender systems (RSs) is to provide personalized recommendations so as to improve users' satisfaction. Many studies are increasingly showing that RSs are moving beyond accuracy and embracing serendipity. Indeed, user satisfaction does not always correlate with high recommender *accuracy/precision* [60]. In fact, when we successfully implement serendipitous encounters in RS, it is possible to avoid predictable recommendations in collaborative filtering systems, solve the over-specification problems in content-based systems and also help users reveal their unexpected interests [61]. Nevertheless, most social media's RSs aim to instant gratification more than long-term satisfaction. Yet, most of the current recommender systems have been criticized to not sufficiently account for serendipity [31]. Studies have also showed that users are willing to sacrifice some amount of accuracy for improved serendipity in the algorithms filter performance [60]. Moreover, it seems that RSs metrics such as novelty, diversity and serendipity can be improved simultaneously, without any apparent trade-off between the three qualities [62]. A question, therefore, arises: does accuracy as a RS metric naturally leads to more profits for social media rather than RS designed mostly for serendipity? In other words, it seems that very accurate personalization increase users' engagement in the short-run more than serendipity might do. Arguably, this is a trade-off that can emerge in knowledge management.

**Table 1. A Theoretical Trade-off in Recommender Systems.**

PLATFORM	MAIN VALUES	EXPLICIT GOAL	LATENT GOAL	TENDENCY
Business Social Media	Relevance and Accuracy	Engagement (Short-term Gratification)	Profit	Determinism
“Alternative Social Media”	Diversity and Serendipity	Unexpected discoveries (Long-term Satisfaction)	Individual and Social fulfillment	Chance and Randomness

There is not even consensus on the definition of serendipity in RSs [33]. However, the two core characteristics of serendipity embedded in RSs are usually *unexpectedness/surprisingness* and *usefulness/relevancy* [61, 63]. Serendipity builds also upon the concept of *novelty*, but expands this by the factor of a positive discovery, because unexpected and useful [64]. Further, other metrics are underpinned by serendipity such as

*diversity* and *unfamiliarity*. This is certainly relevant in the context of media policy's attempts to cultivate information diversity exposure and experience. Serendipity can actually encompass diverse metrics: a user is surprised by a novel, unexpected (thus, diverse) and relevant information, see Fig.1. This finding can also be a moment of unfamiliarity, in which the user is pulled away from automated actions and is required to acknowledge and reflect on the interaction itself [43].



**Fig. 1.** Recommended items from a user's point of view (Kotkov et al, 2016).

Of course, optimizing current RS for more serendipitous recommendations is not a trivial task. Firstly, increase serendipity might negatively impact accuracy. Therefore, it has to be strategically done in order to alleviate the risk of having a distrust effect [31]. Hence, a good balance between novelty, serendipity and accuracy of recommendations seems to be necessary. There have already been, nonetheless, promising attempts of stimulating serendipitous insights in RSs, like the “serendipity equation” by Campos and Figueiredo [65, 66, 67]. Notably, Max, their information retrieval software, reached the level of 52.7% of (pseudo)serendipitous suggestions. Despite the subjective character of the results, it seems that programming *for* serendipity is indeed possible. Among hundreds of variables, then, it is possible to design serendipity-driven algorithms. Interestingly, in their evaluation of Max, Campos and Figueiredo offered a granular approach to the question of assessing serendipitous findings and encountering: by dividing user results into six distinct categories, according to their possible outcomes. By opening space for similar granularity in other approaches to digital interactions, it is possible to expand and encompass a wide range of results that can be considered serendipitously valuable. In fact, under the more general principled commitment to serendipity there are several other concepts related to information seeking; for instance, pseudo-serendipity, opportunistic acquisition of information [68]; micro-serendipity [69]; accidental discovery of information [70] etc. Design for serendipity would indeed mean to aim to cultivate all of these indirectly, and openly serendipity *par excellence*.

