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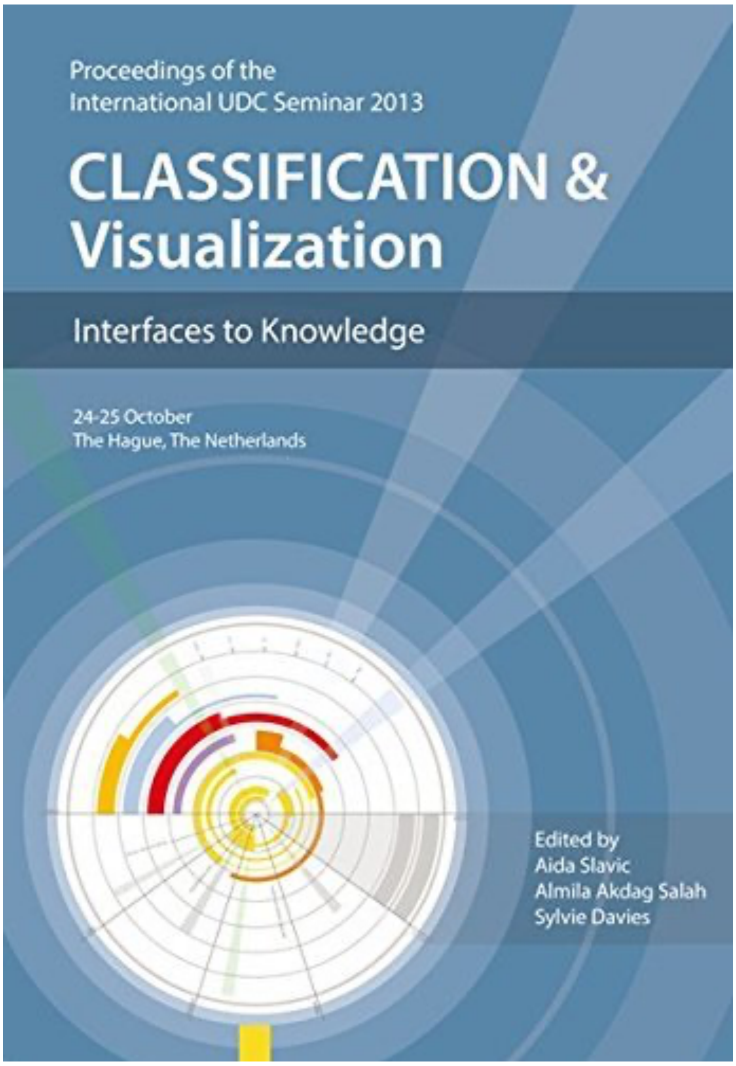

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How to design interfaces for choice: Hick-Hyman law and classification for information architecture

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Abstract: In a market dominated by an increasing variety of products and information, we are constantly forced to choose among a large number of options, not only in the web but also in the physical world. On one hand, this availability is a richness we are not be prepared to give up easily; on the other the excess of choice often generates stress, and in turn leads to 'non-choice' or 'non-purchase'. It is the so-called 'paradox of choice'. The comparison between some aspects of human-computer interaction, such as those covered by Hick-Hyman law, and canons of library classifications such as those proposed by Ranganathan's, shows however that the time and stress of choice does not depend so much on the number of options available, but overall on the way the choices are organized and presented. The 'paradox of choice' is therefore a matter of quality rather than quantity. Through concrete examples, the paper suggests some heuristics to improve the choice in menus, catalogues and interfaces in general, by acting on the architecture of the choices themselves.

Keywords: information architecture; interface design; choice; consistency; helpful sequence; Hick-Hyman law; menu selection; Ranganathan; resilience

1. Introduction

Through a comparison of well-known classification principles, the paper aims to emphasize the role of the Hick-Hyman law and propose some heuristics to design interfaces capable to reduce the time of choice. Hick-Hyman law and canons of classification building principles (such as the Canon of helpful Sequence by Ranganathan[1]) can, in fact, enlighten each other. Classification theory offers a theoretical confirmation to the law, and the law provides a mathematical model to quantify classification issues. The hypothesis, put forward by this paper, is that the time of choice is less dependent on the number of options available, and more on the way they are organized and presented.

