IDENTIFYING AND EXPLOITING TACIT PROCESSES IN DESIGN THINKING: WHAT CAN PHINEAS GAGE TEACH US ABOUT MAKING BETTER SYSTEMS?

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Accepted to the 3rd International workshop on IT Artefact Design & Workpractice Improvement, 2 June, 2014, Friedrichshafen

Abstract

This study presents a design thinking technique that facilitates the discovery and exploitation of tacit processes in advanced system users. The design thinking technique targets tacit processes that have accumulated over prolonged periods of technology use, in the absence of conscious reflection. Such tacit processes may be impossible for users to verbalize, as the manner in which they have been learned means that users may be unaware that they exist. This makes them difficult or even impossible to uncover with traditional discursive and participatory approaches. For this reason, the proposed technique offers a means of 'lesioning' information sources, i.e. removing aspects of the information system and observing how and when behavior breaks down. This deconstruction allows dependencies to be exposed, resulting in a better understanding of tacit processes, and consequently, improved assimilation of them into design ideation. This technique is tested over multiple experimental iterations in the context of Twitter, a social network and micro-blogging service. These iterations present several insights regarding how users determine which users to follow, as well as how information is consumed on a user's content feed.

Keywords*: Design Thinking, Tacit Processes, Ideation, Lesion Studies, Twitter.*

1. Introduction

The design of products and services is often an incremental process, building upon embedded legacy systems, accumulated knowledge bases, and existing skill sets (Ortiz de Guinea & Markus 2009, Limayem et al. 2007). The design thinking approach has emerged to address the complex and embedded nature of design, by presenting a set of approaches to problem solving and design that emphasise exploration, contextual immersion, and iterative testing (Cross, 2001, Dunne & Martin, 2006, Brown & Wyatt, 2010). These central ideas of design thinking are linked by the formative philosophy of 'human-centred design' (Hanington, 2003, Michlewski, 2008, Brown & Wyatt, 2010). Human-centred design prescribes that designers interact extensively with users so that they can better understand these users' existing preferences and capabilities, and so design in a way that best aligns to them (Norman & Draper, 1986, Veryzer, 2005). Yet herein lies the problem. Many of the skills individuals rely upon in everyday life are tacit in nature – learned and refined through experience – in the absence of conscious reflection (Baars 2002, Kahneman 2011). This means that advanced users may not be able to account for important processes, particularly those activities performed quickly and instinctively. This study seeks to augment design thinking approaches with a technique to help identify and leverage such tacit processes as part of design ideation.

This paper begins by presenting a brief discussion on the concept of tacit processes and IS design before drawing an analogy with historic attempts to understand the brain by observing individuals with damage or 'lesions' to specific neurophysiological regions (as seen in the classic case of Phineas Gage). A design thinking technique was developed to assimilate the principles of the brain lesion methodology (though not the brain lesions themselves) into an IS design context. This technique was implemented in the context of Twitter, a well-established and socially complex social media platform. Three rounds of interviews were performed, the first to identify tacit processes, the second and third to attempt to experimentally lesion user behaviour to gain insights into their tacit processes. Finally, the findings are discussed as well as contributions and limitations of the study and future implementation possibilities.

2. Tacit Processes and IS Design

The concept of tacit knowledge was first introduced to capture the types of knowledge that can't be verbally transferred from one person to another (c.f. Polanyi 1966). This type of unconscious knowledge forms the basis for a range of advanced skills, however individuals possessing it are often unaware of the role it plays, or even that it exists (Bargh 1999). More recently, these processes have been defined as those of 'system 1', which refers to the fast, instinctive, and emotional cognitive processes performed in the absence of the slow, sequential, and deliberate logic of 'system 2' (Kahneman 2011). This system 1/system 2 distinction is described as almost adversarial in places, whereby conscious system 2 processes and unconscious system 1 processes can actually contradict one another. This can be observed in the context of several documented visual illusions that viewers find difficult to reject, even once they have seen how and why they work, e.g. the *Müller-Lyer* and *Hering* illusions (Gregory 1968).

The importance of tacit processes in organizational contexts is well-established (e.g. Alavi and Leidner 2001, Nonaka and Von Krogh 2009), as well as during the design process (Markus et al. 2002, Nissen 2006). Indeed this respect for users' less-easily articulated existing knowledge and processes is the primary motivation for the human-centred and participatory techniques at the core of the design thinking methodology (Michlewski, 2008, Brown 2008). Yet while such techniques are valuable for capturing processes that are difficult to verbalise, they remain unsuitable for capturing system 1 processes of which users are unaware. With enough participation, it is possible that designers may accrue similar tacit processes to system users. However, they are unlikely to be able to match the tacit

learning of advanced users, who make the most out of existing designs and functionalities. Similarly, with enough trial-and-error in design, it is possible that designers can come across designs that leverage advanced users' existing tacit processes. However, this is time-consuming, inefficient, and unsuitable for discovering the underlying reasons why preferred designs are effective. Thus, a different technique is needed with the capacity to disentangle tacit processes without relying solely on observation or self-reporting.

