Information Processing and Management 56 (2019) 1667–1679

Contents lists available at ScienceDirect

Information Processing and Management

journal homepage: www.elsevier.com/locate/infoproman

The effects of perceived chronic pressure and time constraint on information search behaviors and experience

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ARTICLE INFO

Keywords:
Time constraint
Stress
Perceived chronic pressure
Search behaviors

ABSTRACT

In this paper, we explore the effects of individual pressure level and time constraint on searchers' behaviors and their assessment of search experience within the framework of interactive information retrieval. A user experiment was conducted in which 40 participants individually searched for information in a laboratory setting under two conditions: with time constraint (TC) and with no time constraint (NTC). Participants filled in a Perceived Stress Scale questionnaire to measure their chronic pressure value (subjective stress), and their pressure value was recorded as their individual characteristic. The results showed that the more chronic pressure the searcher has, the more search efforts they devote, including more time in searching and more time to complete the search tasks, especially when there was no time constraint. Time constraint and searchers' pressure value had a significant effect on users' numbers of scrolling actions per minute. The results indicate that when given a time constraint, searchers with higher-pressure values tend to lower their reading or scanning speed, while searchers with lower-pressure values tend to accelerate their reading or scanning speed. The results suggested different people would react to the time condition change in different ways, especially people with higher pressure. Therefore, it is necessary to examine users' search behaviors in person-in-situation frameworks to analyze the effects of contextual factors on users. This study contributes to our knowledge of how contextual factors and individual characteristics affect searchers' behaviors and have implications for the design of IIR systems.

1. Introduction

User experience has long been an important consideration in the design of interactive information retrieval (IIR) systems. To provide users with more effective and efficient search service, users' individual characteristics and search contexts are critical for information retrieval systems. For instance, in a review of the historical development of IIR, it is recognized that searchers' characteristics, conceptualized as levels of user expertise and behavioral characteristics inherent in searchers, should be specifically considered in the feedback that IR systems provide for users (Savage-Knepshield & Belkin, 1999). Recent research on this topic has focused on the attributes of searchers, such as users' domain knowledge, search skills, cognitive styles and types of search tasks, and

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https://doi.org/10.1016/j.ipm.2019.04.004
Received 8 February 2018; Received in revised form 8 April 2019; Accepted 14 April 2019
Available online 17 May 2019
0306-4573/

how they influence users' information search behaviors (e.g., Liu, Thomas, Bacic, Gedeon, & Li, 2017; Liu & Wacholder, 2017; O'Brien, Dickinson, & Askin, 2017; Wittek, Liu, Darányi, Gedeon, & Lim, 2016).

More generally, the variable of time has been conceptualized as a contextual factor and constraints that affect people's information seeking behavior and decision-making (Landry, 2014; Savolainen, 2006; Wegier & Spaniol, 2015). When the available time is limited, users may change their information seeking strategies or behaviors over their information search processes. In the conceptualization of search tasks, Li and Belkin (2008) proposed to examine time length as a feature of search tasks, and urgency as a subjective measure of searchers' characteristics. This thread of research suggests that IIR research should examine the effect of time constraints on user search behaviors and how users perceive their overall search experience within information seeking contexts.

IIR researchers have investigated the effect of imposed time constraint on user perceptions, search behaviors and search performance during information seeking processes (e.g., Crescenzi, Kelly, & Azzopardi, 2015; Fujikawa, Joho, & Shin'ichi, 2012; Liu & Wei, 2016; Liu, Yang, Zhao, Jiang, & Zhang, 2014). These studies generally suggest that time constraints affect users' perceptions about their search experiences and search behaviors during information seeking processes. For example, time pressure has a significant effect on the evaluation of search performance (Liu et al., 2014) and user search behaviors (Crescenzi et al., 2015), such as the query rate and the number of documents viewed per query. However, when given a time constraint, whether different individuals would have different coping strategies during the information search process remains unclear.

When analyzing users' search behaviors, Allen and Kim (2001) have proposed the adoption of a person-in-situation approach to understanding human information behaviors by taking account of the interaction effects of individual characteristics and situational factors. Kim and Allen (2002) also demonstrated that the combination of the task type and problem-solving style/cognitive ability variables had significant interaction effects on users' search activities. Therefore, when examining the effect of contextual factors, it is important to consider users' individual characteristics, especially the personality/cognitive style variables, to investigate how different users cope in different search situations.

One possible characteristic that may influence users' interactions under different time conditions is their individual pressure. Research on pressure and stress suggests that individual pressure could be classified as chronic pressure and acute pressure (Petrac, Bedwell, Renk, Orem, & Sims, 2009). Acute pressure is seen as healthy and adaptive responding to the environment, often caused by contextual factors such as time constraints. Chronic pressure is constant and persists over an extended period of time, which can be referred to as an internal individual characteristic (Lundberg, 2005; Selye, 1973). Comparing types of pressure, acute pressure is a reaction to recent events or immediate surroundings, such as a time constraint, whereas chronic pressure describes individual pressure levels that may not change during a period of time. Studies have shown that chronic pressure is related to people's academic performance and tasks of attention (e.g., Aspinwall & Taylor, 1992; Elias, Ping, & Abdullah, 2011; Simons, Aysan, Thompson, Hamarat, & Steele, 2002; Vedhara, Hyde, Gilchrist, Tytherleigh, & Plummer, 2000). However, it is unclear how the chronic pressure level as an individual characteristic will affect users' search behaviors, particularly when a certain time constraint is imposed. The relationship between the individual characteristic of chronic pressure level and time constraints needs further investigation, because searchers may have different coping strategies in different situations. We specifically consider how users with different chronic pressure levels will accomplish search tasks, especially when a certain time constraint is imposed. We examined such research questions using a mixed-effects model method to not only examine the main effects of time conditions and users' chronic pressure, but also the interaction effects of these two factors.

The contributions of this paper include: First, our study examines the effect of users' chronic pressure value on their search behaviors and search effort, and the results indicate that more chronic pressure could lead to significantly more search efforts; second, the results help us understand how different people behave to cope with situational change, such as a time constraint; third, the study also sheds light on the design of interactive information retrieval, especially the mixed model method could be provided as the data analysis method for us to examine the effects of task and user and other variables together.

2. Research objectives

This study was designed to determine the interaction effects of perceived chronic pressure and time constraint on searchers' behaviors and their assessment of search experience within the person-in-situation framework of interactive information retrieval. We focus on chronic pressure as one kind of individual characteristic, and use *pressure* to indicate the user experience of stress, measured by internal perceptions of an individual, as opposed to the broader definition of stress which is classified based on different contexts, such as city driving (high stress) and country driving (low stress) (Healey & Picard, 2005). The situational factor examined in this study is operationalized as the available time provided for users to conduct search in a user experiment, i.e., users were subjected to two experimental conditions, with and without a time constraint. The operationalization allows us to examine the effect of individual pressure and time constraint on users' search behaviors in a controlled IIR user experiment. Specifically, we would like to address the research question: Does search behavior differ under time-constraints for people with different perceived chronic pressure?

