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REVIEWS ON TEMPORAL AND COGNITIVE SEARCH
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ANALYSIS OF THE IMPACT OF ONLINE PRODUCT REVIEWS ON TEMPORAL AND COGNITIVE SEARCH COSTS: AN EYE-TRACKING APPROACH

The literature on online product reviews examine the fundamental premise that reviews reduce search costs and also increase consumer confidence in their purchase decisions, which has not been proven in the previous literature. We conducted an experiment using an eye-tracking machine to measure the impact of online reviews on consumer information search costs and on decision confidence. We find that both editorial reviews and customer reviews when presented separately reduce the search time considerably, but not when present together. However, we find that the presence of both types of reviews increases decision confidence considerably, thereby, suggesting a trade-off between search time and decision confidence. When both types of reviews are presented together, the cognitive cost of processing non-review information is significantly reduced implying more efficient allocation of cognitive resources. We conclude with several managerial recommendations for ecommerce firms.

Key Words *ecommerce, product reviews, decision confidence, eye-tracking*

1. INTRODUCTION AND LITERATURE REVIEW

Shopping is not only restricted to visit in person to any near or far shopping store. In early times, the consumers were unable to shop 24/7 with only the movements of fingers. Twenty first century has witnessed a giant leap towards online shopping by technology. The speedy growth of online retailing has led to a dynamic market space and competition within all shopping channels. It has reshaped the consumers shopping habits and challenged the traditional retailers. "Internet has received popularity as a vehicle for providing portal to a huge amount of information." (Alba et al., 1997). As an information source, the internet has given rise to the need for intermediaries that provide information tailored to consumers' needs and wants. There are various ways in which recommendation agents give rise to information from consumers regarding their preferences.

Amid the growing trends in online shopping, previous studies have shown that reduction in search costs for product and product-related information are the primary benefits of online shopping (Lynch and Ariely 2000). Search cost is defined as the money, energy and time spend by a consumer who is searching for a product or service to purchase. Alba et al. (1997) reported that the main attraction of online shopping is the decrease in search costs for products and product-related information for consumers. In other words, time and cost of visiting a shopping store are virtually eliminated for consumers, who can shop from any place with internet access. In particular, search cost reduction has allowed shoppers to engage more efficiently in competitive shopping (Alba et al 1997, Klien 1998). It is argued that since the basic role of an online store is to provide product and price related information to reduce search cost (Bakos1977), better and extensive information about products, available on the shopping website, leads to higher consumer satisfaction and improved buying-decisions (Peterson et al, 1997). Consumers are

satisfied with online shopping if the retailer sites are uncluttered, fast and easy to navigate. These sites reduce cognitive effort and shopping time of consumers, and expend to understand how to do effective shopping online (Szymanski and Hise 2000).

Moreover, It has been suggested that consumers' search for information online and subsequent decision making are depend on the interactive decision aids that are available online (Haubl and Trifts 2000). Decision aids are defined as software tools that attempt to understand decision making preference function and make recommendations based on understanding of preference structure (Haubl and Trifts 2000). Consumers actively search for cues such as online decision aids and comparison agents that might support them and to save their cognitive resources (Jacso 1998, Todd & Benbasat 1992,1999). Online stores have considerably reduced the amount of effort consumers spend during decision making processes by providing them several decision aids (Armstrong & Hagel, 1996; Swaminathan, 2003). Among those decision aids, product recommendations that can obtained from electronic agents and other online peer consumers are quite popular. These product recommendations can be helpful and influential in building trust in specific products (Gershoff, Mukherjee, & Mukhopadhyay,2003; Häubl & Murray, 2003), as well as raise consumer comfort with the whole online shopping processes (Dayal, Landesberg, & Zeisser, 1999). Haubl and Trifts noted that interactive tools empower consumers to evaluate available alternatives and facilitate thorough comparisons among alternatives. Their results also show that the use of recommendation agents has a favorable effects on decision making quality and the efficiency of purchase decisions.

In this regard, online product reviews are among the most widely used decision aids in ecommerce. A primary motive for consumers to read online customer reviews is to reduce both search effort and purchase risk (Schiffman and LL 1987; Hennig-Thurau, Walsh et al. 2003; Dabholkar 2006). It has been claimed that online decision aids “appear to reduce consumer effort in decision making” (Dabholkar 2006). Both physical and cognitive processing efforts form the search cost (Mudambi and Schuff 2010). Research has shown that consumers rely on “competent advisors” to help them become informed while reducing cognitively demanding and time-consuming activities (Wiedmann, Walsh et al. 2001)

Apart from easing the search effort, consumers also seek to reduce purchase risk while conducting information search online. Risk and confidence have been shown to be amorphous and inversely related (Meyer and Johnson 1995). In an online environment, variability in the consumers' decision confidence arises from both the consumer attributes and the nature of the decision tools provided (Kamis and Davern 2004). Recommendation agents have been shown to increase confidence in decisions in online shopping environments (Haubl and Trifts 2000). Better decision making is considered the main reason for consumers to use ratings, which serve as a decision making aid (Dabholkar 2006). However,previous

research has a limited scope of inquiry to reviews as decision aids, help consumers reduce their search cost. We are unaware of any study to date that proves that reviews reduce consumer's information search costs, and increase decision confidence.

Given that many of the seminal papers in the area of online word-of-mouth are based on this assumption, in this paper we conduct an experiment to determine if online reviews do indeed reduce search costs and increase decision confidence. To accurately measure search costs, we use an eye-tracking machine which allows us to measure both the search time while viewing a webpage and the cognitive load of each participant in our experiment. In the first stage of our study, we examine the reviews impact on search costs such as Observation length, Fixation length, Fixation mean, Fixation count etc. This is followed by an examination of individual area of interests (AOIs) on webpage such as Book image on webpage, Book title, Price, information about the book author, etc. Finally, we test whether online customer reviews have an impact on customer decision confidence.

We conducted an experiment using an eye-tracking machine to measure the impact of online reviews on consumer information search costs and on decision confidence. We find that both editorial reviews and customer reviews when presented separately reduce the search time considerably, but not when present together. However, we find that the presence of both types of reviews increases decision confidence considerably, thereby, suggesting a trade-off between search time and decision confidence. When both types of reviews are presented together, the cognitive cost of processing non-review information is significantly reduced implying more efficient allocation of cognitive resources.

Our study lays a ground for other researcher's by suggesting the way how we can approach the issue. Our findings not only provide an understanding and measurement of the nature of customer reviews impact on search cost, but also suggest some important implications to managers of e-commerce. Our study shows that editorial and customer reviews together increase decision confidence to a very high level and managers should make both editorial and customer reviews available on the product website.

The paper is organized as follows. Section 1 contains the literature review and hypothesis about search cost and decision confidence. Section 2 contains the details of the experiment, the results and discussion. Section 3 concludes the paper with managerial implications and limitations of the study.