3. Brain Lesions, Phineas Gage, and Learning from Breakdowns

The brain is recognised as a highly complex system in which interdependencies are common and extricating specific processes is challenging [c.f. Uttal 2011]. Many recent breakthroughs have been made in terms of understanding the brain using tools that allow neuroimaging during cognitive and behavioural tasks, such as those often employed in neuroIS studies [Dimoka et al. 2012, Riedl et al. 2010]. Yet many of the most ground-breaking insights – in terms of unravelling the functionality 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 either through accidents or 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 processes associated with missing components can be better understood.

A classic case of this relates to the insights gained from studying Phineas Gage, which are explored in depth by Damasio [1996]. Phineas Gage was a railroad worker in the North East of the 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. Having survived the accident, Gage's personality was changed in a way that impacted both his personal and professional life. He became cold, emotionally distant, and took excessively long times to perform simple tasks. From observations of this injury and other patients with similar brain damage, the purpose of the frontal lobe became clearer over subsequent years. This area was determined to have responsibilities assimilating emotional associations, or 'somatic markers', into decision making to both speed up the process, as well as facilitate emotional empathy. Furthermore, the manner in which the observed brain damage in Phineas Gage impacted upon his cognitive function revealed the importance of such emotional associations in all decision-making.

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 the core principles of the lesion methodology can be applied to unravel tacit knowledge in advanced systems' use. This can be done by 'lesioning' (i.e. removing) information cues within an IS environment and observing the impact these lesions have on advanced users. If this is done systematically and in a way that can pinpoint when, how, and why such lesions prevent effective use of the system, then this can be used to understand exactly how advanced users typically make use of the removed information cues.

Thus, assuming the existence of tacit processes has been identified in advanced users, the following process is proposed as a means of discovering tacit processes and using them to inform design ideation:

1. Identify and remove individual information sources available to an advanced user for the selected task.
2. Ask advanced 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 advanced user interacting with the system – to identify when, how and why these users are using the information currently available to them.

5. Ask advanced 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 advanced user in Step 5.
7. Discuss the key characteristics and interrelationships between information sources identified by the user and ideate possible amendments that could be made to the design to better capture these characteristics and interrelationships.

4. The case of Twitter

To test the proposed system lesioning method, a suitable IS domain must be selected in which use is complex, on-going, and varying in intensity. Social media presents such a domain, manifesting complexities in regard to finding quality content [Agichtein et al. 2008], determining the strength of ties between users [Gilbert and Karahalios 2009], and understanding how social presence emerges [Kietzmann et al. 2011]. Twitter in particular is known to manifest a range of tacit and complex practices and behaviours [Java et al. 2007, Marwick 2011], hence it was selected here as an appropriate domain to instantiate the lesioning technique.

Twitter is a social network and micro-blogging tool that enables users to discover and share content with a group of followers [c.f. Sadikov & Martinez 2009]. Twitter posts are known as "tweets", which have a maximum of 140 characters, and social connectivity in Twitter enables an individual to follow any number of users in a way that need not be reciprocal. Users are presented with posts from users whom they follow in a chronological timeline, with many users tweeting multiple times a day and retweeting other users' posts to make them visible to their own followers [Java et al. 2007, Lerman & Ghosh 2010, O'Riordan et al. 2012].

The exploratory nature of the study lent itself towards a qualitative approach to theory testing, as this would allow a greater capacity to assimilate emergent findings [Lee 1989, Myers 1997]. Thus the exploration of Twitter in this study is performed across three stages of qualitative data gathering. Firstly, a series of semi-structured interviews were conducted to identify instances of advanced use in Twitter associated with tacit processes. These interviews identify one key tacit process of tasks in the form of determining what other users to follow; hence eight subsequent interviews were conducted to apply the proposed design thinking method to this process. A subsequent key tacit process emerged from the second round of interviews in the form of how users distil content from the vast amount of tweets they encounter on a daily basis. Hence, eight more interviews are conducted to apply the proposed design thinking method to the process of timeline scanning.

4.1 Identifying Advanced Usage in Twitter

The exploration of tacit processes and advanced usage in Twitter took place as part of 12 semi-structured interviews with Twitter users. The use of Twitter varies between those who use it in a focused way relating to specific interests, as well as those who use it less discriminately [O'Riordan et al. 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 minutes, the purpose being to identify areas of advanced Twitter use reliant upon tacit processes.