3. Related work

3.1. Person-in-situation approach

The person-in-situation theory posits that intelligence, reasoning and problem solving are situated and personal, and they should be interpreted as in the person-situation interaction, not the person alone or the situation alone (Snow, 1994). Allen (1997) proposed

a person-in-situation approach in information science and advocated for an interactionist perspective on the relationship between situational and individual determinants of behavior. From the interactionist perspective, users' behaviors, including information search behaviors, are influenced by the interaction between individual characteristics and their social contexts. Specifically, the interaction effect of cognitive abilities/problem-solving style and task type has been interpreted as a "fit" with those of the situation, which implies that the information system is flexible enough to allow different searchers to explore different search options for different tasks (Kim & Allen, 2002). Other empirical studies have explored users' individual characteristics and task features together and their interaction effect on users' search interactions. For instance, Liu, Liu, Cole, Belkin and Zhang (2012) explored the interaction effects of task difficulty and domain knowledge on users' search behaviors, with particular focus on the dwell time on content pages. The person-in-situation approach has been applied to analysis and understanding of users' information behaviors, stressing that people with different characteristics may react to the situational changes or contexts in different ways, therefore, when analyzing users' behaviors, it is necessary to examine whether different users would interact with the search systems in different ways to cope with the situational factors, and using a person-in-situation framework would allow us to have a comprehensive view of users' search behaviors.

3.2. Time constraint as a contextual factor

Time constraint as a contextual factor has been recognized in information behavior research. One of the outstanding research questions is "how people's perceptions of time available for task performance or problem-solving affect their source preferences and relevance judgments in job-related and non-work contexts" (Savolainen, 2006, p. 124). In the context of IIR, researchers have investigated the effect of time constraints on user perceptions, search behaviors and search performance during the information seeking processes, with mixed results. Research has shown that time constraint makes no difference in user search goals in public library settings (Slone, 2007). There is no significant relationship between search constraints (time, number of queries which can be submitted and the number of documents which can be viewed) and users' perception, search behavior, and performance (Fujikawa et al., 2012). According to Ackerman and Lauterman (2012), when people are working under time pressure, there were mainly two consequences: one is that people may be distracted from the task at hand which causes a reduction in their working memory; the other possible consequence is that when the time pressure is mild, it could help people to excel and implement intentions which result in improvement of their working efficiency. Yerkes-Dodson's law (1908) also suggested that performance increases when physiological or mental arousal is present but only up to a point: when the levels of arousal become too high, people's performance will decrease. However, perceived time pressure and task difficulty are good predictors of users' satisfaction with their search strategies (Crescenzi, Capra, & Arguello, 2013).

Time constraint affects people's coping and search strategies and their perceptions about the whole information seeking processes. For example, time-pressured participants were more anxious and energetic, and they used a number of different strategies to cope with the deadline (Maule, Hockey, & Bdzola, 2000). Users may employ different search strategies at different search stages, depending on their perceptions of the time constraint (Liu & Wei, 2016). When there was no time constraint, users tended to employ an economic-style search strategy at the beginning of search; but when a time constraint was imposed, users became more selective and cautious in examining the search results. Our preliminary analysis also demonstrated that users' search interactions, especially the frequency of search interactions, i.e. number of mouse clicks or keystrokes per page, were also affected by a time constraint (Liu et al., 2014). Time constraint significantly influences searchers' pre-search confidence, evaluation of search performance, knowledge acquisition and after-search affective states (Liu et al., 2014). Interestingly, users' affective experiences were sometimes influenced by temporal issues: longer search durations tended to induce negative affective responses like frustration (Chen & Rieh, 2009). There is also some evidence that the certain search behaviors, such as queries issued, number of SERPs (search engine results pages) displayed and number of SERP clicks are indicators of frustration (Edwards & Kelly, 2017). These studies overall suggest that user perceptions of time constraints may affect their self-efficacy, search strategies, search behaviors and affective states, but how time constraints interact with other variables, such as individual characteristics and search tasks needs to be clarified.

3.3. Individual characteristic of perceived pressure

Perceived pressure refers to the degree to which situations in one's life are appraised as stressful. Psychological pressure has been defined as the extent to which persons perceive or appraise that their demands exceed their ability to cope (Cohen, Kamarck, & Mermelstein, 1983). Pressure responses have been classified into acute and chronic states. Acute reactions are considered healthy and adaptive responding to the environment, while chronic states are considered constant health problems and persist over an extended period of time (Lundberg, 2005; Selye, 1973). Acute pressure is often caused by contextual factors such as time constraints, whereas chronic pressure can be considered an internal individual characteristic.

The Perceived Stress Scale (PSS) developed by Cohen et al. (1983) has been one of the most widely used psychological instruments to measure nonspecific perceived stress, specifically to measure the degree to which situations in one's life are appraised as stressful. It has been used for assessing the stressfulness of situations, the effectiveness of stress-reducing interventions, and the associations between psychological stress and psychiatric, physical disorders. These studies have demonstrated the association between individual chronic pressure and life satisfaction (Simons et al., 2002), academic performance (Aspinwall & Taylor, 1992; Rafidah et al., 2009) and cognitive tasks performance (Petrac et al., 2009; Plieger et al., 2017; Vedhara et al., 2000).

Research has suggested that perceived chronic pressure has a negative effect on task performance, and there may be interactional effects when other factors are involved, such as the types of cognitive tasks and contextual factors (e.g., Plieger et al., 2017; Rafidah

et al., 2009; Vedhara et al., 2000). For instance, more stress might reduce students' self-esteem and therefore impinge on students' academic performance (Vedhara et al., 2000), while high pressure or desire for control mostly leads to better academic performance (Aspinwall & Taylor, 1992). There are negative correlations between perceived pressure and levels of life satisfaction (Simons et al., 2002). More specifically, the relationship between pressure and performance could be unstable when other factors were changing (i.e., interactional effects) (Rafidah et al., 2009), or due to the effect of individual differences and types of cognitive tasks (Plieger et al., 2017).

3.4. Affective and cognitive factors of information seeking

The effect of individual characteristics on information seeking and search behaviors has been extensively studied, but the research on the impact of individual differences on search behaviors and outcomes has been inconsistent (e.g., Heinström, 2010; Kim & Allen, 2002; Liu & Wacholder, 2017; O'Brien et al., 2017). The most studied individual differences in information seeking behavior and retrieval research are demographic, cognitive, and personality and affective variables (O'Brien et al., 2017). Yet very few studies have focused on perceived chronic pressure as part of individual characteristics and examined their possible interactions with contextual factors.

It is well-recognized that affective variables influence users' cognitive states and information behaviors and they are associated with the search stage (Kuhlthau, 1991). Among the affective characteristics, user preference, anticipated and felt effort, uncertainty, self-efficacy and satisfaction have been considered important factors affecting information seeking and user search behavior (Nahl, 2004; Savolainen, 2016; Wilson, 2016). For instance, affective coping skills, consisting of self-efficacy and optimism, have a positive impact on search performance: people with higher affective skills can better manage uncertainty (Nahl, 2004). Researchers have examined people's coping strategies in information seeking from the perspectives of stress and copying theory. For example, emotion-focused subjects who make efforts to regulate the stressful emotions caused by an event need longer times to complete tasks and navigate much more linearly within the system (Kim, 1999). There are differences in types of information seeking behaviors for different developmental groups, and importantly the purposes of information seeking are beyond problem-focused (Lu, 2010). Overall, the conceptualization of affective barriers to information seeking as contextual factors (Savolainen, 2016) and their relationship with user's interactions with search systems need further research.

In IIR research, self-efficacy has been conceptualized as part of individual characteristics of search expertise (Brennan, Kelly, & Zhang, 2016), as an indicator of digital skills and confidence (Ishita, Miyata, Ueda, & Kurata, 2017) and confidence levels of pre-search task completion (Albertson & Ju, 2016). Methodologically, questionnaires have been used to assess users' perceptions about their levels of confidence, perceived ability to accomplish search tasks prior to or after the actual search activities in IIR user experiments (e.g., Kelly, 2009; Tang, Liu, & Wu, 2013; White, 2016). There is some evidence that the affective state affects user's information processing strategies but its relationship with search performance is weak (González-Ibáñez & Shah, 2016). However, the joint influences of perceived pressure as individual characteristic and contextual factors, such as affective barriers to information seeking and time constraints on search processes and performance have received scant attention in information behavior and retrieval research.

