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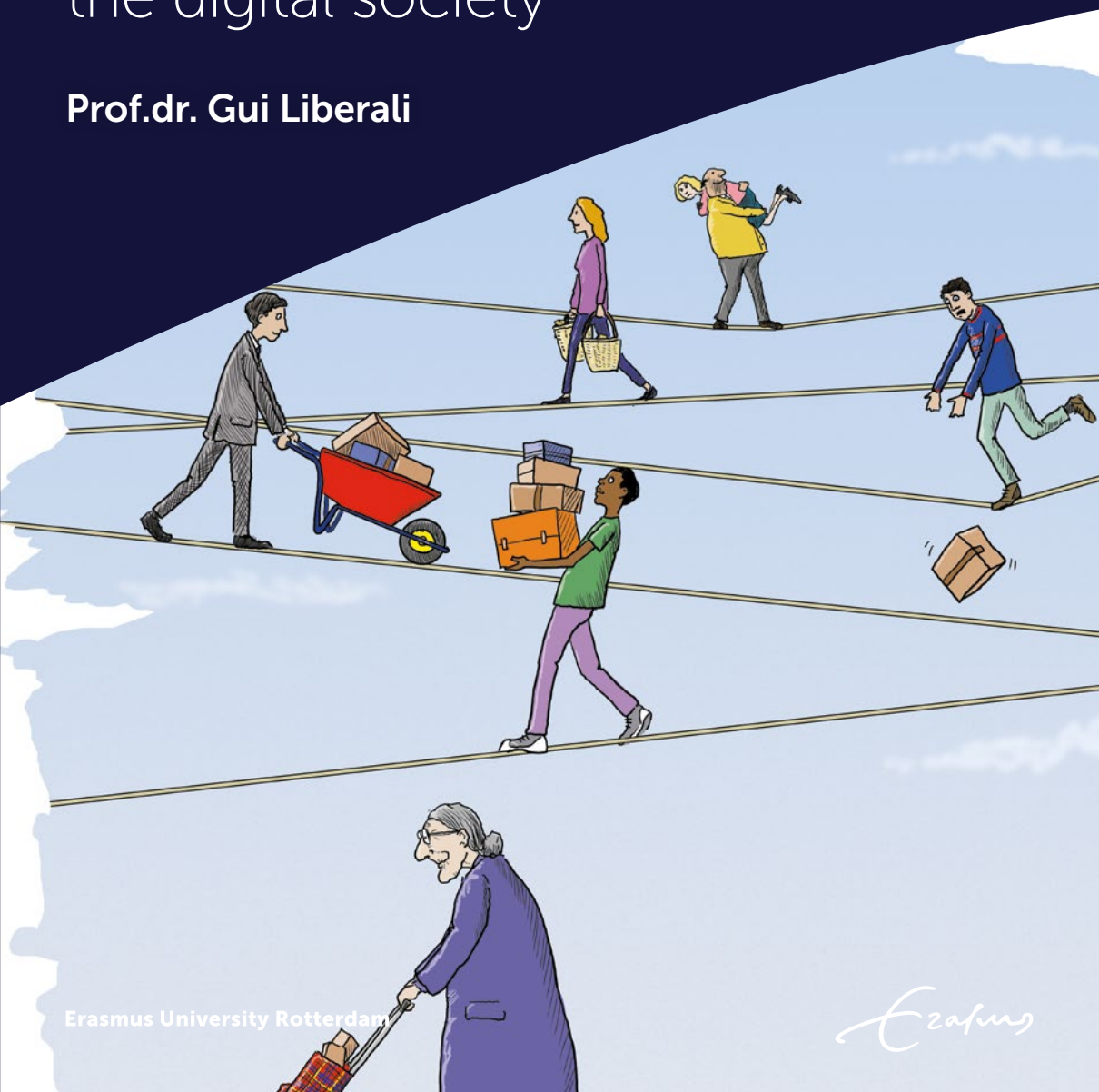
Learning with a purpose:

The balancing acts of machine learning and individuals in the digital society

Prof.dr. Gui Liberali



Erasmus University Rotterdam

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Learning with a purpose:

