Learning by Doing: Understanding the Role of Affordance Informativity in Information Search Performance

Completed Research Paper

Fei Liu

Department of IT Management
Copenhagen Business School
Howitzvej 60, 5.20
DK-2000 Frederiksberg, Copenhagen
Denmark
afl.itm@cbs.dk

Bo Xiao

Information Technology Management
Department
Shidler College of Business
University of Hawaiʻi at Mānoa
2404 Maile Way
HI 96822, Honolulu
USA
boxiao@hawaii.edu

Eric Lim

School of Information Systems and
Technology Management
UNSW Australia Business School
High St, Kensington, NSW 2052
Australia
e.t.lim@unsw.edu.au

Chee-Wee Tan

Department of IT Management
Copenhagen Business School
Howitzvej 60, 5.18
DK-2000 Frederiksberg, Copenhagen
Denmark
cta.itm@cbs.dk

Abstract

Information search is becoming increasingly demanding due to the booming of Consumer Generated Content (CGC) in online environment. This has led to growing scholarly interest in designing search features to accommodate diverse user preferences. Drawing on the Theory of Affordance Informativity, we advance ostensive informativity and performative informativity as focal mechanisms for search features to convey actions afforded to users. We further put forth a typology of search features that is grounded in both dimensions of search affordance informativities. Next, we construct a research framework that depicts how search affordance informativity bolsters information search performance. By conducting a field experiment on our custom-made online restaurant review website, we discovered that performative informativity increases search result anticipation and reduces search costs whereas ostensive informativity only facilitates the former. Search result anticipation in turn enhances search performance in terms of efficiency and utility, but the opposite effect is observed for search costs.

Keywords: Online Information Search, Search Affordance Informativity, Search Efficiency, Search Utility, Filed Experiment

Introduction

With the World Wide Web being increasingly recognized as a vital source of information (Hsieh-Yee 2001), information search has emerged as the most dominant task performed by Internet users (Byrne et al. 1999). In United States alone, the number of search engine users reached approximately 213.6 million in 2014[1]. Nevertheless, information search is becoming much more demanding due to a surge in Consumer Generated Content (CGC) within online environments (McAfee et al. 2012): a "perfect" search engine is no longer adequate in aiding users to overcome the hurdles in locating desired information. In fact, in 2012 alone, approximately 2.5 Exabyte of text, images, sensor readings, GPS signals, and other forms of data are collected by websites on a daily basis (McAfee et al. 2012). As CGC continues to accumulate[2], it is not uncommon for websites to implement custom-made search features to assist users in information search (Teevan et al. 2004). However, the configuration of information search features on these websites is often not optimized to accommodate users' information search behavior, leading to adverse outcome such as information overload (Hölscher and Strube 2000), sub-optimal search performance (Öörni 2003), and false discoveries (Lohr 2012). An in-depth appreciation of information search behavior is thus imperative to guide the design and development of search features that can reconcile potential conflict between the system's search capabilities and users' search preferences (Kuhlthau 1999).

Technological affordance, which refers to possibilities and limits for action that a technology offers to a user (Robey et al. 2013), is key to understanding the interaction between users and design elements (Gibson 1986, 2013). Prior research has corroborated this ecological perspective by articulating how the design of search features endows users with control over their search process (Liu et al. 2016a). Nonetheless, such capabilities (i.e., control over search process) have to be conveyed to users via the website hosting the search features. A number of recent studies have attested to the notion that websites can utilize information scent to guide users' information search behavior. For instance, Pirolli and colleagues (Fu and Pirolli 2007; Pirolli et al. 2005, 2001; Pirolli and Fu 2003) demonstrated that information scent can boost the efficiency of information search, especially in visually dense informational environments. Users rely on information scent (e.g., hyperlinks) to evaluate the utility of accessed content, and in turn determine how to proceed with their information search. Moody and Galleta (2015) also observed that information scent helps users to better orientate their search for information, which in turn increases the likelihood of locating relevant information. Whereas prior research has focused on exploring how websites can employ information cues to direct users' information search, the Theory of Affordance Informativity (Gaver 1991) holds that another options of conveying perceptible affordance is to engage users in interaction with a technology. In this study, we thus distinguish between *ostensive informativity* (i.e., conveying perceptible affordance to users by providing *a priori* information) and *performative informativity* (i.e., conveying perceptible affordance to users by engaging them in interaction) (Pentland and Feldman 2008; Robey et al. 2013) as two distinct mechanisms by which search features direct users' information search behavior.

In order to capture the effects of both *ostensive informativity* and *performative informativity* on information search behavior, we elicit two constructs that are instrumental to the performance of information search. According to Browne et al. (2007), an information search is deemed to have concluded if the search results coincide with the searcher's anticipation. Consequently, we adopt *search result anticipation*, which reflects extent to which users can anticipate the search results, as the mediator between the two search affordance informativities and *search efficiency* (Liu et al. 2016a). Furthermore, *matching law* implies that the estimated utility of obtained information should be discounted by the effort expended during the information search process (Smith and Hantula 2008). We hence adopt *search costs*, which is defined as the amount of effort required to conduct an information search, as the mediator between the two forms of search affordance informativities and *search utility* (Liu et al. 2016b). Essentially, the focus of this study is to explicate the roles of both *ostensive informativity* and *performative informativity* in shaping the performance of information search behavior. By investigating how *ostensive informativity* and *performative informativity*, as induced by search features, affect the performance of online information

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[1] Worldwide desktop market share of leading search engines from January 2010 to January 2016, http://www.statista.com/statistics/216573/worldwide-market-share-of-search-engines/, accessed in 2016.