Other search environments have been designed with the purpose of creating opportunities for accidental information discovery [13, 32]. Paradigmatically, some of these are usually effective in supporting serendipity but the recommendations are not always considered particularly interesting or relevant. This unveils again a trade-off related to the previous one: the more you want to discover accidental information, the more you

need to invest your time (because filtering is less accurate). Of course, looking for serendipity is time-consuming. This highlights the importance to consider the context in which users may be searching; accidental information discovery may be more useful when trying to get news of developments in a specific area rather than when trying to get a background understanding. Otherwise, in the perspective of Negroponte [45], sometimes one may want to access the personalized “*daily me*”, perhaps during the week when one does not have much time, and other times the more generalized “*daily us*”, perhaps in the weekend, when one has time to look for more serendipitous information. In essence, the “sweet spot” is likely to differ based on the user’s information needs and tasks.

Actually, users have not much influence on the recommendation process itself, apart from providing implicit or explicit ratings for items, usually in the long-term use of the system [71]. Several problems indeed arise from the limited degree of interactivity and user control over the recommendation process. For instance, a lack of transparency prevents users from comprehending why certain items are suggested and, as a potential cause, a reduced trust in the system. In fact, users often desire a more active role in the recommendation process, and that interactive control might increase the system’s transparency and acceptance. Thus, design for serendipity implies the need for more interactive and transparent recommenders. This has also the potential for increasing the overall quality and acceptance of recommendations.

To conclude, from a policy perspective it seems that optimizing RSs for serendipity does not appear as a viable approach. As one can imagine, its implementation and assessment are indeed extremely problematic, not to say that consensus on the metrics have not been found. Instead, from an ethical perspective, such approach would be considered a form of stealthy paternalism. Furthermore, the aim of serendipity by design would be to find a right balance between personalization (more accurate recommendations) and personalized ‘generalization’ (more serendipitous recommendations). It is their dynamic relation which can actually better sustain a serendipitous environment. Therefore, serendipitous RSs can only represent a principled commitment. What is more viable, then, is a structural and informational nudging that stimulate users’ activity.

### 2.2.2 Serendipitous Meta-personalization

Aside from RSs, it is possible to design several potential features that could nudge users to seek and encounter diverse, challenging and, eventually, serendipitous information. Open the possibility for users to personalize their personalized filtering experience is what one may call “meta-personalization”, namely dynamically personalize personalization outcomes depending on needs, tasks and mood. Considering the lack of users’ autonomy and awareness about their information consumption, there are indeed several ways to empower users, extract value from their profiles meaningfully, to illustrate

connections, and to stimulate creative and serendipitous associations, without being particularly intrusive nor radically against social media's policies.

Speculating, there are fundamental affordances [72] that might satisfy the preconditions for triggering more serendipitous encountering; firstly, visualization tools about users' information bubbles consumption. Secondly, multiple profiles, namely to overcome the dogma of a unique filtering per person and, thirdly, an informational nudging about users' information consumption. Finally, an efficient accessibility of all the information filtered by algorithms.

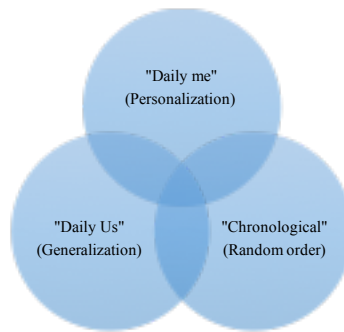
First of all, to stumble upon more serendipitous information it is better to know what one is actually missing. To mention few softwares, the visualization design developed by Nagulendra and Vassileva [73, 74] displays to users their filter bubbles, showing them which categories and friends are in their bubble and which ones are not, allowing them to control the algorithm by manipulating the visualization to escape the bubble, by adding or removing friends on a certain topic to the filters. The results are truly promising: 72 % of participants said that it was easy to find an interest which was not inside their filter bubble, so that they were able to “discover new interests that they didn't display otherwise in their behavior” [74].

