Exploring hidden influences on users' decision-making: A feature-lesioning technique to assist design thinking

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Exploring hidden influences on users’ decision-making: A feature-lesioning technique to assist design thinking

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ABSTRACT
This study presents a qualitative design thinking technique to help system designers explore hidden influences on users’ decision-making processes. This technique targets context-specific influences that have accumulated in the absence of conscious reflection, and hence may exist without users’ awareness. Such processes may lie outside the reach of traditional discursive approaches; thus, our technique augments existing approaches with a method for ‘lesioning’ information sources, i.e. removing specific information sources and observing how and when users’ decision-making behaviour breaks down. This deconstruction allows dependencies to be exposed, allowing a better understanding of hidden influences, which can then be assimilated into design ideation. The lesioning technique is tested and demonstrated over multiple experimental iterations in the context of Twitter, a leading social media service. These iterations present several insights and design opportunities surrounding how users determine what connections to form and how those users make sense of information on busy content feeds.

Introduction

The design of products and services represents a complex task in which designers must consider wide-ranging future possibilities and embedded legacy systems, as well as accumulated knowledge bases and skill sets (De Guinea & Markus, 2009; Limayem, Hirt, & Cheung, 2007). Some design problems are so fundamentally intractable that the very act of defining them may become counter-productive (Buchanan, 1992; Coyne, 2005; Rittel, 1972). Design thinking (DT) has emerged as a means for addressing this latter type of ‘wicked’ design problems, which it does by emphasising needs exploration, contextual immersion and iterative testing (Brown & Wyatt, 2010; Cross, 2001; Dunne & Martin, 2006).

At the heart of the DT approach is the philosophy of ‘human-centred design’ (Brown & Wyatt, 2010; Hanington, 2003; Michlewski, 2008). Human-centred design prescribes that designers interact extensively with users so that they can better understand these users’ existing influences, preferences, capabilities and practices (Norman & Draper, 1986; Veryzer &
This idea has grown popular for the design of new products and services (Fallman, 2008; Kim & Ryu, 2014) and the design of new organisational processes (Avital, Boland, & Lyytinen, 2009; Brown, 2008). More recently, DT is evolving from an artefact-based paradigm to a practice-based paradigm (Björgvinsson, Ehn, & Hillgren, 2012; Suchman, 2002; Tonkinwise, 2011). Yet herein lies a problem. Much of the information that influences decision-making processes is tacit in nature – learned and refined through experience – in the absence of conscious reflection (cf. Nonaka & von Krogh, 2009). This means that users may not be able to account for information influences for important decision-making processes, particularly those decisions made quickly and instinctively.

This study seeks to augment DT approaches with a technique to help identify hidden influences on users’ decision-making processes, so they can be leveraged to better inform design ideation. The next section presents a discussion of hidden influences on decision-making processes and their relevance to information system (IS) design. Following this, an analogy is drawn between the analysis of complex sociotechnical systems and historical attempts to understand the brain, particularly those who did so by observing individuals with damage or ‘lesions’ to specific neurophysiological regions. This allows a DT technique to be developed that assimilates the principles of brain lesion methodology (though not the brain lesions themselves) into an IS design context. To test the technique, it is implemented in the context of Twitter, a popular social media platform with simple functionalities yet complex information-related user behaviours. First, a round of interviews is conducted with Twitter users to identify decision-making processes that may be susceptible to hidden influences. Two rounds of participatory experiments are then performed to lesion target users’ decision-making processes and gain insights into relevant hidden influences.

**Design thinking and human-centred design**

DT describes an approach to system design in which designers are encouraged to be needs orientated, responsive, contextually immersive and, most importantly, ‘human-centred’ (Brown & Wyatt, 2010; Cross, 2001; Dunne & Martin, 2006). These core concepts have emerged over several key phases of discussion and reflection in the philosophy of design (cf. Kimbell, 2009).