4. Methodology

Drawing from the theoretical model of person-in-situation, a laboratory-based user experiment was conducted to investigate the effects of time constraint and perceived chronic pressure on users' search behaviors and perception of search experience. A lab-based user experiment was selected because the goal of this study is to examine how different users react to the same level of time constraint, therefore a lab experiment could help us control that all the participants were searching for the same tasks and experiencing the same level of time constraint.

4.1. Participants

Forty undergraduate students from Peking University were randomly recruited through a campus Bulletin Board System (BBS) in this experiment. The final participant pool was 20 females and 20 males, evenly distributed by the gender. There were 5 freshmen, 11 sophomores, 15 juniors and 9 seniors. Their ages were between 18 and 23 years old ($M = 20.25$, SD $= 1.37$). Most of them were experienced users of computers and searching. When self-assessing their own computer expertise: most of them ($N = 29$) rated themselves as competent, some ($N = 9$) rated as proficient, and two rated as advanced beginners, whereas none rated themselves as novices or experts. The diversity of fields of study represented included humanities, social science, natural science, engineering and medicine.

4.2. Procedure

Each user was invited to our interaction lab and asked to search for four assigned search tasks through a desktop computer. After reading and signing the consent form, they filled out a background questionnaire, including the Perceived Stress Scale (PSS) to measure their perceived chronic pressure, and were then given a training task to warm up. During their searching, searchers were allowed to use any search systems they like and were asked to respond to each task by typing or copying/pasting useful information for their tasks into a notebook file. In the notebook file, searchers were instructed to write texts rather than the URLs of useful Web

pages, even though some searchers might paste the URLs when they found they did not have enough time. After reading the task description and before searching for each of the tasks, they filled out a pre-search questionnaire about their topic familiarity and anticipated task difficulty; after finishing the task (or they used up the time given in the time constraint condition), they were given a post-search questionnaire to evaluate their own search performance. The task descriptions were written on a piece of paper and were shown to users while they were searching. At the end (after having finished all four tasks), an exit questionnaire was used to assess their overall search experience.

All participants were informed in advance that they would receive an 8GB USB Flash drive as compensation for participation, and that the eight searchers who have produced the best answers in the notebook file for all four tasks, as judged by the experimenters, would receive an additional gift. The rationale was to ensure that searchers treat tasks seriously and they would be selective in composing the notebook file.

4.3. Time constraint

The time constraint is the main independent variable in this study. Two types of time condition were set for participants: with time constraint (TC) and without time constraint (NTC). In the TC condition, the time available for searchers to finish a single search task was restricted to 5 min. This limit was based on prior studies (e.g., Topi, Valacich, & Hoffer, 2005; Weenig & Maarleveld, 2002), which indicated that the levels of time availability should be determined in pilot tests. That is, a “high” level of time availability was determined by the average time required by searchers in a pilot study without time constraint. The “moderate” and “low” time availabilities should be set to 75% and 50% of that of the “high” condition, respectively. In our experiment, the time constraint in TC condition was set to be 5 min, a bit less than 50% of the average time spent by searchers in our pilot studies, to enforce a severe time constraint.

In the TC condition, searchers were informed of the 5 min’ time limitation before they started. When describing the time constraint to our participants, we described such a context: imagine that this is an assignment given by your teacher, but you forgot to do this assignment. You just remember to do this five minutes before the class, and you would like to search something on the Internet for this assignment before the class. During their search, the computer time is always shown on the corner of the screen, and the experimenter reminded them again when there was only one-minute left. In the NTC condition, searchers were told in advance that they could stop searching anytime when they thought enough information had been collected for the task in the notebook file. A within-subject design was conducted. Each searcher conducted searches under both conditions: two search tasks in the TC condition and the other two search tasks in the NTC condition. Half of the participants searched in the TC conditions first and followed by the NTC conditions, and the other half of participants searched in the NTC conditions first and followed by the TC conditions.

4.4. Search tasks

When designing search tasks for this experiment, we refer to the comprehensive classification scheme proposed by Li and Belkin (2008) to manipulate the task type of search tasks. Previous studies (Liu and Li (2012); Jiang, He & Allan, 2014) have demonstrated that product and goal (quality) were two important facets in task types. The product of a search task can be either factual (locating facts) or intellectual (to enhance users’ understanding and creation of new topics). The goal of a search task can be either specific (well-defined) or amorphous (ill-defined in the task description or unclear goals that may evolve along with the user's searching). The product facet, especially the intellectual dimension, may involve multiple sub-dimensions, depending upon the level of cognitive process involved, which Li and Belkin (2008) did not distinguish. In this study, we refer to the cognitive process dimensions of Anderson and Krathwohl (2001) Taxonomy of Learning and constructed two types of search tasks according to the first two cognitive process dimensions Remember (Retrieving, recognizing, and recalling relevant knowledge from long-term memory) and Understanding (constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining). For the goal (quality) facet, we controlled all the search tasks with specific goals. Therefore, we have two types of search task designed in this experiment: Fact Finding and Information Understanding. Each type of task consists of two tasks with different topics, and each task was constructed in a simulated work task situation (Borlund, 2003). The description of these four search tasks[1] is shown below:

- **Fact Finding 1 (FF1):** You heard that India has very interesting wedding traditions, and now you want to search for the following aspects of Indian Weddings: Wedding dresses, painted hands, and the types of food served.
- **Fact Finding 2 (FF2):** One of your friends said he was bitten by a rove beetle, and felt very itchy, and the wound festered after scratching. You were quite worried about this type of beetle. You want to search what is a rove beetle? Is it poisonous? What should you do if you see a rove beetle? If bitten by a rove beetle, how should we treat it?
- **Information Understanding 1 (IU1):** Your nephew is considering trying out for a football team. Most of your relatives are supportive of the idea, but you think this sport is dangerous and are worried about the potential health risks. Specifically, what are some long-term health risks faced by teen football players?

[1] The experiment was conducted in Chinese, and these task descriptions were written in Chinese for the participants. In this paper, we have translated them into English for the readers of the paper and scholarly communication.

- **Information Understanding 2 (IU2):** A Doric Column is a distinctive architectural form in Ancient Greek architecture. Please search for information about the general characteristics and representative examples of Doric columns, and whether Doric columns have had any influence on Chinese architecture. If so, what are some representative examples?

Under each time condition, participants searched for both types of search tasks. The order of search tasks and time conditions was systematically balanced using a 2 × 2 Graeco-Latin Square design (Kirk, 2013).

4.5. Perceived chronic pressure

Studies have shown that users' perceived pressure can be divided into chronic and acute pressure (Petrac et al., 2009). Our study is focused on the effect of perceived chronic pressure, and it was measured using the Perceived Pressure Scale (PPS) questionnaire (Cohen et al., 1983), as part of the background questionnaire. The PPS consists of 14 items asking participants to rate their pressure during the past month on five-point Likert scales (never, almost never, sometimes, fairly often, very often). When analyzing data, seven of the fourteen items are negatively stated items and the others are positively stated items. For negatively stated items, choices from "never" to "very often" were given 0 to 4; for positively items, choices from "never" to "very often" were given 4 to 0. The final scores for each participant are calculated by adding up their scores from all of the questions. The PPS questionnaire has been shown to be a reliable tool to measure the amount of stress, and a higher score is indicative of greater levels of perceived stress, i.e. individual pressure. Three subjects' scores were lost due to unsuccessful submission of the questionnaire, so we have pressure scores for 37 participants (M = 25.0 SD = 5.57). Our means are consistent with the mean of pressure value (23.67) of college student sample in Cohen et al. (1983)'s study.

