HEC MONTRÉAL

Le rôle de l'incertitude et de la complexité mathématique en contexte d'épicerie en ligne

par

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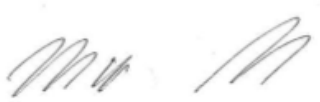

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Sommaire

L'achat d'épicerie en ligne est perçu comme étant plus cognitivement complexe que d'autres formes d'achats de produits en ligne (par exemple, de multiples décisions d'achat par séance de magasinage, différents types de produits, et une complexité arithmétique variée). Dans cette étude, nous investiguons les facteurs qui ont potentiellement un rôle sur l'attitude envers le site dans l'épicerie en ligne. Plus spécifiquement, nous posons l'hypothèse que l'influence du type de produit (recherche ou expérience), la complexité arithmétique de la tâche, l'attention visuelle et la charge cognitive en lien avec les photos de produit ont un effet sur l'attitude envers le site. Pour tester les hypothèses, 31 participants ont participé à une expérience en laboratoire. Les résultats suggèrent que l'attention visuelle envers les photos de produit a un effet positif sur l'attitude envers le site lors du magasinage de produits expérientiels et qu'elle a un effet négatif sur l'attitude envers le site lorsque la complexité arithmétique de la tâche est élevée. La charge cognitive associée aux photos de produits démontre un effet négatif sur l'attitude envers le site lors du magasinage de produits d'expérience, et une indication de fluctuations de la charge cognitive élevée a un effet positif sur l'attitude envers le site lorsque la complexité arithmétique est élevée. Les contributions théoriques et les implications pratiques sont discutées.

Mots clés : épicerie en ligne, produit d'expérience, incertitude, complexité arithmétique, attention visuelle, charge cognitive, attitude envers le site, dilatation de la pupille

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Je tiens aussi à remercier toute l'équipe du Tech3Lab pour leur précieuse collaboration lors des différents projets auxquels j'ai contribué. Merci à François Courtemanche, directeur des opérations du Tech3Lab qui a une contribution inestimable dans l'avancement de l'expertise de pointe du laboratoire de recherche qui permet à ce genre de projet de recherche d'émerger.

Je remercie aussi les chercheurs qui m'ont offert des commentaires constructifs lors de la première phase d'analyse de projet de recherche lors de ma présentation des résultats à The 14th Annual Pre-ICIS Workshop on HCI Research in MIS Sponsored by AIS SIGHCI (Desrochers et al. 2015). Ces échanges ont permis d'enrichir l'article dans sa deuxième phase d'analyse.

Enfin, je veux remercier mes proches et mes ami(e)s qui ont démontré un support et un intérêt important dans mon parcours.

Avant-propos

Le mémoire suivant est présenté sous la forme d'un article avec l'accord de la direction du programme de la MSc., HEC Montréal. Le consentement a été obtenu de la part des auteurs pour présenter cet article dans le contexte de ce mémoire. De plus, le CER a approuvé le projet de recherche qui a servi à produire cet article.

Chapitre 1 : Problématique et questions de recherche

1.1 Mise en contexte de l'étude

La littérature sur le magasinage en ligne est principalement concentrée sur des contextes d'achats où seulement un ou quelques items sont achetés (e.g., Aljukhadar et al. (2012)). L'épicerie en ligne est différente de la tâche typique d'achats en ligne sur plusieurs dimensions et a peu été étudiée.

Faire l'épicerie implique souvent l'achat de plusieurs produits dans une seule séance de magasinage, ce qui contraste avec les contextes de magasinage dans lequel le consommateur achète un seul produit (par exemple, un livre ou un téléphone mobile). Le magasinage d'épicerie en ligne peut être considéré comme une tâche à multiples décisions concernant l'achat de différents produits : alors que chaque sous-tâche peut prendre moins de temps à exécuter qu'une tâche typique d'achat en ligne, le temps de la séance complète de magasinage va augmenter linéairement selon le nombre de prise de décisions à faire en lien avec le nombre d'items sur la liste de l'épicerie du consommateur.

Le processus décisionnel de chaque sous-tâche peut s'avérer plutôt demandant pour le consommateur. Une première considération est que plusieurs produits alimentaires, surtout les produits périssables, ne sont pas vendus dans des formats standardisés ; les quantités peuvent contenir des décimales et il peut y avoir de la variabilité dans la taille des produits achetés à l'unité. De plus, si un consommateur utilise une recette pour faire sa liste d'épicerie, il aura potentiellement une portion de la quantité requise d'un ingrédient chez lui, ce qui impliquera une soustraction dans son processus de décision de la quantité du produit à acheter. Avec tous ces facteurs pris en compte, les opérations arithmétiques pour calculer la quantité de produit à acheter font nécessairement partie du processus décisionnel d'achat dans la séance de magasinage en ligne. En somme, les consommateurs seront plus enclins à recourir à des calculs mathématiques lors de leur expérience d'achat d'épicerie en ligne comparativement à d'autres contextes d'achats en ligne.

Les environnements en ligne empêchent aussi les consommateurs de toucher et d'avoir une interaction physique avec le produit avant de l'acheter (Peck and Childers 2003). Plusieurs biens alimentaires sont des produits d'expérience, c'est-à-dire, des biens pour lesquels la qualité est plus difficile à évaluer avant la consommation. Dans un magasin physique, la qualité des aliments périssables comme un

morceau de viande peu partiellement être inférée en regardant, comparant et touchant le produit pour déterminer sa fraicheur ou la grosseur de son paquet, ce qui en fait donc une source d'information pour déterminer la qualité du produit (Lederman and Klatzky 1987).

De la recherche antérieure a démontré qu'un stimulus visuel tel qu'une image et description de produit peuvent être utilisés pour améliorer la confiance du consommateur dans la qualité et les attributs désirés du produit (Xiao and Benbasat 2011). Il n'est toutefois pas possible de voir le vrai produit lors de l'achat de ce type de produit en ligne. La classification des produits de recherche et d'expérience (Nelson 1970) est donc un cadre conceptuel pertinent pour cadrer l'expérience de l'achat d'épicerie en ligne à cause de la difficulté à évaluer les attributs variables des produits d'expérience avant la livraison du produit.

Afin d'étudier l'achat d'épicerie en ligne, nous devons considérer ces caractéristiques distinctives et notre capacité limitée à traiter de l'information pour évaluer 1) la qualité du produit pour les biens expérientiels, 2) résoudre des décisions d'achats mathématiquement complexes et 3) l'ajustement de quantités afin d'obtenir le nombre de portions souhaitées dans une recette.

L'impact subjectif de ces caractéristiques peut être évalué à travers des mesures auto rapportées telle que l'attitude envers le site qui ont été étudiées extensivement dans la littérature pour la recherche sur l'expérience de l'utilisateur dans les sites d'achats en ligne. Une compréhension objective de ce qui explique l'attitude envers le site, mesurée à l'aide de mesures neurophysiologiques, peut donc contribuer à déterminer l'effet de l'incertitude et la complexité sur l'attitude envers le site dans un contexte d'achat d'épicerie en ligne.

1.2 Questions de recherche

L'étude que nous avons effectuée cherchait à répondre aux questions suivantes concernant les caractéristiques du magasinage de produits d'épicerie en ligne :
Pour déterminer l'effet causé par l'incertitude reliée au type de produit, nous cherchons à répondre aux questions suivantes :

> **1.a** Le magasinage en ligne de produits de recherche mène-t-il à une attitude envers le site web plus positive que le magasinage de produits d'expérience ?

1.b L'attention visuelle sur les photos de produit contribue-t-elle positivement à l'attitude envers le site pour les produits expérientiels ?

1.c Une charge cognitive soutenue et élevée sur les photos de produits expérientiels contribue-t-elle à une attitude négative envers le site ?

En lien avec la complexité arithmétique dans la prise de décision de la quantité d'achats de produits, les questions suivantes sont posées :

2.a La complexité arithmétique des tâches de magasinage d'épicerie en ligne a-t-elle une influence négative sur l'attitude envers le site ?

2.b Est-ce que l'attention visuelle sur les photos de produit dans les tâches mathématiquement complexes contribue à une attitude négative envers le site ?

2.c Est-ce qu'une charge cognitive élevée et soutenue sur les photos de produit dans les tâches d'achat de produits arithmétiquement complexes contribue à une attitude négative envers le site ?

1.3 Objectifs de l'étude

En tentant de répondre aux questions de recherche mentionnées précédemment, l'étude que nous avons effectuée avait deux objectifs. Elle cherchait d'abord à déterminer si la complexité et l'incertitude ont un impact sur l'attitude envers le site dans l'achat d'épicerie en ligne. En lien avec cet objectif, nous cherchions à déterminer si l'attention visuelle et la charge cognitive modèrent l'attitude envers le site dans des tâches d'achats incertaines ou complexes.

1.4 Contribution potentielle au champ de recherche

Les concepts étudiés en contexte expérimental dans cette étude ont le potentiel de contribuer à différents champs de recherche. Le contexte expérimental authentique des tâches étudiées a le potentiel de contribuer à la littérature sur les achats de produits d'épicerie en ligne. De plus, les concepts d'incertitude et de complexité ont le potentiel de contribuer à la littérature sur les produits de recherche et d'expérience. L'étude des effets modérateurs de la charge cognitive sur l'attitude envers le site a le potentiel de contribuer à la littérature qui étudie le lien entre la cognition et l'émotion perçue. L'étude du stimulus visuel des photos de produits a le potentiel d'apporter une contribution aux connaissances actuelles sur les effets modérateur des photos de produits dans la prise de décision sur des sites d'achat en ligne. Enfin, la

méthodologie de l'étude a le potentiel de contribuer dans l'avancement des méthodes de recherche sur l'expérience de l'utilisateur dans l'utilisation d'interfaces de systèmes. Cette contribution potentielle est ancrée dans la façon d'opérationnaliser les mesures de l'expérience de l'utilisateur en combinant des mesures auto rapportées à des mesures automatiques et non-intrusives, et ce dans un contexte expérimental authentique.

1.5 Informations sur l'article

Une première version de cet article a été soumise et acceptée pour présentation dans un atelier scientifique en décembre 2015 à Forth Worth au Texas dans le cadre de ICIS (international Conference on Information Systems) 2015: The 14th Annual Pre-ICIS Workshop on HCI Research in MIS Sponsored by AIS SIGHCI (Desrochers et al. 2015) L'étudiante de ce mémoire a conduit cette première phase de recherche à l'été 2015 sous une bourse de rechercher de premier cycle (CRSNG) et a présenté les résultats dans un atelier de la conférence à des chercheurs issus du domaine de recherche de l'interaction humain-machine. La version abrégée de l'article contenant les résultats de la première phase d'analyse est disponible dans les actes de conférence de l'atelier de recherche. Les données de dilatation de la pupille n'avaient pas été analysées dans cette première phase d'analyse.

L'article qui fait l'objet de ce mémoire inclue la deuxième phase d'analyse de données et est en finalisation de préparation pour soumission dans la revue Data Base for Advances in Information Systems.