2. LITERATURE REVIEW

2.1 Search Costs: Search Time and Effort

Consumers have a need to reduce purchase uncertainty and will seek information to reduce risk (Mudambi and Schuff 2010). While seeking out this information, the theory of information search posits that consumers will engage in search as long as the marginal benefits of search are greater than the marginal costs involved (Stigler 1961; Peterson and Merino 2003; Mudambi and Schuff 2010). The Internet is widely believed to reduce search costs by making information easily accessible (Bakos 1997) and reducing the search costs. This includes both general product information as well as the opinions of other consumers, the latter available most commonly in the form of customer reviews.

As such a primary motive for consumers to read online customer reviews is to reduce both purchase risk and the search effort (Schiffman and LL 1987; Hennig-Thurau, Walsh et al. 2003; Dabholkar 2006). It has been claimed that online decision aids “appear to reduce consumer effort in decision making” (Dabholkar 2006), implying that the use of the decision support systems such as online review platforms should reduce consumer effort. Consumers usually search for cues such as comparison agents and decision aids online that might support them and to lessen their cognitive resources (Jacso 1998, Todd & Benbasat 1992,1999). Previous research has shown that in such contexts consumer preferences are certainly affected by information cues that are made prominent at the time of decision making. For example: included attributes in the recommendation of an electronic agent (Häubl & Murray, 2003), attributes primed via Web site back-ground (Mandel & Johnson, 2002), and the processing information perceived cost (Lynch & Ariely, 2000) have been found to influence consumer decisions. It has been reported that consumers may like to depend on word-of-mouth information rather than information about the attributes of the products (Herr, Kardes, & Kim, 1991). This may be because word-of-mouth information, as compared to marketer-provided attributes information or advertisements, is more clear (Herr et al., 1991), because it is based on other experiences which is easy to use and considered more truthful (Smith, 1993). Therefore, the literature supports the impact of peer recommenders in e-commerce settings.

Bettman et al. (1998) noted that as the product complexity increases, consumers are likely look to simpler selective information processing, often decreasing decision effectiveness. The recommendation agent arrange the product information in such a way, which enable consumer to focus on those attributes that are most probably to increase utility. Therefore, in a high complex category where consumers often need assistance in decision making to manage information overload, the impact of using interactive decision aid on decision making is likely to be high. A benefit of internet is, it provides large amount of

information with minimal marginal search cost to the consumers. Research has shown that significantly less effort is required for consumers to make purchase decisions with the presence of personalized product recommendations. Haubl and Trifts (2000) considered consumers' search effort on a shopping trip as the number of products for which a detailed characterization was inspected. They found that, only 6.6 products when they were assisted by an ICDA (interactive consumer decision aids), consumers looked at the detailed descriptions; while an average of 11.7 alternatives was looked at those who shopped without such assistance. This finding suggest that primary motivation for using a recommendation agent is to reducing the effort needed to make a decision, which is widely accepted in the field of consumer research (e.g., Alba et al. 1997; Diehl et al. 2003; Swaminathan 2003; West et al. 1999) and more generally in the literature on decision support systems (e.g., Todd and Benbasat 1999).

Additionally, research has shown that consumers rely on "competent advisors" to help them become informed while reducing cognitively demanding and time-consuming activities (Wiedmann, Walsh et al. 2001) while both physical and cognitive processing efforts form the search cost (Mudambi and Schuff 2010). In an online environment, the opinions of other customers can serve as input from such competent advisors. Indeed, it has been shown that consumers use decision aids such as numerical content ratings (although not online product reviews) to conserve cognitive resources and improve decision making (Poston and Speier 2005; Mudambi and Schuff 2010).

Thus is logical to assume, as has been done in the extant literature, that online customer reviews reduce search costs, based on the theory of information search. However, in the ever growing body of research on online reviews, we are not aware of any study that proves that reviews reduce consumer's information search costs, although this assumption is often used as a fundamental premise to the research at hand. Thus we propose:

Hypothesis 1: The presence of online reviews will reduce cognitive search costs.

2.2 Search Costs and Decision Confidence

Apart from easing the search effort, consumers also seek to reduce purchase risk while conducting information search online. Risk and confidence are considered to be amorphous and inversely related (Meyer and Johnson 1995). Confidence is a psychological construct that deals with the consumers' confidence in their ability to evaluate an item (Bennett and Harrell 1975). Decision confidence is defined as the feeling of having done something correctly or incorrectly, and is considered to be an important aspect of the decision making experience (Insabato, Pannunzi et al.). It is a subjective and qualitative judgment or evaluation of one's decision (Kamis and Davern 2004).

Previous empirical research has shown that presence of an attribute based recommendation agent in an electronic shopping environment may affect significant reduction in the amount of consumers' pre-purchase information search (Häubl & Trifts, 2000). This finding suggest that, human mind having limited information processing capacity, consumers tend to depend heavily upon electronic agents product recommendations to reduce the amount of required effort to make a purchase decision. Due to rapidly increasing prevalence of such decisions aids and suggestions made by recommendation agents in electronic market places, it is important to know how electronic recommendation agents may influence consumer preferences. A study on the use of online information in the decision making processes of physicians found that when new information regarding a diagnosis confirmed the physician's original diagnosis decision (whether right or wrong), confidence in the decision increased considerably (Westbrook et al,2005)].

Research has shown that for making decisions, the online sources provide more information than before to consumers and cognitive effort is shifting from consumers to interactive decision aids (Bechwati and Xia 2003). Therefore online interactive decision aids are capable to transform the way in which consumers are looking for product information in order to make purchase decisions (Häubl and Trifts 2000). It has been reported that, online shopping aid role is to provide decision guides and information in order to help consumers to make better decisions (Vijayasarathy and Jones 2003). Researchers noted that by being able to make information for themselves, online shoppers are likely to feel more in control of their decision process and information search (Grenci and Todd 2002; Smith 2002). Haubl and Trifts noted that interactive tools empower consumers to examine available alternatives and facilitate in depth comparison among alternatives. Their results also shows that recommendation agents use has a favorable effects on decision making quality and the efficiency of purchase decisions.

In an online environment, variability in the consumers' decision confidence arises from consumer attributes and the nature of the decision tools provided (Kamis and Davern 2004). It is widely believed that consumers in an online environment will attempt to minimize effort and maximize accuracy (Kamis and Davern 2004). In addition, recommendation agents have been shown to increase confidence in decisions in online shopping environments (Haubl and Trifts 2000). Therefore, better decision making is considered as the main reason for consumers to use ratings, which serve as a decision making aid (Dabholkar 2006). However, we are unaware OR it is not been explored yet in any study that actually shows that online reviews increase decision confidence. Therefore we propose the following hypothesis:

Hypothesis 2: The presence of online reviews will increase decision confidence.

3. EXPERIMENT, RESULTS AND DISCUSSION

To study how online reviews impact consumer search costs and decision confidence, we conducted an experiment, where participants were asked to evaluate an e-book sold on Amazon.com. The e-book was an Amazon Single, a short e-book available exclusively at Amazon.com for a low price. The e-book was “Board Room Babies” by Stanley Bing and was priced at 99 cents. Since Amazon Singles are exclusively sold on Amazon.com and are a niche product, it reduces the likelihood of participants having prior exposure to the e-book and we also confirm that participants have not read the book before. Amazon.com provides an editorial review in addition to allowing customers to post their own reviews. The editorial review is purely textual in nature, while the customer review contains both a rating score (1 to 5 stars) and textual content.