1 Principles for building knowledge classification in bibliographic domain were proposed in the past by a number of theoreticians of library classification. These are often referred to as 'canons', the term first introduced by W. C. B. Sayers (*Canons of classification: a study in bibliographical classification method*. London: [s.l.], 1915) and continued to be used by other others, notably H. E. Bliss (*The organization of knowledge and the system of the sciences*. New York: Henry Holt, 1929.), or E. C. Richardson (*Classification: theoretical and practical*. 3.ed. New York: H. W. Wilson, 1912). S. R. Ranganathan, in his seminal work *Prolegomena to Library Classification* (1967) proposed a series of canons for building library classification schemes. In this paper I will be referring to his canons dealing with the structuring of classification schedules described in Chapters E: *Canons for work in the idea plane* and *F: Principles for helpful sequence* (Ranganathan, 1967: 143-147, 183-197).

Hick-Hyman law expresses the relation between the time taken to choose a command or action, the number of options available and some contextual parameters. Despite the fact that its first formulation dates back to the 1950s, the law was rarely taken into consideration and was scarcely applied in interaction design (Cockburn, Gutwin & Greenberg, 2007: 627). The reasons are usually attributed to a combination of factors: the poor level of application was sometimes related to a misunderstanding of the law itself; errors in the successive reviews or experiments; and sometimes, uncritical application of the law to the interface design. Cockburn, Gutwin & Greenberg (2007) provided a comprehensive synthesis of the studies concerning the Hick-Hyman law.

2. *Long tail* and *paradox of choice*

In modern, highly industrialized countries, the business model is moving toward what Chris Anderson (2006) has defined as the *long tail market* model: the trend of selling fewer items in a large number of niche markets, rather than many items (bestsellers) only in the mainstream market. This means a strong differentiation and personalization of products, services and information, and in turn a strong increase in the available choice. However, choosing among an ever-growing number of heterogeneous options may cause an increase in stress and lead to a *non-choice or non-purchase* situation. What we can observe here is known as the *paradox of choice* (Schwartz 2005).

Thus, the *long tail* market model and a person's ability to choose seem to be two irreconcilable issues. However, this is only superficially so and the ease of choice is, actually, not only a matter of numbers. A comparison between the Hick-Hyman law and, for instance, the *canon of helpful sequence* proposed for library classifications by Ranganathan (1967: 163) shows, in fact, that the time and stress of choice do not depend so much on the number of options available, but overall on the way the choices are organized and presented. The *paradox of choice* is therefore a matter of quality, rather than quantity. In other words, the inconsistency, the lack of a meaningful order and the contextual unsuitability of the options are the actual problem.

Then again, information and product overload is a kind of richness we would not wish to renounce:

> "Despite the detriments associated with choice overload, consumers want choice and they want a lot of it. The benefits that stem from choice, however, come not from the options themselves, but rather from the process of choosing. By allowing choosers to perceive themselves as volitional agents having successfully constructed their preference and ultimate selection outcomes during the choosing task, the importance of choice is reinstated. Consider the request in Forbes' recent 'I'm Pro-Choice' article: 'Offer customers abundant choices, but also help them search.' We now know how" (Mogilner, Rudicki & Iyengar, quoted by Anderson, 2006: 172).

More choice, indeed, but only for what really interests the user. Considered from the point of view of the individual, the *long tail* economy actually results in a narrowing of the choices: from all the possible options down to those of true interest. The narrowing is achieved through mechanisms capable of filtering unnecessary information, allowing people to easily obtain what they want. An often highlighted example is Amazon's customization system "Recommended for you", "Customers who bought this item also bought…", "Look for similar items by…", and so on.

3. Hick-Hyman law

The Hick-Hyman law (named after the two psychologists who formulated it) provides a mathematical model to understand the apparent conflict between the *long tail* model and the stress due to an excess of options. Because of that it also offers some solutions to address the *paradox of choice*.

The law says that given n equally probable choices, the average reaction time required to choose among them is approximately proportional to the logarithm to base 2 of the number of choices, plus 1:

$\text{Time} = a + b \log_2 (n + 1)$.

Coefficients a and b depend on context conditions, including the way the choices are presented and the user's degree of familiarity with the subject. For instance, if choices are presented poorly (without a clear criterion - see further in below), both a and b increase, while familiarity decreases b. These parameters are experimentally calculated or set through predefined values (Raskin, 2000: 93-98).