4.6. Dependent variables

During the experiment, participants' search interactions were recorded through Morae Recorder (version 3.3.3), and their perceptions of search experience were elicited through pre-search and post-search questionnaires. The users' subsequent search behaviors were taken as dependent variables, and they were calculated for each task session:

- Task completion time: measured for the period from when searchers started to search the task, until they decided they had collected enough information as answers to the task in the notebook file. Searchers in the TC must stop working on the task when they have used up the five minutes for them.
- Time on writing = the time the searcher spent on writing in the notebook file during search
- Time on searching = Task completion time - Time on writing
- Number of interactions = Amount of keyboard activities + Amount of mouse activities
- Number of scrolling actions per minute = Amount of scrolling actions / Task completion time

5. Data analysis

In this study, mixed-effects models are constructed for determining the effects of pressure value and time condition on user search behaviors. Mixed-effects distinguish between fixed effects that are due to experimental conditions, and random effects that are due to individual differences in a sample. We are concerned with both fixed effects of pressure value and time condition and random effects of individual differences. We choose mixed-effects models because they are useful for the analysis of repeated measurement data (i.e., the same search task in different time conditions from one individual), with subjects and search tasks as crossed random effects (Baayen, Davidson, & Bates, 2008). Examples of mixed-effects models in information retrieval research have included modeling of search topics effects (Carterette, Kanoulas, & Yilmaz, 2011) and analyses of eye gaze behavior (Hofmann, Mitra, Radlinski, & Shokouhi, 2014; Xie et al., 2017). We primarily use the lme4 package in the R statistical computing software for model fitting (Bates, Mächler, Bolker, & Walker, 2015; Kuznetsova, Brockhoff, & Christensen, 2017; R Core Team, 2018), and other packages for the purposes of visualizing and communicating results (Hlavac, 2018; Long, 2018; Lüdecke, 2018; Robson & Pevalin, 2016).

To consider the possible correlation between the measurements from one individual, a Pearson correlation analysis revealed that there is no statistically significant relationship between grade standing and pressure value (r = 0.002, p > .05), as well as between

Table 1
Summary of measures of search behavior as dependent variables.

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Completion time (s)	134[a]	587.9	423.8	161	301.8	714	2337
Searching time (s)	134	476.6	343.2	98.8	248.7	635	1641.20
Writing time (s)	134	111.3	148.7	3	41	131	1411
# of interactions	134	878.8	681.4	141	430.5	1160.20	4530
# of scrolls per min	134	46.2	26	3	29.5	57.7	148.5

[a] *Notes:* We used Morae Recording 3.3 to record participants' interactions with the computers; however, the recording data of 26 sessions among all the 160 sessions were either broken or missing.

Table 2
Model selection of fixed and random effects for measures of search behavior.

	Fixed and Random Effects Model
Completion time (s)	PV + TC + (1|task) + (1|user) + PV:TC
Searching time (s)	PV + TC + (1|task) + (1|user) + PV:TC
# of interactions	PV + TC + (1|task) + PV:TC
# of scrolling actions per min	PV + TC + (1|task) + (1|user) + PV:TC

Note: PV = Pressure Value, TC = Time Condition, PV:TC refers to interaction effect of PV and TC. Random intercepts for task and user are specified with (1|task) and (1|user) respectively.

age and pressure value ($r = 0.025$, $p > .05$). We selected the following variables for further analysis based on a Pearson correlation analysis of independent variables regarding measurements of user search behavior: completion time, searching time, writing time, number of interactions and number of scrolling actions per minute (See Table 1 for an overview). However, we found that there are significant relationships between the task order and the selected variables of: completion time ($r = 0.35$, $p < .001$), searching time ($r = 0.33$, $p < .001$) and number of interactions ($r = 0.32$, $p < .001$). In addition to the fixed effects of pressure value and time condition, the random effects of search order, search task and user were considered in our full model construction and data fitting.

Our strategy for model fitting followed the approach by Baayen et al. (2008). First, we specified the structure of random effects by introducing adjustments to the intercept grouped by task and task order. We introduced by-user adjustments to the intercept and by-user adjustments to pressure value. Second, since there is a high correlation of the intercept and slope for user random effects, the model has been over-parameterized. We simplified the model by assuming homoscedasticity for the users regarding the pressure value. Third, since the variance for the by-user adjustments is small, we simplified to a model with random intercepts for users. Finally, to verify that this model is justified, we carried out the likelihood ratio test. The Akaike information criterion (AIC) was examined to select the best model. Therefore, our null model initially included random intercepts for search task, task order and user.

To fit the data, we performed an automatic backward model selection of fixed and random parts of the linear mixed model (Kuznetsova et al., 2017). Since the random intercepts for task and user are significant, with $4.884e-05$ and $p < .001$ respectively for time spent in searching, we chose a mixed-effects model with search task and user controlled as random effects. Model assessments based on diagnostic checks for non-normality of residuals and outliers, distribution of random effects and heteroscedasticity were conducted. The effect sizes were calculated based on pseudo-R-squared for generalized mixed-effect models (Nakagawa, Johnson, & Schielzeth, 2017).

Table 2 presents the final model for all the measures of search behavior. Completion time, searching time and number of scrolling actions per minute had a similar pattern, with search task and user controlled as random effects. The search task random effect was present for the number of interactions. In addition, there was no random effect for writing time. Task order was dropped in the final random effects structure due to insignificance in modeling.

6. Results

Table 3 presents the results from the mixed effects of pressure value and time condition on the time spent in searching. Our null model included the random effects of search task and user, as shown in Table 2. The fixed effects of pressure value, time condition and their interaction effects were added to other models.

Table 4 presents the results from the mixed effects of pressure value and time condition on the behavioral variables we examined the study. The results indicated that three variables show the same pattern: the completion time, searching time and number of interactions. For example, the pressure value alone had no significant effect on the time spent in searching. However, time condition alone had an extremely significant effect on searching time. When the individual characteristic of pressure value and time condition

Table 3
Model selection of effects of pressure value and time condition on time spent in searching.

	Time spent in searching Null	Null + PV	Null + TC	Null + PV:TC
Pressure Value (PV)		7.663		18.315*
		(6.158)		(7.189)
Time Condition (TC)			−404.547***	337.766
			(41.046)	(318.850)
PV:TC				−19.109*
				(8.131)
Constant	482.542***	185.292	683.887***	−26.079
	(65.713)	(247.611)	(66.448)	(287.384)
N	127	127	127	127
Log Likelihood	−916.159	−912.650	−878.016	−868.513
AIC (Akaike Information Criterion)	1840.318	1835.301	1766.033	1751.027

*$p < .05$; **$p < .01$; ***$p < .001$.

Table 4
Summary of effects of pressure value and time condition on search behavior measures.