Participants were informed that they needed to evaluate the e-book and advise a professor on whether or not to use that e-book in a finance course. This was done to increase the product involvement of the participants, and to reduce the impact of variations in personal preferences towards the product. To perform the evaluation, the participants were shown the contents of the Amazon.com webpage selling the e-book. The webpage was shown on an eye-tracking machine, so that the participant’s ocular movements could be recorded and analyzed. The content of the webpage was stored offline, and then manipulated to represent various treatment levels.

Students from a leading school in East Asia participated in this experiment and were randomly placed into one of four groups. The first group was the control group, and participants were shown the e-book’s webpage where both the editorial review and customer reviews had been removed. The second group was shown only the editorial review and is henceforth referred to Treatment 1. The third group was only shown the customer reviews (Treatment 2), and the fourth group was shown both types of reviews (Treatment 3).

Participants were given a maximum of 5 minutes to evaluate the e-book, during which the eye-tracking machine recorded their complete ocular movements. After evaluating the e-book, participants were asked to fill out a questionnaire, which recorded their opinions of the e-book and of various informational elements on the webpage, recommendation and advice to the professor, level of decision confidence, as well as information regarding the experiment and demographic details.

3.1 Measuring Ocular Movements

Eye movements consist of saccades and fixations. Saccades are rapid eye movements from location to location during which vision is suppressed. A fixation is a pause in eye movements and indicates visual

attention (followed by cognition) to a stimuli (Pieters, Rosbergen et al. 1999). Thus it is the fixation data is of interest to us.

To collect the fixation data we used the Tobii eye-tracker, which has several benefits over other forms of eye-tracking, such as specialized glasses, or external cameras. The Tobii eye-tracker is unobtrusive, as the cameras are built into the monitor and are placed behind dark glass, leaving the user generally unaware of their existence, except during the initial calibration stage. The eye-tracker is also very accurate in its tracking of the user's ocular movements, and allows for considerable freedom of movement of the user's head. Additionally it has a sophisticated software solution that is designed to generate research oriented data.

We divided the webpage into Areas of Interest (AOI), for which we collected eye-tracking data. We recorded the length of time that each participant spent evaluating the ebook, as well as the participant's ocular activities via several measures commonly used in eye-tracking studies (list of measures is shown in Table 1). A screenshot of the webpage with all reviews present (Treatment 3) is shown in Figure 1. The areas shaded in green are product information AOIs. The area shaded in blue is the editorial review AOI, and the areas shaded in light purple are the customer review AOIs.

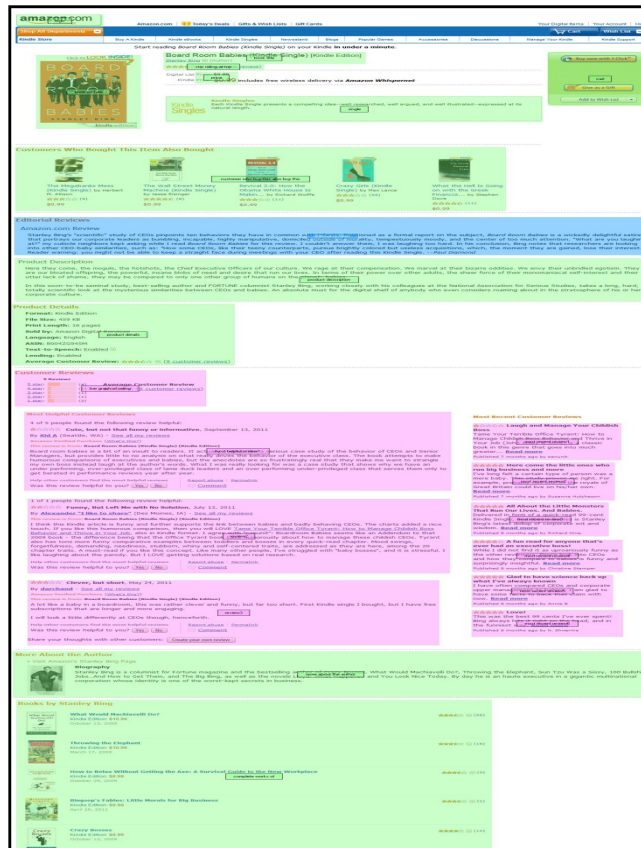


Figure X. Product webpage with AOIs

Table 1. Legend of variables used in the analysis

Variable	Measure of
AOI	Area of Interest: Part of the page for which we are obtaining data
OBSLEN	Observation length: Duration of a visit to an AOI
FIXLEN	Total fixation length during a visit to an AOI
OBSCOUNT	Number of separate visits to an AOI
FIXCOUNT	Number of fixations: The number of times that a participant fixates on an AOI
FIXRATIO	The number of fixations on an single AOI divided by total number of fixations
FIXMEAN	Mean fixation duration: Average time of individual fixations within an AOI
CONFIDENCE	Participant's confidence in their decision
BOOKIMAGE	AOI containing the e-book's cover image
BOOKTITLE	AOI containing the e-book's title
PRICE	AOI containing the price of the e-book
ALSOBUY	AOI showing other items bought by previous buyers of this e-book
PDTDETAIL	AOI showing details about the product including format, number of pages, etc
AUTHOR	AOI containing details about the author of the e-book
ALLWORKS	AOI containing a list of all other books written by the author of this e-book
LOGO	AOI containing the Amazon.com company logo
DESCRIPT	AOI containing a description of the product
SINGLES	AOI containing a note about what Amazon Singles are
CART	AOI containing the shopping cart and associated buying buttons
EDITORIAL	AOI containing the editorial review of the e-book
CUSTOMERS	AOI containing all the customer reviews of this e-book
RATING	AOI showing the ratings at the top of the page
BARGRAPH	AOI showing the spread of ratings in bar graph format (below PDTDETAIL AOI)

3.2 Effects of Product Review on Search Costs

In an online environment, physical costs are minimal, but there is a temporal as well as a cognitive cost (Bettman, Luce et al. 1998). To measure the temporal component of the search cost, we recorded the amount of time that the participant spent observing the webpage while making her decision. This length of time is provided by the eye-tracker and is recorded as OBSLEN in Table 2. To determine if the presence of online reviews affects the amount of search time, we conduct an ANOVA test. Results show that the presence of an editorial review reduces the webpage visit duration by an average of 34.6 seconds (about 20%), while the presence of customer reviews reduces the visit duration by 45.7 seconds (about 25%). On the other hand, the presence of both types of reviews does not significantly reduce the visit duration (see Table 2).