For the purpose of this paper, the most relevant concern about the Hick-Hyman law is that the relationship between the time taken to choose and the number of choices themselves is logarithmic, that is to say *sub-linear* (Figure 1). One would, however, expect such a relationship to be linear, namely that there would be some kind of proportional correlation between time and the number of options (Figure 2).

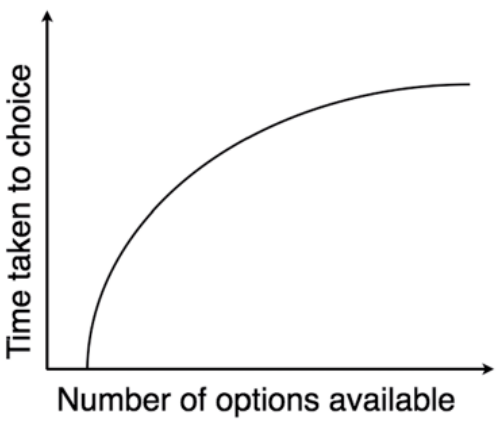

Figure 1: *Hick-Hyman law function*

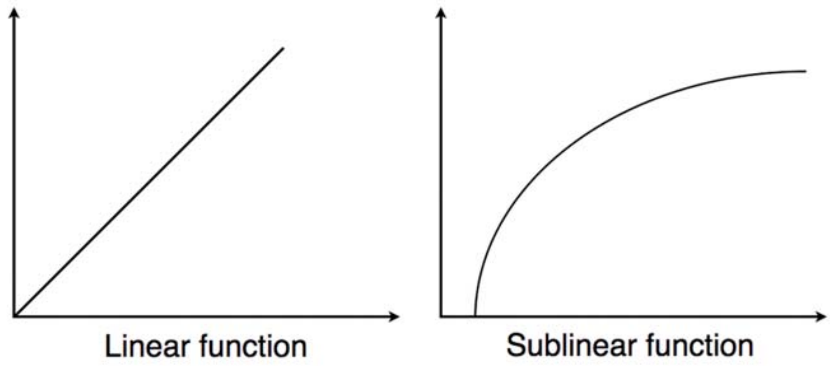

Figure 2: *Examples of linear and sub-linear functions (Hick-Hyman law follows the latter pattern)*

Such a behaviour may be explained if we take into account that every time we choose we do not evaluate every available option (linear time), but we tend as far as possible to cluster options in categories, dismissing parts of them progressively. Think, for instance, that we shop for wine, and we know exactly which kind we want to buy. Usually, especially in specialised shops, wines are arranged by country and region of origin. Hence, if we are looking for, e.g., "Prosecco di Valdobbiadene", we do not have to browse all the shelves. Knowing that this is an Italian wine from Veneto, we can immediately select Italian sector and then the Veneto shelf (discarding all other options).

That means that in the same contextual conditions (for *a* and *b* constants), if the number of options grows, so does the reaction time, but in a sub-linear way (non-proportional). In fact:

- with 2 options, log2 2 = 1
- with 4 options, log2 4 = 2
- with 8 options, log2 8 = 3

And *vice versa*, given an equal number of choices, *a* and *b* influence reaction time.

This is, precisely, the reason why we have to exercise caution when applying the Hick-Hyman law to the menu selection. If the menu does not provide a meaningful ordering criterion from the user's point of view, no clustering is possible and the user has to browse through each item on the list; as a consequence the reaction time becomes *linear* (Figure 2). On the contrary, menus arranged according to some meaningful ordering criterion allow the clustering process assumed by the law, and the time of choice is *sub-linear.* Let's consider again our wine example, and imagine that the user is not a great wine connoisseur. He has not in mind a specific label; he only wants an excellent red wine to combine with a green pepper steak. In this case the wine arrangement in the shelves by country and region is useless for the user: the criterion by which to look for is the match with the dish, not the geography. Thus he have to browse all the possible options, perhaps discarding only white wines, and the time taken to choose becomes linear.

Moreover, there is another important implication of the Hick-Hyman law: it regards the, so-called, 'wideness' (more choices distributed to one or more levels) or 'deepness' (less choices distributed on more levels) of the menus structure. According to the Hick-Hyman law, choosing once from an 8-item-menu is quicker than choosing twice from two 4-item-menus (Figure 3): 'wide' structures (less levels) are preferable over 'deep' structures (more levels). In fact we have:

1. $a + b \log_2 8 = a + 3b$, in the first case
2. $2 (a + b \log_2 4) = 2a + 4b$, in the second case

as a and b are positive non-zero coefficients, and $\log_2 8 = 3$ and $\log_2 4 = 2$ (in the computation we can ignore the +1). Then $a + 3b$ is surely less than $2a + 4b$, i.e. 8 options in one level requires less time of choice than 4+4 options on two levels.