	Completion Time	Searching Time	# of Interactions	Scrolling Actions per Minute
Pressure Value (PV)	19.200*	18.315*	30.071*	0.742
	(−8.538)	(−7.189)	(−13.035)	(−0.783)
Time Condition (TC)	283.641	337.704	673.879	38.53
	(−408.227)	(−318.844)	(−738.729)	(−23.019)
PV:TC	−20.801*	−19.108*	−37.501*	−1.183*
	(−10.415	(−8.131)	(−18.863)	(−0.586)
Constant	115.177	−26.056	112.265	22.794
	(−340.078)	(−287.392)	(−523.846)	(−31.107)
N	127	127	127	127
Log Likelihood	−895.355	−868.513	−959.794	−561.409
AIC (Akaike Information Criterion)	1804.71	1751.027	1931.588	1136.818
ICC (IntraClass Correlation)	0.16_{user}	0.23_{user}		0.53_{user}
	0.15_{task}	0.18_{task}	0.18_{task}	0.14_{task}
R^2 (fixed)	0.38	0.35	0.33	0.03
R^2 (total)	0.57	0.61	0.45	0.69

*$p < .05$; **$p < .01$; ***$p < .001$.
Notes. The pressure scale questionnaires missed data for three participants, therefore, compared with Table 1, there were seven more sessions missing. (There should 12 sessions missing given 3 questionnaires missing, but 5 of them were overlapped with previous missing data, so there are additional 7 sessions missing.) The total complete dataset is 127, as shown in this table.

were taken together, pressure value and the interaction effect of pressure value and time condition had significant effects on the time spent in searching. The intraclass correlation (ICC) for user and search task was 0.23 and 0.18 respectively. The low ICC suggested high variability within users and search tasks. The total and fixed effect size was 0.61 and 0.35 respectively for searching time. This was the best model based on AIC.

Fig. 1 illustrates the distribution of time spent in searching for different time conditions, with or without time constraint (TC and NTC are shown respectively in the figure). When there was a time constraint, users tended to spend less time in searching compared with when there was no time constraint. In addition, when given time constraints, all searchers, no matter their pressure value, spent similar time in searching. Without time constraint (NTC condition), the higher pressure value individuals spend more time in searching than lower pressure value individuals. Another two variables, task completion time and the number of interactions also showed the same pattern.

However, the time spent in writing was found to have a different pattern. The time spent in writing was not found to be significantly influenced by users' pressure value, but only influenced by the time condition. Users spent significantly longer time in writing when there was no time constraint than when there was a time constraint.

With respect to the number of scrolling actions per minute, results show that neither time condition nor pressure value alone had a strongly significant effect. The intraclass correlation (ICC) for user and search task was 0.53 and 0.14 respectively, which indicates

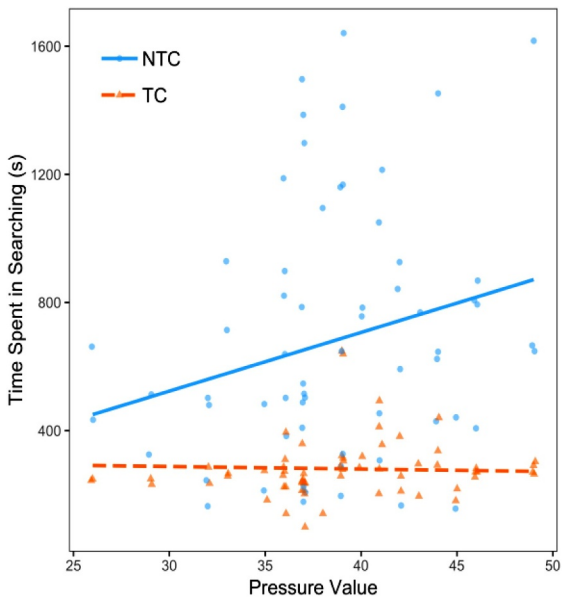

Fig. 1. Plot of interaction effects of pressure value and time condition on searching time. NTC = no time constraint, TC = with time constraint.

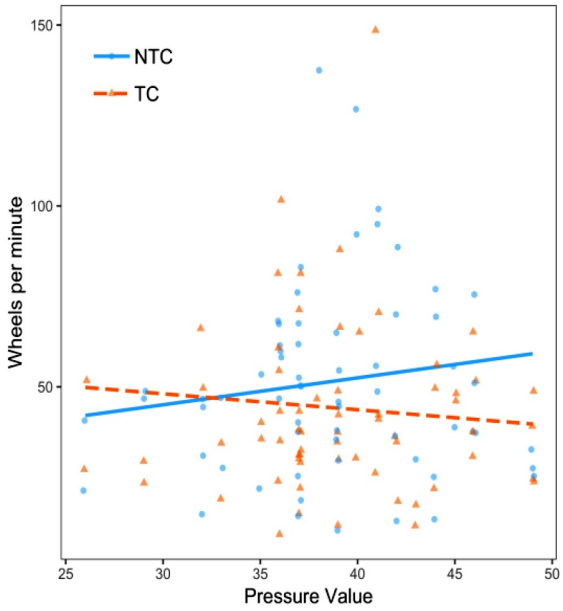

Fig. 2. Plot of interaction effects of pressure value and time condition on the number of scrolling actions per minute. NTC = no time constraint, TC = with time constraint.

low variability within users and high variability within search tasks. This suggests that the number of scrolling actions per minute is search tasks dependent.

Fig. 2 illustrates the distribution of the number of scrolling actions per minute for different time conditions, with or without time constraint (TC and NTC are shown respectively in the figure). When there was no time constraint, users with higher pressure value tended to have more scrolling actions per minute compared with users with lower pressure value. In addition, when given a time constraint, higher pressure value individuals have fewer scrolling actions per minute than lower pressure value ones.

7. Discussion

This study adopted a person-in-situation framework to investigate the effects of time constraint on users' search behaviors by considering users' perceived chronic pressure as an individual characteristic. Our findings suggest that both perceived chronic pressure and time constraints have significant effects on users' search behaviors, and these two factors have interaction effects on users' search behaviors.

First, our results show that searchers with higher perceived chronic pressure spent relatively more time on searching, more time to complete the search task, and more interactions during search than searchers with lower pressure. These results might be explained by the fact that the stressed searchers were more likely to make greater efforts in searching to regulate their stressful emotions (Kim, 1999). More interactions and longer time on searching may help users with higher pressure to relieve their pressure and uncertainty.

Our results also indicate that users' writing time was not significantly influenced by searchers' chronic pressure value, and was only influenced by the time condition. Such a result may indicate that searchers allocate their writing effort according to the amount of time they have to complete the work task, and there were not many individual differences. Even though the work task requires searchers to produce writing while searching, searchers often devoted most of their efforts in searching and collecting new information, and they reserved a certain amount of time to produce the writing for the task. Liu and Belkin (2012) also examined users' allocation of time to writing; they found that users' knowledge of task topics, and experience on task type may affect their writing behaviors. Our study indicates that searchers' chronic pressure value does not influence users' time allocated to writing. Therefore, this variable may be more related to searchers' individual characteristics rather than their pressure value. More studies are needed to further examine this issue.

In addition, we found that there were significant interaction effects of time constraint and users' perceived chronic pressure on searchers' search behaviors. The patterns were the same for the variables of task completion time, searching time and the number of interactions during search. Specifically, searchers with higher chronic pressure had significantly more interactions, longer time to complete the task, and longer searching time than searchers with lower chronic pressure when there was no time constraint; however, when there was a time constraint, there was no significant difference between searchers with different chronic pressure. These results indicate that users with higher pressure may still experience much pressure when there was no time constraint, and all users had to alter their behaviors to react to the time constraint.