1.6 Résumé de l'article

L'achat d'épicerie en ligne est perçu comme étant plus cognitivement complexe que d'autres formes d'achats de produits en ligne. De multiples décisions d'achat par séance de magasinage, différents types de produits, et une complexité arithmétique variée décrivent les caractéristiques distinctives de l'expérience. Dans cette étude, nous investiguons les facteurs qui ont potentiellement un rôle sur l'attitude envers le site dans l'épicerie en ligne. Plus spécifiquement, nous posons l'hypothèse que l'influence du type de produit (**recherche** : produits avec des attributs physique standards facilement descriptibles ou **expérience** : produit avec des attributs physiques variables plus difficilement descriptibles sans une interaction physique avec le produit), la complexité arithmétique de la tâche, l'attention visuelle et la

charge cognitive en lien avec les photos de produit ont un effet sur l'attitude envers le site. Pour tester les hypothèses, 31 participants ont participé à une expérience en laboratoire. Les résultats suggèrent que l'attention visuelle sur les photos de produit a un effet positif sur l'attitude envers le site lors du magasinage de produits expérientiels et qu'elle a un effet négatif sur l'attitude envers le site lorsque la complexité arithmétique de la tâche est élevée. La charge cognitive élevée associée aux photos de produits influence négativement l'attitude envers le site lors du magasinage de produits d'expérience. Enfin, une variation plus grande de la charge cognitive a un effet positif sur l'attitude envers le site lorsque la complexité arithmétique est élevée. Les contributions théoriques et les implications pratiques sont discutées.

Chapitre 2 : Article

The user experience of online grocery shopping sites feels like a math test: How uncertainty and task complexity predict attitude toward the site

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Abstract

Online grocery shopping is perceived as more cognitively complex that other ecommerce transaction to other online retailers (e.g., multiple decisions per shopping session, different product types, and varied arithmetical complexity). In this research, we investigate factors that may play a role in this attitude toward online grocery shopping. Specifically, we hypothesized that the influence of product types (search or experience), arithmetic task complexity, visual attention and cognitive load related to product pictures have an effect on the attitude toward the website. To test our hypotheses, 31 users participated in a laboratory experiment. Results suggest that visual attention to product pictures have a positive effect on attitude toward the website when shopping for experience goods and that it has a negative effect on attitude toward the website when arithmetic task complexity is high. Cognitive load associated to product pictures has a negative effect on attitude toward the website when shopping for experience goods and high fluctuations in cognitive load in complex tasks has a positive effect on the attitude toward the site when arithmetic task complexity is high. Theoretical contributions and managerial implications are discussed.

Keywords: online grocery shopping, experience product, uncertainty, arithmetic complexity, visual attention, cognitive load, attitude toward the site, pupil dilation

Introduction

Figures on the market penetration rate of online grocery shopping show that it has been progressing at a much slower rate than other consumer good categories. Euromonitor International Consumer survey conducted in 2012 reveals that 40% of consumers have a preference for e-commerce to conduct their non-essential purchases. For their essential purchases (which include grocery products), this figure falls to 5% (Euromonitor 2013). These findings reveal that a high proportion of consumers are already doing some of their shopping primarily online, but that essential good purchases are being left to brick and mortar stores for a significant proportion of existing e-commerce consumers.

To our knowledge, the category of essential goods has not been studied extensively in the e-commerce literature. Research on e-commerce has focused mainly on shopping sessions which involve a limited number of items being purchased. E-commerce transactions with dozens of items, such as a typical grocery list, involve repeated decisions during one single shopping session. Moreover, grocery shopping usually involves making decisions about products of different types.

In a study on consumer adoption of online grocery shopping, it has been shown that consumers that do not buy groceries on the internet but do buy other goods on the internet perceive online grocery shopping to be more complex than purchasing non-grocery goods online compared to consumers that do buy groceries online (Hansen 2005). All in all, online grocery shopping is perceived as being more cognitively complex than ecommerce transactions at other types of online retailers. A better understanding of the decision-making context of these types of e-commerce sessions should help better explain some of the factors underlying the slow adoption of online grocery shopping.

In this research, we investigate factors that may play a role in this attitude toward online grocery shopping. Two constructs that affect decision-making in online grocery shopping are considered in this study: uncertainty, caused by the type of product (search or experience) being bought and complexity, from the arithmetically complex product quantity purchasing decisions. We conducted a laboratory experiment with 31 participants to investigate these two important constructs that we suggest have an impact on the decision-making process and consequently on the user's attitude toward an online grocery shopping website.

Literature Review

Specificity of Online Grocery Shopping

While research on online shopping has been mostly focused on single item shopping contexts (e.g., Aljukhadar et al. (2012)), online grocery shopping, which is different from the typical online task on several dimensions, has rarely been studied. Online grocery shopping usually involves buying multiple items in a single online session in contrast to a typical online shopping task in which users purchase a single product (e.g., a book, a mobile phone). Online grocery shopping can be considered as a task of multiple single-product decisions when going through a list or buying the ingredients needed to make a recipe: while each subtask can take less time to perform than a typical online task, the whole process will scale linearly with the number of items on the grocery list.

The decision-making process of each subtask can also be quite challenging for consumers. A first consideration is that many food items, especially perishable foods, are not sold in standardized packages. Quantities are likely to involve decimals and variability in product weights. Also, if a customer is using a recipe to build a shopping list, he may already have partial inventory of his ingredients at home. His decision making process will therefore involve subtractions when deciding on the quantity of product to purchase. Taken together, users are thus likely to perform arithmetic operations to calculate the desired amount of a product in a majority of the decision tasks of the session. In sum, consumers are more likely to use fractions and subtractions in online grocery shopping compared to other e-commerce transactions.

Online environments also prevent consumers from touching or having a direct experience with a product before purchasing it (Peck and Childers 2003). Many grocery items are experience goods, i.e., goods for which the quality is more difficult to evaluate before its consumption. In a brick and mortar store, the quality of a perishable grocery product such as a piece of meat can be partly inferred by looking at and comparing the product to determine freshness or package size, and consequently be a source of information for assessing product quality (Lederman and Klatzky 1987). While this is not possible to physically assess product attributes when making online purchases, previous research has demonstrated that visual stimuli such as product image and description can be used to improve consumer confidence in the quality and desired attributes of products (Xiao and Benbasat 2011). The search and experience good

classification (Nelson 1970) is therefore a relevant framing to the grocery shopping experience. When online grocery shopping, search goods are easier to assess than experience goods due to the inability to assess the variable attributes of the latter, as is the case when trying to determine the freshness of perishable meat and produce before delivery of these types of product.

In order to study online grocery shopping, we need to take into account these unique characteristics and our limited information processing capacity to both evaluate product quality for experience goods and solve mathematically-complex purchasing decisions. The subjective impact of these characteristics can be evaluated through self-reported measures such as the attitude toward the site that have extensively been used in the literature for the study of the user's experience in e-commerce sites. This can therefore help uncover whether uncertainty and complexity significantly affect the users perceived attitude toward the site in the context of online grocery shopping.

Characteristics of Online Grocery Shopping

In online grocery shopping, the variations in the attributes of a product can lead the shopper to experience uncertainty when making a purchasing decision. For example, when a shopper purchases fresh meat, package weight and cuts are likely to vary in size and the value of product will be more difficult to assess than when buying boxed cookies that have less variability in the product's physical attributes. In addition to the physical characteristic variations of products when grocery shopping, shoppers are faced with complexity in their quantity purchasing decisions. Portion calculations beyond unit calculations, such as planning the ingredients to purchase for a recipe to serve to a given number of guests, are more frequent in online grocery shopping compared to when buying other consumption goods online. Therefore, complexity should be considered as an important factor in the multiple decision-making processes that occur when consumers use grocery e-commerce sites.

Uncertainty: Product Type

When consumers shop online, the type of good influences their shopping behaviour. For instance, when consumers shop for an experience good, they spend more time per web page and visit fewer pages per session than consumers shopping for a search good (i.e., a product that can be more easily evaluated before

purchase) (Huang et al. 2009). Thus, consumers process information differently when facing different types of products. Weathers et al. (2007) suggest that "the greater the need to use one's senses to evaluate a good, the more experience qualities the good possesses." Goods are defined by their set of attributes, some possess more experience attributes and some others possess more search attributes (Sheffet 1983). In the grocery context, some products are packaged goods (standardized weight, size and quality) and some other products are unpackaged goods (where weight, size, and quality can vary). We suggest that packaged goods (e.g., a can of soup) possess more search attributes whereas unpackaged goods (e.g., apples) possess more experience attributes. In a service context, prior research suggests that perceived risk increases from search to experience services (Mitra et al. 1999). Moreover, in the context of online grocery shopping, unpackaged goods represented on the website (e.g., picture of an apple) are not the actual goods that consumers will receive, increasing their perceived risk (Aljukhadar et al. 2010; Kim et al. 2009; Lee 2009). Perceived risk in e-commerce settings has a negative influence on attitude and intention toward the website (Aljukhadar et al. 2010; Lee 2009).Thus, it is suggested that experience goods will lead to a less positive attitude toward the website than search goods, the former being perceived as riskier (H1a).

Complexity: Quantity Purchasing Decisions

The neuroscience literature suggests that mathematical tasks mobilize higher cognitive functions and that several regions of both the prefrontal cortex and the inferior parietal lobe are involved in reasoning and calculation (Kroger et al. 2008). Working memory is one of the executive functions involved in mathematical tasks. Working memory is the mental workspace involved to control, regulate and maintain information to achieve a complex cognitive task, such as mathematical processing (Raghubar et al. 2010). Working memory resources are mobilized to hold interim and partial information during the processes required for solving a problem that may involve various mathematical concepts and procedures.

The complexity of the mathematical tasks influences the working memory resources involved in the processing. The complexity arises from the size of the problem and the mathematical operation involved (Raghubar et al. 2010). For instance, operations with fractions are known to be cognitively more demanding than single-digit operations. A fraction involves two pieces of information (a numerator and denominator) and appears to demand more working memory resources than representing whole numbers (Siegler et al. 2013). Recent research shows that in more complex calculations, which involve number detection or comparison, specific regions of the prefrontal area of the brain are involved in quantity

representation and manipulation while other regions serve in the management of successive operations (Dehaene et al. 2004).

Mathematical complexity can impair self-control. Based on the strength model, self-control is theorized as a finite resource that governs the capacity for effortful control over dominant response (Baumeister et al. 1998). According to this theory, self-control is limited and is susceptible to depletion over time (Hagger et al. 2010). As a consequence, once self-control is expended, the performance of subsequent acts of self-control will be impaired, leading to a state known as ego depletion. In other words, self-control is like a muscle that can be exhausted after a period of effort (Baumeister et al. 2007). Exertions of working memory may directly affect the active mental representation of an individual's self-control (Hofmann et al. 2012). The capacity to self-regulate to accomplish a goal can be affected by a task in which working memory capacity is repeatedly solicited, such as in the case of mathematically complex tasks.