However this is true, if and only if, the items are organized in a meaningful way, i.e. according to some convenient and significant principle by the user's point of view. Otherwise the law does not apply, and this implication is not valid.

In conclusion, the main result of the Hick-Hyman law is that the time taken to perform a choice depends not just on the number of choices but also on the way these choices are presented. If the options are arranged according to a criterion which is meaningful to the user, then the time needed to make a choice is not linear - as the user can cluster the options and focus her or his attention on a subset of the whole. In other words, choice is, by and large, a classification issue.

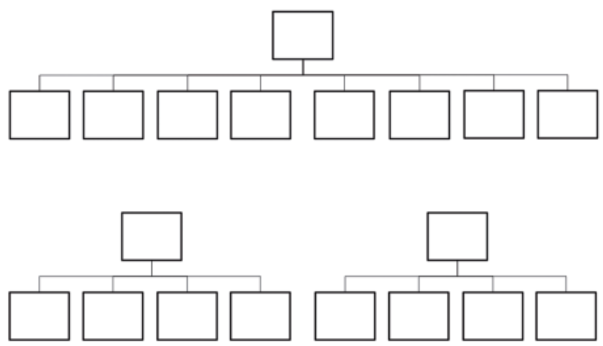

Figure 3: *According to the Hick-Hyman law, wide structures are more time-saving than deeper ones, but only if the options are presented in a meaningful way.*

4. Hick-Hyman law and classification

The Hick-Hyman law reveals a strong connection with some important classification principles. This relationship, in turn, provides key insights on how to structure and present menus (and lists of items in general), both in digital and physical environments.

We saw above that the time of choice is *sub-linear* (low) only if the choices are arranged according to a convenient criterion for the user. Thus we uncover the first link with the "Canon of Helpful Sequence" by Ranganathan:

> "The sequence of the classes in an array of classes, and of ranked isolates in an array of ranked isolates, should be helpful to the purpose of those for whom it is intended." (Ranganathan, 1967: 163)

In this context, we can define "convenient" as:

1. meaningful by the users point of view
2. consistent with the content nature
3. useful for the purposes of the classification

Users, content and context are in fact the three components of the so-called 'information ecology' which is an important part of every information architecture:

> "We use the concept of an "information ecology" composed of users, content, and context to address the complex dependencies that exist. And we draw upon our trusty Venn diagram to help people visualize and understand these relationships. The three circles illustrate the interdependent nature of users, content, and context within a complex, adaptive information ecology.
>
> In short, we need to understand the business goals behind the web site and the resources available for design and implementation. We need to be aware of the nature and volume of content that exists today and how that might change a year from now. And we must learn about the needs and information seeking behaviours of our major audiences. Good information architecture design is informed by all three areas" (Rosenfeld & Morville, 2006: 24).

The information ecology also reflects the three axes defining usability: users, goals and context:

> "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (ISO 9241-11, 1998: 6).

In such a perspective, we can see a convergence with some other of Ranganathan's canons and principles (1967):

> **Part E: Canons for idea plane**
>
> Canon of Relevance
>
> "A characteristic used as the basis for the classification of a universe should be relevant to the purpose of the classification." (ibid.: 146)

Canon of Relevant Succession

"The succession of the characteristics in the associated scheme of characteristics should be relevant to the purpose of the classification. […]" (ibid.: 154)

Part F: Principles for helpful sequence

Principle of Alphabetical Sequence

"When no other sequence of the subjects in an array of subjects or of the isolates in an array of isolates is more helpful, they are arranged alphabetically by their names current in international usage". (ibid.: 197)

The reason why the alphabetical order is to be avoided is that, despite its exact appearance, often this is not "convenient": namely it is not useful for the purpose of the user (while on the contrary it is frequently useful only for the purpose of those who manage the classification itself).