To exclude any bias arising from varying browsing patterns and speeds¹ caused by individual characteristics or off-screen diversions, we measure just the total amount of visual attention given by the participant to the webpage by examining the total fixation length (FIXLEN), which is the sum of all the fixations made, measured in seconds. FIXLEN differs from OBSLEN in that saccades are not included. Since no visual processing occurs during saccades, FIXLEN would provide a more accurate indication of cognitive costs, as FIXLEN measures visual attention which is a precondition to cognitive processing.

We find a very strong correlation between OBSLEN and FIXLEN ($r=0.850$, $p<0.01$) which validates our conclusions derived from OBSLEN. FIXLEN gives us the total visual attention paid by each participant to the webpage, but does not give us information on search efficiency or task complexity. For this, the total fixation duration must be separated into the total number of fixations, and the average duration of the fixations. The former is related to search efficiency and the latter is related to the level of cognitive load.

The total number of fixations (FIXCOUNT) is strongly correlated to task time and is negatively correlated with search efficiency (Jacob and Karn 2003). Our analysis of FIXCOUNT corroborates the results from OBSLEN. We find that participants who had access to the editorial review had 86 fewer fixations (~25%), and similarly those who had accessed to customer reviews had 88 fewer fixations (~26%), on average. The presence of both types of reviews did not reduce the number of fixations in a statistically significant manner. Based on the findings from analyzing OBSLEN and FIXCOUNT, we conclude that the presence of either editorial or customer reviews reduces the amount of time needed to make a decision by making the search for information more efficient. The fixation count is also an indicator of the cognitive cost of search, in that a lower fixation count is potentially indicative of lesser cognitive effort expended. However, to conclusively determine this, we need to examine the cognitive load.

We measure the cognitive load during evaluation of the e-book using the mean fixation duration (FIXMEAN) of the participant over key areas of interest (AOI) on the webpage. FIXMEAN is a metric widely used in eye-tracking studies, and has been shown to be positively related to information complexity and task difficulty (Rayner 1998; Pan, Hembrooke et al. 2004). It is an indicator of difficulty in information extraction and interpretation, due to either unclear or high density information. As such, it is inversely related to information clarity (Bojko, Gaddy et al. 2005). Thus FIXMEAN is correlated to the participant's cognitive load, which is a component of the overall search cost.

While we find that there is no difference in FIXMEAN for the entire webpage across treatments, this result is misleading, since the treatment levels include differing pieces of information (via the absence or

¹ While the amount of time spent by participants on the webpage is a direct measure of search time, there is the small possibility that varied browsing speeds of individuals may influence the results. However this is unlikely since the effect should be spread across treatment groups and therefore be cancelled out.

presence of reviews), which have varying levels of information complexity. To accurately measure the impact of reviews on the consumer’s cognitive load, we combine the AOIs for the non-review informational elements into a single AOI that contains common information across treatment groups, thereby allowing us to examine the impact of online reviews on the participant’s cognitive load on a consistent basis across treatments.

Table 2. Key eye-tracking metrics for entire webpage*

	NONE	EDIT	CUST	BOTH	ALL
OBSLEN	182.32 _{ax,b}	147.68 _{ax}	136.59 _b	163.18	157.39
σ	(43.02)	(60.58)	(47.42)	(89.67)	(64.17)
FIXLEN	137.55 _b	110.47	100.33 _b	117.40	116.43
σ	(45.28)	(61.14)	(42.64)	(71.39)	(57.16)
FIXCOUNT	347.33 _{a,b}	261.03 _a	258.73 _b	305.59	293.07
σ	(120.09)	(112.44)	(81.15)	(197.69)	(137.44)
FIXMEAN	0.410	0.411	0.385	0.402	0.402
σ	(0.099)	(0.121)	(0.103)	(0.139)	(0.115)
CONFIDENCE	4.70 _c	4.67 _f	5.17	5.76 _{c,f}	5.07
σ	(1.18)	(1.40)	(1.26)	(0.951)	(1.27)
N	30	30	30	29	119

*The subscripts represent pairs with significantly different means ($p < 0.05$). The postfix “_x” denotes significance at the 0.10 level.

Table 3. FIXMEAN for non-review vs. review AOIs*

	NONE	EDITORIAL	CUSTOMERS	BOTH
NONREVIEW	0.358 _{bx,c}	0.352	0.311 _{bx}	0.287 _c
σ	(0.063)	(0.117)	(0.085)	(0.116)
REVIEW	-	0.420	0.398	0.381
σ	-	(0.199)	(0.118)	(0.193)
N	30	30	30	29

*The subscripts represent pairs with significantly different means ($p < 0.05$). The postfix “_x” denotes significance at the 0.10 level.

We find that the presence of customer reviews or both types of reviews significant reduces the cognitive load of participants who are evaluating non-review product information. Participants with access to customer reviews experience a significantly lower mean fixation duration (47 milliseconds less, ~13%) than customers without access to reviews. When editorial and customer reviews are present together, the

cognitive load is reduced even further, with the mean fixation duration for the non-review (common across treatments) AOIs reducing by 71 milliseconds or about 20% (see Table 3). An increase in FIXMEAN is often viewed as an increase in difficulty in information extraction. However it does not necessarily mean that the informational element is inherently difficult to extract information from, rather that the participant is exerting greater cognitive resources to interpret this information. Conversely, a decrease in FIXMEAN indicates that lesser cognitive resources are being expended. Since this non-review related information is the same across treatments, it implies that the presence of customer reviews or both reviews reduces the cognitive load of the non-review product information by reducing the task difficulty for the participant – the task being evaluating the e-book.