Visualization tools can also increase users' awareness about their information diet. For example, *Balancer* shows an approximate histogram of the user's liberal and conservative pages, with the aim to increase user-awareness so that they would make their reading behaviour more balanced. A similar aim is taken by *Scoopinion* which visualizes what journals you are used to read and for how long. Such tools also aim to increase the transparency of information intermediaries and shed the light on the user information consumption. They can nudge users to shift to more balanced reading behavior, though it can also lead some users to more polarized or unbalanced views [75]. Of course, given that users' proclivities vary among individuals and topics, effects of certain interface designs on users' behavior may also vary. Nevertheless, a multi-layered serendipitous environment focused on values such as autonomy, transparency and identity seem to favour more diversity experience in the majority of users. Similar plug-ins in social media can become legally implemented by default, and they might actually represent a viable way for further experimentations before any intervention.

Furthermore, a fundamental affordance to cultivate a serendipitous environment might occur by overcoming the dogma of one profiling per user. In fact, in mainstream media there is no possibility to have more identities (namely more filtering). As Facebook Chief Mark Zuckerberg himself believes: “having two identities for yourself is an example of a lack of integrity” [76]. Thus, there is room for claiming an alternative approach to enjoy multiple filtering. Fundamentally, it must be acknowledged the dynamicity of users' identities, because one may want (and need) to seek different information at a different time. In fact, many factors, such as weather, mood or location, can influence user preferences for recommended items [77]. Changing the current approach

can increase users' resiliency in seeking more serendipitous information by subtracting from the determined path offered by Facebook's personalization [5].

Ideally, any user might be able to access to information filtered in a varied spectrum from the most relevant to the most potentially serendipitous information, namely from relevant personalized (daily me), through generalized (daily us), to random-serendipitous (by chronological order, which is already available in Facebook but it resets itself after a couple of hours). As shown in Fig.1, these would actually satisfy the three broad information environments that sustain the information-seeking processes that lead to serendipity [78]. First, design-centred information environment, based on interests and users' preferences (daily me), then a user-centred information environments which are intended to address a broad community of users' needs rather than the designers' needs (daily us), and finally an environment in which order is absent (by chronological order).



**Fig. 2.** Information environments that sustain the information-seeking processes that lead to serendipity.

Yet, many other design choices can be explored to increase the exposure to diverse information. For instance, *multiple personalized filters* could be deployed in different settings, so that any user could even re-start its profilation from scratch. Even more importantly, graphs could show you whether your information filtering diet is “sustainable” providing *suggestions* for a good balance between daily me and daily us, based on shared parameters (I.e EU-based?). In other words, whether a certain percentage of potentially public information has been consumed can make you aware of the need for diverse information. Finally, it would be as much important to provide the possibility *to filter the kind of the content*, such as articles, friends' life, video, opposing political views (as it does the plug-in *Escape Your Bubble*) and, of course, explicit serendipitous content, namely content which intersects users' profiled interests.

To conclude, if one analyzes the phenomenon of hyper-personalization through the lens of serendipity, it is possible to rebalance many of the well-established rights of information intermediaries, so that any user would eventually benefit from having the autonomy to meta-personalize their information seeking process by potentially access all the information of its own social networks and to enjoy an information diet analysis through visualization tools. Taken all together, the above design choices and visualization tools might represent a structural and informational nudging approach, which is

non-intrusive and it would satisfy the preconditions for the implementation of such design principle. Certainly, it is easy to consider such requests as mere speculations with no concrete potential for being applied, because based on assumptions without specific boundaries that could actually permit any sort of requests. However, as long as the research would point to the benefits of serendipity and its cultivation by design, and such process were to be internalized by Internet users, enriching the “algorithmic imaginary” [79], there would be potential to find compromises for eventual affordances implementation.

### 2.2.3 Limitations and Unintended Consequences

There are several limitations and potential unintended consequences for the proposal above presented that have been considered so far. These can be roughly summed up as a) ineffectiveness; most people indeed won't use such affordances and some other would even personalize further their social media experience. And b) unfeasibility; social media would never come to such a compromise, and any assessment of serendipity will never be objective and scientific. Let me try to briefly explain.

