BENTLEY UNIVERSITY

Working Memory

A Case Study on Yahoo’s Methods for Recovering User Trust

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Creatures with cognitive abilities utilize working memory to gather new information from their surroundings and from problem solving (Van Merriënboer & Sweller, 2005). Scientists theorize that early humans utilized working memory in order to recognize threats, to locate food, and to identify potential mates (Nairne et al, 2007). Working memory serves as a meeting point between sensory information from the environment and the schemas constructed in long-term memory (Cowan, 2014). However, unlike long-term memory, which serves as a permanent storage area for information, working memory is only supposed to be a temporary repository for information (Cowan, 2008). While there are known strategies to best utilize working memory, Yahoo, when it comes to instilling trust in the users, does not adhere to these suggestions, making customers question their own safety in Yahoo's hands. As this case study progresses, there will be discussions concerning the components of working memory, the inherent limitations of working memory, and how emotion impacts working memory.

In today's technological society, e-mail is one of the most used services connecting individuals and companies to one another. As such, a lot of sensitive information pertaining to people's livelihoods are transmitted and stored within e-mail accounts, and safeguards are supposed to be in place to ensure the data is only accessible by the owner of the account, primarily through the use of passwords. However, in the past several months, it has been revealed that hackers, on multiple occasions, have broken into Yahoo's servers and potentially compromised the e-mail accounts of their customers. Yahoo's current methods for informing and allowing the user to establish good security measures after these hacks are not easing the user's burden on their working memory.

Attributes of Working Memory

In the current consensus of how working memory is structured, the brain utilizes two temporary storage systems, a component to guide information, and an overarching component for cross component memory allocation (Baddeley, 2003; Nobre et al, 2014). Each of the storage systems specialize in utilizing particular types of information (Baddeley, 2003). While the Phonological Loop is responsible for auditory and language-based items (Baddeley, 2003, Wynn & Collidge, 2009; Nobre et al, 2014), the Visuospatial Sketchpad remembers visual and spatial information (Baddeley, 2003, Hubber et al, 2014; Nobre et al, 2014). Meanwhile, the Central Executive is responsible for determining what information is paid attention to during observation (Baddeley, 2003; Wynn & Collidge, 2009). By utilizing the information in the two temporary storage systems as well as schemas constructed in long-term memory, the Central Executive is capable of processing potential strategies for resolving the person's current task (Baddeley, 2003; Van Merriënboer & Sweller, 2005; Nobre et al, 2014). To retrieve this information, the Central Executive relies on the Episodic Buffer, the multimodal component to working memory that pieces together information from these three systems into something the Central Executive is more likely to understand (Nobre et al, 2014; Langerock et al, 2014).

Limitations to Working Memory

Cognitive Load Theory aims to explain why there are limitations on the brain's working memory and how to maximize the efficiency of the transfer of knowledge between Working Memory and Long Term Memory (Paas & Ayers, 2014). There are three types of loads that comprise working memory, and many scientists (Van Merriënboer & Sweller, 2005; DeLeeuw & Mayer, 2008; Mostyn, 2012; Paas & Ayers, 2014) concur on the nature of each of the loads. Extraneous load is the cognitive load required to process irrelevant information for a given task. Intrinsic load is the cognitive burden a person takes on when assessing the complexity of a task. Germane load is the required load that organizes the information and compares the new data with the schemas already constructed in long-term memory. These three share the same mental resource, so if one type of load requires more processing power, the other two will suffer in their processing ability (Mostyn, 2012; Paas & Ayers, 2014). When processing a task that would require a high cognitive load, minimizing extraneous load and utilizing Intrinsic and Germane loads is considered the most optimal strategy for learning and comprehension (DeLeeuw & Mayer, 2008; Mostyn, 2012). However, cognitive load limited to the temporary amount of time information can be retained, the low number of items to be held at the same time, and the susceptibility of memories to be compromised.

When an item is placed into working memory, the item is susceptible to being forgotten if not attended to (Barrouillet et al, 2007; Ricker & Cowan, 2010). Once a piece of information enters working memory, the information begins to decay unless the person continuously reminds himself of the information (Ricker & Cowan, 2010). When information is being rehearsed, it allows that information and any connections to be transcribed to long-term memory (Roediger & Butler, 2011). Retaining one item in working memory without rehearsal becomes completely lost after 20 seconds (Van Merriënboer & Sweller, 2005; Oberauer et al, 2016). However, the amount of time for information in working memory to decay and be forgotten decreases as more items are to be remembered (Barrouillet et al, 2007).