Most of the modern discussion of design as a rational science-like process can be traced to Alexander (1964) and Simon (1969). These scholars conceptualised design as a reasoning process, in which designers compare alternative patterns and actions in terms of their ability to address the specific requirements characterising a design problem. A second phase of design theorising emphasised the limitations of a rational problem-solving approach, arguing that the complexity of human social systems means they may not always be usefully reduced to clearly defined objectives and requirements (e.g. Ackoff, 1979; Churchman, 1964; Rittel, 1972). Given the challenges associated with design under such circumstances, this second phase of researchers proposed that more useful design knowledge could be obtained by studying the cognitive processes used by practising designers, particularly when faced with seemingly irreducible design problems (e.g. Buchanan, 1992; Cross, 2001; Lawson, 1980). This revealed a style of design that came to be known as ‘design thinking’, thanks to proponents such as Rowe (1987) and Faste, Roth, and Wilde (1993). Central to the DT approach was the ability of a designer to nurture empathy with eventual users so that they might best leverage their own creative and reflective abilities to create something of subjective value (even if...
that value was not a ‘solution’ in the strictest sense of the word). This concept was refined for business purposes by organisations such as IDEO, which proposed a DT methodology based upon iterative cycles of (1) inspiration: looking for new ways to think about a specific problem; (2) ideation: generating and testing multiple new design ideas/solutions; and (3) implementation: executing the proposed solution (Brown, 2008).

A third phase in design theorising extended the core concepts of human-centrism and empathy in DT, arguing that the most effective means of creating something of value to users required those users’ active participation in the design process (Kensing & Blomberg, 1998; Krippendorff, 2004; Suchman, 1987). The justification for this participation came from the idea that much of what a user thought and did was ‘tacit’ in nature and could not be easily described to designers in advance; hence, those users had to be observed directly and continuously to meet their needs (Michlewski, 2008; Sanders, 2002).

**Hidden influences on decision-making**

The importance of understanding hidden influences on decision-making is well established in decision and executive support systems research (e.g. Dane, Rockmann & Pratt, 2012; Gao, Zhang, Wang, & Ba, 2012; Hoch & Schkade, 1996; Klein, 1989; Newell & Shanks, 2014; Robey & Taggart, 1982). The importance of these hidden influences arises from Polanyi’s observation that much of the knowledge that forms the basis for advanced skills is ‘tacit’ (cf. Polanyi, 1966). This tacit knowledge plays a crucial part in the day-to-day activities of organisations, particularly the context-specific and routinised aspects of behaviour (Grant, 1996; Nonaka & Toyama, 2007; Nonaka & von Krogh, 2009; Reber, 1996). Yet there are suggestions that individuals possessing important tacit knowledge are often unaware of the role it plays, or even that it exists (Bargh & Chartrand, 1999). A similar perspective was put forward by Kahneman (2011), who divided reasoning into ‘system 1’ processes, which are fast, instinctive and emotional, and ‘system 2’ processes, which are slow, deliberate and logical. This system 1/system 2 distinction is described as adversarial in places, whereby unconscious system 1
processes frequently overpower conscious system 2 processes and dictate behaviour, even when more considered reflection may be beneficial.

The distinction between system 1 and system 2 decision-making processes means that influential tacit knowledge that is learned without conscious reflection may be fundamentally inexplicable unless behaviours break down (see Figure 1).

This challenge presented by tacit knowledge and hidden influences on decision-making becomes even more problematic in the context of the fourth phase of design theorising, which takes the social dimension of DT a step further and adds a practice-based view focused upon the co-creation of behaviours by users (Kaptelinin, 2006; Orlikowski, 2008). The goal of these practice-based views of DT is to avoid ‘mistaking one’s own ignorance of what exists elsewhere – knowledges, information systems, practices – for their absence’ (Suchman, 2002, p. 140). This means that hidden influences on decision-making must be identified if the benefits of a practice-based perspective are to be realised.