Firstly (a), is it really sufficient to provide the autonomy for a “serendipitous personalized diversity exposure” to fulfil the pluralistic media goal to expose citizen to information diversity? Of course, it is not. Studies on de-polarizing techniques are more often contrasting. Usually some people polarize further, while others enjoy more information diversity. Even worse, it seems that people that ideally would benefit more to be exposed to challenging perspectives are those less willing to do that. Hence, for some people it is possible that design serendipity becomes only a mean to further personalize their Internet experience. This, however, do not represent a valid argument against such potential principled framework. It is obvious that the answer lies on education in the first instance. In this respect, it is worth to acknowledge that there is also room to study and teach serendipity in educational settings [44]. Plus, as educators might not be available during networked learning, a mixed supply of information provided through the mediation of people could advance self-directed networked learning [80]. Actually, the challenges that users usually must overcome to experience media diversity in an online environment and, eventually, to experience serendipity, are rather well known [22]. All these must be taken into consideration while designing effectively for serendipity.

Then (b), another prominent issue is how to frame a measure for the assessment of perceived serendipity afterwards. It is perhaps one the most problematic issue. Foremost, it is needed a clear theoretical and methodological framework of 'serendipity by design'. In particular, what are the boundaries of the human rights underpinned by serendipity, and then how this could be assessed. There are, nonetheless, already experimented techniques. Apart from indirect assessment throughout surveys and other novel methodologies [69], it is possible to observe serendipity in controlled research environments, by directly observing information encountering behaviour rather than relying only on self-reported data [32], for instance with the “critical incident techniques” on

representative samples [93], or, more specifically, Information Seeking in Facebook Scale (ISFS) [82]. However, in order to quantify serendipity at a large scale, it is needed a principled method to automatically identify serendipitous events and this has still to be defined [83]. Alternative measures to the might also be represented by other measures and ratio such as the percentage of people changing idea about political issues in social media, or even a percentage of specific recommended content. Certainly, many challenges persist, even more considering how it is hard to ever prospect a one-size-fits-all design.

To conclude, from a media ethics perspective this preliminary framework might convey the principle of media pluralism, updated to the emerging practices of media exposure. Serendipity as a media goal would convey different perspectives in a more general and, essentially, positive goal. Arguably, even more serendipitous and personalized information diversity exposure, in a more dynamic and interactive environment, could be considered sufficient outcomes in the age of personalization. Such approach would not represent a complete solution but, nonetheless, it has the potential to prevent information redundancy, and further polarization. Of course, any concrete form of policy intervention with the goal of promoting serendipity by design will require a more systematic and detailed conceptualization of diversity and serendipity, because very little experience exists so far.

## Conclusions

The paper analyzed serendipity as an alternative design principle for social media. With “serendipity by design” was intended an alternative approach to systems engineering which takes serendipity into account throughout the design process and the users’ interaction within the system. The ultimate goal is to cultivate an even more serendipitous environment in order to trigger more serendipitous information encounters, as the best conceivable outcome from a user perspective. Serendipity, in fact, is a fundamental feature of social reality, a complex process which occurs in all realms of human life, especially in scientific progress. Thus, it represents an inherently positive experience that embraces fundamental values and experiences like curiosity, research, discovery, and identity development. It can, however, be limited and facilitated by design choices and recommender systems.

Seen in its paradoxical nature of being both a capability and an accidental perception, thus dependent on conditions and context, it is suitable to encompass all the phases of production and consumption of information: from algorithmic filtering to information behaviour affordances and capabilities. Considering serendipity as a design principle helped to stress how it can tackle the risks of hyper-personalization and redesign the media policy protection of pluralism by strengthening individual self-determination. To occur, in fact, serendipity requires novel and diverse information as preconditions. Eventually, it also causes cognitive diversity. Such aims might be facilitated by designing recommender system that are serendipity-driven that, broadly speaking, intersect



users' interests and, also, by providing further innovative and interactive affordances to users. The presented framework was broadly meant to imply more autonomy and awareness to increase users' capability to seek, encounter and process serendipitous information – what has been called meta-personalization. In particular, it has been stressed the potential consequences to unfold multiple filtering and to provide an effective information diet management. Of course, these represented arbitrary affordances among many possible, though essential ones to cultivate a more dynamic and serendipitous environment. These could indeed shuffle the cards of information management power, bringing it back to the users. Yet, it is questionable to what extent would users be willing to actually experiment them. Plus, digital literacy and critical thinking remain fundamental *condition sine qua non* for a beneficial expression of serendipity.