While long-term memory has a limitless amount of storage space, it's generally accepted that working memory can only hold between 3 to 5 items concurrently (Baddeley, 2003; DeLeeuw & Mayer, 2008; Wynn & Coolidge, 2009; Cowan, 2010; Paas & Ayers, 2014; Oberauer et al, 2016). To compensate for this drawback, the episodic buffer is capable of grouping items into chunks, and these items would be processed together, allowing for more information to be retained in working memory (Wynn & Coolidge, 2009; Cowan, 2010; Oberauer et al, 2016). Some of the methods that can illicit items to be chunked together include physical or spatial similarities from what is presented to the viewer (Abbes et al, 2014) and being reminded of already-established connections between items in long-term memory (Paas & Ayers, 2014). However, the more elements that comprise each chunk, the fewer concurrent chunks an individual is able to remember (Oberauer et al, 2016).

The method that Yahoo chooses to inform customers on what steps need to be taken in case their accounts have been compromised adds an unnecessary cognitive burden to the end user. Yahoo's webpage detailing the hacks on their servers (See Figure 1) provides no obvious method for organization. Information pertaining to the technological background of the event and the actions the user should perform is woven together under a large number of expandable options. In the event that a user's personal information has been potentially compromised, the average user would not want to have a technology lesson concerning how the attack occurred; rather, he wants to immediately secure his information. Instead, the user needs to figure out which options he should view in order to take the appropriate actions.

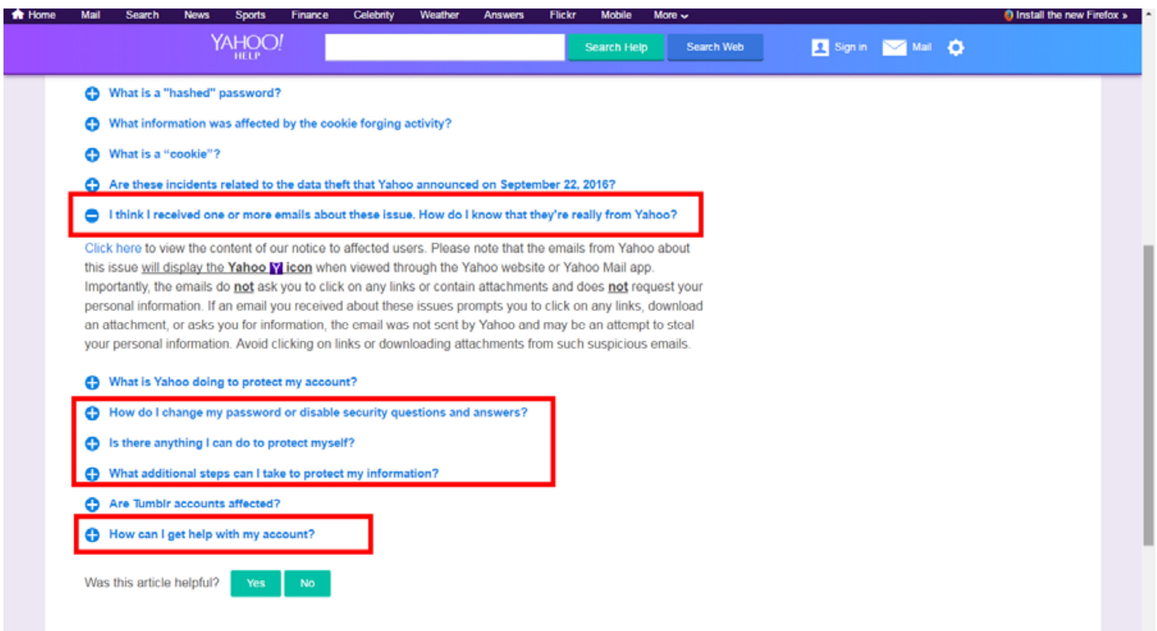

Figure 1: Yahoo Information Page with user action items highlighted.