5. Strategies to reduce the *paradox of choice*

The Hick-Hyman law explains, in a mathematical way, the consequences that a well-known classification principles can have on the issues of choice. It, thus, provides useful guidelines for better interface design (Resmini & Rosati, 2011: 155-159):

1. menu items arranged according to a "convenient" principle implies a shorter time of choice (and less stress)
2. if the items are arranged in such a convenient way, wide structures are preferable to deep ones (the first take less time for the user to make a choice)
3. if not, it is preferable to split the menu into sub-menus, in order to re-establish the conditions in which the law works (i.e. create sub-groups of items in which some kind of clustering is possible).

Below, I will illustrate some strategies related to the last point, i.e. contexts in which the Hick-Hyman law does not apply. The purpose of the following heuristics is to restore a *sub-linear* (low) time of choice when the *linear* (high) time is enacted because of the lack of a helpful sequence of options.

5.1 Split

When the heterogeneity of the items of a menu makes it impossible to organize them in a "convenient" way (according to the canon of helpful sequence by Ranganathan), then it is preferable to split the menu into sub-levels. In such a condition, in fact, a wide structure does not offer any benefits over a deep one, as the Hick-Hyman law does not apply in this case (Resmini & Rosati, 2011: 155).

Thus, splitting the menu into more levels has two benefits:

1. reduce the number and the heterogeneity of options at each level
2. allow the restoration of some degree of clustering.

A paradigmatic example of this heuristic is given by the do-it-yourself scales used in several retailers (Figure 4). Most of them show a flat list of numbered buttons (about 60-100), each associated with a fruit or vegetable. The association, however, is not stable, as it changes with the normal turnover of products, so that fruits belonging to the same family may be placed in very distant categories. This is a typical context in which the Hick-Hyman law doesn't apply, and the time required to choose is *linear* (high). From the user perspective, there is no useful criterion in the arrangement of options - the numerical one, in fact, is convenient only for the retailers but not for the customers, as the association number-product is totally arbitrary. Moreover, the familiarity with the scale is useless, as the association number-product changes over time.

A growing number of supermarkets adopt a more functional model of scales, capable of refining the choice (Figure 5). These scales do not list all the available products in one flat list, but split the menu into two levels: they require an initial choice from a first-level menu listing for instance *Fresh fruit, Vegetables, and Dried fruit* or just *Fruit* and *Vegetables*; once an option has been selected, its second-level content become visible.

Following the principle of the Hick-Hyman law, explained earlier in Section 3, which states that structures with less levels are more preferable than those with more levels, it seems that the former kind of scale (with one flat menu) should be more functional than the latter (two levels menu). Yet this is true only if the list is structured according to some "convenient" principle for the users, and this is not the case. Thus, splitting the choice into more levels re-establishes a consistent list at first level, and reduces the number of options presented at one time on the second level.

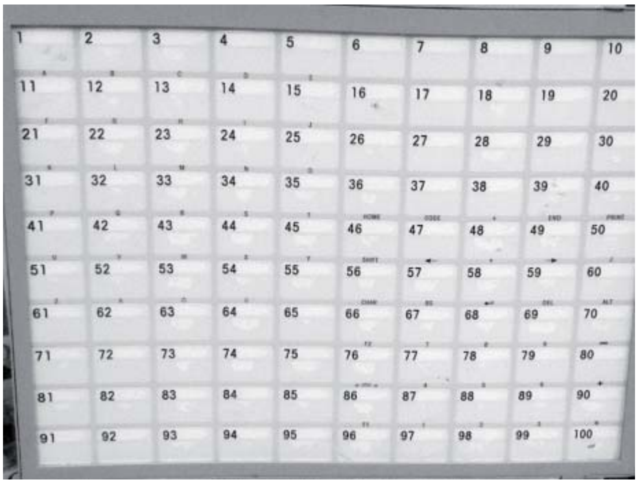

Figure 4: *A do-it-yourself scale with the options presented all together in one flat menu*