Finally, serendipity by design can represent a technical attempt to recapture a sense of freedom and mystery that is available in less networked information environments. It might indeed become fundamental in the infosphere to maintain the pleasing feelings that elevate accidental discoveries to sensations of serendipity. By treating users as active seekers, indeed, they will perceive their findings as triumphs of personal agency, intuition, and inspiration, and as a self-reinforcing expectation, increase their freedom from algorithms. Conceived as a principle, indeed, serendipity can foster a vivid imaginary that stimulates Internet users' expectations and, as a consequence, their information behavior. Similarly, it could also represent an educational goal for individuals to flourish in mature information societies. It can, in fact, increase belief change, creativity and innovation. Yet, a scientific information behaviour was subtly advocated.

Far from having systematically framed its boundaries, a preliminary framework for what has been termed “serendipity by design” has been presented. Such approach has the potential to help designing systems and nudging individuals to be more resilient to the redundancy coming from increasingly sophisticated content personalization. Of course, given the extraordinary complexity of social media, its rapid evolution, and potential unintended consequences, a skeptical approach about the above-mentioned outcomes must be maintained. Nonetheless, there is room for experimenting the potential of designing serendipity. This introductory framework can indeed be further developed as an effective semanticization able to address new ICT-related challenges.

## References

1. Floridi, L. (2014) *The fourth revolution: How the infosphere is reshaping human reality*. OUP Oxford.
2. Thurman, N. (2011). Making ‘The Daily Me’: Technology, economics and habit in the mainstream assimilation of personalized news. *Journalism*, 12(4), 395-415
3. Sunstein, C. R. (2009) *Republic. com 2.0*. Princeton University Press.
4. Pariser, E. (2011) *The filter bubble: How the new personalized web is changing what we read and how we think*. Penguin.
5. Bozdag, E., and Timmermans E. (2011) "Values in the filter bubble Ethics of Personalization Algorithms in Cloud Computing." 1st International Workshop on Values in Design–Building Bridges between RE, HCI and Ethics.