Table 4. OBSLEN (OL) and FIXLEN (FL) statistics for individual AOIs*

	NONE		EDITORIAL		CUSTOMERS		BOTH	
	OL	FL	OL	FL	OL	FL	OL	FL
BOOKIMAGE	7.70 _{b,c}	6.06 _{h,i}	6.33	5.04	4.50 _b	3.47 _h	4.57 _c	3.87 _i
σ	(3.45)	(2.92)	(4.95)	(3.57)	(3.28)	(2.86)	(3.74)	(2.99)
BOOKTITLE	6.44 _{a,bx,c}	5.25 _{g,h,i}	2.65 _a	2.20 _g	3.48 _{bx}	2.21 _h	2.89 _c	2.53 _i
σ	(4.60)	(4.12)	(2.36)	(1.93)	(4.18)	(1.62)	(2.10)	(1.87)
PRICE	1.37	1.15	1.16	1.01	0.955	0.798	1.32	1.03
σ	(1.04)	(0.911)	(1.14)	(0.980)	(0.946)	(0.845)	(1.09)	(0.888)
ALSOBUY	22.92 _{b,c}	17.53 _{g,h,i}	16.63	9.00 _g	12.42 _b	8.74 _h	14.12 _c	9.78 _i
σ	(13.75)	(11.08)	(15.71)	(6.03)	(8.12)	(5.65)	(9.50)	(6.52)
PDTDETAIL	10.14 _{a,bx,c}	8.54 _{g,h,i}	5.77 _a	4.98 _g	6.53 _{bx}	5.34 _h	5.17 _c	4.06 _i
σ	(6.52)	(5.93)	(4.68)	(4.15)	(3.78)	(3.56)	(4.71)	(4.36)
AUTHOR	22.83 _{a,b,c}	16.37 _{h,i}	12.44 _{a,d}	10.32 _j	5.07 _{b,d}	4.38 _{h,j}	10.17 _c	5.85 _i
σ	(15.81)	(12.51)	(10.49)	(9.26)	(4.80)	(4.33)	(12.28)	(7.08)
ALLWORKS	17.81 _{ax,b,c}	14.47 _{gx,h,i}	10.99 _{ax}	8.40 _{gx}	8.61 _b	6.63 _h	6.50 _c	5.08 _i
σ	(12.50)	(11.02)	(8.88)	(7.10)	(8.34)	(6.53)	(7.69)	(6.60)
LOGO	0.764	0.572 _h	0.327	0.271	0.259	0.156 _h	0.590	0.368
σ	(0.985)	(0.687)	(0.722)	(0.625)	(0.463)	(0.319)	(1.53)	(0.782)
DESCRIPT	54.78 _{a,b,c}	40.43 _{gx,h,i}	31.54 _a	24.24 _{gx,kx}	20.90 _b	16.09 _h	18.54 _c	11.19 _{i,kx}
σ	(29.98)	(24.65)	(25.67)	(22.62)	(19.20)	(17.12)	(29.44)	(14.59)
SINGLES	7.67 _{b,c}	6.12 _{h,i}	6.04	5.00	3.59 _b	2.71 _h	3.39 _c	2.82 _i
σ	(6.21)	(5.16)	(5.75)	(5.16)	(3.50)	(2.95)	(4.90)	(4.14)
CART	2.08	1.31	1.91	1.29	1.22	0.878	1.35	0.776
σ	(2.42)	(1.38)	(2.38)	(1.56)	(1.73)	(1.38)	(2.97)	(1.51)
EDITORIAL	-	-	33.24	25.57	-	-	32.80	27.11
σ	-	-	(23.11)	(19.13)	-	-	(27.86)	(23.04)

RATING	-	-	-	-	0.766	0.679	0.863	0.686
σ	-	-	-	-	(0.825)	(0.786)	(1.01)	(0.764)
CUSTOMERS	-	-	-	-	46.01	33.33	37.57	26.39
σ	-	-	-	-	(30.48)	(21.69)	(35.21)	(28.93)
BARGRAPH	-	-	-	-	3.79	3.12	3.06	2.43
σ	-	-	-	-	(2.77)	(2.56)	(3.07)	(2.37)
N	30	30	30	30	30	30	29	29

*The subscripts represent pairs with significantly different means ($p < 0.05$). The postfix “_x” denotes significance at the 0.10 level.

3.3 Importance of individual AOIs

While the overall number of fixations is inversely related to search efficiency, the number of fixations on each *individual* area of interest can be used as a measure of the importance of that element compared to other elements (Jacob and Karn 2003). Thus the number of fixations of an AOI relative to other AOIs is an indicator of importance, while the change in the number of fixations on the same AOI *across* treatments is an indicator of search efficiency.

We determine relative importance by the size of FIXCOUNT (Table 5) and the top AOIs in terms of importance for each AOI are shown in Table 6. When no reviews are present, the product description (DESCRIP) is the most important AOI, accounting for 30.40% of all fixations, followed by ALSOBUY (16.80%), AUTHOR (13.84%) and ALLWORKS (13.01%). When the editorial review is shown, it becomes the most important AOI (26.61%), followed by DESCRIP (21.05%), ALSOBUY (11.50%), ALLWORKS (10.29%) and AUTHOR (10.26%). When customer reviews are present, they constitute the most frequently fixated upon AOI (37.00%), followed by DESCRIP (17.90%), ALSOBUY (11.97%) and ALLWORKS (8.65%). The AUTHOR AOI gets only 5.56% when customer reviews are present. When both types of reviews are present, customer reviews are the most important AOI (26.37%), followed by the editorial review (23.93%), ALSOBUY (11.47%) and DESCRIP (10.77%). Once again the AUTHOR AOI receives a smaller share of fixations (6.36%). Thus our results show that product reviews become the most important source of information when they are present. When both types of reviews are present together, they account for half (50.30%) of all fixations.

Table 5. FIXCOUNT (FC) and FIXMEAN (FM) statistics for individual AOIs*

	NONE		EDITORIAL		CUSTOMERS		BOTH	
	FC	FM	FC	FM	FC	FM	FC	FM
BOOKIMAGE	17.47 _{b,c}	0.375	12.83	0.391	9.57 _b	0.351	9.62 _c	0.406
σ	(8.89)	(0.145)	(9.07)	(0.212)	(6.20)	(0.181)	(8.02)	(8.02)
BOOKTITLE	14.40 _{a,b,c}	0.372	6.10 _a	0.313	6.37 _b	0.358	6.48 _c	0.352
σ	(10.69)	(0.146)	(5.24)	(0.173)	(4.82)	(0.178)	(5.09)	(0.208)
PRICE	3.17 _b	0.337	2.13	0.389	1.77 _b	0.338	2.41	0.412
σ	(2.26)	(0.185)	(1.57)	(0.290)	(1.55)	(0.299)	(2.29)	(0.432)
ALSOBUY	48.70 _{a,b,c}	0.351	25.60 _a	0.340	25.70 _b	0.337	29.41 _c	0.315
σ	(27.73)	(0.094)	(15.56)	(0.126)	(12.52)	(0.116)	(17.45)	(0.119)
PDTDETAIL	18.27 _{a,c}	0.471 _i	9.87 _a	0.447	12.80	0.393	9.48 _c	0.317 _i
σ	(10.54)	(0.139)	(7.39)	(0.211)	(7.97)	(0.174)	(7.88)	(0.233)
AUTHOR	40.13 _{a,b,c}	0.403 _{h,i}	22.83 _{a,d}	0.411 _{jx,kx}	11.93 _{b,d}	0.286 _{h,jx}	16.31 _c	0.276 _{i,kx}
σ	(26.94)	(0.128)	(15.74)	(0.210)	(11.35)	(0.164)	(21.79)	(0.217)
ALLWORKS	37.73 _{ax>b,c}	0.368 _i	22.90 _{ax}	0.354 _k	18.57 _b	0.306	14.24 _c	0.215 _{i,k}
σ	(27.50)	(0.113)	(18.21)	(0.120)	(18.11)	(0.167)	(17.44)	(0.176)
LOGO	1.67 _b	0.202	0.670	0.105	0.500 _b	0.095	1.24	0.105
σ	(2.06)	(0.200)	(1.35)	(0.263)	(0.861)	(0.184)	(2.74)	(0.213)
DESCRIPT	88.13 _{a,b,c}	0.470 _{h,i}	46.87 _a	0.466	38.43 _b	0.361 _h	27.62 _c	0.330 _i
σ	(48.75)	(0.173)	(41.14)	(0.270)	(35.11)	(0.125)	(34.69)	(0.188)
SINGLES	16.23 _{b,cx}	0.365 _i	10.03	0.429 _k	6.97 _b	0.398	8.21 _{cx}	0.262 _{i,k}
σ	(13.85)	(0.122)	(6.91)	(0.238)	(6.32)	(0.364)	(9.59)	(0.170)
CART	4.03	0.224	3.57	0.224	2.67	0.199	2.41	0.162
σ	(4.05)	(0.171)	(3.92)	(0.210)	(3.56)	(0.177)	(4.02)	(0.180)
EDITORIAL	-	-	59.23	0.420	-	-	61.38	0.444
σ	-	-	(42.89)	(0.199)	-	-	(52.20)	(0.269)
RATING	-	-	-	-	1.57	0.316	1.62	0.305
σ	-	-	-	-	(1.52)	(0.279)	(1.72)	(0.377)
CUSTOMERS	-	-	-	-	79.43	0.398 _i	67.62	0.318 _i
σ	-	-	-	-	(45.17)	(0.118)	(67.71)	(0.205)
BARGRAPH	-	-	-	-	7.90	0.343	6.86	0.296
σ	-	-	-	-	(5.06)	(0.179)	(7.42)	(0.226)
N	30	30	30	30	30	30	29	29