The balancing acts of machine learning and individuals in the digital society

Prof.dr. Gui Liberali

Address delivered in adjusted form at the occasion of accepting the appointment of Endowed Professor of Digital Marketing at the Erasmus School of Economics, Erasmus University Rotterdam, on behalf of Vereniging Trustfonds EUR, on Friday, May 25, 2018

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Inaugural Lecture on Friday, May 25, 2018. Gui Liberali

Learning with a purpose:
The balancing acts of machine learning and individuals in the digital society

Abstract

The Internet has transformed some of the most basic processes in our society, such as trade, payment, and communication. We now have more access to products, services, and opinions than we ever had, but at the same time our behavior is tracked more closely than ever. For example, large online retailers offer hundreds of thousands of products and can readily observe how each consumer interacts with any of them in great detail. They can also rapidly deploy individual-level, in-vivo, randomized online experiments at population scale to test concepts, insights, and communication approaches which can lead to better services and products. However, there are often billions of possibilities, such as product-consumer combinations for product recommendations. The scale and complexity of these experiments create amazing challenges.

Thus, firms face balancing acts. For example, they need to constantly choose between profiting from what they already know about consumers (such as the genres of movies already watched) and learning more about the same consumers (such as by recommending a movie of an untested genre). Consumers also face their own balancing acts. In the digital society, we inevitably leave digital footprints, but we have some discretion in terms of how much information we want to keep private. Typically, consumers who are more open to sharing their preferences are also exposed to higher risks, but at the same time they can get better access to the products and services they need.

In this talk, I'll explain how advances in machine learning and reinforcement learning can alleviate these challenging balancing acts. First, I'll give you some background information and then I'll briefly describe how these methods are helping firms and consumers, using examples from my own work. Next, I'll indicate some exciting areas for future research. I'll conclude by illustrating the implications for marketing science and prescriptive analytics more generally.

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Samenvatting

Het internet heeft een aantal van de meest fundamentele processen in onze samenleving, zoals handel, betaling en communicatie, veranderd. Nog nooit konden we zo gemakkelijk aan producten, diensten en meningen komen als nu, maar tegelijkertijd wordt ons gedrag nauwlettender in de gaten gehouden dan ooit. Grote online retailers bieden bijvoorbeeld honderdduizenden producten aan en kunnen tot in detail zien hoe elke consument erop reageert. Zij kunnen ook op elk moment persoonsgerichte, grootschalige, gerandomiseerde online-experimenten inzetten om concepten, inzichten en communicatie te testen die tot betere diensten en producten kunnen leiden. Maar vaak zijn er eindeloos veel mogelijkheden, zoals productaanbevelingen op basis van eerdere aankopen. De omvang en complexiteit van zulke experimenten brengen gigantische uitdagingen met zich mee.

Ondernemingen hebben zodoende veel te wikken en te wegen. Zo moeten ze voortdurend balanceren tussen profiteren van wat ze al weten over consumenten (bijvoorbeeld de genres van films die ze al hebben bekeken) of juist inzetten op nog meer informatie (bijvoorbeeld door het aanbevelen van een genre waarover nog niks bekend is). Intussen moeten consumenten hun eigen balans zien te vinden. In de digitale samenleving laten we onvermijdelijk digitale voetafdrukken na, maar hebben we nog wel enige vrijheid als het gaat om de informatie die we voor onszelf willen houden. Consumenten die meer openstaan voor het delen van hun voorkeuren, lopen doorgaans ook hogere risico's. Maar de producten en diensten die ze nodig hebben, zijn dan weer veel gemakkelijker te vinden.

In deze presentatie laat ik zien hoe de vooruitgang in machine learning en reinforcement learning het balanceren gemakkelijker maakt. Na wat achtergrondinformatie zal ik in het kort beschrijven hoe deze methoden bedrijven en consumenten ten goede komen, met voorbeelden uit mijn eigen werk. Daarna geef ik aan welke gebieden uitermate interessant zijn voor toekomstig onderzoek. Tot slot laat ik zien wat de implicaties zijn voor marketing en prescriptieve analytics in algemenere zin.