6. Lazarsfeld, P. F., Berelson, B., & Gandel, H. (1944) *The People's Choice*, New York, Duell, Sloan, and Pearce.
7. Sunstein, C. R. (2009) *Going to extremes: How like minds unite and divide*. Oxford University Press.
8. Wojcieszak, M. (2010) 'Don't talk to me': effects of ideologically homogeneous online groups and politically dissimilar offline ties on extremism. *New Media & Society*.
9. Del Vicario, M., Bessi, A., Zollo, F., Petroni, F., Scala, A., Caldarelli, G., Quattrociocchi, W. (2016) The spreading of misinformation online. *Proceedings of the National Academy of Sciences*, 113(3), 554-559.
10. Gazoia, A. (2016) Senza filtro. Chi controlla l'informazione. *Minimum Fax*.
11. Wojcieszak, M. E., and Mutz, D. C. (2009) Online groups and political discourse: Do online discussion spaces facilitate exposure to political disagreement?. *Journal of communication*, 59(1), 40-56.
12. Bakshy, E., Messing, S., and Adamic, L. A. (2015) Exposure to ideologically diverse news and opinion on Facebook. *Science*, 348(6239), 1130-1132.
13. Bozdog, E., and van den Hoven, J. (2015) Breaking the filter bubble: democracy and design. *Ethics and Information Technology*, 17(4), 249-265.
14. O'Hara, K., and Stevens, D. (2015) Echo chambers and online radicalism: Assessing the Internet's complicity in violent extremism. *Policy & Internet*, 7(4), 401-422.
15. Zuiderveen Borgesius, F. J., Trilling, D., Moeller, J., Bodó, B., De Vreese, C. H., & Helberger, N. (2016) Should We Worry About Filter Bubbles?. *Internet Policy Review. Journal on Internet Regulation*, 5(1).
16. Quattrociocchi, W., Scala, A., & Sunstein, C. R. (2016) Echo chambers on Facebook. *Harvard Law Review*.
17. Sunstein, C. R., & Vermeule, A. (2009) Conspiracy theories: Causes and cures. *Journal of Political Philosophy*, 17(2), 202-227.
18. Xing, X., Meng, W., Doozan, D., Feamster, N., Lee, W., and Snoeren, A. C. (2014) Exposing inconsistent web search results with bobble. In *International Conference on Passive and Active Network Measurement* (pp. 131-140). Springer International Publishing.
19. Semaan, B. C., Robertson, S. P., Douglas, S., and Maruyama, M. (2014) Social media supporting political deliberation across multiple public spheres: towards depolarization. In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing* (pp. 1409-1421). ACM.
20. Liao, Q. V., & Fu, W. T. (2014) Can you hear me now?: mitigating the echo chamber effect by source position indicators. In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing* (pp. 184-196). ACM.
21. Helberger, N. (2011) Design by diversity. *Journal of Information Policy*, 1, 441-469.
22. Hoffmann, C. P., Lutz, C., Meckel, M., & Ranzini, G. (2015) Diversity by choice: Applying a social cognitive perspective to the role of public service media in the digital age. *International Journal of Communication*, 9(1), 1360-1381.
23. Helberger, N., Karppinen, K., & D'Acunto, L. (2016) Exposure diversity as a design principle for recommender systems. *Information, Communication & Society*, 1-17.
24. Hildebrandt, M., & Koops, B. J. (2010) The challenges of ambient law and legal protection in the profiling era. *The Modern Law Review*, 73(3), 428-460.
25. Hildebrandt, M. (2011) Legal protection by design: Objections and refutations. *Legisprudence*, 5(2), 223-248.
26. Friedman, B. (1996) Value-sensitive design. *interactions*, 3(6), 16-23.
27. Floridi, L. (2016) Tolerant paternalism: Pro-ethical design as a resolution of the dilemma of toleration. *Science and engineering ethics*, 22(6), 1669-1688.
28. Helberger, N., Klein-von Königslöw, K., & van der Noll, R. (2014) Convergence, information intermediaries and media pluralism—Mapping the legal, social, and economic issues at hand. A quick scan. Institute for Information Law, Research Report.