Previous studies (e.g., Khanna & Sasikumar, 2010; Maehr, 2008) found that higher stress may lead to slower keystroke speed or acceleration in mouse clicks. Mouse movement has also been found to indicate various types of user engagement in searching,

especially users' interests in webpages (Shapira, Taieb-Maimon, & Moskowitz, 2006). In our study, we also found searchers' scrolling behaviors were sensitive to the time constraint, users' chronic pressure value and search tasks. The results showed that neither time constraint nor users' chronic pressure value had a significant effect on the number of scrolling actions per minute during search, but the interaction effect of these two factors have a significant effect. Searchers with high pressure had significantly more scrolling actions per minute than searchers with low pressure when there was no time constraint, and searchers with high pressure had significantly fewer scrolling actions per minute than searchers with low pressure when there was a severe time constraint. Information foraging theory and its application to search behavior (Pirolli & Card, 1999; Wittek et al., 2016) may also help explain the findings in this study, since it indicates that information searchers would modify their strategies to maximize their gaining of valuable information per unit cost based on the resources available to individuals and environmental conditions. In our study, we also examined users' reading behaviors, and we used the variable "number of scrolling actions per minute" to reflect the reading speed during search, and the results seem to confirm previous studies (Duggan & Payne, 2009). When people were searching without time constraint, people who had higher pressure values experienced more pressure, and they increased their reading speed, with more scrolling per minute; however, when searching under time constraints, people who had higher pressure value might have experienced too much time pressure. This pattern is also similar to what Yerkes and Dodson (1908) suggested, that a moderate increase of pressure may increase users' performance, but when searchers had too much pressure, they may lower their performance by reading more slowly.

Therefore, it is very necessary to examine users' search behaviors using person-in-situation frameworks, as different users may react to the same situational change with different strategies and different behaviors. In this study, even though we did not find any significant difference when searchers were searching with time constraints, there was a significant difference when users were searching without time constraints. Therefore, to some extent, we can conclude that users' chronic pressure had more effects on users' search behaviors than the time constraint. When time constraints were given, all searchers would conduct searches in similar ways.

By adopting a person-in-situation framework, our research explored one of users' individual characteristics and search time condition together in a user experiment. The results indicate that the individual characteristics and time constraint had interaction effects on users' search behaviors. We found that users with high-pressure levels were more sensitive to time constraints, and that time constraint alone did not have large effects on search behavior measures. These results demonstrated that it is necessary to consider users' individual characteristics when examining the effects of contextual variables on users' search behaviors, since different users may adopt different coping strategies to deal with contextual changes during search. In addition, the mixed model method is an appropriate statistical analysis technique to help solve such research questions.

8. Limitation and future research

Our study has some limitations. As a laboratory experiment, participants' search behavior observed in the lab may not be the same as in naturalistic settings. Particularly for the time constraint, we manipulated the time constraint as a five-minute limit for each of the search tasks in our settings, which was only about half of the required time in the pilot study. The reason we set a five-minute limit was to ensure that participants experience a severe time constraint in searching, since some previous studies did not find much effect of time constraint when the "low" or "moderate" availability of time limit was used. Future research could conduct a naturalistic study to investigate the effect of time constraint on search interactions and search experience in real life.

The recruitment of college students is a limitation as they may not be sufficiently representative of general Web searchers, but in our study we focused on their chronic pressure value and we were able to identify participants with a relatively wide range of pressure values. The independent variable, time constraint, was used in a within-subject design in our experiment. We acknowledge that in the within-subject design, one condition the participant experienced may influence how they perform in the second condition. In order to eliminate such effects, we asked participants to take a five-minute break after they have finished two search tasks in one condition. The participants were also told that the goal of this experiment was not to test their search skills with and without time constraint, but to investigate how the IR system could provide assistance for information search in different contexts.

9. Implications

The findings of the current study indicate that users with higher-pressure may need more assistance than users with lower-pressure, since they often need longer time and more interactions to accomplish search tasks. Further investigation should explore the effects of time constraint and individual's chronic pressure on users' search strategies, their interaction on Web pages, evaluation criteria for the usefulness of information during search, and their search performance. The results also shed light on the design of search systems. Users with higher perceived chronic pressure had more concern when searching information on the Internet, they felt more worried, so they interacted more and searched for longer times to ensure that they have collected enough information for the task. If the search system could be able to show participants an overview of search results or the information they have collected, this may help searchers to feel relieved that they would not need to conduct further searches for the task and complete the task with more confidence.

10. Conclusion

This study demonstrated that both time constraint and pressure level had a remarkable influence upon searchers' search behaviors. Searchers' perceived chronic pressure influenced searchers' task completion time, searching time and number of interactions

during search. Compared to searchers with low-pressure, searchers with high-pressure tended to be more active during search, devoted a longer time to search, and took a longer time to accomplish tasks. However, searchers' chronic pressure was not found to influence searchers' time to allocate for writing, but only the time condition had a significant effect. In addition, when examining the interaction effects of time constraint and perceived chronic pressure on searchers' behaviors, our results demonstrated that individual's perceived chronic pressure often exerts significant effects on searchers' behaviors when there was no time constraint. Different searchers tended to behave similarly when there was a severe time constraint. Searchers' reading speed, characterized by the number of scrolling actions per minute during search was found to be significantly influenced by the interaction of time condition, searcher' pressure and search tasks. Searchers with high pressure had a higher frequency in scrolling actions per minute when there was no time constraint, and they had a lower frequency in scrolling actions per minute when there was severe time constraint. The relative importance of time constraint and individual's perceived chronic pressure on searchers' behaviors and experiences deserves further research.

Acknowledgments

This research was funded by The National Social Science Fund of China (project number 18BTQ090) and partially by Australian Government through the Australian Research Council (project number LP140100995).

References

Ackerman, R., & Lauterman, T. (2012). Taking reading comprehension exams on screen or on paper? A metacognitive analysis of learning texts under time pressure. *Computers in Human Behavior, 28*(5), 1816–1828.

Albertson, D., & Ju, B. (2016). Perceived self-efficacy and interactive video retrieval. *Journal of Documentation, 72*(5), 832–857. https://doi.org/10.1108/JD-09-2015-0109.

Allen, B. (1997). Information needs: A person-in-situation approach. *Proceedings of an International Conference on Information Seeking in Context* (pp. 111–122). Taylor Graham.

Allen, B., & Kim, K.-S. (2001). Person and context in information seeking: Interactions between cognitive and task variables. *The New Review of Information Behaviour Research, 2*, 1–16.

Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives.* New York: Longman.

Aspinwall, L. G., & Taylor, S. E. (1992). Modeling cognitive adaptation: A longitudinal investigation of the impact of individual differences and coping on college adjustment and performance. *Journal of Personality and Social Psychology, 63*(6), 989–1003. https://doi.org/10.1037/0022-3514.63.6.989.

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language, 59*(4), 390–412. https://doi.org/10.1016/j.jml.2007.12.005.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software, 67*(1), 48. https://doi.org/10.18637/jss.v067.i01.

Borlund, P. (2003). The IIR evaluation model: A framework for evaluation of interactive information retrieval systems. *Information Research, 8*(3)http://informationr.net/ir/8-3/paper152.html.

Brennan, K., Kelly, D., & Zhang, Y. (2016). Factor analysis of a search self-efficacy scale. *Proceedings of the ACM CHIIR conference* (pp. 241–244). https://doi.org/10.1145/2854946.2855002.

Carterette, B., Kanoulas, E., & Yilmaz, E. (2011). Simulating simple user behavior for system effectiveness evaluation. *Proceedings of the 20th ACM international conference on Information and knowledge management - CIKM '11* (pp. 611–620). New York: ACM Press. https://doi.org/10.1145/2063576.2063668.