Building on these arguments, this article hypothesizes that mathematically complex online shopping tasks are likely to influence the attitude toward a merchant website. Garbarino and Edell (1997) found that a task that requires more cognitive effort to evaluate can lead to more negative affect. Additionally, consumers that are in a good mood and that are exposed to especially negative stimuli may lose their good mood to a neutral or negative mood that may lead them to quit their shopping task (Swinyard 1993). We posit that online shopping tasks involving more complex mathematical operations (such as fractions), number representation (such as decimals), and partial information that needs to be held in memory, should negatively affect users' attitude toward the website (H2a).

Measuring the User Experience

Successful e-commerce websites have interfaces that create a positive user experience (UX) for their consumers (Kuusinen 2014). The perceptions and responses of a user that occur from their interaction with an IT product or service define the user experience (9241-11 1998). This goes beyond the ergonomics of a user interface. It describes the whole experience of the user while using the product. The usage context and the cognitive and affective states of the user are included in the factors that describe this experience (Hartson 2012).

In the Technology acceptance model, the most important influencers of users' information use intentions and behaviours have been shown to be behavioural beliefs, which can be defined by perceived usefulness and perceived ease of use (de Guinea et al. 2014) It has been mentioned several times in the literature that because of the exclusive use of self-reported measures, IS acceptance research is likely to suffer from common method bias (de Guinea et al. 2014; Sharma et al. 2009; Straub Jr and Burton-Jones 2007). In their study, de Guinea et al. demonstrate the importance of emotional perceptions for moderating the effects of neurophysiological states on behavioral beliefs. The results show that investigating implicit (automatic or unconscious) determinants of cognitive beliefs can reveal additional insights through potential nonlinear relationships with explicit (perceptual) antecedents (de Guinea et al. 2014) In a previous study, they also suggest that further research should be conducted to better understand the temporal correlations (Gratton 2007) between self-reported and neurophysiological measures. Research on this subject would help clarify the links between both types of measures. They also noted that in the potential occurrence of retrospective biases, their effects could be taken into account (Ortiz De Guinea et al. 2013). In the context of online grocery shopping, post-task self-reported measures are likely to involve significant retrospective bias due to the long time span of the activity and the necessity to limit task interruption to keep the experimental context as authentic as possible. The necessity to limit task interruption means that infrequent self-report sampling is likely to produce an inaccurate retrospective perceived assessment that is representative of the entire user experience occurring over the course of the task duration. Therefore, the use of non-intrusive real-time measures allows researchers to measure and isolate the user's current state during the decision-making process on informational visual stimuli.

To study the implicit determinants of cognitive beliefs during a task, the use of non-intrusive measures allows us to capture cognitive and attentional states of the user objectively and in a non-obtrusive way. The use of neurophysiological tools such as eye trackers and eye tracking software allows researchers to capture information that the subject may not be able to correctly self-report after the studied task (Riedl and Léger 2016). These objective measures can give us a more complete picture of the user's experience by expanding the scope of information that can allow us to further comprehend the subject's self-reported experience, which can be measured by the attitude toward the site in the case of the study of an online shopping site. Gaining insight on specific elements of the interface can also allow user-experience researchers to derive more specific and actionable insight on key elements of the interface instead of relying on a more global self-reported explicit satisfaction measure. Self-reported measures

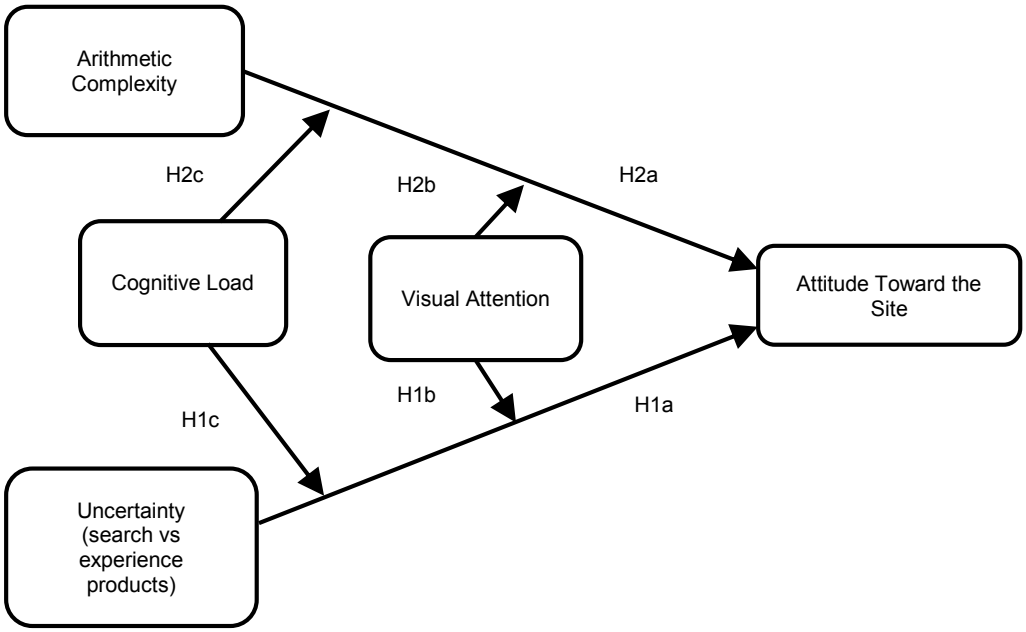
may not convey specific information about stimuli that is key for a given task or portray the repeated use of the stimuli over several decision-making tasks.

As discussed previously, perceptual and unconscious antecedents are both useful in studying the user experience. Studying how they interact offers an opportunity to better understand the nuances of the results of the research model constructs. The literature is much richer on the subject of perceptual antecedents for the study on online shopping sites. Based on the Technology Acceptance Model (TAM), prior research suggests that perceived ease of use, usefulness, and enjoyment positively influence users' responses toward a website (Elliott and Speck 2005; Van der Heijden et al. 2003). Furthermore, previous studies report a positive relationship between website product information and attitude toward a website (Chen 1999; Elliott and Speck 2005; Kwon et al. 2002; Yoo and Donthu 2001). Product information can be defined as the amount of information about products and services presented on the website, its accuracy, and format (text, tables, graphs photos, audio, and video) (Elliott and Speck 2005). Finally, a positive relationship between a website's visual attractiveness and the above TAM perceptions has been reported (Van der Heijden et al. 2003). When perceptual measures are combined with automatic measures, greater nuances can be detected and offer the possibility of enlarging the scope of contributions of a research model.

Proposed Research Model and Hypothesis

In this section, we present the proposed research model of the study (Figure 1). The goal of the model is to identify predictors of the attitude toward the site. For this research context, the predictive power of complexity and uncertainty, the two theoretical constructs of interest of the experimental design, were assessed. We are also interested in capturing the moderating effects of unconscious measures on these two theoretical constructs in order to determine whether they had a contributing effect on the user's attitude toward the site.

Figure 1: Research Model



The attitude toward a website can be defined as users' "predispositions to respond favourably or unfavourably to web content in natural exposure situations" (Wells et al. 1999). The Theory of Planned Behaviour (TPB), proposes a relationship between attitude, intention, and behaviour, which has been empirically supported in many contexts (Ajzen 1991). Thus, attitude toward the website is suggested to be important both for theory and practice because it is a behavioural antecedent.

Theoretical Constructs of Interest in Online Grocery Shopping

As discussed in the literature, uncertainty and complexity are two specificities of online grocery shopping that are likely to have an effect on the user's self-reported perception of his experience on the site. This leads to a first pair of hypotheses concerning to the two main theoretical constructs of this study:

Uncertainty: Product Type

Considering that experience goods have variable characteristics that are easier to assess when having physical access to the product, we hypothesize that online shopping of search products leads to a more positive attitude toward the website than online shopping for experience products (H1a).

Complexity: Quantity Purchasing Decisions

Considering that cumulative arithmetically complex tasks contribute to sustained cognitive load and mental effort during the repeat decision-making processes that occur over the course of an online grocery shopping session, we hypothesize that arithmetic complexity in online grocery shopping tasks has a negative influence on the attitude toward the site (H2a).

Visual Attention

Measuring visual attention on specific visual stimuli allows researchers to better understand consumers' information search strategies on the site. This helps quantify the user's experience with the site and therefore helps us gain a more precise understanding of the causes of user's self-reported perceptions, such as their attitude toward the site. It has been shown that top-down, or goal-oriented, attention refers to the voluntary allocation of attention. Users therefore direct their attention to the stimuli that is most informative for their current goal or task (Rayner et al. 2008; van der Laan et al. 2015). We hypothesize that visual attention moderates the attitude toward the site by acting a proxy for users' information search behaviour.

Uncertainty: Product Type

Weathers et al. (2007) note that online retailers need to make product information more vivid by providing pictures in order to help shoppers assess experience products. Thus, experience good product pictures should help contribute valuable information to the decision making process. Peck and Childers (2003) suggest that product pictures can partially compensate for the lack of haptic information when consumers cannot touch products. In addition to contributing decision making information, prior research suggests that vividness and aesthetically pleasing design elements are positively related to attitude toward a website (Chen 1999; Coyle and Thorson 2001; Kwon et al. 2002; McMillan et al. 2003). Thus, we suggest that consumers' attention on product pictures during their shopping session will moderate the relationship between product type and attitude toward the website. Specifically, we suggest that attention to product pictures will improve consumers' attitude toward the website when shopping for experience products. We posit that visual attention on product pictures contributes to positive attitude toward the site for experience goods (H1b).

Information processing requires cognitive effort, especially when the information displayed is not readily comprehensible (Coupey 1994). When a web-site design does not facilitate information processing, it may cause negative affect (Chen and Dubinsky 2003). It has been shown that vividness from visual stimuli such as product pictures is effective in improving consumers' understanding of products (i.e., perceived diagnosticity), in enhancing consumers' beliefs that their virtual experiences are compatible with their physical shopping behaviour (compatibility), and in improving their shopping enjoyment (Jiang and Benbasat 2007).

Based on the cognitive-affective model (Babin et al. 1994; Eroglu et al. 2001; Eroglu et al. 2003), two cognitive beliefs, perceived diagnosticity and compatibility, are identified as antecedents of attitudes toward shopping at a website in the context of online product demonstrations (Jiang and Benbasat 2007). If consumers believe that a particular website can help them understand and evaluate products, and if they believe shopping on the website is congruent with their existing experiences in physical shopping, they will form more positive attitudes toward shopping at the website (Jiang and Benbasat 2007). When information on quantities conveyed by product pictures is incoherent with accompanying text quantity descriptions, quantity calculations become confusing and information search can lead to negative affect.