In addition, there's the possibility that once the password has been fixed, a user would consider his issue resolved and not take any further recommended actions to safeguard his account. While changing the account password is a good start to secure the user's account, the webpage also suggests verifying that the user's identity isn't stolen. However, links on this page that visit other parts of Yahoo's website, such as the Change Password page, go to new pages within that window. Any progress made on viewing this list is lost when the user leaves this page. If the user tries to return to this page, all the options are automatically closed, and the user needs to recall what portions of this page he already examined.

It is suggested that there should be an "Emergency Information" template that should be prepared in case another issue concerning customer security arises. While this template might be viewed as unnecessary since the breach would be fixed for now, the number of revealed Yahoo Security breaches that occurred in the past few months and the current climate surrounding cybersecurity warrants its existence. On this emergency information template, information could be separated into categories such as technical background, measures Yahoo is taking, and actions the user can take. Whenever Yahoo needs to use this page, they would organize the talking points needed to be made into these categories. All links should open a new tab rather than using the current tab, which is a quick way to keep the state of the list intact if the user wishes to revisit this list. Another addition to consider for this page is to display an in-browser alert if the user is attempting to close that tab or browser window, asking him to confirm that he reviewed all the security data. Doing this should not only ease the load by lessening the need for users to hunt down pertinent information, but will keep information from being forgotten.

Information kept in working memory is susceptible to being forgotten or altered due to the volatility of working memory (Oberauer et al, 2016). External distractions and mind wandering are considered attention-diverting actions, forcing the Central Executive to divert attention from the primary task to a secondary task (Cowan, 2014). When attempting to return to the primary task, cognitive load is spent attempting to recall the progress made on the task; this often results in errors being made (Robison & Unsworth, 2015). An effective strategy for counteracting this effect is to have a salient cue to remind the individual about the progress that has been made on the task (Abbes et al, 2014). Meanwhile, excessive irrelevant content can cause memory interference, which would increase the extraneous load on a person due to the need to filter out the task-irrelevant information (DeLeeuw & Mayer, 2008). While proactive interference involves introducing extraneous information prior to presenting desired material, retroactive interference involves introducing extraneous data after presenting prior material (Mayer et al, 2007, Unsworth et al, 2013). The extraneous load would be even greater if the irrelevant information to be remembered is similar in properties to another presented task, as the individual might confuse the two concepts when attempting to recall just one of them (Bunting, 2006; Unsworth et al, 2013; Oberauer et al, 2016).

A person may also have issues logging onto his Yahoo account due to the volatility of working memory. When attempting to log into an account with an established password (See Figure 2), some users would enter their password to log into their account, with characters replaced by dots to keep the password hidden in case the user is in a public area. However, if the user is in the process of writing his password and gets interrupted, the user would have to either recall where he last finished writing his password, or delete what was written thus far and retype his password. If the user encounters this issue too often, he might make a simpler password even though his account would be easier to hack by doing so. When generating a new password, Yahoo gives users the opportunity to show their password as they are writing it. Yahoo should allow users to view what was written on the login screen. This would allow users to see progress made on the text they have written thus far and ease the cognitive load of accessing their account.

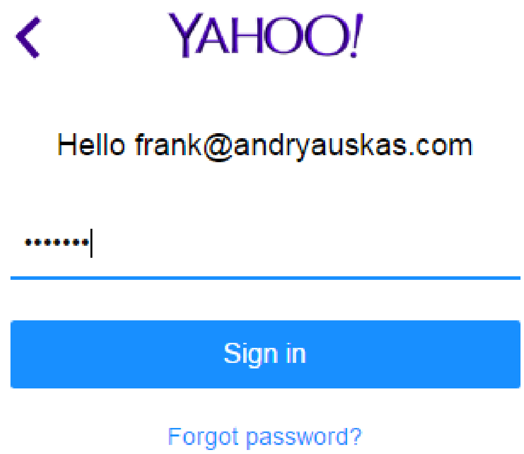

Figure 2: User Password Login Portion.