Yet while standard participatory techniques are valuable for capturing influences on decision-making processes that are difficult to verbalise, they have no capacity for reliably capturing those influences of which users are unaware. With enough participation, it is possible that designers may accrue similar processes to system users, or observe breakdowns that reveal complex interdependencies. Similarly, with enough trial and error in design, it is possible that designers can come across designs that leverage hidden influences on decision-making without necessarily understanding why they are important. However, such strategies rely upon serendipity and brute-force search, making them inefficient and undependable. Thus, a participatory technique is needed with the capacity to disentangle hidden influences on decision-making processes in a more systematic fashion.

The study of ‘lesions’ in the brain sciences

The brain is recognised as a highly complex system in which interdependencies are common and extricating specific processes is challenging (cf. Uttal, 2011). A number of recent breakthroughs have been made due to tools that allow neuroimaging during cognitive and behavioural tasks, such as those often employed in neuroIS studies (Dimoka et al., 2012; Riedl, Banker, Benbasat, Davis, & Dennis, 2010). Yet many of the most groundbreaking insights for unravelling the functional specialisation and interconnectivity of the brain have come from observations of brain lesions (Chatterjee, 2005; Fellows et al., 2005). In such studies, researchers examine individuals who have encountered brain damage through accidents, lesions introduced as part of medical treatment, or lesions introduced intentionally in sacrificial animals. These individuals or animals are observed for a lack of capabilities corresponding to their missing neurophysiological components, such that the influence of damaged or missing components can be better understood.

A classic case of this relates to the insights gained from studying Phineas Gage (cf. Damasio, 1994). Phineas Gage was a railroad worker in the northeast USA in the mid-1800s who lost a portion of his left frontal lobe when a metal pipe pierced his skull as a result of some prematurely detonating gunpowder. Although he survived the accident, Gage’s personality was changed in a way that impacted both his personal and his professional life. He became cold and emotionally distant, and took an excessively long time to perform simple tasks. From observations of this injury and other patients with similar brain damage, the purpose of the frontal lobe became clearer. This area was determined to have responsibilities
in assimilating emotional associations, or ‘somatic markers’, into decision-making to speed up the process and facilitate emotional considerations. Moreover, the manner in which Phineas Gage’s injuries impacted upon his cognitive function revealed the influence of such emotional associations in all of decision-making. By observing the impact of Gage’s brain lesion, researchers were not only able to better understand the role of the lesioned brain area, they were able to use this understanding to theorise more broadly as to the cognitive processes at play in healthy subjects.

Another famous instance of brain lesions leading to scientific insights can be found in Henry Molaison, often referred to as H.M. during the course of his life for privacy reasons. Henry Molaison suffered from extreme epilepsy thought to originate within hippocampal and parahippocampal regions of his brain (Corkin, 2002). When these areas were surgically removed to address his epilepsy in his late 20s, it was found that Molaison’s memory was impacted in a very specific and peculiar manner. He maintained his long-term memories formed before the surgery and had enough working memory to follow reasonably long conversations, yet he was unable to create new long-term memories (Milner, Corkin, & Teuber, 1968). Observations of Henry Molaison led to a series of realisations about the influence of specific areas of the brain on different types of memory, as well as the distinction between memory and other intellectual and perceptual abilities (Koch, 2010).

A system-lesioning technique for design thinking

This study argues that in the same way brain lesion studies have helped to make sense of the complex and interdependent system that is the brain, so too can the core principles of the lesion methodology be applied to unravel hidden influences on decision-making. This can be done by ‘lesioning’ (i.e. removing) information cues within an information technology (IT) environment and observing the impact these lesions have on users. At a system-component level, this parallels with Heidegger’s transition of task-related objects from ‘ready at hand’, in which the object in question is used routinely without theorising, to ‘present at hand’, in which the object is theoretically deconstructed (Heidegger, 1996). System lesioning in this context offers a means to force this transition by ‘obtruding’ hidden influences on users’ decision-making, thus forcing them to break down. If this is done systematically and in a way that can pinpoint when, how, and why such lesions prevent effective use of

![Figure 2. Positioning the lesioning technique in the design thinking process.](image-url)
the system, then this can be used to understand more precisely how users make use of the removed information cues. Note that this approach focuses on the identification of hidden influences on decision-making and subsequent ideation; it does not seek to augment the implementation phase of DT (see Figure 2).