In an online grocery shopping context, we suggest that product pictures that do not clearly represent the purchasing quantity indicated in the product description could weaken diagnosticity. In this experiment, product pictures did not clearly convey product quantities being purchased in mathematically complex purchase decisions. Quantities selected did not scale besides the number of units associated to a given weight or package size selected, and visual stimuli did not scale to the quantity selected. Information search is costly in time and energy, which can lead the shopping session to be perceived as unpleasant if search efforts are conceived to be excessive (Jacoby, 1984). We suggest that due to the lack of diagnosticity that users can infer from product pictures for arithmetically complex decisions, increased attention on product pictures will lead to a more negative attitude toward the site. Thereof, we posit that increased visual attention to product pictures in arithmetically complex tasks contributes to a more negative attitude toward the website (H2b).

Cognitive Load

It has been recommended that short-term memory load be kept low to improve the usability of interfaces (Schmutz 2009). Cognitive load is the working memory demanded for problem solving, reasoning, or thinking. It may affect users' satisfaction in tasks that can be described as complex (Schmutz 2009). Pupil dilation measures are demonstrated as effective ways to capture cognitive load. The pupil dilates when an increase in attentional allocation, memory use or interpretation of more difficult material is solicited from the user (Beatty 1982; Siegle et al. 2003; Steinhauer and Hakerem 1992). When high cognitive load persists, pupil dilation remains heightened. Research has shown that pupil dilation occurs in response to emotional information (Janisse 1974; Siegle et al. 2003) and is associated to brain areas related to cognitive and emotional processing (Siegle et al. 2003; Szabadi and Bradshaw 1996). Pupil dilation metrics could therefore contribute additional objective insight to multiple performance indicators of an online shopping site, such as ease of use and decision-making (cognitive indicators) and measure their effects on affective indicators such as attitude toward the site.

There is a consensus in the literature that pupil size is an accurate and unobtrusive measure of the resources invested in a task (Bijleveld et al. 2009). When controlling for luminosity and depth, research has demonstrated that pupil dilation increases when tasks require more resources due to variations within or between tasks (Bijleveld et al. 2009; Kahneman 1973; Riedl and Léger 2016) or due to individual differences in cognitive ability (Ahern and Beatty 1979; Bijleveld et al. 2009).

Uncertainty: Product Type

Other neurophysiological measures can help clarify the interpretation that is made from commonly used eye tracking metrics, such as mean fixation duration, that are best used as a way to measure visual attention. In a study of multimodal measurements of users' experience shopping online, the author makes a case for the use of multiple measures when evaluating laboratory experiment studies of online shopping (Guo et al. 2015).

As concluded by Sørensen, eye-tracking measures attention, which can indicate emotional reactions (Sørensen, 2008). It does not measure emotions (Guo et al. 2015). Therefore, other measures can bring insight in clarifying the emotions happening behind the visual attention toward some given visual

stimuli. Guo et al. points to a study made by Mahlke and Minge (2008) with results that showed that subjective feelings were significantly correlated with cognitive assessment (Guo et al. 2015).

Pupil dilation as a proxy for cognitive assessment could therefore be investigated as a predictor of subjective feelings that can be captured through metrics relevant to the task, such as the self-reported measure of attitude toward the site in the case of the study of an online grocery shopping website. A challenge that remains with the current state of the literature, as Guo et al. state, is the lack of consensus about the physiological indicators that affect emotion (Guo et al. 2015). Given the early stages of this research field, the use of these metrics to draw specific conclusions remains exploratory and further research needs to be conducted to tie specific pupil dilation measures to the user's emotional experience (Guo et al. 2015).

Since product pictures for experience goods contribute more information in the consumer's purchase decision process than in the case of search goods, excessive cognitive load could indicate that the pictures are not contributing to or may even harm the decision-making process. Therefore, sustained high cognitive load on experience good product pictures contributes to a negative attitude toward the site (H1c). More specifically, increased average pupil dilation on experience good product pictures contributes to a negative attitude toward the site (H1ci). Increased pupil dilation standard deviations on experience good product pictures contribute to a positive attitude toward the site (H1cii). The following section on complexity clarifies the use of two separate pupil dilation metrics and their respective corresponding constructs of cognitive load.

Complexity: Quantity Purchasing Decisions

Effortful, cognitive emotion regulation strategies have been shown to cause pupil dilation (Allard et al. 2010). A study by van Reekum et al. (2007) showed that increased pupil dilation may indicate the enhanced cognitive control effort required to respond to stimuli with an emotion regulation strategy (Allard et al. 2010; van Reekum et al. 2007). Given these findings, we would expect that pupil dilation would fluctuate when users engage in these demanding cognitive emotion regulation strategies, given the increased pupil size when regulating and a decreased pupil size when the subject is back to a regulated state.

Fluctuations in cognitive load have been studied in learning and research suggests that it should be viewed as a dynamic construct that reflects fluctuations in resource allocation (Xie and Salvendy 2000). Xie and Salvendy (2000) classified cognitive load into instantaneous load, peak load, accumulated load, average load and overall load. Their classification calls for online measures that capture fluctuations in load throughout a task (Xie and Salvendy 2000; Zheng and Cook 2012). They highlight the point that researchers need to select their pupil dilation metrics according to the cognitive load process they are trying to study. Their findings suggest that there may be associations and dissociations between the different measures and aspects of cognitive load (Cook et al. 2009; Xie and Salvendy 2000; Zheng and Cook 2012) To capture the variations in cognitive load, Zheng and Cook used the following methodology: they identified low and high points on the response curve and then computed the difference between each low point and every succeeding high point. They defined peak amplitude as the greatest observed difference (Zheng and Cook 2012). Fluctuations in pupil dilation have therefore been used as a metric allowing researchers to measure some of the variability in cognitive load on a given stimulus and over the time duration of the user's visual interaction with visual stimuli.

With this in mind, we posit that **s**ustained high cognitive load on product pictures in arithmetically complex tasks contributes to a more negative attitude toward the website (H2c). Increased average pupil dilation on product pictures in arithmetically complex tasks contributes to a more negative attitude toward the website (H2ci). Increased pupil dilation standard deviation, used to measure variation amplitude of cognitive load on product pictures in arithmetically complex tasks contributes to a more positive attitude toward the website (H2cii).

Methodology

Experimental design, Sample, and Procedure

To test our hypotheses, a 2 (high vs low arithmetic complexity) X 2 (search/experience goods) within-subject experiment was performed. Each participant completed an experimental session consisting of four (4) randomly ordered online grocery shopping tasks.

The experiment was approved by the Institutional Review Board (IRB) of our institution. Recruitment was done through the business school's research subject panel. Thirty-eight (38) subjects took part in the

experiment. Due to missing data and other technical issues, 31 participants were valid for analysis. 97% of these participants were between 19 and 30 years of age; 56% were male.

The experimental session started with participants giving their consent. The total duration of the experiment was of two (2) hours, with one (1) hour dedicated to set up and removal of apparatus and one (1) hour to participant task execution. An initial questionnaire was completed before the start of four online grocery shopping tasks. Each task was accompanied with a paper instruction sheet. The first step of each task was to search for the recipe indicated by the instruction sheet on the grocery shopping website. Then, the participant was instructed to purchase a predefined selection of products from the recipe. On the recipe web page, participants had to select the ingredients to purchase from the recipe. The website would then generate a searchable list from which the participants could shop for their products, select quantities and add them to the cart. Once the participant was ready for checkout, the research assistant ended the shopping task and the participant filled in a questionnaire about the task that he had just accomplished. Following the four experimental tasks and questionnaires, a final questionnaire was completed. Subjects received a gift card of 30$ as compensation for their participation in the experiment. The study was conducted over a two-week time frame and no changes occurred on the online grocery shopping website over this time period besides weekly promotions, which were not relevant to our experiment.

Manipulations and Measures

The manipulations of search/experience and arithmetic complexity were integrated into each shopping task through a detailed paper instruction sheet that the user could refer to at any time during his shopping task. In the search (experience) good condition, participants had to shop for packaged (unpackaged) goods listed on a specific recipe. To increase realism, they had to only shop for the products that they did not already have at home, which was stated on the instruction sheet. This is how experience and search goods were manipulated in each condition. In the arithmetically complex conditions, participants were instructed to scale portions or consider their balance of inventory at home, for which they had to do divisions or multiplications on fractional numbers to accomplish their task. In the non-arithmetically complex conditions, required operations were scarce and limited to additions and subtractions of integers. More specifically, in the non-arithmetically complex tasks, participants were simply asked to buy or not a product for the standard portion yields of the specified recipe. In the arithmetically complex condition,

participants had to make two to three arithmetical calculations for each purchased ingredient of the specified recipe. Practically, these calculations included: multiplying the quantities of the ingredients to scale the recipe to the number of desired portions instructed to the participant (ex. converting the ingredient requirements of a 4 portion recipe to a 6 portion recipe), subtracting a partial ingredient quantity from the total required quantity because the participant already possessed some of the required ingredient in his fridge (ex. the participant already has a 100g bag of an ingredient but requires 350g of this ingredient for his recipe), and finally converting the net required quantity of an ingredient to a unit online basket addition of the product on the online grocery website (ex. 600g of pork shoulders, which can be purchased by units, 1 unit being approx. 450g of pork shoulders on the online grocery site). Finally, in order to assess participants' information search behaviour, time spent looking at product pictures was recorded.

Figure 2: Experimental Design and Tasks

Manipulations (2×2, within subject, randomized)	Low Arithmetic Complexity*	High Arithmetic Complexity*
Packaged Goods	Recipe A	Recipe B
Unpackaged Goods	Recipe C	Recipe D

*Valid manipulation check on complexity, p-value=0.001

In addition, participants completed a manipulation check question after each online grocery task for arithmetic complexity. The manipulation check question was *The online grocery task that I did was*: (very difficult to very easy, 7-point scale). As expected, a paired t-test showed a significant difference between less arithmetically complex (M=4.38) and more arithmetically complex tasks (M=3.09; $p < 0.001$), thus showing the effectiveness of the task complexity manipulation.