[2] Search Engine Unfriendliness of Web 2.0, http://searchengineland.com/the-search-engine-unfriendliness-of-web-20-12465, accessed in 2016.

search (i.e., *search efficiency* and *search utility*) through *search result anticipation* and *search costs*, this study endeavors to answer the research questions below:

1. *How does the design of search features convey their affordance to users via search affordance informativities?*
2. *How do search affordance informativities influence online information search performance in terms of efficiency and utility?*
3. *How do search result anticipation and search costs influence the impact of search affordance informativities on users' online information search performance?*

Related Works

Technological Affordance

Affordance was coined by Gibson (1986, 2013) to represent the "possibilities and limits for action that a material object offers to an actor" (Robey et al. 2013, p. 386). Before interacting with an object, human actors can perceive the actions that are permitted or forbidden by this object (Gibson 2013). Affordance thus bridges the properties of material objects (i.e., IT artefacts) and human users' perceived control of action (Turvey 1992). Observing the relational characteristic of affordance, Hutchby (2001) posited that affordance is exclusive to neither actors nor artefacts. Rather, it is a manifestation of the relationship between actors and the objects they interact with in a given context. Likewise, Stoffregen (2003) conceptualized affordance as emergent relational properties embedded in the interactions between actors and artefacts. In the context of technology usage, users' interpretation of the possibilities for actions, which are afforded by an IT artefact, stems from their own goals (Markus and Silver 2008). Leonardi (2011) termed such interaction as an imbrication of human and material agencies: affordance reflects the functional interdependency between a user's agency, which captures the capacity for realizing his/her goals, and the material agency of a technology, which represents the actions supported by this technology (Leonardi 2011). In this sense, affordance acts as a catalyst to facilitate the aforementioned imbrication in two ways: a user can either perceive the possible actions afforded by a technology in accordance with his/her goals or realign his/her goals to resonate with possible actions afforded by a technology (Leonardi 2011). The lens of technological affordance thus helps to balance the social and material aspects of technology in order to arrive at a more comprehensive understanding of technology use that embraces both aspects, such as that of online information search (Faraj and Azad 2012).

Affordance is a common design element in Human Computer Interaction (HCI) studies. Past studies in HCI have examined how affordance can be realized by design features. For instance, through an empirical study of an e-government case handling system, Goldkuhl (2008) contended that the design of information systems should aim for *actability* in order to fulfil users' expectation of affordance by allowing the latter to engage in desired actions. Mesgari and Faraj (2012) summarized three categories of elements (i.e., technical, social, and personal) that contribute to shaping the affordance offered by Wikipedia. Technical elements encompass system implementation and design elements while social elements can be manipulated through the enforcement of user policies (Mesgari and Faraj 2012). Oshlyansky (2007) attested to the importance of incorporating cultural factors into interface designs (i.e., light switches, dials, and cooker hobs) because individuals' perceived affordance is subjected to the influence of cultural differences. Wagner et al. (2014) proposed six categories of social media affordances (i.e., reviewability, recombinability, experimentation, editability, association, and authoring) and integrated these affordances to form the dynamic model of knowledge conversion (i.e., SECI model). Wagner et al. (2014) further suggested that novel technology not only facilitates existing behaviors, but also afford new ones, which are previously unavailable.

The concept of affordance has also been widely adopted in education research. For instance, Bower (2008) devised an evaluative model for e-learning design by categorizing functional affordances for e-learning system into static/instructive affordances, which allow information transfer, and collaborative/productive affordances, which support customizability. Mao (2014), in analyzing both quantitative responses and qualitative feedback from 166 middle school students regarding their experience with social media usage in a learning context, suggested that reconciling students' preconception of social media as a means for leisure and social purpose with the educational affordance of social media tools is the key to improving the design of learning activities. Roblyer and Wiencke (2004) scrutinized post-course evaluations from 68 college

students and noted that, without attending to the engagement of both instructor and students as well as the design of course activities, the range of affordances offered by technological interactivity cannot be realized. Likewise, via an online survey of 120 students and 62 faculty members, Roblyer et al. (2010) found that the educational affordance of social media (i.e., Facebook) in the provision of a more interactive learning environment is obfuscated by the disagreement between students and faculty members regarding the perceived roles of social media. More specifically, students tend to agree that Facebook can boost the accessibility and interactivity of learning activities, whereas faculty members share the view that Facebook is simply not suitable for education (Roblyer et al. 2010). Findings along this stream of research further corroborate the relational property of affordance as an imbrication between human and technological agencies (Leonardi 2011).

By adopting the lens of technological affordance, this study zeros in on the imbrication between users and design elements in the context of online information search. In order to explicate how such imbrication between searchers and search features can be established, we draw on the Theory of Affordance Informativity (Gaver 1991) to advance both *ostensive informativity* and *performative informativity* as key linkages between searchers' perceptual affordance and the capabilities afforded by search features.

Theory of Affordance Informativity

Gaver (1991) built on the concept of *technology affordance* to emphasize the importance of informing individuals about the affordance of a technology prior to actual usage. Gaver (1991) suggested two methods to convey perceptible affordance to users: through information and/or interaction. Vyas et al. (2006) also proposed two ways for users to interpret the capacity of a system, namely *information* and *articulation,* both of which can be *clear* or *unclear*. On one hand, design elements can communicate clear information or implement clear articulation that ensures users' precise and unambiguous inference of the technological affordance. Conversely, designers can provide unclear information or implement unclear articulation that allows more flexibility and ambiguity in users' interpretation (Vyas et al. 2006). In the context of online information search, we expect design elements to provide both *ostensive informativity*, which conveys perceptible affordance to users via the provision of relevant information to improve perceptibility of search affordance for users, and *performative informativity*, which conveys perceptible affordance via engaging users in interaction to improve users' understanding of search affordance (Pentland and Feldman 2008; Robey et al. 2013). For example, a button with a label employs *ostensive informativity* to inform users about how this button functions (Gaver 1991). Conversely, *performative informativity* allows individuals to learn about how a door handle helps them open a door by interacting with this door handle (Gaver 1991). We thus incorporate both ostensive and performative aspects of *search affordance informativity* in this study to account for the mechanism through which users infer the search actions afforded by various search features. We consider *search affordance informativities* as integral parts of the mechanism of each search feature without the need for extra introductions and tutorials.

Theory Development

By drawing from the Theory of Affordance Informativity (Gaver 1991), we construct a research model (see Figure 1) to articulate how both ostensive informativity and performative informativity contribute to users' online information search performance. In the next sections, we explicate a typology of online information search features in accordance with their corresponding search affordance informativities, and then formulate testable hypotheses based on our research model.