Identifying hidden influences on decision-making presents two challenges to the basic principles of lesioning. Firstly, because users may not be aware of hidden influences on decision-making, they may not immediately realise when task-supporting information cues have been removed or impeded. Secondly, even after hidden influences on decision-making are brought to the users’ attention, their account of those processes may present a rationalisation, rather than a true explanation. The essence of this limitation was observed in studies of ‘split brain’ patients described by Gazzaniga (2011). For clinical reasons these patients had their corpus callosum removed, the area of the brain that communicates signals between the two cortical hemispheres. This limited these patients’ conscious awareness of stimuli perceived by their dominant left hemisphere – e.g. they could describe images seen through their right eye but not their left. To test this effect, a stress-inducing image was shown to patients within the lateral field of vision processed by their left eye only. Patients were not consciously aware an image had appeared, yet because they were still able to process the image at a subconscious level, they responded with the normal physiological response of elevated stress levels. When asked why they were stressed, the patients provided reasonable but erroneous explanations, e.g. attributing the response to a sudden change in the body language of the experiment administrator in the room at the time.

These limitations can be controlled with experimental design in cognitive neuroscience, e.g. by setting objective quantitative measurements for the efficiency of behaviours, or by targeting known behaviours in advance. Yet such solutions are not as applicable in a DT context, in which practices of interest are not assumed to be known in advance, nor are quantifiable metrics specific to their outcomes. Two steps are added to the DT lesioning approach as a means of addressing these concerns. First, to ensure the removal of hidden influences is detected, users are asked to numerically score their confidence with their behaviours before and after lesioned information sources are reintroduced. This is done to capture outcome-based changes at the level of emotions and feelings, which can then be used to prompt discussion. Second, to minimise the potential for erroneous rationalisation during this discussion, users are asked to account for their expectations of a lesioned information source before its reintroduction, as well as its actual impact when reintroduced. While it is impossible to guarantee an accurate explanation, this allows some level of triangulation to uncover flawed or paradoxical explanations.

Thus, assuming the existence of hidden influences on users’ decision-making has been established in users, the following process is proposed as a means of discovering these influences and using them to inform design ideation:

1. Identify and remove individual information sources available to a user for the selected task.
2. Ask the user to select one information source of their choice to be reintroduced, and explain why they believe it will help them perform the task at hand.
3. Reintroduce the selected information source.
(4) Observe the user interacting with the system – to identify when, how and why the user is using the information currently available to them, as well as the role of the reintroduced information source.

(5) Ask the user to quantify their confidence in their ability to perform the specific task under the current information conditions.

(6) Repeat steps 2–5 until all information sources have been reintroduced, clarifying why any changes in confidence have been indicated by the user in Step 5.

(7) Discuss the key characteristics and interrelationships of the information sources identified by the user and ideate possible amendments that could be made to the design to better capture these characteristics and interrelationships.

**Demonstrating and evaluating the lesioning technique: The case of Twitter**

Having developed the lesioning technique, a suitable domain was necessary to test its usefulness. A live design project would have allowed the technique to be applied within the full three cycles of the DT approach. However because the lesioning technique has no direct link to the ‘implementation’ phase, it was most important to select an environment in which the ‘inspiration’ and ‘ideation’ phases were complex and challenging. With this in mind, a social media domain was selected, as it is known to manifest complexities in regard to finding quality content (Agichtein, Castillo, Donato, Gionis, & Mishne, 2008), determining the strength of ties between users (Gilbert & Karahalios, 2009) and understanding how social presence emerges (Kietzmann, Hermkens, McCarthy, & Silvestre, 2011). More specifically, the demonstration used Twitter, a platform noted for its range of complex informational practices and inter-social behaviours (Java, Song, Finin, & Tseng, 2007; Marwick, 2011).