*The subscripts represent pairs with significantly different means ($p < 0.05$). The postfix “_x” denotes significance at the 0.10 level.

Table 6. Importance ranking for individual AOIs

Rank	NONE	EDITORIAL	CUSTOMERS	BOTH
1	DESCRIPT	EDITORIAL	CUSTOMERS*	CUSTOMERS*
2	ALSOBUY	DESCRIPT	DESCRIPT	EDITORIAL
3	AUTHOR	ALSOBUY	ALSOBUY	ALSOBUY
4	ALLWORKS	ALLWORKS	ALLWORKS	DESCRIPT
5	PDTDETAIL	AUTHOR	PDTDETAIL	AUTHOR
6	BOOKIMAGE	BOOKIMAGE	AUTHOR	ALLWORKS
7	SINGLES	SINGLES	BOOKIMAGE	BOOKIMAGE
8	BOOKTITLE	PDTDETAIL	SINGLES	PDTDETAIL

* For the ranking, the CUSTOMERS AOI includes the BARGRAPH

By examining the number of fixations for each AOI across treatments, we find that different AOIs representing different pieces of information receive varying amounts of visual attention in a non-uniform manner across treatments (see ANOVA results in Table 5). We find that for most AOIs, the number of fixations reduces considerably once either editorial and/or customer reviews are present. This implies that the efficiency in processing the information present in these AOIs is increased due to the presence of product reviews. We also find that the cognitive load involved in processing the information in certain AOIs is reduced with the presence of reviews. The presence of customer reviews reduces FIXMEAN for the AUTHOR, DESCRIPT and SINGLES AOIs considerably, while the presence of both reviews together diminishes FIXMEAN for PDTDETAIL, ALLWORKS, DESCRIPT and SINGLES (See Table 5 under FM). This supports our earlier analysis that the presence of customer reviews and/or both review types together helped participants to better process and integrate the non-review information while making a decision.

To better understand why the search cost is higher when reviews are not present, we look at the number of distinct observational visits to an AOI (OBSCOUNT, see Table 7 under OLM). We find that for most AOIs, the absence of customer reviews leads to a greater number of observational visits to different AOIs, or conversely, the presence of product reviews causes fewer visits and a more efficient search for information. To determine if indeed the variation in OBSCOUNT is an indicator of search efficiency, we

look at the mean amount of time spent by participants during each distinct visit (OBSLENMEAN), and find that for all AOIs except for SINGLES², there is no significant difference in the OBSLENMEAN across treatments (see Table 7 under OC). Thus the increase in OBSCOUNT when reviews are not present can be taken as an additional indicator of inefficient search, as a greater number of visits to an AOI indicate that the participant does not have enough information to make a confident decision, and is attempting to extract more information from the AOI. A greater number of visits coupled with a higher FIXMEAN could indicate that the participant is having difficulty in processing the information, while a lower FIXMEAN could indicate that the participant is looking for additional information regarding the product.

² For the SINGLES AOI, the OBSLENMEAN is longer when no reviews are present, and as such does not contradict our finding that search is less efficient without product reviews.

Table 7. OBSLENMEAN (OLM) and OBSCOUNT (OC) statistics for individual AOIs*

	NONE		EDITORIAL		CUSTOMERS		BOTH	
	OLM	OC	OLM	OC	OLM	OC	OLM	OC
BOOKIMAGE	1.15	7.67 _{h,i}	1.07	5.50	1.04	4.67 _h	1.25	4.10 _i
σ	(0.542)	(4.32)	(0.516)	(3.78)	(0.834)	(3.27)	(1.08)	(4.28)
BOOKTITLE	1.04	6.00 _{g,h,i}	0.898	2.77 _g	1.52	3.60 _h	1.21	2.59 _i
σ	(0.473)	(3.62)	(0.610)	(2.16)	(4.07)	(2.55)	(0.993)	(2.40)
PRICE	0.497	2.77 _h	0.480	1.97	0.443	1.57 _h	0.639	1.97
σ	(0.371)	(2.00)	(0.347)	(1.45)	(0.356)	(1.28)	(0.585)	(1.94)
ALSOBUY	2.03	12.60 _{g,h,i}	3.51	8.03 _g	2.05	7.73 _h	2.47	8.31 _i
σ	(1.40)	(6.10)	(6.04)	(4.97)	(1.68)	(3.88)	(3.61)	(6.25)
PDTDETAIL	1.81	5.63 _{g,hx,i}	2.10	3.03 _g	2.11	3.97 _{hx}	1.69	3.07 _i
σ	(0.953)	(2.70)	(2.20)	(2.24)	(1.95)	(2.79)	(2.13)	(2.31)
AUTHOR	5.44	7.43 _{h,i}	2.71	5.20	1.83	3.03 _h	3.58	3.48 _i
σ	(11.69)	(4.22)	(2.16)	(3.84)	(2.47)	(2.88)	(7.73)	(3.67)
ALLWORKS	3.04	6.27 _{h,i}	2.84	4.33	3.32	2.77 _h	2.35	2.83 _i
σ	(2.34)	(4.33)	(2.37)	(3.34)	(3.87)	(2.37)	(3.82)	(4.24)
LOGO	0.323	1.37 _{gx,h}	0.150	0.500 _{gx}	0.206	0.400 _h	0.226	0.790
σ	(0.356)	(1.59)	(0.320)	(1.04)	(0.387)	(0.675)	(0.422)	(1.66)
DESCRIPT	5.63	12.07 _{g,h,i}	4.77	6.33 _g	3.92	6.10 _h	3.30	4.41 _i
σ	(4.95)	(5.77)	(3.71)	(3.91)	(5.19)	(3.53)	(4.21)	(3.73)
SINGLES	1.45	5.93 _i	1.65 _{ex}	4.13	1.19	4.03	0.796 _{ex}	3.55 _i
σ	(1.14)	(3.52)	(1.62)	(2.85)	(1.38)	(3.21)	(1.04)	(3.01)
CART	0.597	2.80	0.560	2.10	0.396	1.80	0.434	1.59
σ	(0.587)	(3.19)	(0.636)	(2.31)	(0.353)	(2.02)	(0.830)	(2.75)
EDITORIAL	-	-	4.38	7.53	-	-	4.77	7.66
σ	-	-	(3.51)	(4.28)	-	-	(4.13)	(6.46)
RATING	-	-	-	-	0.433	1.37	0.471	1.31
	-	-	-	-	(0.432)	(1.22)	(0.638)	(1.39)
CUSTOMERS	-	-	-	-	8.28	6.97	6.56	5.97
σ	-	-	-	-	(6.96)	(4.56)	(8.18)	(5.08)
BARGRAPH	-	-	-	-	1.20	3.13	0.981	2.62
	-	-	-	-	(0.826)	(2.11)	(0.921)	(2.54)
N	30	30	30	30	30	30	29	29