Search Feature and Search Affordance Informativity

In this study, *search affordance informativities* are ingrained in the mechanism of each search feature rather than being induced by additional introductions or tutorials. For this reason, the two dimensions of *search affordance informativities* (i.e., *ostensive* and *performative informativity*) allow us to categorize the designs of contemporary search feature in accordance with the *search affordance informativities* each search feature entails (see Table 1). *Faceted search* is a categorized filter that displays pre-defined categories of attributes and corresponding attribute values for users to determine their search criteria by selecting one or more values for each attribute (Hearst 2006). This in turn provide users with precise information cues about the search actions. Nonetheless, due to the opaque process between input and output, the articulation

for users to infer permitted pattern of usage is *unclear*. Consequently, *faceted search* offers *clear ostensive informativity* yet *unclear performative informativity*.
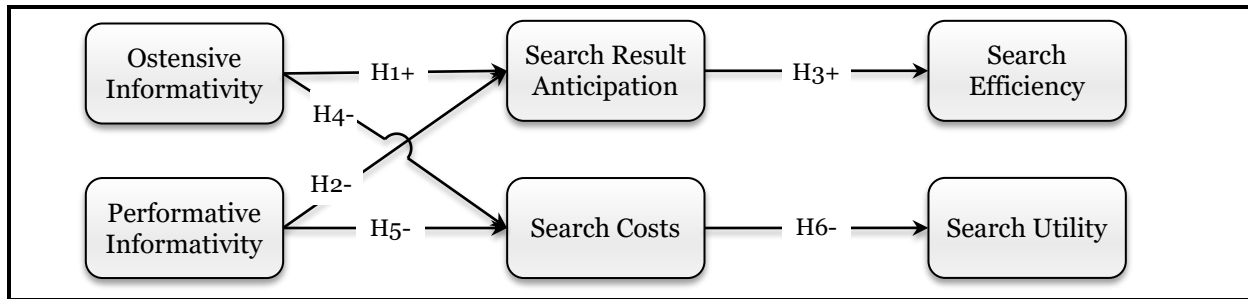

Figure 1. Research Model for This Study

Keyword search, a search bar that allows users to specify their own keywords to conduct search (Teevan et al. 2004), only offers *unclear* information about how users can conduct the search by typing in customized keywords (e.g., a text field says "type in keyword to search"). Moreover, *keyword search* often directly retrieves a list of search results, leaving a limited window for users to observe the mechanism through which the system retrieves information items to match their search criteria. Therefore, *keyword search* offers *unclear ostensive informativity* and *unclear performative informativity*.

Ranking search allows users to sort the list of information items according to pre-determined attributes in either ascending or descending order, hence providing users with clear information regarding how a list of information can be arranged prior to browsing. In addition, users of *ranking search* have more opportunity to experience the feedback mechanism that reacts to their input (e.g., scrolling down the list to retrieve addition information items) (Vyas et al. 2006). As a consequence, ranking search offers *clear ostensive informativity* and *clear performative informativity*.

Last but not least, *interactive search* in the likes of an interactive map, allows the users to search for information items within the view port by moving or zooming the view port. Information about how an *interactive search* feature can be manipulated is often obscure. For example, when a user moves the mouse cursor over an interactive map, the cursor changes to a hand shape to signify the possibility to move the mop around. However, the articulation for *interactive search* is usually visible to users such that they can observe how their search actions unfold (e.g., the map moves along the mouse cursor and new information items appears on the updated map). Thereby, *interactive search* offers *unclear ostensive informativity* yet *clear performative informativity*.

Search Affordance Informativity and Search Result Anticipation

Both types of search affordance informativities are expected to shape how users anticipate their search results. In this study, we define *search result anticipation* as the extent to which users are able to anticipate the contents of search results. Search features with *ostensive informativity* guide users in their search process by providing information scent. Consequently, information scent tends to deepen users' understanding of how the system retrieve information in accordance with their criteria. An extensive comprehension of the underlying mechanism of a search feature can helps users to better predict the search results. In addition, information scent often carries clues about the search results that will be retrieved by users if they perform the suggested search actions. Furthermore, since information scent is generated in accordance with the information in the database of a website (Moody and Galletta 2015), they tend to resemble the characteristics of the related information items with high accuracy, hence facilitate *search result anticipation*. With insufficient *ostensive informativity*, the potential discrepancy between users' expected search results and the information items available on a website is likely to be amplified, thus undermining users' *search result anticipation*. In a sense, *ostensive informativity* can promote the *pretention* aspect of *search result anticipation* by aiding users to form a more accurate expectation for the search results that can be obtained by performing certain search actions. We thus hypothesize:

Hypothesis 1: A user's perceived ostensive informativity on a website positively influences his/her search result anticipation.
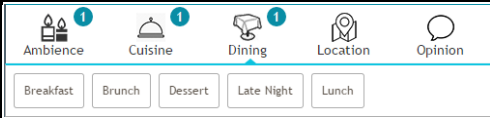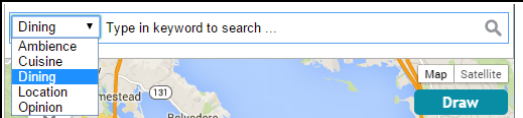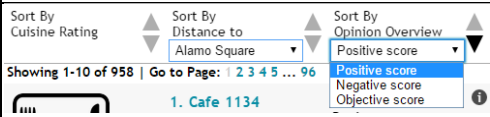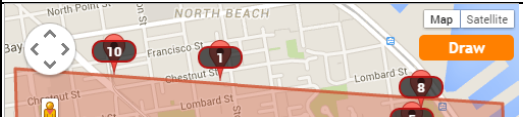
Ostensive Informativity	
Conveying affordance through information	
Clear Information: Ensuring precise and unambiguous inference of search affordance	**Unclear Information**: Allowing flexibility and ambiguity in interpretation of search affordance
Faceted Search (FS)	**Keyword Search (KS)**
A categorized filter that displays pre-defined categories of attributes and corresponding attribute values for users to determine their search criteria by selecting one or more values for each attribute.	A standard search bar that allows users to specify a category of keywords and type in one more multiple keywords to conduct search.
Ranking Search (RS)	**Interactive Search (IS)**
A feature that allows users to sort the list of information items according to pre-defined attributes in either ascending or descending order.	A Feature that allows the users to search for information items in two ways: (1) Moving or zooming the view port of the map to find information items within the updated view port. (2) Drawing boundaries around an area of interest via mouse cursor to find information items within this area of interest.