29. Lerman, K., Yan, X., & Wu, X. Z. (2016) The "majority illusion" in social networks. *PloS one*, 11(2)
30. Semaan, B. C., Robertson, S. P., Douglas, S., and Maruyama, M. (2014) Social media supporting political deliberation across multiple public spheres: towards depolarization. In *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing* (pp. 1409-1421). ACM.
31. Matt, C., Benlian, A., Hess, T., & Weiß, C. (2014) Escaping from the Filter Bubble? The Effects of Novelty and Serendipity on Users' Evaluations of Online Recommendations.
32. Race, T. and Makri, S. (2016) *Accidental Information Discovery: Cultivating serendipity in the Digital Age*. Chandos Publishing.
33. Kotkov, D., Wang, S., & Veijalainen, J. (2016) A survey of serendipity in recommender systems. *Knowledge-Based Systems*, 111, 180-192.
34. Corneli, J., Pease, A., Colton, S., Jordanous, A., & Guckelsberger, C. (2014) Modelling serendipity in a computational context
35. Merton, R. K., and Barber, E. (2006) *The travels and adventures of serendipity: A study in sociological semantics and the sociology of science*. Princeton University Press.
36. McCay-Peet, L., Toms, E. G., and Kelloway, E. K. (2014) Development and assessment of the content validity of a scale to measure how well a digital environment facilitates serendipity. *Information Research*, 19(3), 19-3.
37. Boden, M. A. (2004) *The Creative Mind: Myths and Mechanisms*. Psychology Press.
38. de Rond, M. (2014) The structure of serendipity. *Culture and Organization*, 20(5), 342-358.
39. McBirnie, A. (2008) Seeking serendipity: the paradox of control. In S. A. Roberts (Ed.), *Aslib Proceedings* (Vol. 60, No. 6, pp. 600-618). Emerald Group Publishing Limited.
40. Dunbar, K., and Fugelsang, J. (2005) Scientific thinking and reasoning. *The Cambridge handbook of thinking and reasoning*, 705-725.
41. Campanario, J. M. (1996) Using Citation Classics to study the incidence of serendipity in scientific discovery. *Scieontometrics*, 37 (1) 3-24.
42. Guha, M. (2009) Serendipity versus the superorganism.
43. Melo, R., & Carvalhais, M. (2016) Regarding Value in Digital Serendipitous Interactions. *Journal of Science and Technology of the Arts*, 8(2), 37-44.
44. Sawaizumi, S., Katai, O., Kawakami, H., & Shiose, T. (2007) Using the concept of serendipity in education.
45. Negroponte, N. (1996) *Being digital*. Vintage. New York
46. Gup, T. (1997) Technology and the end of serendipity. *The Chronicle of Higher Education*, 44(21), A52.
47. Abbott, A. (2008) The traditional future: A computational theory of library research. *College & Research Libraries*, 69(6), 524-545.
48. Meckel M. (2011) "SOS – SAVE OUR SERENDIPITY", Personal Blog (October, 11). [http://www.miriammeckel.de/2011/10/11/sos-save-our-serendipity/?goback=%2Egde\\_1975471\\_member\\_112072885](http://www.miriammeckel.de/2011/10/11/sos-save-our-serendipity/?goback=%2Egde_1975471_member_112072885)
49. Zuckerman, E. (2008) Homophily, serendipity, xenophilia. *My Heart's in Accra*, 25.
50. Zuckerman, E. (2013) *Rewire: Digital cosmopolitans in the age of connection*.
51. Sunstein, C. (2016) "Facebook's New News Feed Isn't Progress" *Bloomberg* (July 5). <https://www.bloomberg.com/view/articles/2016-07-05/facebook-is-bad-for-democracy>
52. Gabriel, Y., Muhr, S. L., & Linstead, S. (2014) Luck of the draw? Serendipity, accident, chance and misfortune in organization and design.
53. Makri, S. & Blandford, A. (2012) Coming Across Information Serendipitously - Part 1, p. A Process Model, *Journal of Documentation*, 68(5), 684-705.
54. Green, D. (2004) *The serendipity machine. A voyage of discovery through the unexpected world of computers*. CreateSpace.
55. Thurman, N., and Schifferes, S. (2012) The future of personalization at news websites: lessons from a longitudinal study. *Journalism Studies*, 13(5-6), 775-790.