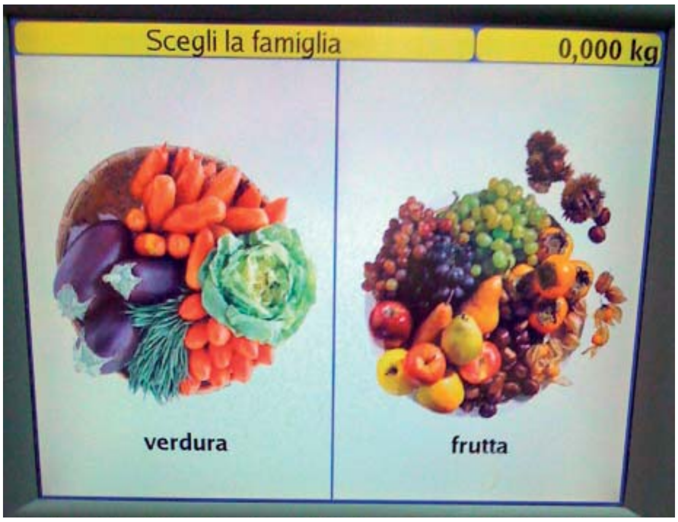

Figure 5: *A do-it-yourself scale with the options arranged into two levels menu.*

Similar approach can be observed in the function *Mission Control* (formerly Exposé) in the Mac OSX operating system which is another example of the splitting technique. This feature allows the user to get an overview of all the running applications, shrinking their size and grouping windows from the same application. In this case this is not a real splitting, but rather a re-organization of the desktop space in order to help findability and choice.

The underlying principle is however the same: re-arranging of a messy list of items (in this case several running applications) in order to allow the shift from a *linear* (high) to a *sub-linear* (low) time of choice. Similar features are employed by other operating systems too; and even if, with a lot of open windows, such features might cause some usability issues, they are usually able to manage the problem of the applications overload (Cockburn, Gutwin & Greenberg, 2007).

5.2 Customize

Reducing the number and the heterogeneity of the options through contextualization or customization of the choices themselves is another way to address the *paradox of choice*. That can be done by showing returning users only a sub-set of all the options (Cockburn, Gutwin & Greenberg, 2007: 632; Resmini & Rosati, 2011: 157):

- items previously viewed ('recency'-based);
- items most viewed by a specific user (frequency-based);
- items most viewed by all the users (popularity-based);
- items similar to those most viewed or bought (especially in e-commerce websites).

The Amazon website is the most well-known example in this perspective. It adopts different strategies to reduce the choice overload:

- *Your Amazon.com*; when registered users access the website they land on a customized page showing them only some recommended items, i.e. items similar to those previously bought or viewed;
- *History, Related;* returning users too (even if not registered, but with cookies enabled) can see some customized suggestions in the homepage, such as *More items to consider, Related to items you've viewed, Recent history.*

All these features have the same goal: to narrow the focus from all the possible options to those of true interest, according to both the *long tail* model and the Hick-Hyman law.

We can apply a similar adaptive behaviour also in physical environments, to make them, so to speak, sentient using for instance the ubiquitous computing or the so-called 'information shadow'.[2] Andrea Resmini and I have defined such capability as "resilience" - a key heuristic for a pervasive information architecture:

> "Resilience makes an information space able to adapt itself to the changing needs of its users in different contexts of use, different places, and different times" (Resmini & Rosati, 2011: 130).

It is best described as a place as a text or a palimpsest, where people write and rewrite their interactions with the environment, other people, or objects: by collecting, filtering and re-using such traces (the information shadows). Resilience also allows users to retrieve their previous actions (history), or discovery paths, services and products close to their interests (Resmini & Rosati, 2011: 131).

Thus, we can imagine a "resilient" retailer allowing users to:

- re-find and re-trace past tasks, paths or products (last bought or frequently bought items)
- personalize their tasks and paths
- create ad hoc paths around aisles, sales and information
- receive custom shopping suggestions or correlations among products.

2 Kuniawsky (2010) defines as information shadow the shadow of bits that objects and people project on the Internet through sensors: "An enormous quantity of user-generated content exists on the Internet tied to nearly every product. Virtually everything made or grown has been reviewed, discussed, photographed, mocked, praised, prodded, measured, disassembled, and hacked. Until the Internet, little of this social life was available; now there is a flood. The digitally accessible information about an object can be called its information shadow. Nearly all industrially created objects have rich information shadows, even if those shadows are invisible to their owners and users. […] Everyday objects have been separated for a long time from their information shadows, as Peter Pan was from his actual shadow. The complexity of finding, organizing, and accessing this information divided the world of objects and the world of information shadows. […] For consumers, ubiquitous computing attaches the information shadow to the object, like Wendy does to Peter Pan's shadow" (Kuniavsky 2010: 71-73).