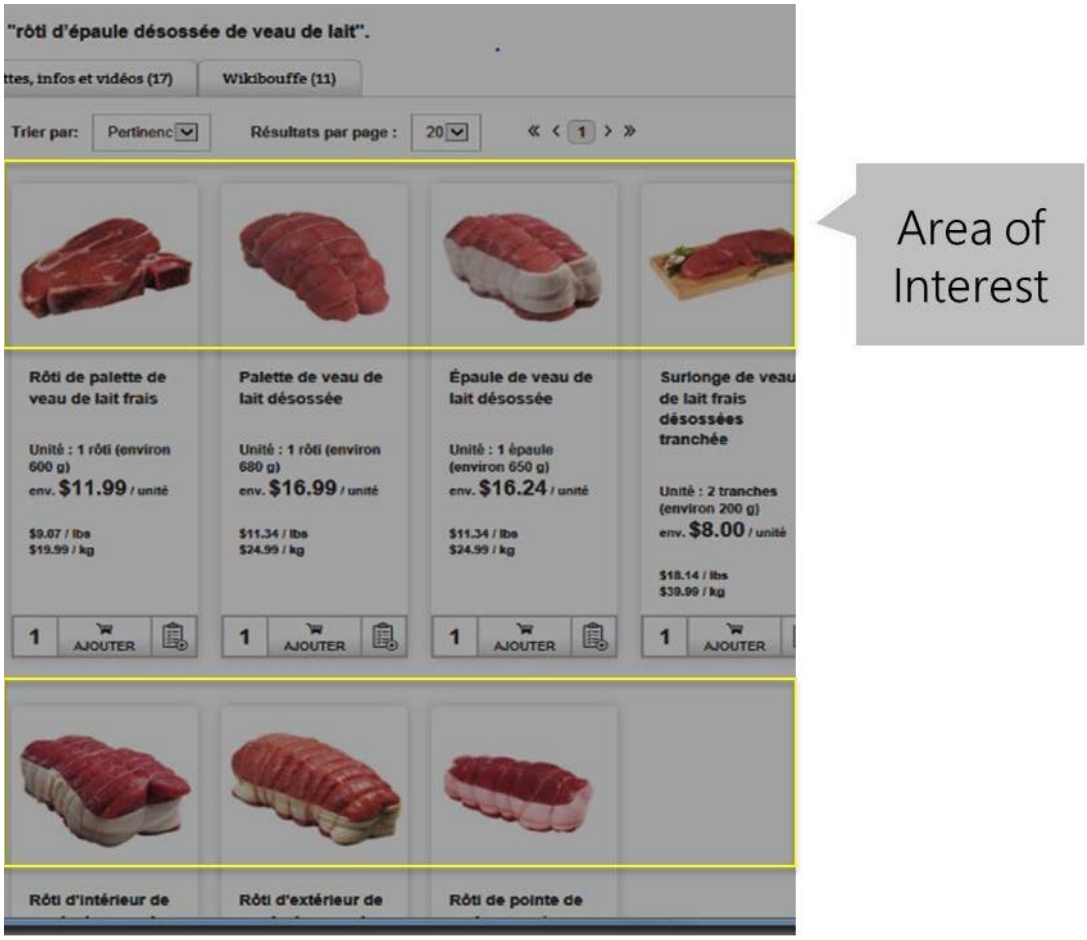
Operationalisation of Variables

Attitude toward the site was measured using Chen and Wells (1999) 7-point measurement scale. Its reliability was satisfactory (Cronbach alpha: 0.88). Visual attention on product pictures was measured by the mean fixation duration (in seconds). In this study, we hypothesized that average and standard deviation of pupil dilation would be relevant metrics to capture cognitive load for the research model constructs. Maximum and minimum pupil diameter were also included in the model for exploratory purposes. The standard deviation was chosen to derive comparable insights to those provided by peak amplitude, which was discussed previously as an indicator of fluctuations in cognitive load. All pupil dilation measures are measured in millimetres.

Apparatus, Data Acquisition, and Analysis

A Tobii X-60 (Tobii Technology AB) eye tracker was used to record subjects' eye movement patterns. Tobii Studio v3.2 was used to process the acquired data and compute the fixation duration on product pictures. Two (2) of the first four (4) products from each condition were selected for the generation of eye-tracking metrics. On each of these product pages, areas of interest (Figure 3), were defined to delimit the product pictures. Mean fixation durations on each AOI group were then generated for each participant using Tobii Studio. AOI groups aggregate eye tracking data from individual AOIs using Tobii Studio. In our case, AOIs are aggregated by experimental condition (Figure 2). Pupil dilation metrics were extracted using the same AOI groups. Three participants' pupil dilation metrics were imputed with the overall participant mean of the given complexity-uncertainty condition due to missing data. These measures were then used for statistical analysis using Stata (Stata).

Figure 3: Product Picture Area of Interest for Eye Tracking Data Analysis



To test the proposed hypotheses, a linear regression was used to fit a model with the following independent variables: mean fixation duration for product pictures and *add* buttons; average, standard deviation, maximum and minimum pupil dilation on product pictures; arithmetical complexity task dummy; product type task dummy. All interaction terms with arithmetic complexity dummy and product type dummy were created on the mean fixation duration variables and the pupil dilation variables and were included with the independent variables of the model. Attitude toward the site was set as the dependent variable. Observations were non-independent, with four (4) consecutive tasks per subject. Therefore, a regression model for repeated measures was performed using Stata (StataCorp LP, Texas). The absence of multicollinearity in the model (with search/experience and complexity) was verified and confirmed.

The regress command was used to fit the robust linear regression. In Stata, the regress command fits a model of depvar (dependent variable) on indepvars (independent variables) using linear regression. Robustness was specified with the vce(vcetype) command specification which specifies the type of

standard error reported […] to allow for intragroup correlation for vce(cluster clustvar). (Stata) The cluster variable (clustvar) was defined as the participant ID. Stata describes the robustness specification as following: "vce(cluster clustvar) specifies that the standard errors allow for intragroup correlation, relaxing the usual requirement that the observations be independent. That is to say, the observations are independent across groups (clusters) but not necessarily within groups. Clustvar specifies to which group each observation belongs, for example, vce(cluster personid) in data with repeated observations on individuals. vce(cluster clustvar) affects the standard errors and variance– covariance matrix of the estimators but not the estimated coefficient" (Stata). The regression was conducted as described above (R-square= 0.284, p-value=0.0001). Additionally, we controlled for order among the four tasks and the model shows no significant learning effects (p-value=0.136).

Results

First, descriptive statistics were computed to ensure that all data was within expected value ranges and to ensure that there were no extreme values (Table 1). The global mean attitude toward the site was 4.3 on a seven-point scale. Fixation duration is measured in seconds and pupil dilation in millimetres.

Table 1: Descriptive Statistics

stats	fix_dur_add (seconds)	fix_dur_picture (seconds)	picture _pupil_avg (millimetres)	picture_ pupil _stdev (millimetres)	picture _ pupil _min (millimetres)	picture _ pupil _max (millimetres)	Attitude Toward the Site (7 points likert scale)
mean	0.21	0.20	3.17	0.16	2.84	3.65	4.30
sd	0.05	0.04	0.28	0.06	0.26	0.39	1.00
min	0.08	0.13	2.53	0.06	2.27	2.78	1.07
max	0.36	0.37	3.99	0.34	3.57	4.78	6.17
N	127	127	127	127	127	127	123

Table 2 presents the regression model that provides the results to the hypotheses targeted by the research model:

Table 2: Moderating effects of visual attention and pupil dilation metrics on product pictures for experience goods and arithmetically complex shopping tasks on attitude toward the site

Dependant variable: Attitude Toward the Site (7-point Likert scale)	**Coef.**	**p-value**
constant	5.62	0.020
1. order	0.12	0.136
2. exp	1.60	0.217*
3. comp	-0.15	0.463*
4. fix_dur_picture	-9.66	0.074
5. fix_dur_add	5.74	0.197
6. picture _pupil_avg	1.40	0.590
7. picture_ pupil _stdev	10.20	0.177
8. picture _ pupil _min	-3.30	0.225
9. picture _ pupil _max	1.53	0.230
10. exp*fix_dur_ picture (H1b)	**8.86**	**0.036***
11. exp *fix_dur_add	-7.99	0.128
12. comp*fix_dur_ picture (H2b)	**-6.61**	**0.053***
13. comp*fix_dur_add	0.11	0.976
14. exp* picture _ pupil _avg (H1ci)	**-5.57**	**0.036***
15. exp * picture _ pupil _stdev (H1cii)	3.95	0.311*
16. exp * picture _ pupil _min	4.41	0.148
17. exp * picture _ pupil _max	0.76	0.618
18. comp* picture _ pupil _avg (H2ci)	0.07	0.489*
19. comp* picture _ pupil _stdev (H2cii)	**10.79**	**0.029***
20. comp* picture _ pupil _min	1.90	0.364
21. comp* picture _ pupil _max	-1.62	0.152

Regression Cluster by participant ID
R-squared=0.284, N=123, p-value=0.0001
*one-tailed p-values

Notes.

1. *order:* sequence of tasks/learning effect;
2. ***exp: exp:*** **experiential products task condition;**
3. ***comp:*** **arithmetically complex task condition*;***
4. *fix_dur_picture :* fixation duration on the product picture*;*
5. *fix_dur_add :* fixation duration on the area where the purchasing quantity is inputted and confirmed;
6. *picture _pupil_avg:* average pupil dilation on product pictures;
7. *picture_ pupil _stdev:* pupil dilation standard deviation on product pictures;
8. *picture _ pupil _min:* minimum pupil dilation on product pictures;
9. *picture _ pupil _max:* maximum pupil dilation on product pictures;
10. ***exp*fix_dur_ picture (H1b):*** **fixation duration on the product picture in an experiential**

product type task (exp=1)*;*

11. *exp *fix_dur_add:* fixation duration on the area where the purchasing quantity is inputted and confirmed in an experiential product type task (exp=1);
12. ***comp*fix_dur_ picture (H2b):* fixation duration on the product picture in an arithmetically complex task (comp=1)*;***
13. *comp*fix_dur_add:* fixation duration on the area where the purchasing quantity is inputted and confirmed in an arithmetically complex task (comp=1);
14. ***exp* picture _ pupil _avg (H1ci):* average pupil dilation in an experiential product type task (exp=1);**
15. ***exp * picture _ pupil _stdev (H1cii):* pupil dilation standard deviation in an experiential product type task (exp=1);**
16. *exp * picture _ pupil _min:* minimum pupil dilation in an experiential product type task (exp=1);
17. *exp * picture _ pupil _max:* maximum pupil dilation in an experiential product type task (exp=1);
18. ***comp* picture _ pupil _avg (H2ci):* average pupil dilation on the product picture in an arithmetically complex task (comp=1);**
19. ***comp* picture _ pupil _stdev (H2cii):* pupil dilation standard deviation on the product picture in an arithmetically complex task (comp=1);**
20. *comp* picture _ pupil _min:* minimum pupil dilation on the product picture in an arithmetically complex task (comp=1);
21. *comp* picture _ pupil _max:* maximum pupil dilation on the product picture in an arithmetically complex task (comp=1);

First, experiential product shopping tasks (H1a) and arithmetically complex tasks (H2a) were hypothesized to influence attitude toward the site negatively. A paired t-test showed that attitude toward the site was not different between experience goods (mean= 4.28) and search goods (mean=4.32, p-value=0.201). No difference was observed between arithmetically complex tasks (mean=4.28) and less arithmetically complex tasks (mean=4.33, p-value=0.199) in terms of attitude toward the site. Thus, H1a and H2a were not supported.

The regression results are presented in Table 2. For H1b and H2b, it was expected that visual attention on product pictures would have a moderating effect on the relationships proposed in H1a and H2a. Increased visual attention to pictures of experiential products has a significant positive moderating effect on attitude toward the site (H1b coefficient=8.86, p-value(one-sided) =0.03). For arithmetically complex tasks, increased visual attention to product pictures has a significant negative effect on attitude toward the site (H2b coefficient= -6.61, p-value(one-sided) = 0.05). Results supported H1b and H2b.