Emotional Effects on Working Memory

A person who is driven to understand a task or scenario has better control over the executive functions involved in managing attention (Kliegel et al, 2004). A motivated person who is attempting to comprehend material has more self-regulartory control, keeping intruding and distracting thoughts away while remaining vigilant (Baumeister & Vohs, 2007). While the reasons for being motivated for a particular task may vary, Cerasoli and his collogues (2015) explain that motivating factors generally fall into two categories. Factors based on personal choice, such as self-improvement or pleasure, are considered intrinsic motivating factors. In contrast, factors based on perceived gains or losses, such as rewards or social expectations, are known as extrinsic motivating factors. From a production prospective, intrinsic motivators work better for quality-based tasks while extrinsic motivators work better for quantity-based tasks (Cerasoli et al, 2014).

Anxiety is the feeling people get when they perceive a threat to their well-being (Derakshan & Eysenck, 2009). As Pessoa (2009) explains, “When emotional content is high in threat, resources are diverted towards the processing of the item.” According to Attention Control Theory, the Central Executive’s capacity is negatively affected as a person’s anxiety level increases, thus reducing the person’s processing efficiency, attentional control, and material comprehension (Eysenck et al, 2007). Due to this consumption of cognitive ability, the ability to block intrusive thoughts, such as worry, declines (Derakshan & Eysenck, 2009). People who are worried about failure consume more working memory resources (Paas & Ayres, 2014), and people with high anxiety are less confident in their own abilities (Delleman & Fernandes, 2015).

Because security breaches make this a trying time for Yahoo users, their increased anxiety levels have lowered their working memory ability. Their emails can potentially contain sensitive information, ranging from contact information to credit card numbers and bank accounts. The breaches of data shakes up the trust they have in Yahoo's service, and they are worried that their information may have fallen into the wrong hands. This scenario compromises their working memory by introducing these intruding thoughts while the user is trying to better protect their accounts. With potential thoughts of possible identity theft and blackmail on users' minds, Yahoo must regain the trust of their users and guide them to better safeguard their data.

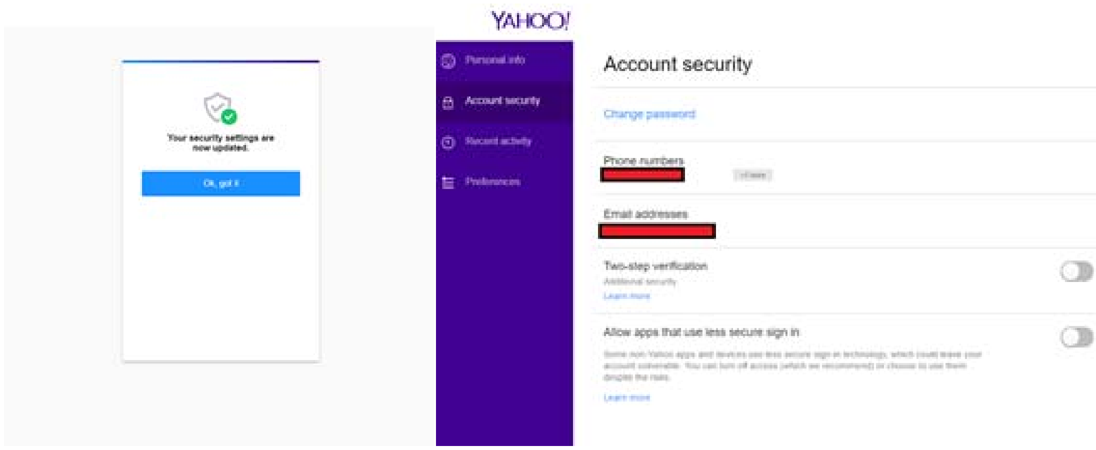

Figure 3: Claims security is set (left), but 2-step verification would strengthen security (right).

In addition to the suggestions made previously in this paper, it is suggested that if a user has no other security safeguards installed on their account, the extra security measures should be displayed after the user changes his password (See Figure 3). Giving the user feedback that Yahoo wants to be an ally to fend off attackers to their accounts can give users the peace of mind that Yahoo is doing everything it can to keep their customers safe.

Closing Thoughts

While it would be ideal for internet security to be perfectly invulnerable, the reality of how the net is structured makes this near impossible. User's trust in Yahoo has certainly been shaken, if not broken, from the recent security breaches, but the UX team can take measures to show that Yahoo cares about their customer's data. This will help put the users mind at ease when using Yahoo in the future.

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