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1. Introduction

Dear Rector Magnificus of Erasmus University,
Dear Board Members of the Trustfonds,
Dear Deans of the Rotterdam School of Management,
Dear family, colleagues, and students,
Dear distinguished guests,

It is an honor and a privilege to accept the appointment of Endowed Professor of Digital Marketing at Erasmus University by giving this inaugural address entitled:

Learning with a purpose:
The balancing acts of machine learning and individuals in the digital society.

As implied in the image that illustrates this talk, consumers and executives go about their lives on digital tightropes, some more successfully than others. Simply by living in today's digital society, we leave behind a long trail of digital footsteps that reveals a lot about us. For example, when we allow companies and governments to access our digital crumbs, we get better products and services in return, but this is a risky process because of leaks and potential abuse.

Figure 1. Consumers and Managers Keeping the Balance

Companies also face a balancing act as they try to learn about consumers so that they can make yet better products and services. The more they learn about consumers, the better products they can make, but learning can be very costly.
In this talk I will show that machine learning and a set of methods called multi-armed bandits can help consumers and companies to handle these tricky balancing acts.
I would like to tell you how I have used these methods in my research in marketing to address problems involving these balancing acts and, more importantly, discuss some of the key challenges I plan to tackle in the near future, as well as some challenges that I hope will be tackled by the field in the longer term.

Before we talk about machines, algorithms, and marketing, let's talk a bit about learning. Let's take a close look at a very simple case of learning: how baby gazelles learn how to walk.

Gazelles struggle to stand immediately after birth. However, just a few minutes after being born, a baby gazelle learns how to keep its balance and walk. After half an hour of trial-and-error, most 30-minute-old baby gazelles can run at 30 km/h. (My kids are taking much longer to run that fast).

There is a lot of experimentation going on: a newborn baby gazelle tries out some moves. Should it move all feet at the same time? How often should it look to the sides? It learns from experience. For example, it soon realizes that it can run faster on a flat field than on a rocky hill.

The baby gazelle wants to grow and survive. It needs to keep switching back and forth between learning how to move and moving away from a lion that may be stalking it. It needs to solve a balancing act. Learn or run? It's learning, but not just learning for the sake of learning. It's learning with a **purpose**: growth and survival. Companies are not different.

Just like the gazelle, companies are also constantly in a learning process. For example, consider a company advertising on social media. Should it continue to advertise on Facebook after the latest privacy scandal? Or should it move more advertising budget to news websites such as cnn.com and telegraaf.nl? Just like the gazelle, a firm also **has a goal, or a short-term purpose**. For example, it may want to regain market share lost to a more media-savvy competitor. Like the gazelle, the firm also needs to solve a balancing act – it needs to learn the tricks of advertising on social media, but at the same time it must keep an eye on its competitors who may be increasing their advertising and perhaps becoming more aggressive. This is the same balance between learning and survival. There is no time to learn about all possible social media channels, all types of advertising messages, and all types of designs. In our example, the firm needs to keep switching back and forth between learning how to advertise and keeping competition at bay. The firm needs to **learn** while it **earns** market share.

Learning while earning. A tricky and challenging balance.

Machine learning has often been used to help firms learn about consumers, markets, and competition. In this inaugural address I argue that both firms and consumers face difficult balancing acts, but both are helped by advances in machine learning, albeit in different ways.

2. On Machine Learning with a Purpose

First, allow me to clarify what I mean by **machine learning**. The most practical and popular definition of machine learning was proposed by Mitchel (1997) and is based on the experiences the machine had. He suggests that **"a machine has learned from the experience with a task if the machine now performs the task better than before because of that experience. In short, the machine learned from the experience with the task so now it is doing the task better."**

For example, consider the task of making a book recommendation. A machine may predict that it is a good idea to recommend a book about the Second World War to people who bought a book about the First World War. The machine then makes the recommendation, observes the outcome (e.g., a purchase or the lack thereof), learns whether the recommendation was a good idea or not, and recommends better next time around.

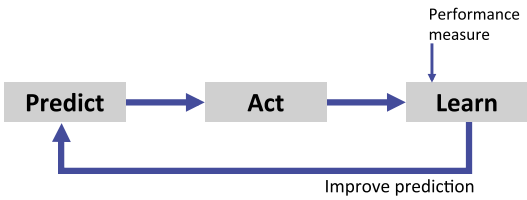

Figure 2. A Perspective on the Building Blocks of Machine Learning

Note that machine learning is based on **predicting** the best way of doing something, acting on it, and learning whether the prediction was right. Then repeat. Over and over again. Predict, act, learn, predict better, act, learn, and so on.