Left row header (top): **Unclear Articulation**: promoting flexibility and ambiguity in inference of supported use patterns

Left row header (bottom): **Clear Articulation**: enforcing rigid and specific interpretation on the supported use patterns

Outer left header: **Performative Informativity** Conveying affordance through interaction

Table 1. Categorizing Search Features regarding Search Affordance Informativity

On the contrary, *performative informativity* requires users to engage in a particular search action prior to obtaining an understanding about how a search feature handles their input. Therefore, users who interact with a search feature, which employ *performative informativity*, tend to engage in a heuristic process in order to uncover its underlining mechanism. Such trial process is less predictable in nature and is likely to lead to unexpected search results. Many designers implement design elements in a consistent way to leverage on users' prior experience to alleviate the drawbacks of utilizing *performative informativity*. For example, the design for search bar is often consistent across multiple websites, with a textbox on the left hand side and a magnifying glass icon on the right hand side. Nonetheless, the uncertainty associated with trying out a search feature can hardly be eliminated, especially when this search feature comes with complex mechanism. As a consequence, *performative informativity* tends to induce uncertainty that impedes users' anticipation for search results. We thus hypothesize:

Hypothesis 2: A user's perceived performative informativity on a website negatively influences his/her search result anticipation.

Search Result Anticipation and Search Efficiency

When performing goal-oriented behavior, reaching a predetermined goal with minimum time and effort often constitutes users' top priority (Bates 2002). According to Browne et al. (2007), users adopt certain *stopping rules* to terminate their information search. Particularly, for goal-oriented searchers with a clear mindset for determining the sufficiency of the information gathered (Browne and Pitts 2004), their search stopping rule is basically one or multiple mental criteria they wish to fulfil by gathering information (Browne et al. 2007). Therefore, an information search is only completed if the searcher obtained

information items that coincide with his/her anticipated search results. For this research, a searcher with higher *search result anticipation* is likely to expend less time and effort before the search process comes to an end because the search results are more anticipatable (Liu et al. 2016a). Finding sufficient information according to the stopping rules with less time and efforts expended throughout the entire search process represents higher *search efficiency*. Consequently, *search result anticipation* can facilitate users' *search efficiency* (Liu et al. 2016a). We thus hypothesize:

Hypothesis 3: A user's perceived search result anticipation on a website positively influences his/her search efficiency.

Search Affordance Informativity and Search Costs

Unlike *search efficiency* which focuses on the time and efforts expended during the entire search process, *search costs* is concerned with the time and effort imposed by each search action. Two types of *search affordance informativities* play diverging roles in shaping *search costs*. To interpret search affordance via *ostensive informativity*, users are compelled to inspect information scent derived from search actions supported by these search features (Pentland and Feldman 2008; Robey et al. 2013). Users often need to devote extra cognitive efforts into observing and interpreting information scents prior to the execution of search actions. Therefore, *ostensive informativity* places additional cognitive load upon users and in turn heightens their *search costs*. Moreover, the affordance indicated by the information scent does not always coincide with users' expectations. Users may need to expend additional time and efforts to improvise their search plans and actions, thus further elevating their *search costs*. We thus hypothesize:

Hypothesis 4: A user's perceived ostensive informativity on a website positively influences his/her perceived search costs.

On the contrary, *performative informativity* conveys search affordance by engaging users through interaction (Pentland and Feldman 2008; Robey et al. 2013). Therefore, the overhead prior to performing search actions is minimized since users' search process is not likely to be disrupted by inspecting information. Although *performative informativity* incurs additional heuristics for users to understand the search actions that are supported by a search feature, it alleviates the need for users to spend time and effort in processing instructive information. Therefore, users' search experience, as a whole, is still rendered much more intuitive and smooth. As result, users tend to feel that the search process entails less time and efforts due to the shortened delay between search actions as well as the improved flow of search (Szameitat et al. 2009). We thus hypothesize:

Hypothesis 5: A user's perceived performative informativity on a website negatively influences his/her perceived search costs.

Search Cost and Search Utility

Matching law postulates that the currencies, which is necessary to reach viable alternatives, is the key to the utility of information search (Herrnstein 1961, 1970). *Search utility* refers to the extent to which a search process yields positive marginal return (Liu et al. 2016b). Past studies on e-commerce identified temporal delay (DiClemente and Hantula 2003; Difonzo et al. 1998; Rajala and Hantula 2000; Szameitat et al. 2009) and monetary budgets (Smith and Hantula 2003) as main factors that discount the value of sampling more options and in turn, deter consumers from searching for alternatives. Likewise, prior research which investigated online information foraging found that users aim to optimize their information yield by maximizing the information intake over the cost of obtaining the information (Pirolli and Card 1999). Specifically, online information searchers often choose to discard even potentially relevant information if they believe consuming the information is too demanding and time consuming (Pirolli and Card 1999). According to the SNIF-ACT model (Fu and Pirolli 2007; Pirolli et al. 2005; Pirolli and Fu 2003), users often follow information scent that is easier to reach and digest in order to minimize the time required to obtain and process relevant information. Moody and Galletta (2015) found that time constraints limit users' cognitive capacity as well as their scope of exploration, which in turn led to suboptimal performance of information retrieval and undermined the yield of the search. Similarly, when carrying out information search, users constantly evaluate the utility of furthering the search by assessing whether the value generated from furthering the search outweighs the extra *search costs* that it incurred (Liu et al. 2016b).

Consequently, lowering *search costs* can heighten users' perceived *search utility* (Liu et al. 2016b). We thus hypothesize:

Hypothesis 6: A user's perceived search costs on a website negatively influences his/her perceived search utility.

Research Methodology

To empirically validate our hypotheses, we employ a field experiment approach to elicit responses from participants. In order to offer a full range of search features, we developed a custom-made online restaurant review website and implemented select search features in accordance with contemporary design and our taxonomy of search features (see Table 1). To preserve the realism of our experimental setting, we populate the website with real data that are extracted from a popular online restaurant review website via web extraction. Our dataset includes detailed descriptions of 1,079 restaurants in the San Francisco area along with about 268,000 reviews for these restaurants, which are written by approximately 91,000 diners. The website offers a realistic and controlled platform for experiment.

Development of Survey Measures

We developed measurement items to capture participants' perceptions for their experience of completing search tasks on our custom-made experimental website. Measurement items for participants' perceived dimensions of *online information search tactics*, which are afforded by various search features, are newly developed in accordance with standard psychometric procedures (Moore and Benbasat 1991). We derived novel measures from Gaver's (1991) definition for affordance informativity to capture both *ostensive informativity* and *performative informativity*. As a consequence of our full factorial experimental design, *ostensive informativity* and *performative informativity* are measured on a 7-point Likert scale in order to accurately capture the variance in both constructs induced by various configurations of search features. Measures for both *search result anticipation* and *search efficiency* are adapted from prior study (Liu et al. 2016a) whereas items for *search costs* are obtained via an adaptation of Burnham et al.'s (2003) operationalization of cost perception to capture the time and effort incurred through the use of search features. Information *search utility* are captured by measurement items that are newly developed on the basis of individuals' perceptions of the corresponding economic concepts (DiClemente and Hantula 2003; Hantula et al. 2008; Rajala and Hantula 2000). Table 2 summarizes our reflective measurement items along with their descriptive statistics.