Chen, S.-Y., & Rieh, S. Y. (2009). Take your time first, time your search later: How college students perceive time in web searching. *Proceedings of the American Society for Information Science and Technology, 46*. https://doi.org/10.1002/meet.2009.1450460253.

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior, 24*(4), 385–396. https://doi.org/10.2307/2136404.

Crescenzi, A., Capra, R., & Arguello, J. (2013). Time pressure, user satisfaction and task difficulty. *Proceedings of the American Society for Information Science and Technology. 50. Proceedings of the American Society for Information Science and Technology* (pp. 1–4). Silver Springs, MD: American Society for Information Science. https://doi.org/10.1002/meet.14505001121.

Crescenzi, A., Kelly, D., & Azzopardi, L. (2015). Time pressure and system delays in information search. *Proceedings of the ACM SIGIR conference. 38. Proceedings of the ACM SIGIR conference* (pp. 767–770). https://doi.org/10.1145/2766462.2767817.

Duggan, G. B., & Payne, S. J. (2009). Text skimming: The process and effectiveness of foraging through text under time pressure. *Journal of Experimental Psychology: Applied, 15*(3), 228–242. https://doi.org/10.1037/a0016995.

Edwards, A., & Kelly, D. (2017). Engaged or frustrated?: Disambiguating emotional state in search. *Proceedings of ACM SIGIR conference. 40. Proceedings of ACM SIGIR conference* (pp. 125–134). https://doi.org/10.1145/3077136.3080818.

Elias, H., Ping, W. S., & Abdullah, M. C. (2011). Stress and academic achievement among undergraduate students in Universiti Putra Malaysia. *Procedia - Social and Behavioral Sciences, 29*, 646–655. https://doi.org/10.1016/j.sbspro.2011.11.288.

Fujikawa, K., Joho, H., & Shin'ichi, N. (2012). Constraint can affect human perception, behaviour, and performance of search. In H.-H. Chen, & G. Chowdhury (Vol. Eds.), *Lecture notes in computer science: . 7634. The outreach of digital libraries: A globalized resource network. ICADL 2012* (pp. 39–48). Berlin: Springer. https://doi.org/10.1007/978-3-642-34752-8_5.

González-Ibáñez, R., & Shah, C. (2016). Using affective signals as implicit indicators of information relevance and information processing strategies. *Proceedings of the Association for Information Science and Technology, 53*(1), 50. https://doi.org/10.1002/pra2.2016.14505301050.

Healey, J. A., & Picard, R. W. (2005). Detecting stress during real-world driving tasks using physiological sensors. *IEEE Transactions on Intelligent Transportation Systems, 6*(2), 156–166. https://doi.org/10.1109/TITS.2005.848368.

Heinström, J. (2010). *From fear to flow: Personality and information interaction.* Oxford, UK: Chandos.

Hlavac, M. (2018). *stargazer: Well-formatted regression and summary statistics tables [Computer software manual].* Central European Labour Studies Institute (CELSI). Bratislava, Slovakia. Retrieved from https://CRAN.R-project.org/package=stargazer (R package version 5.2.2) .

Hofmann, K., Mitra, B., Radlinski, F., & Shokouhi, M. (2014). An eye-tracking study of user interactions with query auto completion. *Proceedings of the 23rd ACM international conference on information and knowledge management* (pp. 549–558). New York: ACM Press. http://doi.acm.org/10.1145/2661829.2661922.

Ishita, E., Miyata, Y., Ueda, S., & Kurata, K. (2017). A structural equation model of information retrieval skills. *Proceedings of the ACM CHIIR conference* (pp. 317–320). https://doi.org/10.1145/3020165.3022142.

Jiang, J., He, D., & Allan, J. (2014). Searching browsing and clicking in a search session: Changes in user behavior by task and over time. *Proceedings of the ACM SIGIR conference* (pp. 607–616). ACM.

Kelly, D. (2009). Methods for evaluating interactive information retrieval systems with users. *Foundations and Trends in Information Retrieval, 3*(1–2), 1–224. https://doi.org/10.1561/1500000012.