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 9,200 to 17, and the number of users whom they followed ranged from 3,012 to 52. Based upon these figures, as well as descriptions of the frequency and durations with which subjects logged into their Twitter accounts, six subjects were

identified as highly experienced users likely to exhibit advanced usage. These users highlighted the issue of determining whom to follow as being both a complex process and one that was difficult to externalise. Thus the lesioning process was applied to disentangle how users determine whom to follow, specifically in the case where those users are evaluating another user for the first time based on profile information.

4.2 Lesioning Tacit Follow/Unfollow Processes in Twitter

The twelve subjects interviewed in the first stage of investigation were dispersed across a range of geographical locations. Hence, eight new subjects available locally were selected with whom to test the lesioning technique. Although the discussion of tacit processes in this study has focused on advanced users, it is not clear from existing research whether related tacit knowledge can also be assimilated from inexperienced users. Hence subjects were selected across a range of backgrounds and experience levels with Twitter. Four of these subjects (two female and two male) use Twitter solely for professional purposes, the remaining four (two male and two female) use Twitter for purposes that include personal interests (see Table 1).

	Use	**Following**	**Tweets**	**Followers**
Subject A	Professional	2018	2527	2409
Subject B	Professional	973	1339	1249
Subject C	Personal	565	1840	132
Subject D	Professional	412	379	96
Subject E	Personal	320	38	80
Subject F	Personal	111	263	34
Subject G	Professional	109	638	133
Subject H	Personal	10	46	1

Table 1. Summary of subjects from first lesioning experiment

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 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 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. Subjects were informed that the information cues removed related to (i) the user's profile picture, (ii) the user's biography, (iii) the user's location and/or Website, (iv) the user's background image, (v) the user's total tweets, followers, and following (vi) other users whom the subject follows who also follow this user, (vii) the user's most recent tweets, and (viii) the times at which the most recent tweets were made.

Subjects were asked 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 on a scale from 0-10, i.e. if their decision would be the same if the information available to them was not restricted. 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 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 0-10. 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. 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 determine 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.

Subject	**Subject is better equipped to explain how they use the profile summary to decide whom to follow?**	**Characterisations as to how the subject determines whether or not to follow a specific user**	**Additional information cues that could assist subject evaluating whether to follow users?**
A	Yes: "Yeah, definitely. It's probably something you don't think will matter but it does"	Subject values recurring tweets to ensure they are not lost in subject's tweet-stream	A priority tweet-stream featuring one 'tweet of the day' from users, so they do not need to continuously tweet the same thing
B	Yes: "Yeah I think so… To be honest, I haven't really considered any of these in isolation"	Subject values users with strong intellectual influence and credentials	The frequency with which links embedded within tweets have been clicked, favourite hashtags
C	Yes: "[nods] I probably find it easier in my own mind to prioritize"	Subject values personality, humour, and individuality	A word cloud for the hashtags used by users, the ratio of broadcast tweets to re-tweets/directed tweets
D	Yes: "Yeah, yeah… now I know I would have overlooked things before."	Subject values users who show professionalism and guarantee of on-going quality content	A graph of average tweets since the user signed up to gauge whether they are losing interest
E	Yes: "Yeah, going through it bit by bit, I probably would [say] yeah"	Subject values users with similar specific interests	A set of keywords summarising the interests of the user
F	No: "I tend to go through a similar process… I don't think so"	Subject values portals to more detailed information	The number of tweets per day, what proportion of the user's tweets contain links
G	No: "No, I think I would have known myself already"	Subject values users researching and working in similar fields	The number of tweets per day, most frequent hashtag used, number of tweets re-tweeted and/or favourited
H	No: "I couldn't have said it as concisely as now… but I maybe could still have explained it"	Subject values frequent tweets to fill out their tweet-stream	The number of tweets per day

Table 1. Summary of findings from first lesioning experiment

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 are often those for whom behaviour is least conscious, and consequently most difficult to articulate. The second main finding is that design ideation following the process produced novel information cues in all eight cases. This supports the usefulness of the proposed technique, not only as a means of gaining a deeper understanding of advanced IS use, but also as a productive means of ideation in the design thinking process. The third finding presents 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 and 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. A fifth finding emerged as information cues were reintroduced and a subject's confidence changed while assessing if they had made the correct decision The confidence of subjects A-C, each of whom have tweeted >1000 times, appeared to vary more from task to task as information cues were reintroduced (see Figure 1). Conversely, the confidence of subjects D-H was comparatively stable. 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 earlier 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. Hence a third iteration of data gathering was initiated in which the proposed lesioning technique was applied to the process of timeline scanning.