Construct	Definition	Reflective Measures [7-point Likert scale]	Mean (S.D.)	Item Loading
Ostensive Informativity [OI] (Newly Developed)	Extent to which a search feature conveys its affordance by providing relevant information.	The website provided information on how I can conduct a search for restaurants by utilizing the available search features.	5.739 (1.099)	0.923
		The website provided information about possible ways to search for restaurants by utilizing the available search features.	5.749 (1.141)	0.948
		The website provided information about search actions which can be performed on the available search features when searching for restaurants.	5.731 (1.110)	0.937
Performative Informativity [PI] (Newly Developed)	Extent to which a search feature conveys its affordance by engaging users through interaction.	The website allowed interactions with the available search features in order for me to experience how I can conduct a search for restaurants.	5.640 (1.100)	0.928
		The website enabled interactions with the available search features in order for me to try out possible ways to search for restaurants.	5.604 (1.169)	0.954
		The website permitted interactions with the available search features in order for me to discover	5.551 (1.179)	0.940

		search actions which can be performed when searching for restaurants.		
Search Result Anticipation [SRA] (Adapted from Liu et al. 2016a)	Extent to which an individual is able to anticipate the search results	I felt that I was able to anticipate the results of each search on the website.	4.728 (1.530)	0.932
		I felt that I was able to foresee the results of each search on the website.	4.590 (1.481)	0.954
		I felt that I was able to predict the results of each search on the website.	4.505 (1.533)	0.951
Search Cost [SC] (Adapted from Burnham et al. 2003)	Time and effort expended by an individual on performing the search	It took effort to locate restaurants on the website.	4.035 (1.810)	0.848
		There is a lot of effort involved in searching for restaurants on the website.	3.572 (1.831)	0.873
		It took effort to search for restaurants on the website.	3.919 (1.833)	0.877
		It was not easy to conduct the search for restaurants on the website.	3.233 (1.853)	0.889
		It took effort to utilize search features on the website to find restaurants.	3.763 (1.807)	0.857
		There is a lot of effort involved in utilizing search features on the website to find restaurants.	3.417 (1.842)	0.912
		It took effort to utilize search features on the website to find restaurants.	3.700 (1.843)	0.885
		It was NOT easy to utilize search features on the website to find restaurants.	3.117 (1.774)	0.865
Search Efficiency [SE] (Adapted from Liu et al. 2016a)	Extent to which an individual is able to find sufficient information according to the stopping rules with less time and efforts	The search process for restaurants is efficient.	5.636 (1.363)	0.917
		The search process for restaurants is fast.	5.512 (1.519)	0.924
		The search process for restaurants is free of hassle.	5.311 (1.565)	0.942
		The search process for restaurants is effortless.	5.074 (1.654)	0.912
Search Utility [SU] (Newly Developed)	Extent to which the search process yields positive marginal return	The search process for restaurants is worthwhile.	5.820 (1.117)	0.942
		The search process for restaurants is valuable.	5.943 (1.044)	0.941
		The search process for restaurants is beneficial.	5.965 (1.055)	0.941

Table 2. Instrument and Measurement Properties for Reflective Measures [*N* = 283]

Field Experiment Procedures

We recruit participants for our experiment from Amazon Mechanical Turk (AMT). AMT is a crowdsourcing online labor marketplace that connect individual works with Human Intelligence Task (HIT) requesters (Paolacci and Chandler 2014). AMT is recognized by researchers as a large and heterogeneous pool of research participants with increasing popularity and viability (Chandler et al. 2014; Paolacci and Chandler 2014). Compared to traditional college samples, AMT is especially advantageous for investigating Internet phenomena, including online information search, due to AMT workers' diverse demographics as well as their rich Internet experience (Paolacci and Chandler 2014). To ensure data quality, we applied the screening criteria recommended by Chen (2012), meaning that we only recruit workers who completed at

least 10,000 HITs with 99% approval rate. Each worker will be awarded USD $1.00 for participating in our experiment.

We adopt a full factorial experimental design and developed 2^4 versions for our website, of which each contains a specific composition of our four search features. Each participant is asked to conduct well-structured, goal-oriented search task (Browne et al. 2007; Campbell 1988) on a randomly assigned version (see Table 3). Prior to taking on the search task on our website, each participant will be directed from our HIT page on AMT to an online questionnaire that describes the experimental procedure in detail and solicit demographic information. Afterwards, participants will follow a link and access one randomly assigned version of our experimental website to complete the search task. To complete the search task, each participant have to bookmark all restaurants that he/she considered and then pick the best one from this consideration set. Participants are also asked to justify how they arrive at their final decisions. Subsequently, participants will be redirected back to the online questionnaire to answer the post-task questions. At the end of the survey, participants will be given a completion code for claiming their reward.

> **Scenario**: Sebastian was your best friend from high school, but you have not seen him for quite a while because he moved to another city right after his graduation. Last night, you received a surprise call from Sebastian who happen to be in town on business and would like to invite you to dinner this weekend. Because Sebastian has been away from San Francisco for many years, he wants you to pick a restaurant that is located midway between Sebastian's hotel and where you live. You live in the Bernal Heights neighborhood, which is located at the central area of San Francisco whereas Sebastian's hotel is situated in the Tenderloin neighborhood, which is to the north-east of your place. Also, even though Sebastian usually prefers authentic American cuisine, he finds other popular cuisines to be equally appealing so long as they are authentic. Likewise, he is easygoing and likes to follow the opinions of the majority. As your old friend, Sebastian wishes to have an enjoyable conversation with you in a casual atmosphere during your dinner. Please utilize the search features on this website to find a desirable restaurant for your dinner with Sebastian.

Table 3. Search Task Scenario

Data Analysis

A total of 344 participants were recruited from AMT, among which 283 participants completed the entire experiment and yielded valid responses for data analysis. Table 4 shows the demographics of our AMT samples. Consistent with the work of Xu et al. (2013), our experimental website was constructed to induce variance in both ostensive and performative informativities. Therefore, SmartPLS 2.0 was utilized to validate both the measurement and nomological properties of our research model (Chin 1998). Partial least squares (PLS) analysis is preferred over other analytical techniques because it simultaneously analyses the psychometric properties of the measures (i.e., the measurement model) as well as both the direction and strength of each hypothesized relationship (i.e., structural model) (Wixom and Watson 2001).