This loop including prediction and action allows us to establish a contrast with **econometrics**. Econometrics has been extremely successful in explaining the world through observation and inference, so its main output is a set of estimators that helps us to understand and explain relationships among economic variables such as, for example, inflation, unemployment, or interest rates. In contrast, machine learning is at its best when you can experiment, rapidly learn from the outcome, experiment, learn, and so on.

Because the Internet is used by millions of consumers and firms to instantaneously communicate, interact, and trade, there has never been a better time for using machine learning. The interactions between companies and consumers, and among consumers present lots of opportunities to predict, act, and learn. Good examples include product recommendations, product personalization, online reviews, targeting, transportation, replication of digital products, and many more.

So, the bottom line is: machine learning is about predicting and about experimenting.

But we can do better than simply predict, act, and learn. What if we could tell machines that we want something? What if a company could tell machines that, just like the gazelle, it has a specific purpose?

If we told machines what the purpose of our learning was, we would learn faster because if you know what you want, you know what you need to learn. If you know what you need to learn, you learn faster. A growing area of machine learning is focused on making sure machines know our purpose before they start learning for us. This specific class of problems is called **multi-armed bandits**. The name **bandit** is used because it is a nickname for slot machines, and a slot machine is a great way of describing the problem of learning with a purpose. While learning about a slot machine, you must choose between **exploiting** the machine you know and **exploring** other machines. Your choice depends on your goal, for example, avoiding a loss or trying to win big no matter what.

The bottom line is: your purpose affects your learning – it decides what you will learn about.

Working with bandits is a multidisciplinary research area. Just to give you an idea, this inaugural address was preceded by an outstanding two-day workshop on bandits here at Erasmus University. During the workshop we had a great set of presenters sharing their work on mathematics, computer science, operations research, marketing, economics, and clinical trials of pharmaceutical drugs.

The concept of this workshop started to take its final shape in 2016. Back then I was testing the idea of a workshop on multi-armed bandits with several colleagues from various disciplines, and by far the most encouraging feedback I received was from John Hauser, from MIT, and Ale Smidts, head of our Marketing Department at RSM. In November 2016 John was visiting Erasmus University for the 2016 Dies Natalis ceremony, when he received his honorary doctorate from our Rector Magnificus, Professor Pols. During lunch with John the next day I remember floating the idea of the workshop, to which he reacted enthusiastically. It was also a good topic to talk about because it was the day after Donald Trump won the election, so he had been busy trying to explain what had just happened in the US.

What about analytics?

I have discussed machine learning and bandits. However, there has been a bit of a frenzy around the term "business analytics", so I will finalize this introduction by very briefly contrasting and comparing bandits, machine learning in general, and analytics. Table 1 lists typical goals and methods used by descriptive analytics, predictive analytics, and prescriptive analytics applications.

	Descriptive Analytics	Predictive Analytics	Prescriptive Analytics
Goal	Understand relationships among key variables	Understand causal relationships & future outcomes allowing for preemptive action. Sometimes referred to as preemptive analytics	Normative. Given current knowledge about variables and relationships, identify optimal decisions to take in the future and learn from experience
Methods and Tools	Statistical inference	Causal inference	Optimization Multi-armed bandits Reinforcement learning

Table 1. Machine learning and the various terms used in business

Descriptive analytics typically describes the relationship between key variables with the goal of understanding a specific phenomenon given accumulated data. Predictive analytics is focused on understanding what may happen in the future, often using machine learning methods. Multi-armed bandits, on the other hand, are described as a subset of machine learning or operations research (depending who you ask). Bandits are often used normatively, in what is called prescriptive analytics.