A qualitative approach to demonstration and evaluation was adopted to encourage the assimilation of emergent findings (Myers & Avison, 1997), based on three stages of data gathering and analysis. First, a series of semi-structured interviews were conducted to identify decision-making processes for Twitter users that may contain hidden influences. These interviews identified one key decision-making process, namely how users decide what other users to follow. Hence, the lesioning technique was applied in eight subsequent participatory interviews surrounding this decision. This revealed another interesting decision-making process concerning how users decide which tweets to actually read, rather than ignore. Thus, the process of timeline scanning was also investigated using the lesioning technique in a subsequent round of participatory interviews involving eight different subjects.

**Identifying hidden influences on users’ decision-making in Twitter**

The search for hidden influences began with 12 minimally structured interviews with Twitter users. The use of Twitter varies between those who use it for specific interests and those who use it less discriminately (O’Riordan, Feller, & Nagle, 2012). To reflect this, six subjects were selected for these interviews within a music-specific context, and six other subjects were selected for whom Twitter use covered a broader range of interests. Interviews were conducted remotely via telephone and took approximately 30 min, the purpose being to identify important decision-making processes that may involve hidden influences. In line with the definition of tacit knowledge from Polanyi (1966), two criteria were applied to identify these
hidden influences: (1) decision-making is a complex behaviour learned over prolonged periods of time, and (2) decision-making cannot easily be explained and transferred to others.

Analysis of the findings from these interviews revealed significant variation in terms of the intensity with which interviewees used Twitter. For example, the number of tweets sent by subjects ranged from 49,226 to 222, the number of followers ranged from 9200 to 17, and the number of users whom they followed ranged from 3012 to 52. Yet despite the range of intensity in terms of use, one decision-making practice emerged repeatedly during discussion, namely the decision which other users to ‘follow’. This is typified by the following quotes:

What I can’t really work out is how to know who to follow, that’s the hard part. Like I don’t know why I would have followed that person in the first instance or how I came across them…. That’s probably where the missing link is, there are people on Twitter that are sharing great artists but how do you find them…. I happen to have one or two of them in my Twitter feed but is that by accident? I don’t know.

Twitter is what you make it. The art of looking out for who to follow is one that a lot of people haven’t got, you know? I’m always seeing people complaining about Twitter saying ‘it’s just this’, or ‘it’s just that’ and I’m always saying ‘it is what you make it’. There’s a little bit of an element to it, in that you have to know who’s good. You have to know the good stuff to get to the good stuff, but you kind of prime the pump once you have started.

Thus, the lesioning technique was applied to disentangle how subjects evaluate other users’ profile information and decide whether to follow them. It is noteworthy that there are numerous other scenarios in which a subject may encounter other users of interest, for example on external websites, or via retweets in their timeline. However, this profile-oriented evaluation was selected as the most fundamental and broadly representative decision-making practice.

Lesioning hidden follow/unfollow decision-making in Twitter

Although the discussion of hidden influences on decision-making in this study has focused on users with some experience within a domain, it is not clear from existing research to what extent related hidden influences on decision-making from other backgrounds are relevant. Hence, eight new subjects were selected across a range of backgrounds and experience levels with Twitter. Four of these subjects (two female and two male) used Twitter solely for professional purposes; the remaining four (two male and two female) used Twitter for purposes that include personal interests (see Table 1).

Subjects were briefed that the purpose of the experiment was to observe how they use Twitter, and they were asked to log in to their account. Subjects were asked to view the three Twitter profiles suggested to them by the ‘Who to Follow’ window on the main interface, refreshing as necessary to cycle through different suggestions. They were then asked to

<table>
<thead>
<tr>
<th>Subject</th>
<th>Use</th>
<th>Following</th>
<th>Tweets</th>
<th>Followers</th>
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</thead>
<tbody>
<tr>
<td>A</td>
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<td>Personal</td>
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<td>46</td>
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</table>
select one of the users suggested within this window, as long as that user (1) was not already familiar to the subject and (2) appeared interesting enough to at least consider following. At this point, subjects were presented with the profile summary for the selected user with all information cues removed except the name of the account (see Figure 3). Subjects were informed that the information cues removed related to (1) the user’s profile picture, (2) the user’s biography, (3) the user’s location and/or website, (4) the user’s background image, (5) the user’s total tweets, followers, and following (6) other users whom the subject follows who also follow this user, (7) the user’s most recent tweets, and (8) the times at which their most recent tweets were made.