Measurement Model

To ensure the reliability and validity of our measurement model, we assess the reliability and internal consistency of all measurement items, as well as the convergent and discriminant validity of all measured constructs in the present study. The internal consistency of reflective measures can be gauged by assessing the quality criteria, including Cronbach's alpha, Composite Reliability (CR) and the Average Variance Extracted (AVE), for each measurement item (Fornell and Larcker 1981; Nunnally and Bernstein 1994). As depicted in Table 5, all quality criteria far exceed recommended thresholds, indicating that convergent validity is assured. Moreover, factor loading is also a crucial reflector of the reliability of measurement items. As illustrated in Table 2, all factor loadings do not fall below the cut-off value of 0.7, further substantiating the internal consistency of our measurement items. Consequently, the convergent validity of each construct is supported since it is measured accurately and reliably by its corresponding indicators.

Guided by Barclay et al. (1995), we evaluate the discriminant validity of all latent constructs in two ways. First, according to the loading and cross-loading matrix (see Table 6), each measurement item loads higher on the construct that it is supposed to reflect instead of on any other constructs, hence indicating

satisfactory discriminant validity (Chin 2001). Second, as shown in Table 5, the discriminant validity holds since the square root of the AVE of each construct surpasses its correlation with any other constructs. This implies that each construct possesses more distinctive variance as compared to its shared variance with other constructs (Fornell and Larcker 1981). Taken together the preceding results, our measurement model thus exhibits sufficient convergent as well as discriminant validity.

	Demographic	No. Respondents	Percentage	Use of Search Features			
				FS	KS	RS	IS
Gender	Male	134	47.3%	275	142	186	228
	Female	145	51.2%	429	146	176	327
	Unwilling to disclose	4	1.4%	0	3	3	4
Age	Age 19 - 29	87	30.7%	136	62	111	100
	Age 30 - 49	155	54.8%	418	155	195	356
	Age 50 - 64	34	12.0%	145	73	56	102
	Age 65+	3	1.1%	5	1	3	1
	Unwilling to disclose	4	1.4%	0	0	0	0
Education	Less than college education	37	13.1%	111	66	63	84
	College education or higher	245	86.6%	593	225	219	392
	Unwilling to disclose	1	0.4%	0	0	0	0
Income	$0-30,000	122	43.1%	313	126	143	204
	$30,000-$50,000	78	27.6%	184	90	91	158
	$50,000-75,000	44	15.5%	109	44	73	95
	$75,000+	29	10.2%	81	10	39	85
	Unwilling to disclose	10	3.5%	17	21	19	17

Table 4. Descriptive Statistics for Online Survey [*N* = 283]

Construct	Cronbach's α [> 0.70]	CR [> 0.70]	AVE [> 0.50]	OI	PI	SRA	SC	SE	SU
OI	0.930	0.955	0.877	**0.936**					
PI	0.935	0.958	0.885	0.701	**0.941**				
SRA	0.941	0.962	0.894	0.406	0.440	**0.945**			
SC	0.957	0.963	0.767	-0.254	-0.340	-0.095	**0.876**		
SE	0.943	0.959	0.853	0.437	0.495	0.570	-0.490	**0.924**	
SU	0.935	0.959	0.886	0.545	0.639	0.469	-0.411	0.722	**0.941**

Note: OI → Ostensive Informativity; PI → Performative Informativity; SRA → Search Result Anticipation; SC → Search Cost; SE → Search Efficiency; SU → Search Utility.

Table 5. Internal Consistencies and Inter-Construct Correlation Matrix [*N* = 283]

Constructs / Items	OI	PI	SRA	SC	SE	SU
OI1	**0.923**	0.641	0.365	-0.271	0.395	0.496
OI2	**0.948**	0.679	0.406	-0.224	0.426	0.531
OI3	**0.937**	0.647	0.369	-0.220	0.407	0.503
PI1	0.667	**0.928**	0.436	-0.334	0.479	0.619
PI2	0.655	**0.954**	0.418	-0.328	0.469	0.626
PI3	0.655	**0.940**	0.384	-0.297	0.448	0.555
SRA1	0.415	0.426	**0.932**	-0.113	0.564	0.478
SRA2	0.377	0.418	**0.954**	-0.107	0.530	0.441
SRA3	0.357	0.401	**0.951**	-0.047	0.520	0.409

SC1	-0.182	-0.273	-0.045	**0.848**	-0.369	-0.267
SC2	-0.228	-0.306	-0.095	**0.873**	-0.418	-0.360
SC3	-0.170	-0.215	-0.072	**0.877**	-0.408	-0.294
SC4	-0.316	-0.405	-0.109	**0.889**	-0.498	-0.489
SC5	-0.153	-0.213	-0.075	**0.857**	-0.372	-0.257
SC6	-0.202	-0.306	-0.079	**0.912**	-0.447	-0.360
SC7	-0.181	-0.221	-0.033	**0.885**	-0.382	-0.291
SC8	-0.264	-0.338	-0.121	**0.865**	-0.474	-0.430
SE1	0.419	0.508	0.512	-0.440	**0.917**	0.734
SE2	0.404	0.435	0.517	-0.452	**0.924**	0.673
SE3	0.435	0.481	0.537	-0.471	**0.942**	0.667
SE4	0.356	0.402	0.541	-0.448	**0.912**	0.590
SU1	0.520	0.571	0.408	-0.426	0.672	**0.942**
SU2	0.521	0.627	0.485	-0.393	0.703	**0.941**
SU3	0.497	0.605	0.430	-0.340	0.662	**0.941**

Note: OI → Ostensive Informativity; PI → Performative Informativity; SRA → Search Result Anticipation; SC → Search Cost; SE → Search Efficiency; SU → Search Utility.