Prescriptive analytics seems to be picking up speed. Together with colleagues from Stanford, Purdue, Singapore National University, and the University of Southern California I am co-editing a special issue of Management Science on prescriptive analytics (Giesecke, Liberali, Nazerzadeh, Shanthikumar, and Teo, 2018)[1]. We are working hard to put together a very special Special Issue, reporting high-quality research that develops innovative solutions based on novel methods that harness advances in areas such as optimization, machine and reinforcement learning (simply put, multi-armed bandits), computation, and algorithms. The issue will cover a broad set of areas, including marketing, finance, operations research, supply-chain management, clinical trials, and many more. The deadline of this Special Issue is March 2019. If you are interested or know anyone who might be, please help us spread the word.

1 Available here: https://pubsonline.informs.org/doi/pdf/10.1287/mnsc.2018.3120

3. Exciting Times, Interesting Problems

In the introduction I proposed two perspectives for using machine learning and multi-armed bandits in marketing: focusing on the company and focusing on the individual. I will illustrate these points of view in more detail, giving examples of my own research and highlighting some areas that I find interesting for future research.

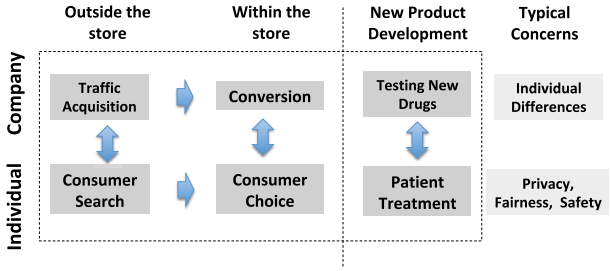

Figure 3. A Setting for Using Multi-Armed Bandits and Machine Learning

As shown in Figure 3, I am particularly interested in three topics: **traffic acquisition, conversion, and testing new pharmaceutical drugs**. Traffic acquisition entails making consumers aware of the company and of its product assortment during their search process, and helping them to realize that it may include products or services that fit their needs. Conversion is a general expression I use to include everything between arriving at the landing page of a website until checking out the shopping cart.

Finally, while the development of new products is a classical area of marketing, testing a new pharmaceutical drug is an exciting universe in itself – it entails designing and analyzing tightly regulated clinical trials under extremely conservative and rigorous statistical standards. I would now like to address these three main areas of interest in more detail.

4. Traffic Acquisition: Getting on the Consumer Radar

One of the major challenges retailers face has always been how to attract consumers to their stores. The retailer wants to know when and how to communicate with the right consumer, and then do so in the right style, providing the right information. In a project, co-authored with John Hauser and Glen Urban, we developed a multi-armed bandit method to tackle, in real time, the most classical problem in online advertising: which advertising ad to show to a specific consumer (Urban et al., 2014). This is an example of morphing theory, an area that the three of us have been developing for the last ten years (Hauser, Urban, Liberali, and Braun, 2009).

Looking forward, at a more general level, I propose that more research is needed on traffic acquisition to tackle two major and tricky problems: (a) the black box of media buying, and (b) the balance between attracting consumers to the store and improving store performance. I will elaborate on both.

4.1 The black box of media buying

The problem of the black box of media buying is related to how ad networks operate and how they sell ad space. An ad network is an organization that connects a company, such as Unilever, that advertise products to websites that host ads, such as cnn.com. Currently, ad networks operate at the segment level. This means that when manufacturers buy advertising, they have little or no control who actually sees the ad within the segment.

You must know the feeling. You just bought a watch and now you are doomed to see the ad of that very same watch over and over again on every news website you visit for several days or weeks. This has negative implications for companies as well – how can you measure and attribute credit for a purchase if you do not know which ads the consumer saw, and how many times he or she saw them? How can you pay for an ad if you can't measure exactly how well it performed?

Opening the black box of media buying can provide great benefits for both consumers and companies. Companies that advertise their products would get more bang for their advertising bucks because they would know exactly who was watching their ads and could target at a much more individual level (today ad networks use segments, an old-school concept that was extremely popular in the 1960s and 1970s). Consumers would be able to better control what ads they were exposed to and would get more value from the informative role of advertising rather than sometimes being annoyed by them.

4.2 Attracting the right traffic

The second topic I think deserves more research is the balance between attracting consumers to the store and improving store performance (i.e., conversion). During a lunch with executives from a major Asian portal of financial products last year it became clear to me that striking the right balance between attracting and converting can be deceptively hard for practical reasons.