*The subscripts represent pairs with significantly different means ($p < 0.05$). The postfix “_x” denotes significance at the 0.10 level.

A possible issue with the OBSCOUNT is that since many AOIs are adjoining to one another, a quick glance just outside the AOI and returning to it will count as a second visit, which could confound the results – although this effect will be the same across treatments and should cancel out. To further validate

our findings, we analyze the scanpath of each participant (see Table 8, SCAN1). A scanpath is a series of fixations in chronological order (Pieters, Rosbergen et al. 1999). We examined the scanpath and manually counted the number of visual movements from the top of the webpage (BOOKIMAGE, BOOKTITLE, PRICE, SINGLES³) towards the bottom of the webpage (AUTHOR, ALLWORKS). We find that participants without access to reviews scanned the webpage on average once more than participants who had access to reviews. Since the customer reviews take up considerable space on the webpage, and appears before AUTHOR and ALLWORKS, it is possible that participants may read the reviews and then move up the webpage without visiting the AOIs that follow. To account for this possibility, we include the CUSTOMERS AOI as part of the bottom of the webpage, and find that the results hold (see Table 8, SCAN2). Additional support is provided by Table 9, which shows the percentage of participants in each treatment group who visited each AOI at least once. We find that a greater percentage of participants in the control group visited the non-review AOIs, indicating that they were putting in a greater search effort as compared to participants who had access to reviews.

Table 8. Number of page scans per participant*

	NONE	EDITORIAL	CUSTOMERS	BOTH
SCAN1	3.33 _{a,b,c}	2.30 _a	2.17 _b	1.79 _c
σ	(1.32)	(0.794)	(1.29)	(1.11)
SCAN2	3.33 _{a,b,c}	2.30 _a	2.33 _b	1.93 _c
σ	(1.32)	(0.794)	(1.35)	(1.44)
N	30	30	30	29

*The subscripts represent pairs with significantly different means ($p < 0.05$).

³ We exclude the LOGO and CART AOIs since they are found infrequently in the scanpath. Including them in the analysis does not change the results.

Table 9. Percentage of participants who looked at each AOI at least once

	NONE	EDIT	CUST	BOTH
BOOKIMAGE	100.00%	96.67%	96.67%	93.33%
BOOKTITLE	100.00%	86.67%	96.67%	86.67%
PRICE	90.00%	83.33%	73.33%	76.67%
ALSOBUY	100.00%	100.00%	100.00%	96.67%
PDTDETAIL	100.00%	93.33%	93.33%	80.00%
AUTHOR	100.00%	93.33%	80.00%	73.33%
ALLWORKS	100.00%	96.67%	86.67%	66.67%
LOGO	56.67%	23.33%	30.00%	33.33%
DESCRIPT	100.00%	93.33%	100.00%	86.67%
SINGLES	100.00%	96.67%	100.00%	86.67%
CART	70.00%	63.33%	66.67%	60.00%
EDITORIAL	-	96.67%	-	96.67%
CUSTOMERS	-	-	100.00%	86.67%
RATING	-	-	76.67%	60.00%
BARCHART	-	-	90.00%	80.00%
N	30	30	30	29

3.4 Impact on Decision Confidence

We find that the presence of both reviews increases participants' confidence in their decision considerably compared to when no reviews are present ($M_{\text{BOTH-CONTROL}}=1.06$, $p<0.01$) or when just the editorial review is present ($M_{\text{BOTH-EDITORIAL}}=1.09$, $p<0.01$). We do not find statistically significant differences among other comparisons of treatments groups. The finding that the presence of editorial and customer reviews together increases decision confidence to a very high level ($M_{\text{CONFIDENCE}}=5.76$) is an important one, as it underpins the widely held but hitherto unproven assumption that consumer reviews increase the confidence of consumers in their purchase decisions.

3.5 Comparison

By combining the analysis of the customer reviews on search costs and decision confidence, we find some interesting results. While there a moderately significant reduction in OBSLEN and FIXCOUNT when editorial reviews are present, as discussed in the previous section, there is no change in decision confidence. Similarly, when customer reviews are present, there is a significant reduction in OBSLEN and FIXCOUNT, as well as a reduction in the cognitive load while processing non-review related information (see Figure2 and Figure3). However there is no significant change in the decision confidence, although it displays a clear upward trajectory as shown in Figure 2.

We conclude that the presence of either editorial reviews or customer reviews seems to be beneficial, since it reduces search costs while maintaining decision confidence. When both editorial and customer reviews are present, there is no significant difference in OBSLEN or FIXCOUNT. However there is a considerable reduction in the cognitive load for processing non-review information ($M_{\text{BOTH-CONTROL}}=71$ milliseconds), and a corresponding and significant increase in decision confidence.

Thus we find what seems to be a trade-off – either editorial or customer reviews by themselves reduce search costs by reducing search time and increasing search efficiency while keeping decision confidence unchanged, while both reviews together keep the search cost mostly unchanged but increase decision confidence significantly. However, the cognitive load for non-review information is reduced, which implies that participants have less difficulty evaluating product attributes (see Figure 4). Therefore, we conclude that the total absence of reviews cause participants to repeatedly return to various product-information AOIs while attempting to make a decision. Thus a lack of decision aids causes the participants to use greater cognitive resources while processing these AOIs. The presence of reviews acting as decision aids relieves the burden on the product-information AOIs. Reading reviews does involve expending significant cognitive resources, although this increase is offset by a decreased use of cognition to evaluate non-review information. Put differently, for the same search cost, the presence of both editorial and customer reviews increases decision confidence considerably by allocating cognitive resources more efficiently. Given that the participants in the experiment were asked to conduct a goal-directed task, confidence in their decision is vital.