As hypothesized, two pupil dilation metrics were of interest for the measure cognitive load: average pupil dilation and pupil dilation standard deviation. For product types, we hypothesized that an increased average pupil dilation on product pictures of experiential products has a moderating effect contributing to a negative attitude toward the site (H1ci coefficient=-5.57, p-value(one-sided) =0.04). For the second cognitive load metric, we hypothesized that an increased pupil standard deviation on product pictures of experiential products has a positive moderating effect on attitude toward the site (H1cii coefficient=3.95, p-value(one-sided) =0.311). Concerning cognitive load and product types, H1ci was supported, whereas H1cii was not supported.

In arithmetically complex tasks, we hypothesized that an increased average pupil dilation on product pictures has a negative moderating on the attitude toward the site (H2ci coefficient=0.07, p-value(one-sided) =0.489). For the second cognitive load metric, we hypothesized that in arithmetically complex tasks, an increase in the pupil dilation standard deviation when looking at product pictures has a significant positive effect on attitude toward the site (H2cii coefficient= 10.79, p-value(one-sided) = 0.029). H2ci was not supported, whereas H2cii was supported. Table 3 summarizes the supported and unsupported hypotheses.

Table 3: Hypothesis Results

Uncertainty: Product Type	
H1a Online shopping of search products leads to a more positive attitude toward the website than online shopping for experience products	**Unsupported**
H1b Visual attention on product pictures, measured by mean fixation duration, contributes to positive attitude toward the site for experience goods	**Supported**
H1c Sustained high cognitive load on experience goods product pictures contribute to a negative attitude toward the site	**Partially Supported**
H1ci Increased average pupil dilation on experience good product pictures contributes to a negative attitude toward the site	**Supported**
H1cii Increased pupil dilation standard deviation on experience goods product pictures contributes to a positive attitude toward the site	**Unsupported**
Complexity: Arithmetic Complexity in Quantity Purchasing Decisions	
H2a Arithmetic complexity in online grocery shopping tasks has a negative influence on the attitude toward the site.	**Unsupported**
H2b Visual attention to product pictures in arithmetically complex tasks, measured by mean fixation duration, contributes to a more negative attitude toward the website	**Supported**
H2c Sustained high cognitive load on product pictures in arithmetically complex tasks contributes to a more negative attitude toward the website	**Partially Supported**
H2ci Increased average pupil dilation on product pictures in arithmetically complex tasks contributes to a more negative attitude toward the website	**Unsupported**
H2cii Increased pupil dilation standard deviation on product pictures in arithmetically complex tasks contributes to a more positive attitude toward the website	**Supported**

Discussion and concluding comments

The goal of this research was to gain insight into complex e-commerce sessions such as online grocery shopping. The results of the study show that increased visual attention to product pictures (mean fixation duration) has a positive moderating effect on the attitude toward the site when shopping for experience goods, and a negative moderating effect on the attitude toward the site when making complex quantity purchasing decisions when product pictures contribute conflicting information in the decision-making task. Sustained high cognitive load (average pupil dilation) on product pictures of experience goods has a negative moderating effect on the attitude toward the site, whereas high variations in cognitive load (pupil dilation standard deviation) in complex quantity purchasing decisions has a positive moderating effect on the attitude toward the site.

These results reinforce the relevance enriching the study of self-reported measures of the user experience on e-commerce sites with automatic measures. Two seemingly important characteristics of online grocery shopping, uncertainty and complexity, seemingly have no effects on the attitude toward the site, until automatic measures nuance the effects of the self-reported measures. This is important in e-commerce research where long sessions are necessary to create an authentic experimental context and where researchers may be losing important information that users have difficulty remembering or wording after their complex interactions with a site. This may explain why H1a and H2a were not supported, given that the effects could not be significantly captured solely with self-reported measures over the course of the long tasks.

The current study has limitations that need to be acknowledged. The selection of relevant pupil dilation metrics in the study of e-commerce sites remains somewhat exploratory and future research should further expand on the current exploratory efforts in the literature of clearly discriminating the interpretations that can be made on different cognitive load metrics. This study attempted to gain further insight into the practical use of these metrics by gaining insight into cognitive load on e-commerce sites. Future studies should seek to control the experimental design around these different pupil dilation metrics in order to clarify the validity of their interpretation related to different components of cognitive load.

Although adequate, the sample size is limited and taken from a homogeneous population consisting mostly of undergraduate students. Additional research using different populations should be conducted. Our

context was limited to online grocery shopping. It would be interesting to investigate if the moderating effects of product pictures remain supported in other contexts. Product pictures are only one way to graphically depict a product in e-commerce. Studies should be performed to test how other product representations (3D, animations, etc.) interact with task characteristics such as product type and arithmetical task complexity. Finally, information diagnosticity and cognitive load need to be investigated in e-commerce settings in order to better understand and determine which information best suit users in their decision-making process.

These results make the following theoretical contributions. First, results suggest that online task characteristics do not only influence behaviour across web pages (e.g., Huang et al. (2009)), but also within web pages. Specifically, in our study, participants' fixations on product pictures did interact with task characteristics to influence their attitude toward the website. Second, it contributes to the body of knowledge on search-experience product categorization by showing that consumers focus more on product pictures when shopping for experience goods. Third, it contributes to research on the interplay of cognition and affect, by showing that product pictures may also play a moderating role in complex online tasks.

For managers, results underscore the importance of product pictures on websites. For decisions involving experience goods, product pictures may act as an important complementary information source and may be more diagnostic than text description. Thus, appealing and representative pictures must be used. However, in arithmetically complex tasks, product pictures may negatively affect consumers' attitude toward the website. In order to mitigate this effect, retailers need to show product pictures aligned with the decision-making process. For instance, if the user is trying to figure out the price/weight of an item (e.g., banana) and the product picture shows more than one item, this misalignment may negatively affect the users' perceptions toward the website.

The results of this study also indicate that people involved in the conception and improvements of online grocery sites should keep in mind the user's experience of dealing with uncertainty and complexity in their purchasing decisions when deciding how to convey decision-making information through product pictures. Product pictures are especially important to assessing the product being purchased for experience goods. Careful consideration should be put into highlighting product attributes in order to ease decision-making. Items should be pictured to clarify all product attributes, including product size and package as

well as showcasing the product itself to assess variable attributes (for examples, bagged apples should be pictured in their selling packaging while also making the apple attributes (type, colour, size) as clear as possible to the shopper so that decision-making is as easy and feels as closely certain to if he were to make his purchase in a physical store. Effective and diagnostic product pictures for experience goods should therefore consume the user's visual attention to positively affect their attitude toward the site. However, if some of the product pictures hamper diagnosticity and provide conflicting or unclear information to the user, cognitive load would be expected to increase on average and contribute to decreasing the shopper's attitude toward the site. The use of pupil dilation metrics can therefore help UX testers validate whether their product pictures for experience goods are as effective as they could be.

Similar insight can be used to improve the user experience of dealing with arithmetically complex purchasing decisions. Our findings show that product pictures that are not conductive to easy product quantity purchase decisions contribute to a decrease attitude toward the site. Therefore, when designing online grocery websites, providing clear single unit quantities with pictures corresponding to the sales unit could help establish a clear baseline on which consumers can work out their quantity requirements. For example, when selling sausages available in different pack sizes, this package size should be clearly obvious on the product picture. Our results show that larger variations in pupil dilation, as measured through pupil dilation standard deviation, contribute to a positive attitude toward the site. Some amount of high cognitive load is inevitable when making complex quantity purchasing decisions. However, limiting the duration of the increased cognitive load and bringing it back to a lower state seems to be an indicator that the shopper has resolved his problem with the help of the visual stimuli. UX designers should therefore seek to offer comprehensible images and other visual cues that can aid in decision-making. For example, product pictures could adjust to the quantity selected by the user to support decision making with visual quantity estimations. Further research on these types on tools and their effects on cognitive load could be pertinent to the field.

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Chapitre 3 : Conclusion

3.1 Questions de recherche et méthodologie

Le but de ce projet de recherche était de mieux comprendre les séances de magasinage en ligne complexes telles que les achats d'épicerie en ligne.

L'étude que nous avons effectuée cherchait à répondre aux questions suivantes en lien avec les caractéristiques du magasinage de produits en ligne :
En lien avec l'incertitude reliée au type de produit, nous cherchons à répondre aux questions suivantes :

1.a Le magasinage en ligne de produits de recherche mène-t-il à une attitude envers le site web plus positive que pour le magasinage de produits d'expérience ?

1.b L'attention visuelle sur les photos de produit contribue-t-elle positivement à l'attitude envers le site pour les produits expérientiels ?

1.c Une charge cognitive soutenue et élevée sur les photos de produits expérientiels contribue-t-elle à une attitude négative envers le site ?

En lien avec la complexité arithmétique dans la prise de décision de la quantité d'achat de produits, les questions suivantes sont posées :

2.a La complexité arithmétique des tâches de magasinage d'épicerie en ligne a-t-elle une influence négative sur l'attitude envers le site ?

2.b Est-ce que l'attention visuelle sur les photos de produit dans les tâches mathématiquement complexes contribue à une attitude négative envers le site ?

2.c Est-ce qu'une charge cognitive élevée et soutenue sur les photos de produit dans les tâches d'achat de produits arithmétiquement complexes contribue à une attitude négative envers le site ?

Pour tester les hypothèses, 31 participants ont participé à une expérience en laboratoire. Le design expérimental a été conçu comme un modèle en 2 (haute vs faible complexité arithmétique) X 2 (produits de recherche vs d'expérience) entre sujets. Chaque participant a complété une séance expérimentale consistant en quatre tâches d'achat d'épicerie en ligne présentées dans un ordre randomisé.

L'attitude envers le site a été mesurée sur une échelle de 7-items de Chen and Wells (1999). Sa fiabilité est satisfaisante (Alpha de Cronbach : 0.88). L'attention visuelle sur les photos de produits a été mesurée

par la durée de fixation moyenne (en secondes). Dans cette étude, nous avons fait l'hypothèse en fonction de la littérature existante que la dilatation moyenne et l'écart type de la dilatation de la pupille soient des mesures pertinentes pour opérationnaliser la charge cognitive dans les construits du modèle de recherche.

Un oculomètre Tobii X-60 (Tobii Technology AB) a été utilisé pour enregistrer les données oculométriques des sujets. Tobii Studio v3.2 a été utilisé pour traiter les données oculométriques des participants. Des groupes de zones d'intérêts ont été créés sur les stimuli visuels pour traite les données oculométriques par condition expérimentale.