Subjects were asked to decide whether or not they would follow this account, based solely on the information now available to them. They were also asked to rate their confidence on whether they were making the correct decision (i.e. if their decision would be the same if the information available to them was not restricted) on a scale from 0 to 10. Following this, subjects were asked to select one of the eight information cues which they felt would be most informative in determining whether or not the selected user was worth following, and explain that suggestion. The information cue was reintroduced and subjects were again asked to decide whether or not they would follow this user based on all of the information now available to them, as well as to once more rate their confidence from 0 to 10. Subjects were asked what they had learned from the reintroduced information cue. This was repeated until all information sources had been reintroduced.

The administrators then asked the subjects whether, having completed the previous steps, they believed they were better equipped to explain how they use profile information to decide whom to follow. This question served to identify the tacit elements of the decision-making process that had been made explicit over the course of the experiment. Finally,
the administrators and subjects revisited and discussed observations surrounding important information cues identified during lesioning. Additional possible cues were then discussed that could be included in a profile summary to help subjects decide whether or not a user is worth following. For each idea generated, the administrators confirmed that the idea in question had emerged during discussion and had not been previously considered by the subject. A summary of the findings from these discussions is presented in Table 2.

The first main finding from this iteration is that five of the eight subjects stated that upon completion of the process, they could now explain more clearly how they decide whether or not to follow specific users. Perhaps more importantly, these five subjects (subjects A–E)
were the five subjects following the highest number of other users, while the three subjects who responded negatively (subjects F–H) were those following the fewest. This supports the idea that the most experienced users had accumulated more hidden influences on their decision-making, making them more difficult to articulate. The second main finding is that subsequent design ideation produced novel design suggestions in all eight cases. This supports the usefulness of the proposed technique, not only as a means of gaining a deeper understanding of hidden influences on decision-making, but also as a productive means of ideation in the design thinking process. The third finding is the relationship between the sophistication of design ideation and the intensity of use. For example, while several subjects referred to considerations of timeline clutter, arguably the more radical and innovative ideas came from those subjects with the most extensive use of Twitter.

The fourth finding of interest emerged when subjects were asked whether they would classify themselves as novice, intermediate or expert. Six of the eight subjects referred to themselves as intermediate and two as novice. Interestingly, the two subjects who described themselves as novice were subjects D and E, who represented the most ‘intermediate’ of the sample of subjects studied (although Subject H did clarify that she only described herself as intermediate in the sense that she understood what Twitter was and what to click upon). Nonetheless, this reflects a common phenomenon known as the Dunning-Kruger effect (Kruger & Dunning, 1999). This describes observations that individuals often overestimate their own abilities after some initial learning in a complex task, but begin to lower those estimations as they continue to learn and become skilled enough to recognise newer hidden complexities.

The fifth finding relates to the changes in subjects’ confidence that they were making the correct decision as information cues were reintroduced. Figure 4 illustrates that the confidence of subjects A–C, each of whom has tweeted > 1000 times, appeared to vary more between tasks as information cues were reintroduced. Conversely, the confidence of subjects D–H was comparatively stable. This is reflected by a comment made by Subject G after only two information sources had been reintroduced, i.e. the tweets and the location/website: I can say for definite now that I’m not going to follow this person…. I could have told you for definite after I saw those tweets there.

Similarly, after the first four information sources had been reintroduced, Subject F remarked that:

I don’t think there’s anything else there that would make me change my mind…. It’s the tweets and the bio. I click on it based on the name and if I saw someone I knew who was interested and following it. Then I make my decision on whether to follow based on what their tweets are.

This suggests that these users make more use of the range of information sources than the less experienced users, for whom the decision was weighted heavily on the earliest information sources requested.