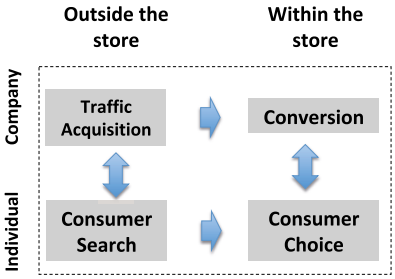

Figure 4. A Setting for Using Multi-Armed Bandits and Machine Learning in Retailing

From a consumer point of view these are two different processes, often characterized in the literature as different parts of the purchase funnel. There are two interesting research problems here.

First, there is a budget allocation problem between allocating resources to ad campaigns or to the store. On the one hand, attracting consumers involves allocating resources to ad campaigns in different channels including search engines, display banners, social media, and others. These channels all differ in terms of cost and ability to bring traffic to a store. On the other hand, having an effective store that can convert traffic in sales involves investing in product recommendation engines, website design, and more. Budgets are always finite, hence striking the right balance is critical.

Second, attracting traffic involves an interesting ad campaign design problem. When you see a search result on Google (or an ad on Facebook) and decide to visit a store, you expect that the store will be consistent with the information you just received on your Google results. Shopping online is risky, so inconsistencies raise red flags. Imagine an insurance company that uses positive messages to attract traffic but negative messages (e.g., focus on loss prevention) on their website. More research is needed on understanding and reconciling need for consistency as well for differences in information needs. Together with Gerrit van Bruggen and PhD student Zhou Xin, we are tackling this problem by expanding the scope of morphing methods to include both attraction and conversion.

5. Improving Stores and Publishers of Online Content

Another major challenge is how to make sure that consumers can find the products they need once they land on the online store. I will now briefly discuss three interesting topics for research: recommendation systems, product personalization, and website design.

Recommending and Designing Digital Products
Amazing work has been done in computer science, machine learning, and marketing science when it comes to methods for product recommendations. However, given the overwhelming high dimensionality of the space in which products exist, most product recommendation algorithms are still not sufficiently forward looking. The curse of dimensionality still stops most modeling efforts from building more-than-one-step look-ahead versions of (collaborative-, content-, and hybrid- filtering-based) recommendation systems. The challenges here are enormous and often involve how to optimally add exploration and surprise to the recommendations, which is a quintessential multi-armed bandit problem.

Another interesting topic is personalization of digital products. There are several published algorithms in computer science for personalizing digital content, but they have not been used in large-scale real-time settings just yet. For example, if we all go to most product- or movie review websites such as imdb.com, we are all going to see the exact same reviews, even though each one of us is a unique individual with our own needs and information preferences. Together with Josh Eliasberg (Wharton) and Zining Wang (Erasmus), we developed an algorithm to automatically design movie reviews based on the pool of content from past reviews and user preferences. Our preliminary results are encouraging as they show synthetic reviews designed by our algorithm lead to higher usefulness scores.

Website design
Many companies routinely use randomized controlled trials to make improvement in their online stores. They refer to them as A/B tests. These trials have been used for decades also in agricultural and medical settings. Today, there is a lot of exciting on-going research on causal inference and choice of estimation methods in randomized trials and bandits, such as the work of Susan Athey and Guido Imbens.

However, I want to call your attention to a different, surprising issue. Figure 4 shows a typical A/B test routinely used today to select the best website design.

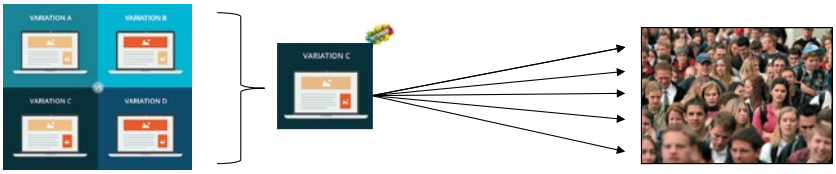

Figure 5. A/B tests typically used to identify the best web-design (stylized illustration)

Nothing surprising on the left side: a few designs are made and tested with an appropriate sample. Classical statistics are then used to find the best design on average. However, note that once the best design is found, it is rolled out to all consumers. One website design to all.