Khanna, P., & Sasikumar, M. (2010). Recognising emotions from keyboard stroke pattern. *International Journal of Computer Applications, 11*(9), 1–5.
Kim, K.-S. (1999). Searching the web: Effects of problem solving style on information-seeking behavior. *EdMedia: World conference on educational media and technology 1999*https://www.learntechlib.org/p/6892.
Kim, K.-S., & Allen, B. (2002). Cognitive and task influences on web searching behavior. *Journal of the American Society for Information Science and Technology, 53*(2), 109–119. https://doi.org/10.1002/asi.10014.
Kirk, R. (2013). *Experimental design: Procedures for the behavioral sciences* (4th ed.). Thousand Oaks, CA: SAGE.
Kuhlthau, C. C. (1991). Inside the search process: Information seeking from the user's perspective. *Journal of the American Society for Information Science, 42*(5), 361–371. https://doi.org/10.1002/(SICI)1097-4571(199106)42:5%3C361::AID-ASI6%3E3.0.CO;2-%23.
Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). LmerTest package: Tests in linear mixed effects models. *Journal of Statistical Software, 1*(13), https://doi.org/10.18637/jss.v082.i13.
Landry, C. F. (2014). *The impacts of time pressure and emotion on the information behavior of high stakes decision makers: The home buying experience*. Seattle, WA: University of Washington. http://hdl.handle.net/1773/27509.
Li, Y., & Belkin, N. J. (2008). A faceted approach to conceptualizing tasks in information seeking. *Information Processing & Management, 44*(6), 1822–1837. https://doi.org/10.1016/j.ipm.2008.07.005.
Liu, C., & Wei, Y. (2016). The impacts of time constraint on users' search strategy during search process. *Proceedings of the Association for Information Science and Technology, 53*. https://doi.org/10.1002/pra2.2016.14505301051.
Liu, J., Liu, C., Cole, M., Belkin, N. J., & Zhang, X. (2012). Exploring and predicting search task difficulty. *Proceedings of the 21st ACM International Conference on Information and Knowledge Management* (pp. 1313–1322). ACM. https://doi.org/10.1145/2396761.2398434.
Liu, P., & Li, Z. (2012). Task complexity: A review and conceptualization framework. *International Journal of Industrial Ergonomics, 42*(6), 553–568. https://doi.org/10.1016/j.ergon.2012.09.001.
Liu, C., Yang, F., Zhao, Y., Jiang, Q., & Zhang, L. (2014). What does time constraint mean to information searchers? *Proceedings of the 5th information interaction in context symposium* (pp. 227–230). New York: ACM. https://doi.org/10.1145/2637002.2637029.
Liu, J., & Belkin, N. J. (2012). Searching vs. writing: Factors affecting information use task performance. *Proceedings of the American Society for Information Science and Technology, 49*(1), 1–10. https://doi.org/10.1002/meet.14504901127.
Liu, Y.-H., Thomas, P., Bacic, M., Gedeon, T., & Li, X. (2017). Natural search user interfaces for complex biomedical search: An eye tracking study. *Journal of the Australian Library and Information Association, 66*(4), 364–381. https://doi.org/10.1080/24750158.2017.1357915.
Liu, Y.-H., & Wacholder, N. (2017). Evaluating the impact of mesh (medical subject headings) terms on different types of searchers. *Information Processing & Management, 53*(4), 851–870. https://doi.org/10.1016/j.ipm.2017.03.004.
Long, J. A. (2018). *jtools: Analysis and presentation of social scientific data [Computer software manual]*. Retrieved from https://cran.r-project.org/package=jtools (R package version 1.1.1) .
Lu, Y.-L. (2010). Children's information seeking in coping with daily-life problems: An investigation of fifth- and sixth-grade students. *Library & Information Science Research, 32*(1), 77–88. https://doi.org/10.1016/j.lisr.2009.09.004.
Lüdecke, D. (2018). *sjplot: Data visualization for statistics in social science [Computer software manual]*. Retrieved from https://CRAN.R-project.org/package=sjPlot (R package version 2.6.2) .
Lundberg, U. (2005). Stress hormones in health and illness: The roles of work and gender. *Psychoneuroendocrinology, 30*(10), 1017–1021. https://doi.org/10.1016/j.psyneuen.2005.03.014.
Maehr, W. (2008). *eMotion: Estimation of user's emotional state by mouse motions.* Saarbrücken, Germany: VDM Verlag.
Maule, A. J., Hockey, G. R. J., & Bdzola, L. (2000). Effects of time-pressure on decision-making under uncertainty: Changes in affective state and information processing strategy. *Acta Psychologica, 104*(3), 283–301. https://doi.org/10.1016/S0001-6918(00)00033-0.
Nahl, D. (2004). Measuring the affective information environment of web searchers. *Proceedings of the American Society for Information Science and Technology, 41*(1), 191–197. https://doi.org/10.1002/meet.1450410122.
Nakagawa, S., Johnson, P. C. D., & Schielzeth, H. (2017). The coefficient of determination R 2 and intra-class correlation coefficient from generalized linear mixed-effects models revisited and expanded. *Journal of The Royal Society Interface, 14*(134)https://doi.org/10.1098/rsif.2017.0213.
O'Brien, H. L., Dickinson, R., & Askin, N. (2017). A scoping review of individual differences in information seeking behavior and retrieval research between 2000 and 2015. *Library & Information Science Research, 39*(3), 244–254. https://doi.org/10.1016/j.lisr.2017.07.007.
Petrac, D. C., Bedwell, J. S., Renk, K., Orem, D. M., & Sims, V. (2009). Differential relationship of recent self-reported stress and acute anxiety with divided attention performance. *Stress, 12*(4), 313–319. https://doi.org/10.1080/10253890802380714.
Pirolli, P., & Card, S. K. (1999). Information foraging. *Psychological Review, 106*(4), 643–675. https://doi.org/10.1093/acprof:oSo/9780195173321.001.0001.
Plieger, T., Felten, A., Diks, E., Tepel, J., Mies, M., & Reuter, M. (2017). The impact of acute stress on cognitive functioning: A matter of cognitive demands? *Cognitive Neuropsychiatry, 22*(1), 69–82. https://doi.org/10.1080/13546805.2016.1261014.
R Core Team. (2018). *R: A language and environment for statistical computing (Version 3.5.1).* Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org.
Rafidah, K., Azizah, A., Norzaidi, M. D., Chong, S. C., Salwani, M. I., & Noraini, I. (2009). Stress and academic performance: Empirical evidence from university students. *Academy of Educational Leadership Journal, 13*(1), 37–51.
Robson, K., & Pevalin, D. (2016). *Multilevel modeling in plain language.* Thousand Oaks, CA: SAGE.
Savage-Knepshield, P. A., & Belkin, N. J. (1999). Interaction in information retrieval: Trends over time. *Journal of the American Society for Information Science, 50*(12), 1067–1082. https://doi.org/10.1002/(Sici)1097-4571(1999)50:12<1067::Aid–Asi6>3.0.Co;2-4.
Savolainen, R. (2006). Time as a context of information seeking. *Library & Information Science Research, 28*(1), 110–127. https://doi.org/10.1016/j.lisr.2005.11.001.
Savolainen, R. (2016). Approaching the affective barriers to information seeking: The viewpoint of appraisal theory. *Information Research, 21*(4)http://www.informationr.net/ir/21-24/isic/isic1603.html.
Selye, H. (1973). The evolution of the stress concept: The originator of the concept traces its development from the discovery in 1936 of the alarm reaction to modern therapeutic applications of syntoxic and catatoxic hormones. *American Scientist, 61*(6), 692–699.
Shapira, B., Taieb-Maimon, M., & Moskowitz, A. (2006). Study of the usefulness of known and new implicit indicators and their optimal combination for accurate inference of users interests. *Proceedings of the 2006 ACM Symposium on Applied Computing* (pp. 1118–1119). New York: ACM. https://doi.org/10.1145/1141277.1141542.
Simons, C., Aysan, F., Thompson, D., Hamarat, E., & Steele, D. (2002). Coping resource availability and level of perceived stress as predictors of life satisfaction in a cohort of Turkish college students. *College Student Journal, 36*(1), 129–142.
Slone, D. J. (2007). The impact of time constraint on internet and web use. *Journal of the American Society for Information Science and Technology, 58*(4), 508–517. https://doi.org/10.1002/asi.20525.
Snow, R.E. (1994). A person-situation interaction theory of intelligence in outline, In A. Demetriou & A. Efklides (Eds.), *Advances in Psychology* 106, 1994, 11–28, North-Holland. https://doi.org/10.1016./S0166-4115(08)62750-8.
Tang, M. C., Liu, Y. H., & Wu, W. C. (2013). A study of the influence of task familiarity on user behaviors and performance with a mesh term suggestion interface for PubMed bibliographic search. *International Journal of Medical Informatics, 82*(9), 832–843. https://doi.org/10.1016/j.ijmedinf.2013.04.005.
Topi, H., Valacich, J. S., & Hoffer, J. A. (2005). The effects of task complexity and time availability limitations on human performance in database query tasks. *International Journal of Human-Computer Studies, 62*(3), 349–379. https://doi.org/10.1016/j.ijhcs.2004.10.003.
Vedhara, K., Hyde, J., Gilchrist, I. D., Tytherleigh, M., & Plummer, S. (2000). Acute stress, memory, attention and cortisol. *Psychoneuroendocrinology, 25*(6), 535–549. https://doi.org/10.1016/S0306-4530(00)00008-1.
Weenig, M. W. H., & Maarleveld, M. (2002). The impact of time constraint on information search strategies in complex choice tasks. *Journal of Economic Psychology, 23*(6), 689–702. https://doi.org/10.1016/S0167-4870(02)00134-4.

Wegier, P., & Spaniol, J. (2015). The effect of time pressure on risky financial decisions from description and decisions from experience. *PLoS One, 10*(4), e0123740. https://doi.org/10.1371/journal.pone.0123740.

White, R. W. (2016). *Interactions with search systems.* Cambridge, MA: Cambridge University Presshttps://doi.org/10.1017/CBO9781139525305.

Wilson, T. D. (2016). A general theory of human information behaviour. *Information Research, 21*(4)http://InformationR.net/ir/21-24/isic/isic1601.html.

Wittek, P., Liu, Y.-H., Darányi, S., Gedeon, T., & Lim, I. S. (2016). Risk and ambiguity in information seeking: Eye gaze patterns reveal contextual behavior in dealing with uncertainty. *Frontiers in Psychology, 7*, 1790. https://doi.org/10.3389/fpsyg.2016.01790.

Xie, X., Liu, Y., Wang, X., Wang, M., Wu, Z., Wu, Y., et al. (2017). Investigating examination behavior of image search users. *Proceedings of the 40th international ACM conference on research and development in information retrieval* (pp. 275–284). New York: ACM Press. http://doi.acm.org/10.1145/3077136.3080799.

Yerkes, R. M., & Dodson, J. D. (1908). The relation of strength of stimulus to rapidity of habit-formation. *Journal of Comparative Neurology and Psychology, 18*(5), 459–482.