The sixth and final finding surrounded the recurring theme of timeline clutter among subjects. All eight subjects highlighted considerations of timeline clutter as central to their follow/don’t follow decision-making processes. Hence, a third iteration of data gathering was initiated in which the lesioning technique was applied to the timeline scanning process.
Lesioning hidden influences on content-consumption decisions in Twitter

Eight new subjects were selected with whom to test the proposed lesioning technique in the context of content consumption decisions. The first iteration confirmed that advanced users offer greater potential in terms of design ideation than newer users; hence, subjects with more experience using Twitter were selected for the second iteration. Again, four of

<table>
<thead>
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Table 4. Summary of findings from the second lesioning experiment.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Is the subject better able to explain how they use the profile summary to decide whom to follow?</th>
<th>Characterisations of how the subject determines whether or not to follow a specific user</th>
<th>Are there additional information cues that could assist the subject in evaluating whether to follow users?</th>
</tr>
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<tbody>
<tr>
<td>I</td>
<td>Yes: 'Yeah...I've always known avatars and names are important to me but it didn't come one-two'.</td>
<td>Looks for respected users, breaking news and discussion of specific topical issues</td>
<td>Use of layout and colour to group contents of similar nature</td>
</tr>
<tr>
<td>J</td>
<td>Yes: 'I'd be better, I think that was interesting. Hashtags are far more important than I thought'.</td>
<td>Looks for respected users, breaking news and discussion of specific topical issues</td>
<td>Tracking of clicks to intelligently identify other appropriate content</td>
</tr>
<tr>
<td>K</td>
<td>Yes: 'Yeah, I think so, because when you're on Twitter on any given day you don't take notice of reading a tweet'.</td>
<td>Looks for key words, particular friends, specific hashtags</td>
<td>A layer of analytics that captured the categories of most clicked-upon tweets and highlighted other tweets on timeline with same category</td>
</tr>
<tr>
<td>L</td>
<td>Yes: 'Oh yeah, definitely....I never knew the hashtags influence me so much...'.</td>
<td>Uses Twitter when certain topics are trending and they want to find out more or hear other users' opinions concerning them</td>
<td>Option to turn off retweeted content to avoid timeline clutter</td>
</tr>
<tr>
<td>M</td>
<td>Yes: 'Yeah, actually...I never thought I scanned that way'.</td>
<td>Focuses on specific users who gain their respect with quality content over time</td>
<td>Option to scan by just images</td>
</tr>
<tr>
<td>N</td>
<td>Yes: 'Yes, definitely...I don't really look at the tweet text and I thought I did'.</td>
<td>Tries to link users by context of scan, e.g. certain users were key when looking for news updates</td>
<td>Rather than lists, would like option to filter content by mood/interests</td>
</tr>
<tr>
<td>O</td>
<td>No: 'I think I'd explain it exactly how I would have thought beforehand...'.</td>
<td>Looks for Tweets from different users at particular times</td>
<td>Would like pop-ups to alert any time they have been mentioned by other users</td>
</tr>
<tr>
<td>P</td>
<td>Yes: 'Yeah. I never thought about why I would read one tweet more than another...apparently I'm very visual.'.</td>
<td>Focuses on specific users who gain their respect with quality content over time</td>
<td>Commonly retweeted or favoured users should be highlighted in timeline</td>
</tr>
</tbody>
</table>

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**Lesioning hidden influences on content-consumption decisions in Twitter**
these subjects (two female and two male) use Twitter solely for professional purposes, while the remaining four (two male and two female) use Twitter for purposes that include personal interests (see Table 3).

As before, subjects were briefed that the purpose of the experiment was to observe how they use Twitter and they were asked to log in to their account. Subjects were informed that all tweet information had been removed from their timeline according to six categories, namely (1) tweet avatars, (2) tweet names/Twitter handles, (3) basic tweet text, (4) tweet times, (5) tweet meta-data, e.g. media and ongoing conversation information, and (6) tweet links, user mentions, and semantic hashtags. Subjects were asked to select one information source to be reintroduced and to explain why they believed this to be most important to their content consumption decisions. They were then given five seconds to scan their timeline with just this information source, and to select the tweet that they believed was most interesting. Subjects were asked to explain why they believed this tweet to be the most interesting from the selection that they had scanned, and asked to rate their confidence from 0 to 10. This process was repeated until all six information sources were present, with each scan taking place on new timeline content to minimise repetition effects. Three final scans were then performed in which the first, second and third information sources selected by the subjects were removed from the complete timeline.