Table 6. Loading and Cross-Loading Matrix [Sample N = 283]

Structural Model

Figure 2 illustrates the structural model from our data analysis. As predicted, *ostensive informativity* positively influences *search result anticipation* (β_1 = 0.193, t = 5.386). Nonetheless, *performative informativity* also facilities rather than undermines *search result anticipation* (β_2 = 0.304, t = 4.765). Whereas *search result anticipation* contribute to enhanced *search efficiency* (β_3 = 0.575, t = 14.639), *ostensive informativity* has no significant effect on *search costs* (β_4 = -0.031, t = 0.788) while its performative counterpart alleviates *search costs* (β_5 = -0.318, t = 5.382). Reducing *search costs* in turn boosts the utility of conducting search (β_6 = -0.414, t = 11.071).
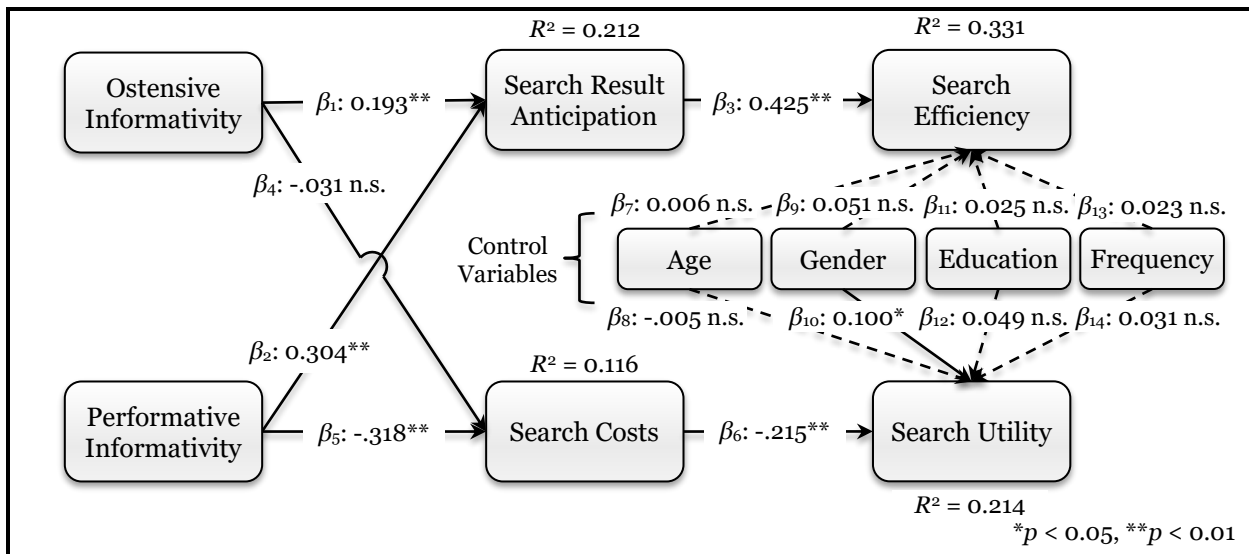

Figure 2. Results of Structural Model Analysis

We controlled a series of relevant variables in the structural model to substantiate the validity of the estimated effects on our dependent variables (i.e., *search efficiency* and *search utility*). Results depicted in Figure 2 testify that respondents' age (β_7 = 0.006, t = 0.103), gender (β_9 = -0.005, t = 0.323), education (β_{11} = 0.025, t = 1.008), and frequency of visiting online review websites to search for restaurants (β_{13} = 0.023, t = 0.958) pose no significant influence on *search efficiency*. Similarly, search utility is not affected by respondents' age (β_8 = -0.005, t = 0.103), education (β_{12} = 0.049, t = 1.562), and frequency of searching for

restaurants on online review websites (β_{14} = 0.031, t = 0.335). However, female respondents tend to perceive a higher degree of *search utility* (β_{10} = 0.100, t = 2.104) when compared to their male counterparts.

The unexpected positive relationship between *performative informativity* and *search result anticipation* implies that comprehending the mechanism of a search feature plays an instrumental role in helping users anticipate the search results. Allowing users to participate in the search mechanism and witness the progression of the search process can be more effective in facilitating *search result anticipation* as compared to simply offering information cues. A plausible explanation to the non-significant relationship between *ostensive informativity* and *search costs* could be that although we expect *ostensive informativity* to induce additional cognitive effort for processing information scent, this averse effect can be minimized if information scents are concise and well-organized.

Mediation Analysis

Adhering to the guidelines prescribed by Baron and Kenny (1986), we performed mediation analysis to ascertain whether *search result anticipation* and *search costs* are full or partial mediators. Table 7 summarizes the results from our mediation analysis. Except for the relationship between ostensive informativity and search costs, coefficients in the *independent paths* column for both independent variables (IVs) are significant, which in turn affirm the mediating roles of *search result anticipation* and *search costs*. Furthermore, as pointed out by Baron and Kenny (1986), when the path from IV to the mediator as well as the path from the mediator to the dependent variable (DV) are controlled, the path coefficient from IV to DV should decrease in both magnitude and significance. If the path coefficient between IV and DV becomes non-significant, we can interpret the mediating effect as a full mediation. Otherwise, it should be interpreted as a partial mediation. Our results demonstrate that *search result anticipation* fully mediates the positive impact of *ostensive informativity* on *search efficiency*, while partially mediating the positive impact of *performative informativity* on *search efficiency*. Moreover, *search costs* partially mediates the positive impact of *performative informativity* on *search utility*. The direct effect of *performative informativity* on *search efficiency* and *search utility* could be attributed to the continuity induced by the smooth transition from input to output, which in turn allows users to better maintain their flow, culminating in a seamless and more enjoyable search process (Agarwal and Karahanna 2000). The positive relationship between *ostensive informativity* and *search utility* is likely caused by the increased likelihood of users to avoid irrelevant information through following the guidance of information cues (Moody and Galletta 2015).

Relationship	IV: OI		Relationship	IV: PI	
	Independent Paths	**Full Model**		**Independent Paths**	**Full Model**
OI → SRA	0.193**	0.193**	**PI → SRA**	0.304**	0.304**
SRA → SE	0.575**	0.425**	**SRA → SE**	0.575**	0.425**
OI → SE	0.177*	0.095 n.s.	**PI → SE**	0.374**	0.242**
Full Mediation			**Partial Mediation**		
OI → SC	-0.031 n.s.	-0.031 n.s.	**PI → SC**	-0.320**	-0.318**
SC → SU	-0.414**	-0.215**	**SC → SU**	-0.414**	-0.215**
OI → SU	0.190**	0.184**	**PI → SU**	0.506**	0.437**
No Mediation			**Partial Mediation**		

Note: OI → Ostensive Informativity; PI → Performative Informativity; SRA → Search Result Anticipation; SC → Search Cost; SE → Search Efficiency; SU → Search Utility.