We tackled this problem in our first morphing bandit paper in 2009 (Hauser, Urban, Liberali, and Braun, 2009). Our method uses a latent structure such as cognitive styles to identify and deliver the best version of the website (call it a morph) to each individual user, instead of rolling out the best on average to all. Our results showed that sales performance could increase up to 20%.

What happens when consumers change?

The approach I just described works really well because we are continuously learning about a latent structure that does not change (or takes years to change), such as cognitive styles. However, there is value in solving a similar bandit problem when the consumer's belonging to the latent structure changes, in part because of marketing action. An obvious application is when the latent structure is the consumer position in the purchase funnel. For example, consumers may arrive at the website in an awareness or consideration stage, and as a function of the interaction with the (personalized) website, move to purchase.

This exact problem is the focus of a project with Alina Ferecatu, from our department. We have developed the analytical solution and are now implementing it in a field application on our own Erasmus' Rotterdam School of Management website. So, yes, we are morphing our own school website. For that, we have the sponsorship of the Marketing and Communications Director of RSM, Willem Koolhaas, and the relentless support from Wilbert Gantwort, RSM's online marketing and communication manager. Wilbert is coordinating a fantastic team including web developers, scientific developers, designers, content managers, content editors, and product managers to operationalize this field experiment.

In this field experiment we are helping potential students who are visiting Erasmus website to learn more about the MBA program. They may be interested in moving from an awareness stage to considering to enroll in the MBA program. While we are learning about a moving target (and helping it move down the purchase funnel), we still treat it as a multi-armed bandit problem, which we supplement with a hidden Markov model (HMM) to account for state changes. This means we still balance the goals of learning and earning when searching for the optimal policy. The first results are promising, above and beyond both current practice and randomized controlled trials.

6. Trials of New Pharmaceutical Drugs

One of the benefits of using bandits instead of the traditional randomized controlled trials in the problems we discussed so far is that bandits learn faster, hence the samples needed are smaller. Having smaller samples can also be important in other settings. Consider a randomized trial of a new pharmaceutical drug for a life-threatening medical condition such as myocardial infarction. First, assume the new drug being tested is superior to existing treatments. In this case, a multi-armed bandit trial gradually assigns more people to the successful new drug than to the old and underperforming drug, which means more lives can be saved with the new successful drug. Second, assume the new drug is inferior or even has until-then unknown severe side effects. In this case, a multi-armed bandit trial will gradually assign fewer people to the new and harmful treatment, saving patients from being exposed to it.

In short, pharmaceutical companies want to learn the performance of new medical drugs through testing, but without having to unnecessarily expose patients to inferior treatments. What is fascinating here is the trade-off between learning and treating. On the one hand, the tension is between learning about the effectiveness of a new drug and, on the other hand, reducing mortality by treating patients in the study with the best treatment given what has been learned.

Multi-armed bandit solutions learn more rapidly, minimize patient mortality, and accelerate the identification of the optimal policy. However, their adoption in clinical trials has been notoriously slow when compared with other fields. This seems to be happening because bandits often require each individual outcome to be observed before the next patient is assigned, but major patient outcomes are often observed several months later after the treatment.

The reason I became interested in clinical trials is because I realized that morphing theory provides the solution to this issue of delayed observations through something we call fractional updating, i.e., morphing uses interim results instead of waiting for long-term outcomes. Together with John Hauser I have been testing our algorithms on data from a major clinical trial that has more than 40 thousand patients in 15 countries and a thousand hospitals. The results are very encouraging and have opened a new avenue of research for us that is expected to grow in the coming years.

7. Closing Remarks

To sum up, I have discussed the type of research that entails this endowed chair and discussed the major topics and research problems that I will be addressing in the coming years. I explained the opportunities for research on how companies can get on the consumer radar and attract traffic to its stores, how to personalize content and recommendations, and how to support more efficient experimental designs of trials of pharmaceutical drugs.

I would like to conclude with some observations on more specific implications on the consumer side.