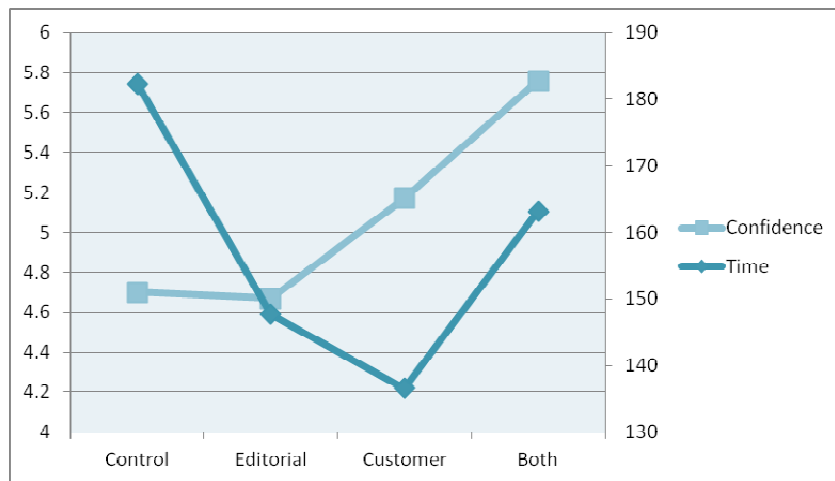


Figure 2. Decision Confidence vs. Observation Length

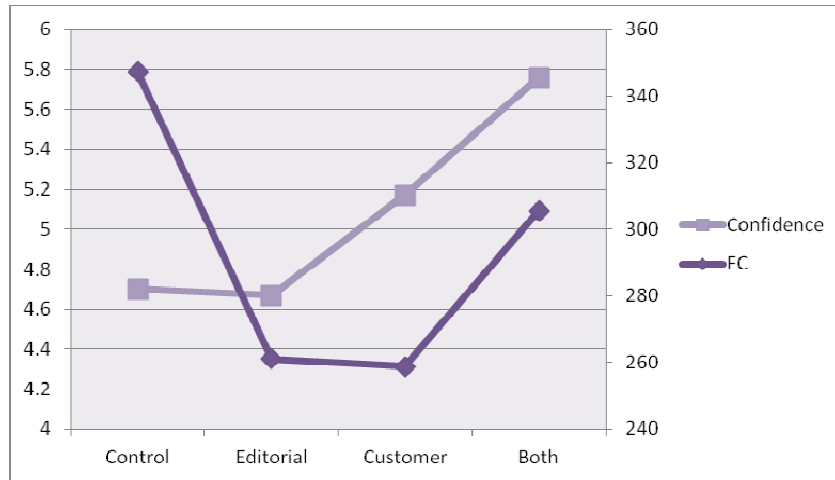


Figure 3. Decision Confidence vs. Fixation Count

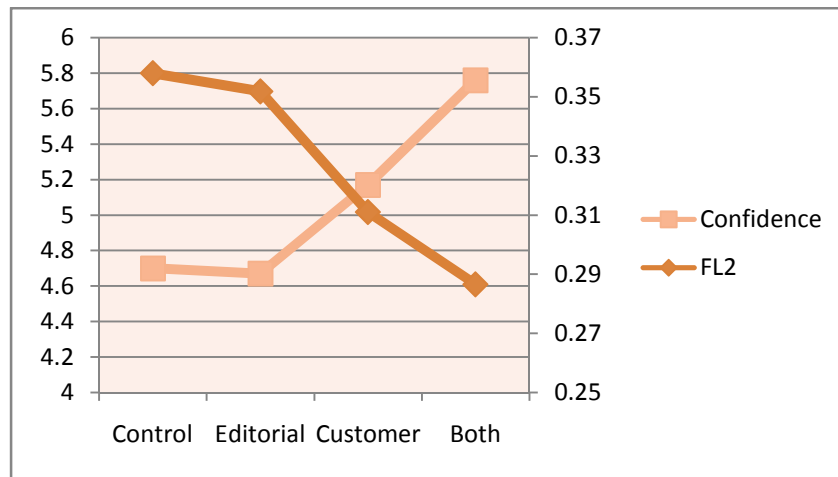


Figure 4. Decision Confidence vs. Mean Fixation Duration

4. MANAGERIAL IMPLICATIONS AND CONCLUSION

This study, through the use of cutting edge eye-tracking technology, has provided new insights into consumer behavior on ecommerce websites, and has validated two key and hitherto unproven assumptions regarding customer reviews vs. search costs and decision confidence. Our results provide a firm foundation for firms to persist with providing online reviews on their websites. By making consumer information search more efficient and by better distributing cognitive resources, online reviews clearly assist in meeting consumers' information search needs. The mere presence of reviews is significant – an editorial review reduces search time by 20% while customer reviews reduce time by 25%⁴. The number

⁴ This will likely vary depending on the number of reviews available for a particular product, and needs to be explored further in future research.

of fixations reduces equally by 25% for either review type. Given that consumers have time constraints while shopping online, reduction in search time can lead to a greater number of products being evaluated, which in turn could lead to greater sales.

However in order to generate a sale, consumer confidence in their decision needs to be high, especially in an online environment where the product is physically separated from the buyer. Since our research shows that the presence of both types of reviews increases decision confidence to a very high level, we recommend that managers make both editorial and customer reviews available on the product website. The presence of both reviews also helps distribute the cognitive load more efficiently which in turn leads to better decision making. Now the second recommendation seemingly contradicts the first, since the presence of both reviews leaves search time unchanged. However, we recommend ecommerce managers to display either or both types of reviews, depending on availability. If only one type of review is available, it will reduce search costs by reducing search time and cognitive load. If both types of reviews are available, they will help the consumer better allocate cognitive resources and increase decision confidence considerably.

Thirdly, since decision confidence is vital to a transaction being concluded, it is also reasonable to assume that consumers with a high degree of confidence in their decision will trust the vendor, regardless of whether the decision to purchase is positive or negative. Thus we recommend that vendors display available reviews, regardless of the positivity or negativity, as long as they are relevant and genuine.

This study has several limitations. The sample size for each treatment group in the experiment is about 30, which could hide or exaggerate some findings. The product used for the experiment is a short e-book and is an experience good. Consumers may use product reviews differently for search goods such as digital cameras. In addition, the most helpful customer review for the e-book in the experiment was a negative review, which could cause different results than if the most helpful review was a positive review. Finally, we did not look at opinion formation in this paper, which is an antecedent to decision making and decision confidence. We aim to explore these issues in future research.

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<i>Abstract:</i> <p><i>The literature on online product reviews examine the fundamental premise that reviews reduce search costs and also increase consumer confidence in their purchase decisions, which has not been proven in the previous literature. We conducted an experiment using an eye-tracking machine to measure the impact of online reviews on consumer information search costs and on decision confidence. We find that both editorial reviews and customer reviews when presented separately reduce the search time considerably, but not when present together. However, we find that the presence of both types of reviews increases decision confidence considerably, thereby, suggesting a trade-off between search time and decision confidence. When both types of reviews are presented together, the cognitive cost of processing non-review information is significantly reduced implying more efficient allocation of cognitive resources. We conclude with several managerial recommendations for ecommerce firms.</i></p>	
<i>Key Words/Phrases: ecommerce, product reviews, decision confidence, eye-tracking</i>	
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