5.3 Information Scent

Another way to improve the choice performance is through *information scent* - the concept developed by Pirolli, Card and other colleagues within the framework of the *information foraging theory* (Pirolli, 2007). The theory arises by the application of the optimal foraging theory (the patterns by which animals look for food) to the human-information interaction; it states that as the animals rely on scents to hunt their prey, so humans rely on various contextual cues to steer their information research (to evaluate the value of a path or resource). Such cues are called *information scent.*

The best way to provide information scent in multi-level menus is by offering a preview of some sub-level items of each class: that helps the users to better understand what they will find in the next level, and as a consequence to shorten the time of choice (Figure 6).

Figure 6: *The main menu of Visit Finland show also the sub-level items: an example of information scent in navigation*

Yet, information scent is useful for flat lists too, to empower the meaningfulness of the items' sequence and to help users in the scanning and evaluation process. That is especially true for search engine results pages, overall if the user cannot filter or personalize the results. In such cases, supplying a preview of the semantic metadata (such as category, tags etc.) related to the listed items, is a valid method to spread information scent (Figure 7).

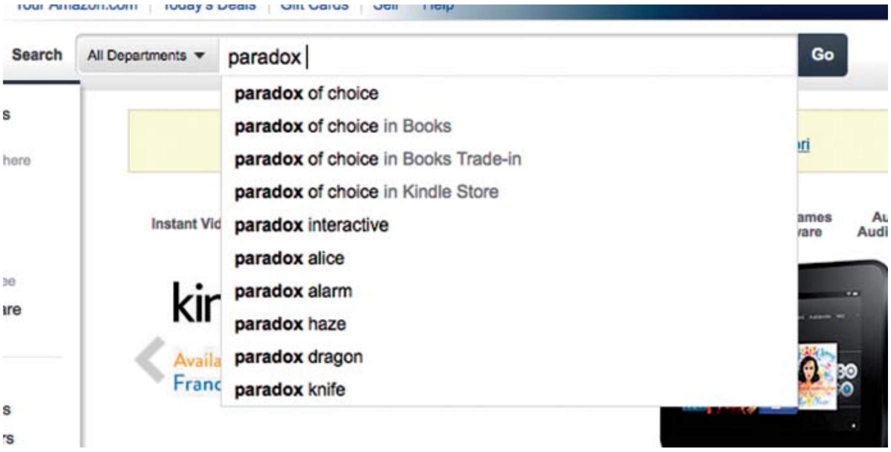

Figure 7: *The suggestion feature of Amazon search engine shows the category of the results: an example of information scent capable to help the choice*

6. Conclusions

In this article I analysed the connection between the Hick-Hyman law and some of Ranganathan's *canons for classification design*. I was interested into the Hick-Hyman law as it provides a way to understand the relationship between the time taken to choose a command or action, the number of options available and some contextual parameters (among these the way in which the options are presented). I, then, also looked into how this last issue of number of options is addressed by Ranganathan's *canons*. Notably, the sequence of the classes in an array and its influence on the quality of the classification. The Hick-Hyman law has so far encountered a low consideration in the human-computer interaction field, primarily because of the difficulties or ambiguities in its application when it comes to the design of menus. My suggestion, put forward in this paper, is that Rangathan's focus on helpful sequence and the importance of the logical properties of the subdivision may improve our understanding of the role the Hick-Hyman law may play in interface design.

This paper provides an explaination how the time taken to choose is less dependent on the number of options available, and more on the way they are organized and presented: if the options are arranged according to some meaningful criterion (from the user's point of view) the time of choice is *sub-linear* (lower), while if the options are not arranged according to some meaningful criterion (from the user's point of view) the time of choice is *linear* (higher). The reason is that, at the point of choosing, we do not evaluate every available option (linear time), but we tend as far as possible to cluster them in categories, dismissing parts of them progressively.

This has important consequences for design that can be summarised as follows:

1. A menu arranged according to a "helpful sequence" implies a shorter time needed to choose;
2. if a menu is organized in a convenient way, 'wide' structures (more items on one level) are preferable to 'deep' ones (less items on more levels): the former take less time for users to choose than the latter;
3. if it is not possible to arrange a menu according to a convenient way, then one needs to:
    a. split the menu, in order to re-establish some kind of helpful sequence
    b. customize or contextualize the options (so as to reduce the choice from all the available options to the relevant ones only): e.g. items previously or most viewed; items similar to those most viewed or bought and so forth;
    c. exploit the "information scent".

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