$* p < 0.05, ** p < 0.01$

Table 7. Results of Mediation Analysis

Post-Hoc Analysis

To assess the validity of our typology of search features, we conducted a post-hoc analysis by estimating the path coefficients for the relationships between search feature usage, which takes the form of a binary variable to denote whether a respondent used a search feature or not, and the two types of *search*

affordance informativities. Table 8 summarizes the results of our post-hoc analysis. Surprisingly, the use of *faceted search* feature heightens both *ostensive* and *performative informativities* instead of just inducing the former. One plausible explanation could be that the tag-based design of faceted search feature allows respondents to conveniently switch among different search criteria, which in turn facilitates their heuristic process through which they can better understand the underlying search mechanism. As we anticipated, *keyword search* feature offers neither clear information nor clear articulation for respondents to comprehend its affordance. *Ranking search* feature usage only facilitates *performative informativity*. Its non-significant effect on *ostensive informativity* can be explained by users' familiarity with list scrolling due to the prevalence of this feature across any website. Therefore, it is likely for respondents to overlook information cues such as the sorting options and the paging information. Lastly, the use of *interactive search* elevates both *ostensive* and *performative informativities*. Its unexpected clear informativity can be explained by the geographical information and navigational options on the interactive map, which can provide respondents with sufficient information cues to infer its affordance for search.

Search Feature Usage [o: did not use; 1: used]	Ostensive Search Affordance Informativity			Performative Search Affordance Informativity		
	Typology	Path Coefficient	Support	Typology	Path Coefficient	Support
Faceted Search	Clear Information	0.140**	Yes	Unclear Articulation	0.153**	No
Keyword Search	Unclear Information	0.013 n.s.	Yes	Unclear Articulation	0.049 n.s.	Yes
Ranking Search	Clear Information	0.022 n.s.	No	Clear Articulation	0.077*	Yes
Interactive Search	Unclear Information	$0.073^{\dagger}$	No	Clear Articulation	$0.072^{\dagger}$	Yes

$^{\dagger}p < 0.1$, * $p < 0.05$, ** $p < 0.01$

Table 8. Results of Post-Hoc Analysis

Discussion

This study espouses the Theory of Affordance Informativity (Gaver 1991) to advance both *ostensive informativity* and *performative informativity* as two mechanisms for online information search features to communicate search actions afforded to users. By categorizing contemporary search feature design into four types (i.e., *faceted search*, *keyword search*, *rank search*, and *interactive search*) along both dimensions of ostensive and performative informativities, we construct a research model to articulate how search features with varying informativities can influence users' *search result anticipation* and *search cost*, which in turn dictate their search performance in terms of efficiency and utility. Based on data gathered from AMT participants, the majority of our hypotheses are validated. We found that search result anticipation fully mediates the positive effect of *ostensive informativity* on *search efficiency* whereas the alleviation of *search costs* partially mediates the positive relationship between *performative informativity* and *search utility*. Surprisingly, *ostensive informativity* poses no significant influence on *search costs*, implying that the extra cognitive effort required to process information scent can be minimized by keeping the scent concise and well-organized. Moreover, *performative informativity* can help users to better anticipate search results by understanding how a search feature functions via their own experience.

Implications for Research and Practice

By investigating the role of search affordance informativity in online information search context via an experimental approach, we seek to contribute to extant literature on several fronts. First, this study draws HCI researchers' attention to how technological affordance can be conveyed from design elements to users, which is understudied as compared to what technological affordance is. Second, we draw on the Theory of Affordance Informativity (Gaver 1991) to elicit both *ostensive* and *performative informativities* as two distinct mechanisms by which search features convey search affordance to users. Furthermore, in distinguishing between *clear* and *unclear* informativity, we are able to proffer a typology of four contemporary search features according to the clarity of their ostensive and performative informativities.

To validate this typology, we conducted a post-hoc analysis by incorporating objective search feature usage data to uncover how the use of each search feature affects *ostensive* and *performative informativities* differently. Third, previous literature tend to focus predominantly on investigating the effects of *ostensive informativity* (i.e., the effect of information scents) (e.g., Moody and Galletta 2015). By putting forth both *search result anticipation* and *search costs* as consequences of search affordance informativity, we found that *ostensive informativity* only facilitates *search result anticipation* whereas *performative informativity* can contribute to both *search result anticipation* and the alleviation of *search costs*. We therefore stress the importance of considering *performative informativity*, which can be more effective than its ostensive counterpart in the context of online information search. Lastly, this study further corroborates the positive relationship between *search result anticipation* and *search efficiency* as well as the negative relationship between *search costs* and *search utility*. Our findings hence bear witness to both *search result anticipation* and *search costs* as antecedents of information search performance that are subjected to the influence of search affordance informativity.

Findings from this study also offer executable guidelines for developers of information search features. First, to maximize the benefits of guiding users with information scents, practitioners should ensure that information scent is concise and well-organized. Additionally, information scent should be used sparingly to avoid overloading or confusing users. Second, to harness *performative informativity*, we recommend practitioners to employ a non-intrusive, heuristic approach to communicate afforded functionalities to users by engaging them in interacting with design features. Moreover, practitioners can utilize transitional animation to encourage users to observe and understand the underlying mechanism of a design feature. Lastly, among the four search features, we found that *ranking search* is the most intuitive since it relies on both *clear ostensive informativity* and *clear performative informativity* to convey its search affordance. Therefore we suggest practitioners to adopt *ranking search* as their default search feature. Prioritizing the implementation of search features is especially paramount when developing mobile apps, since the limited screen size places strict restriction on the amount of search features that can be presented concurrently.

Limitations and Future Research Directions

This study comes with a number of limitations. First, consistent with examples in previous literature (Xu et al. 2013), we manipulate the configuration of information search features on our experimental website to create variation in both *ostensive informativity* and *performative informativity*. For this reason, we did not implement manipulation control for the provision of search features. Future studies can control for the manipulation of information search features to empirically validate our typology of information search features. Second, while we acknowledge that previous literature identified other predictors for *search result anticipation* and *search costs* (Liu et al. 2016a, 2016b), we only focus on search affordance informativity on the basis of the Theory of Affordance Informativity (Gaver 1991) in order to maintain the parsimony of our research model. Future studies can explore a more comprehensive set of antecedents for *result anticipation* and *search costs* in a unified model.

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