4.3 Lesioning Tacit Timeline-Scanning Processes in Twitter

Eight new subjects were selected with whom to test the proposed lesioning technique in the context of timeline scanning. 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 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 (i) tweet avatars, (ii) tweets names/Twitter handles, (iii), basic tweet text, (iv) tweet times, (v), tweet meta-data, e.g. media and ongoing conversation information, and (vi) 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 timeline scanning capabilities. 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 most interesting of the selection that they had scanned, and asked to rate their confidence from 0-10. This process was repeated until all six information sources were present, with each scan taking place on new timeline content to minimize 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.

	Use	Following	Tweets	Followers
Subject I	Professional	1691	847	181
Subject J	Professional	1066	2038	812
Subject K	Personal	352	5242	410
Subject L	Personal	272	609	173
Subject M	Personal	252	725	113
Subject N	Personal	211	356	80
Subject O	Professional	179	332	110
Subject P	Professional	146	326	118

Table 3. Summary of subjects from second lesioning experiment

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 scan their timeline to decide which tweets to read. The administrators and subject then revisited and discussed observations surrounding important information cues for timeline scanning that were identified by the subject during lesioning. Subjects and the administrators then ideated new timeline presentation designs that could assist them in scanning their timeline. The administrators confirmed with the subject 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.

Subject	**Subject is better equipped to explain how they scan tweets to identify those worth reading?**	**Characterisations as to how the subject determines whether or not to read a specific tweet**	**Additional emerging information cues that could assist subject evaluating which tweets to read?**
I	Yes: "Yeah… I've always known avatars and names are important to me but it didn't come one-two… they're complementary"	Looks for respected users, breaking news and discussion of specific topical issues	Use of layout and colour to group content of similar nature
J	Yes: "I'd be better, I think that was interesting. Hashtags are far more important than I thought"	Looks for respected users, breaking news and discussion of specific topical issues	Tracking of clicks to intelligently identify other appropriate content
K	Yes: "Yeah I think so because when you're on Twitter on any given day you don't take notice of reading a tweet"	Looks for key words, particular friends, specific hashtags	A layer of analytics that captured the categories of most clicked-upon tweets and highlighted other tweets on timeline with same category
L	Yes: "Oh yeah definitely… I never knew the hashtags influence me so much…"	Uses Twitter when certain topics are trending and they want to find out more or hear other users' opinions concerning them	Option to turn off retweeted content to avoid timeline clutter

M	Yes: "Yeah, actually… I never thought I scanned that way "	Focuses on specific users who gain their respect with quality content over time	Option to scan by just images
N	Yes: "Yes definitely… I don't really look at the tweet text and I thought I did"	Subject was primarily trying to link users to the context of the scan, e.g. certain users were key when looking for news updates	Rather than lists, would like option to filter content by mood/interests
O	No: "I think I'd explain it exactly how I would have thought [I would have] beforehand… "	Looks for Tweets from different users at particular times	Would like pop-ups to alert any time they have been mentioned by other users
P	Yes: "Yeah. I never thought about why I would read one tweet more than another… apparently I'm very visual"	Focuses on specific users who gain their respect with quality content over time	Commonly retweeted or favourited users should be highlighted in timeline

Table 4. Summary of findings from second lesioning experiment

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 how they scan their timeline. The single subject that 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.

5. Discussion and Conclusions

The goal of this study was to develop a design thinking technique for the discovery and assimilation of users' tacit processes. This was done by adapting the lesion methodology used in cognitive neuroscience into a system-level process for investigating tacit processes in IS use. The implementation and evaluation of the lesioning technique revealed several insights.

Overall, the findings supported the usefulness of the lesioning technique when applied to more advanced users. More experienced users rated the process as more illuminating than less experienced users, and more sophisticated design possibilities emerged from ideation with advanced users. The more complex use of information by advanced users was also 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. Another insight relates to inaccuracies in the self-reported expertise of users (i.e. more experienced users may underestimate their capabilities, whereas less experienced users may overestimate them). This illustrates issues that may arise when self-reporting is used to identify instances of advanced system use. Instead, the authors of this study argue that the selection of appropriate subjects should be informed by as much objective information as possible.

Several insights were also gained with regard to the use of Twitter. The 28 interviews conducted (including 12 unstructured interviews and 16 lesioning experiments) revealed that as usage of this platform grows more sophisticated, the interests of users appear to focus and compartmentalize. 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 unmanageable.

Twitter-related insights were also presented in terms of the outputs of the design ideation carried out. 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 as a means of design ideation, they nonetheless offer insights to industrial designers working in the social media 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. For example, the epistemological limitations of lesion studies must be explored in more detail with regards the types of conclusions that can reliably be drawn. The technique must also be tested in a broad range of contexts, particularly those in which system use also includes direct, non-system mediated interaction with other users. Nonetheless, a new technique is presented for IS researchers and industrial designers to explore the tacit processes that support advanced users. Such explorations promise both a richer theoretical understanding of these important processes and consequently, better designed IT systems.

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