56. Dantonio, L., Makri, S., & Blandford, A. (2012) Coming across academic social media content serendipitously. *Proceedings of the American Society for Information Science and Technology*, 49(1), 1-10.
57. Floridi, L. (2015) *The onlife manifesto*. Springer-Verlag GmbH.
58. Floridi, L. (2016) *Mature Information Societies - a Matter of Expectations*. *Philosophy & Technology*, 29(1), 1-4.
59. Domingos, P. (2015) *The Master Algorithm: How the Quest for the Ultimate Learning Machine Will Remake Our World*. Basic Books, New York.
60. Ziegler, C. N., McNee, S. M., Konstan, J. A., and Lausen, G. (2005) Improving recommendation lists through topic diversification. In *Proceedings of the 14th international conference on World Wide Web* (pp. 22-32). ACM.3403366441
61. Ge, M., Delgado-Battenfeld, C., & Jannach, D. (2010) Beyond accuracy: evaluating recommender systems by coverage and serendipity. In *Proceedings of the fourth ACM conference on Recommender systems* (pp. 257-260). ACM.
62. Zhang, Y. C., Séaghdha, D. Ó., Quercia, D., & Jambor, T. (2012) Auralist: introducing serendipity into music recommendation. In *Proceedings of the fifth ACM international conference on Web search and data mining* (pp. 13-22). ACM. ISO 690
63. André, P., Teevan, J., and Dumais, S. T. (2009) Discovery is never by chance: designing for (un) serendipity. In *Proceedings of the seventh ACM conference on Creativity and cognition* (pp. 305-314). ACM.
64. Herlocker, J. L., Konstan, J. A., Terveen, L. G., & Riedl, J. T. (2004) Evaluating collaborative filtering recommender systems. *ACM Transactions on Information Systems (TOIS)*, 22(1), 5-53
65. Campos, J., & Figueiredo, A. D. (2001) *The serendipity equations*. Navy Center for Applied Research in Artificial Intelligence, Naval Research Laboratory, Washington, DC, Technical Note AIC-01-003.
66. Campos, J., & Figueiredo, A. D. (2002) Programming for serendipity. In *Proc. of the AAAI Fall Symposium on Chance Discovery – The Discovery and Management of Chance Events*.
67. Campos, J. M. M., & De Figueiredo, A. C. D. (2008) U.S. Patent No. 7,319,998. Washington, DC: U.S. Patent and Trademark Office.
68. Erdelez, S. (1999) Information encountering: It's more than just bumping into information. *Bulletin of the Association for Information Science and Technology*, 25(3), 26-29.
69. Bogers, T., & Björneborn, L. (2013) Micro-serendipity: Meaningful coincidences in everyday life shared on Twitter. *iConference 2013*, 196-208.
70. Williamson, K. (1998) Discovered by chance: The role of incidental information acquisition in an ecological model of information use. *Library & Information Science Research*, 20(1), 23-40.
71. Loepp, B., Hussein, T., & Ziegler, J. (2014) Choice-Based Preference Elicitation for Collaborative Filtering Recommender Systems.
72. Gibson, J. J. (2014) *The ecological approach to visual perception: classic edition*. Psychology Press.
73. Nagulendra, S., and Vassileva, J. (2014) Understanding and controlling the filter bubble through interactive visualization: a user study. In *Proceedings of the 25th ACM conference on Hypertext and social media* (pp. 107-115). ACM.
74. Nagulendra, S., & Vassileva, J. (2016) Providing awareness, explanation and control of personalized filtering in a social networking site. *Information Systems Frontiers*, 18(1), 145-158.
75. Munson, S. A., Lee, S. Y., and Resnick, P. (2013) Encouraging Reading of Diverse Political Viewpoints with a Browser Widget. In *ICWSM*.
76. Kirkpatrick, M. (2010) Facebook's Zuckerberg says the age of privacy is over. p.198
77. Verbert, K., Manouselis, N., Ochoa, X., Wolpers, M., Drachsler, H., Bosnic, I., & Duval, E. (2012) Context-aware recommender systems for learning: a survey and future challenges. *IEEE Transactions on Learning Technologies*, 5(4), 318-335.
78. Carr, P. L. (2015) Serendipity in the stacks: libraries, information architecture, and the problems of accidental discovery. *College & Research Libraries*, crl14-655.

79. Bucher, T. (2017) The algorithmic imaginary: exploring the ordinary affects of Facebook algorithms. *Information, Communication & Society*, 20(1), 30-44.
80. Makri, S., Bhuiya, J., Carthy, J., & Owusu-Bonsu, J. (2015) Observing serendipity in digital information environments. *Proceedings of the Association for Information Science and Technology*, 52(1), 1-10.
81. Dantonio, L., Makri, S., & Blandford, A. (2012) Coming across academic social media content serendipitously. *Proceedings of the American Society for Information Science and Technology*, 49(1), 1-10.
82. Asghar, H. M. (2015) Measuring Information Seeking through Facebook: Scale development and initial evidence of Information Seeking in Facebook Scale (ISFS). *Computers in Human Behavior*, 52, 259-270.
83. Sun, T., Zhang, M., & Mei, Q. (2013) Unexpected Relevance: An Empirical Study of Serendipity in Retweets. In ICWSM.

1 - To provide a concrete example, the accidental discovery of mirror neurons by Federico Rizzolatti. Indeed, he and his team had implanted electrodes in the brains of several monkeys to study their brain activity during different motor actions. One day, as a researcher reached for his own food, he casually noticed neurons begin to fire in the monkeys' premotor cortex, the same area that showed activity when the animals made a similar hand movement. This serendipitous discovery has radically altered the way we think about our brains and ourselves, particularly our social selves.