Personalization can provide better products and services but there are risks, and the personalization of news on Facebook has reminded us of them. As we know now, in that case, individuals were targeted with **fake** news with the goal of influencing in an election. Better regulation and training can help to ensure that these situations do not happen again, but I must say I was worried about the naivety of the questions the CEO of Facebook, Mark Zuckerberg, received during a recent Senate hearing. Perhaps machine learning can help. More specifically, there are two ways more research in machine learning can help.

First, machine learning can be used in clever ways to fact-check news before it is put on social media sites. Initiatives such as the **Fake News Challenge**[2] encourage researchers to develop methods and algorithms to combat the fake news problem.

Second, more research is needed on privacy-guaranteed algorithms. In 2006 Netflix started a prediction competition that paid a million dollars to the team that produced an algorithm that could best predict user ratings for films. By 2010 Netflix decided to not have further sequels in response to privacy concerns of the Federal Trade Commission and to a class action lawsuit, based on the fact it could be proved that it was possible to de-anonymize the data. This all happened with movie watching data, but several machine learning applications all over the world use much more sensitive training data, which can be reverse-engineered to give away information on individuals. Privacy-guarantee algorithms[3] are algorithms that assume that attackers have unlimited access to model parameters, so they have safeguards that guarantee that the original individuals from training data can never be recovered through re-engineering.

2 http://www.fakenewschallenge.org/

3 Such as Papernot et al. (2017)

Finally, training. The recent Cambridge Analytica-Facebook scandals suggest that the threats involving individual-level data were handled in very primitive ways and left room for inappropriate use of the data. Handling individual-level data is in many ways like driving a car. You need training, experience, and a clear understanding of the implication of your actions before you can sit behind the wheel of a car, and before you can start collecting and processing individual data. The scandal showed that in absence of specific training it is often not clear ex-ante which lines should not be crossed, and which safety measures should be in place.

Some said that machine learning (or artificial intelligence, broadly speaking) is too dangerous and some even claim it should be banned from certain domains. At times like these I recall what I heard during my lessons when I was getting my private pilot certification many years ago: they used to say that the safest plane in the world is the one that never leaves the airport. Flying is a risky endeavor, but the way forward is not to avoid flying. Similar intuition applies to machine learning – the way forward is through better training, more research, and better practice. Today I have proposed some ideas and approaches that I hope can help to make the digital society safer and more productive. It is a balancing act, but it's worth it.

8. Word of Thanks

I would like to acknowledge the people who made it possible for me to be here today.

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As we approach the end of this session, I would like to express my gratitude to my family in Brazil; to my parents for their unconditional support and love and to my brother and sister who I often turn to for advice and some good laughs.

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Ik heb gezegd.

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Gui Liberali is an Endowed Professor of Digital Marketing at RSM. He holds a doctorate in marketing and a BSc in computer science. His research interests include optimal learning, multi-armed bandits, digital experimentation, natural language processing, morphing theory and applications (e.g., website morphing, advertisement morphing), dynamic programming, machine learning, and product line optimisation. His work has appeared in journals such as Marketing Science, Management Science, International Journal of Marketing Research, Sloan Management Review, and European Journal of Operational Research. He is Vice-President for Membership of the INFORMS Society for Marketing Science (ISMS) for the 2018-2019 term.

He is the founder and director of the Erasmus Centre for Optimization of Digital Experiments (eCode), with the goal of developing and disseminating machine learning and optimisation methods, concepts, and tools that help firms improve the way they use the internet to connect with and interact with their consumers. This includes new ways to design and optimise digital experiments, new multi-armed bandits algorithms (such as website morphing), randomised controlled trials of marketing methods and tools (A/B experiments), online field experiments, and behavioural analytics.

In his inaugural speech Gui Liberali shows that companies and consumers face tricky balancing acts in the digital age. For example,

1. Companies need to constantly choose between profiting from what they already know about consumers and learning more about the same consumers.
2. Consumers who are more open to sharing their preferences and data are exposed to higher risks, but at the same time they can get better access to the products and services they need.

Gui shows how advances in machine learning can alleviate these challenging balancing acts. First, he provides some background information and briefly describes how these methods are helping firms and consumers, using examples from his own work. Next, he discusses some exciting areas for future research. He concludes by illustrating the implications for marketing science and prescriptive analytics more generally.

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