Upon completion of this portion of the experiment, the administrators asked the subjects whether, having completed the previous steps, they believed they were better equipped to explain how they decide which tweets to read. The administrators and subject then revisited and discussed observations surrounding important influences that were identified by the subject during lesioning. Following this, subjects and the administrators ideated new designs that could assist their content consumption decisions. The administrators once more confirmed that new design ideas had emerged during discussion and had not been previously considered by the subject. A summary of the findings from these discussions is presented in Table 4.

The second lesioning experiment confirmed the findings from the first iteration, with all eight subjects producing novel design possibilities that they felt would improve the Twitter interface. Seven of the eight subjects self-reported an improved understanding of their content consumption decisions. The single subject who did not feel the lesioning technique had improved their understanding (Subject O) clarified during the course of the experiment that, although they use Twitter frequently on their phone, they had not used it on a desktop or laptop computer in several months. This finding is interesting, as it demonstrates the importance of targeting not only users with high levels of experience with a technology, but users whose typical usage is accurately reflected by the context in which the lesioning method is being employed.

**Discussion and conclusions**

The goal of this study was to develop a design thinking (DT) technique capable of leveraging hidden influences on users’ decision-making. This was done by adapting the lesion methodology from cognitive neuroscience into an IT design process. The implementation and evaluation of the lesioning technique revealed several insights.

Overall, the findings supported the usefulness of the lesioning technique. The core principle offers a useful means of engaging with hidden influences on users’ decision-making.
Furthermore, the limitations of lesioning in the context of hidden decision-making are mitigated by the quantification of confidence levels and comparisons of the predicted and observed impact of information sources. The lesioning technique also appears more effective when applied to users who have large amounts of experience in the target domain, and hence have accumulated more hidden influences. The increased role of hidden influences by experienced users was further supported by the continuing fluctuations observed in these subjects’ confidence as information sources were reintroduced. This was in contrast to the earlier, and consequently less information rich, commitment to decisions made by less experienced users. Perhaps most importantly, experienced users rated the process as more illuminating than less experienced users, and more sophisticated design possibilities emerged from ideation with these experienced users.

Another insight relates to inaccuracies in the self-reported expertise of users (i.e. more experienced users underestimated their expertise, whereas less experienced users overestimated them). Thus, the authors of this study argue that the selection of subjects should be informed by behaviour-centric metrics where possible, rather than relying upon the self-identification of experts.

Several insights were also gained with regard to the use of Twitter. The 28 interviews conducted (including 12 unstructured interviews and 16 participatory lesioning experiments) revealed that, as usage of this platform grows more sophisticated, the interests of users appear to focus and compartmentalise. Users follow other individuals according to specific interests and are then able to distinguish between different groups by picking up on subtle information combinations and different indicators of context. This appears to explain how advanced users continue to take value from the content delivered to them, even as the sheer quantity of that content ought to make it perceptually unmanageable.

Twitter-related insights were also presented by the outputs of design ideation. Design suggestions such as the hashtag word cloud, graphs of tweeting activity, the colour-coding of user themes, mention pop-ups, etc. all offer the ability to inform interface design for Twitter and other micro-blogging platforms. While these suggestions were primarily gathered to validate the usefulness of the lesioning technique, they nonetheless offer insights to industrial designers working in the social media and micro-blogging space.

Several limitations of this study must also be acknowledged. While this study provides a framework for the lesioning technique that is both theoretically grounded and empirically tested, neither this theoretical grounding nor this empirical testing is sufficient to ensure all of the issues with the technique have been addressed. The technique must be tested in a broad range of contexts, particularly those in which system use also includes face-to-face (rather than system-mediated) interaction with other users.

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