Les analyses statistiques des données ont été faites sur des données en panel. Les observations étaient non indépendantes, avec quatre (4) taches consécutives par sujet. Une régression avec un modèle pour mesures répétées a été produit dans Stata (StataCorp LP). Le modèle de régression avec interactions tenant compte de la corrélation intra sujet a été utilisé pour produire les résultats. La commande regress a été utilisée pour produire la régression linéaire robuste. La robustesse a été spécifiée avec l'option de commande vce(vcetype), qui spécifie le type d'erreurs standard rapporté. Dans notre cas, le modèle permet la corrélation intragroupe avec la variable clustvar étant définie comme l'ID du participant en utilisant vce(cluster clustvar). (Stata)

3.2 Principaux résultats

Les résultats démontrent qu'une attention visuelle accrue sur les photos de produits contribue positivement à l'attitude envers le site lors du magasinage de produits d'expérience. Une attention visuelle accrue contribue négativement à l'attitude envers le site lorsque des décisions sur des quantités d'achats de produits complexes doivent être prises sur des photos de produit qui offrent de l'information conflictuelle sur les quantités entre la photo de produit et la description du produit. Une charge cognitive élevée et soutenue sur les photos de produits de biens expérientiels a un effet modérateur négatif sur l'attitude envers le site, alors que de grandes variations dans la charge cognitive dans les tâches d'achats de produits où les prises de décision sur les quantités d'achats sont complexes ont un effet modérateur positif sur l'attitude envers le site.

3.3 Contributions à la littérature

3.3.1 Contributions théoriques

Les résultats apportent les contributions théoriques suivantes. Premièrement, les résultats suggèrent que les caractéristiques des tâches d'achats en ligne influence non seulement le comportement de l'utilisateur à travers les différentes pages du site (e.g., Huang et al. (2009)), mais aussi à l'intérieur même d'une même page. Plus spécifiquement, dans notre étude, les fixations des participants sur les photos de produits démontrent que des interactions avec les caractéristiques de la tâche influencent leur attitude envers le site. Deuxièmement, l'article contribue à la recherche antérieure sur la catégorisation de produits de recherche et d'expérience avec la démonstration que les consommateurs portent plus d'attention sur les photos de produits quand ils magasinent des produits expérientiels. Troisièmement, l'article apporte des contributions à la recherche sur le lien entre la cognition et l'émotion en démontrant que les photos de produits peuvent avoir un rôle modérateur dans des tâches d'achats en ligne complexes.

Les résultats renforcent aussi la pertinence d'enrichir l'utilisation de mesures auto rapportées de l'expérience de l'utilisateur sur des sites transactionnels en ligne. Incorporer des mesures automatiques qui permettent de capturer en temps réel et de façon non intrusive l'état actuel sur des tâches de longue durée peut s'avérer un démarche méthodologique clé dans la compréhension d'expérience vécue par le participant. Par rapport à cette contribution, notre étude démontre en pratique que deux caractéristiques d'une apparence importance dans l'achat d'épicerie en ligne, l'incertitude et la complexité, n'ont à première vue aucune influence sur l'attitude envers le site. Par contre, lorsque des mesures automatiques viennent nuancer leurs effets sur les mesures auto rapportées, on peut conclure que ces caractéristiques ont en effet un impact significatif sur l'expérience de l'utilisateur sur le site. Cet enrichissement de la littérature sur l'étude de sites d'achats en ligne est d'une importance considérable si on considère que de longues durées des séances d'achats en ligne sont nécessaires afin de créer un contexte expérimental authentique. Les chercheurs sont à risque de perdre de l'information importante que les utilisateurs auraient de la difficulté à rapporter ou formuler à la suite de leurs interactions complexes et multiples avec le site. Ceci contribue possiblement à expliquer pourquoi H1a et H2b n'ont pas été supportés dans notre étude.

3.3.2 Contributions pratiques

Pour les praticiens qui opèrent des sites d'achats en ligne, les résultats démontrent l'importance des photos de produit sur leurs sites transactionnels. Pour la prise de décision d'achat sur des produits expérientiels, les photos de produit peuvent agir comme une source d'information complémentaire importante et peuvent être plus conclusives dans la prise de décision qu'une description texte. Considérant ceci, des photos de produits attrayantes et représentatives devraient être utilisées sur les sites d'achats d'épicerie en ligne. Dans le cas des tâches arithmétiquement complexes, afin d'éviter que les photos de produits affectent négativement l'attitude du consommateur envers le site, celles-ci devraient être alignées avec le processus décisionnel des quantités d'achat. Par exemple si l'utilisateur essaie de déterminer le prix au poids d'un aliment, par exemple une banane, et que la photo de produit montre plus qu'une unité de produit, l'incohérence entre les deux sources d'informations présentées peut affecter l'attitude du consommateur envers le site négativement.

Les résultats de cette étude indiquent aussi que les gens impliqués dans la conception et l'amélioration des sites d'épicerie en ligne devraient garder en tête l'incertitude et la complexité que doit gérer le consommateur dans ses décisions et adapter en conséquence la façon de transmettre l'information contribuant à la prise de décision à travers les photos de produit. Les photos de produit sont surtout importantes pour faciliter la prise de décision sur l'achat de produits expérientiels. Une attention particulière devrait être portée à mettre en valeur les attributs du produit afin de faciliter le processus décisionnel. Les items devraient être photographiés de façon à clarifier les attributs de produits importants à la prise de décision, incluant la grosseur du produit ou de son emballage en plus de donner de la visibilité au produit alimentaire même afin d'assimiler ses différents attributs variables. Par exemple, des pommes vendues en sac devraient être photographiées dans leur emballage de vente tout en transmettant aussi les attributs de la pomme (son type, sa couleur, sa grosseur) de façon aussi claire que possible au consommateur afin que sa prise de décision soit facile et aussi rapprochées de son expérience de prise de décision lorsqu'il achète le produit en magasin physiquement. Des photos de produits efficaces et qui facilitent la prise de décision pour les produits expérientiels devraient donc consommer l'attention visuelle du consommateur afin d'affecter positivement son attitude envers le site. Toutefois, si les photos de produit nuisent à la prise de décision et fournissent de l'information conflictuelle ou floue au consommateur, la charge cognitive devrait augmenter et contribuer négativement à l'attitude du consommateur envers le site. L'utilisation de mesures de dilatation de la pupille peut alors aider les

chercheurs qui effectuent des tests UX à valider si leurs photos de produits pour les biens expérientiels sont aussi efficaces qu'elles pourraient l'être.

Une logique similaire peut être utilisée pour améliorer l'expérience de l'utilisateur avec les décisions d'achats arithmétiquement complexes. Nos résultats montrent que les photos de produits qui ne facilitent pas la prise de décision sur les quantités d'achats contribuent à diminuer l'attitude envers le site. Avec ceci en tête, les professionnels qui conçoivent des sites d'épicerie en ligne devraient penser à fournir des quantités unitaires uniques simples avec des photos de produit qui correspondent au format de l'unité de vente du produit. Ceci permet donc d'établir une quantité unitaire claire qui offre une base sur laquelle les consommateurs peuvent dériver leurs quantités d'achats de produit requises. Par exemple, dans le cas saucisses vendues dans différents formats de paquets, la grosseur du paquet devrait être clair sur la photo du produit. Les résultats de cette étude démontrent que des variations plus grandes de la dilatation de la pupille contribuent à une attitude positive envers le site. Un niveau minimal de charge cognitive est inévitable lors de la prise de décision de quantités d'achats complexes. Toutefois, limiter la durée de la charge cognitive élevée et la ramener à un état moins élevé semble être un indicateur que le consommateur a résolu son problème décisionnel à l'aide du stimulus visuel. Les concepteurs UX devraient donc s'efforcer de présenter dans leurs sites des images compréhensibles et d'autres indicateurs visuels qui peuvent aider à faciliter la prise de décision. Par exemple, les photos de produits pourraient être conçues interactivement de façon à ajuster le visuel selon la quantité sélectionnée par l'utilisateur du site. Ceci permettrait de faciliter la prise de décision à l'aide d'un support visuel aux estimations de quantités. De la recherche additionnelle sur ce genre de fonctionnalités pourrait être pertinente au champ de recherche.

3.4 Limites et recherche future

Cette étude présente des limitations qui doivent être mentionnées afin de contextualiser les résultats. Premièrement, la sélection de mesures pupilométriques pertinentes dans le contexte de l'étude de sites d'achats en ligne demeure en quelque sorte exploratoire et de la recherche future devrait élargir les efforts et résultats de nature exploratoires qu'on retrouve actuellement dans la littérature. Une première piste à explorer davantage serait de discriminer clairement les interprétations qui peuvent être faites sur différentes mesures reliées à la charge cognitive. Cette étude a tenté d'explorer l'utilisation pratique de ce type de mesures afin de fournir davantage d'information sur la charge cognitive dans l'utilisation de sites transactionnels. Des études futures devraient miser de contrôler le design expérimental sur différentes

mesures de dilatation de la pupille afin de clarifier la validité de leur interprétation reliée aux différents types de charge cognitive.

Bien qu'il soit adéquat, la taille de l'échantillon est limitée et prise d'une population homogène constituée principalement d'étudiants du premier cycle universitaire. De la recherche utilisant différentes populations devrait être conduite.

Enfin, l'information décisionnelle et la charge cognitive devraient être étudiées dans des contextes d'achats en ligne afin de mieux comprendre et déterminer quelle information convient le mieux aux utilisateurs dans leur processus décisionnel.

Annexe : Article sommaire de la phase 1 de recherche

Première phase de recherche de l'article présentée à The 14th Annual Pre-ICIS Workshop on HCI Research in MIS Sponsored by AIS SIGHCI (Desrochers et al. 2015)

The Influence of Product Type, Mathematical Complexity, and Visual Attention on the Attitude toward the Website: The Case of Online Grocery Shopping

Abstract

Online grocery shopping possesses unique characteristics compared to other online retailers (e.g., multiple decisions per session, different product types, and varied arithmetical complexity). This research investigates the influence of product types (search or experience), arithmetic task complexity, and visual attention to product pictures on attitude toward the website. To test our hypotheses, 32 users participated in a laboratory experiment. Results suggest that visual attention to product pictures have a positive effect on attitude toward the website when shopping for experience goods and that it has a negative effect on attitude toward the website when arithmetic task complexity is high. Theoretical contributions and managerial implications are discussed.

Keywords

Online grocery shopping, experience product, arithmetic complexity, visual attention, attitude toward the site.

Introduction

In this research project, we conducted a laboratory experiment with 32 participants to investigate two important factors that we suggest have an impact on the decision-making process and consequently on the user attitude toward an online grocery shopping website: i) the type of good being purchased and ii) the mathematical calculation involved in purchasing multiple quantities of an item. Furthermore, we investigate how visual attention on product pictures moderates these relationships.

Literature Review and Hypotheses

Specificity of Online Grocery

While research on online shopping has been mostly focused on single item shopping contexts (e.g. book purchases), online grocery shopping, which is different from the typical online task on several dimensions, has been rarely studied. A first consideration is that, many food items, especially perishable foods, are not sold in standardized weight packages. Consumers are therefore more likely to use fractions and subtractions in online grocery shopping compared to other e-commerce transactions. Additionally, the search and experience good classification (Nelson 1970) is a relevant framing to the grocery shopping experience due to the inability to assess the variable attributes of experience goods before delivery of the product. In order to study online grocery shopping, we need to take into account these unique

characteristics and our limited information processing capacity to both evaluate product quality for experience goods and solve mathematically complex purchasing decisions.

Attitude Toward the Site

The attitude toward a website can be defined as users' "predispositions to respond favourably or unfavourably to web content in natural exposure situations" (Wells et al. 1999). The Theory of Planned Behaviour (TPB), proposes a relationship between attitude, intention, and behaviour, which has been empirically supported in many contexts (Ajzen 1991). Thus, attitude toward the website is suggested to be important both for theory and practice because it is a behavioural antecedent.

Based on the Technology Acceptance Model (TAM), prior research suggests that perceived ease of use, usefulness, and enjoyment positively influence users' responses toward a website (Elliott and Speck 2005; Van der Heijden 2003). Furthermore, prior research reports a positive relationship between website product information and attitude toward a website (Chen 1999; Elliott and Speck 2005; Kwon et al. 2002; Yoo and Donthu 2001). Product information can be defined as the amount of information about products and services presented on the website, its accuracy, and format (text, tables, graphs photos, audio, and video) (Elliott and Speck 2005). Finally, a positive relationship between a website's visual attractiveness and the above TAM perceptions has been reported (Van der Heijden 2003).

Product Type

When consumers shop online, the type of good influences their shopping behaviour. For instance, when consumers shop for an experience good (i.e., a product that is difficult to evaluate before purchase) they spend more time per web page and visit fewer pages per session than consumers shopping for a search good (i.e., a product that can be more easily evaluated before purchase) (Huang et al. 2009). Thus, consumers process information differently when facing different types of products. Weathers et al. (2007) suggest that "the greater the need to use one's senses to evaluate a good, the more experience qualities the good possesses." Goods are defined by their set of attributes, some possess more experience attributes and some others possess more search attributes (Sheffet 1983). In the grocery context, some products are packaged goods (standardized weight, size and quality) and some other products are unpackaged goods (where weight, size, and quality can vary). We suggest that packaged goods (e.g., a can of soup) possess more search attributes whereas unpackaged goods (e.g., apples) possess more experience attributes. In a service context, prior research suggests that perceived risk increases from search to experience services (Mitra et al. 1999). Moreover, in the context of online grocery shopping, unpackaged goods represented on the website (e.g., picture of an apple) are not the actual goods that consumers will receive, increasing their perceived risk (Aljukhadar et al. 2010; Kim et al. 2009; Lee 2009). Perceived risk in e-commerce settings has a negative influence on attitude and intention

toward the website (Aljukhadar et al. 2010; Lee 2009).Thus, it is suggested that experience goods will lead to a less positive attitude toward the website than search goods, the former perceived as more risky,

H1 Online shopping of search products leads to a more positive attitude toward the website than online shopping for experience products.

Weathers et al. (2007) note that online retailers need to make product information more vivid by providing pictures in order to help shoppers assess experience products. Thus, product pictures should be more diagnostic for experience goods than search goods. In addition, Peck and Childers (2003) suggest that product pictures can partially compensate for the lack of haptic information when consumers cannot touch products. Prior research suggests that vividness and aesthetically pleasing design elements are positively related to attitude toward a website (Chen 1999; Coyle and Thorson 2001; Kwon et al. 2002; McMillan et al. 2003). Thus, we suggest that consumers' attention on product pictures during their shopping session will moderate the relationship between product type and attitude toward the website. Specifically, we suggest that attention to product pictures will improve consumers' attitude toward the website when shopping for experience products.

H2 Visual attention on product pictures contributes to positive attitude toward the site for experience goods.

Mathematical Complexity

The neuroscience literature suggests that mathematical tasks mobilize higher cognitive functions of our brain. Mathematical complexity can impair self-control. Exertions of working memory may directly affect the active mental representation of an individual's self-control (Hofmann et al. 2012). The capacity to self-regulate to accomplish a goal can affected by a task in which working memory capacity is repeatedly solicited, such as in the case of mathematically complex tasks. This article hypothesizes that mathematically complex online shopping tasks are likely to influence the attitude toward a merchant website. Garbarino and Edell (1997) found that a task that requires more cognitive effort to evaluate can lead to more negative affect. In online grocery shopping, making complex quantity purchasing decisions (such as deciding the size and quantity of meat portions to buy for dinner) may negatively affect the shopping experience for the consumer. Additionally, consumers that are in a good mood that are exposed to especially negative stimuli may lose their good mood to a neutral or negative mood that may lead them to quit their shopping task (Swinyard 1993). We posit that online shopping tasks involving more complex mathematical operations (such as fractions), number representation (such as decimals), and partial information that needs to be held in memory, should negatively affect users' attitude toward the website.

H3 Arithmetic complexity in online grocery shopping tasks has a negative influence on the attitude toward the site.

When a web-site design does not facilitate information processing, it may cause negative affect. (Chen and Dubinsky 2003). It has been shown that vividness from visual stimuli such as product pictures is effective

in improving consumers' understanding of products (i.e., perceived diagnosticity). If consumers believe that a particular website can help them understand and evaluate products, they will form more positive attitudes toward shopping at the website (Jiang and Benbasat 2007). We suggest that due to the lack of purchasing quantity diagnosticity that users can infer from product pictures for arithmetically complex decisions, increased attention on product pictures will lead to a more negative attitude toward the site.

H4 Visual attention to product pictures in arithmetically complex tasks leads to a more negative attitude toward the website.

Methodology

Sample, Experimental Design and Procedure

The experiment was approved by the Institutional Review Board (IRB) of our institution. Thirty-eight (32) subjects took part in the experiment and 56% were male. To test our hypotheses, a 2 (Arithmetic complexity) X 2 (Search/Experience goods) within-subject experiment was performed. Each participant completed an experimental session consisting of four (4) randomly ordered online grocery shopping tasks. The first step of each task was to search for the recipe indicated by the instruction sheet on the grocery shopping website. Then, the participant was instructed to go on the website to purchase a predefined selection of products from the recipe. After the shopping task, the participant filled in a questionnaire.

Manipulations and Measures

The manipulations of search/experience and arithmetic complexity were integrated into each shopping task. In the search good condition, participants had to shop for packaged goods such as a spice jar. In the experience good condition, participants had to shop for a given quantity of unpackaged goods such as carrots that are sold in bulk and sold by weight. Participants completed a manipulation check question after each online grocery task for arithmetic complexity. A significant difference was observed between noncomplex (M=4.38) and more complex tasks (M=3.09; $p < 0.001$.) Attitude toward the site was measured using Chen and Wells (1999) measurement scale. Visual attention on product pictures was recorded using an eye tracker.

Apparatus, Data Acquisition, and Analysis

A Tobii X-60 (Tobii Technology AB) eye tracker was used to record subjects' eye movement patterns. On product search pages, areas of interest (AOI) were defined on the product pictures and grouped according to the experimental design (complexity and product type) to generate mean individual fixation durations (seconds) per participant.

To test the proposed hypotheses, a regression analysis with mean fixation durations, arithmetical complexity, and product type as the independent variables and attitude toward the site as the dependent variable was performed. Observations were non-independent, with four (4) consecutive tasks per subject. Therefore, a regression model for repeated measures was performed. A multivariate model was used for regression analysis. The absence of multicollinearity in the model (with

search/experience and complexity) was verified and confirmed. Cluster ID regression for repeated measures was conducted with fixation durations as the independent variable and attitude toward the website as the dependent variable (R-square= 0.207, p-value=0.091). RE and MLE regression models yielded similar results. Additionally, we controlled for order among the four tasks and the model shows no significant learning effects (p-value=0.120).

Results

Product type (H1) and arithmetical complexity (H3) were hypothesized to influence attitude toward the site. Results showed no significant relationships (See Table 1). Attitude toward the site was not different between experience goods (mean= 4.28) and search goods (mean=4.32) (p-value=0.201). No difference was observed between arithmetically complex tasks (mean=4.28) and less arithmetically complex tasks (mean=4.33) (p-value=0.199) in terms of attitude toward the site. Thus, H1 and H3 were not supported.

For H2 and H4, it was expected that visual attention on product pictures would have a moderating effect on the relationships proposed in H1 and H3. A panel regression cluster ID (R-squared=0.207, N=123, p-value=0.091) was conducted and results supported H2 and H4 (Table 1). Increased visual attention to pictures of experiential products has a significant positive moderating effect on attitude toward the site (coefficient=11.82, p-value=0.012). For arithmetically complex tasks, increased visual attention to product pictures has a significant negative effect on attitude toward the site (coefficient= -7.75, p-value= 0.035). This model explains 20.7% of the variance in the attitude toward the site.

Table 1: Moderating effects of visual attention on product pictures for experience products and arithmetically complex shopping tasks on attitude toward the site

Attitude toward the website		
	Mean fixation duration (seconds)	
	Coef.	p-value*
constant	5.57	0
order	0.09	0.120
dummy_exp	-0.80	0.140
dummy_compl	-0.24	0.413
add	7.44	0.074
calc	-0.98	0.443
picture	-12.36	0.016
name	-1.84	0.369
expXadd	-8.03	0.088
expXcalc	-0.51	0.480
expXpicture	**11.82**	**0.012**
expXname	1.18	0.438
complXadd	-2.51	0.295
complXcalc	4.63	0.195
complXpicture	**-7.75**	**0.035**
complXname	6.71	0.128

Notes. *order:* sequence of tasks; *dummy_exp:* experiential products; *dummy_compl:* arithmetically complex tasks*; add:* mean fixation duration on the area where the purchasing quantity is inputted and confirmed; *calc:* mean fixation duration on the area where product unit price, product size, brand and price per weight are listed; *picture:* mean fixation duration on the product picture*; name:* mean fixation duration on the descriptive name of the product; *exp_x*: mean fixation duration

on an experiential product area of interest (exp=1); *compl_x:* mean fixation duration on an arithmetically complex task area of interest (compl=1); Regression Cluster ID R-squared=0.207, N=123, p-value=0.091 *one-tail

Discussion and concluding comments

These results make the following theoretical contributions. First, results suggest that online task characteristics do not only influence behaviour across web pages (e.g., Huang et al. (2009)), but also within web pages. Specifically, in our study, participants' fixations on product pictures did interact with task characteristics to influence their attitude toward the website. Second, it contributes to the body of knowledge on search-experience product categorization by showing that consumers focus more on product pictures when shopping for experience goods. Third, it contributes to research on the interplay of cognition and affect, by showing that product pictures may also play a moderating role in complex online tasks.

For managers, results underscore the importance of product pictures on websites. For decisions involving experience goods, product pictures may act as an important complementary information source and may be more diagnostic than text description. However, in arithmetically complex tasks, product pictures that are not diagnostic to the quantity being purchased may negatively affect consumers' attitude toward the website. In order to mitigate this effect, retailers need to show product pictures aligned with the decision-making process.

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