The Language That Drives Engagement:

A Systematic Large-scale Analysis of Headline Experiments.

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Abstract

We use a large-scale dataset of thousands of field experiments conducted on Upworthy.com, an online media platform, to investigate the informational, cognitive, linguistic, and affective factors implementable in messages to motivate people to engage with online content. We map from textual cues measured with Natural Language Processing tools to constructs implied to be relevant by a broad range of prior research literatures. We then test which constructs drive click-through to articles when implemented in headlines. Our findings suggest that the use of textual cues identified in previous research does impact the effectiveness of headlines overall, but the prior research does not provide useful guidance as to the direction of the effects. We identify the specific textual characteristics that make headlines most effective at motivating engagement.

Keywords: Natural Language Processing; Information Processing; Cognitive Psychology; Linguistic Process; Social Psychology; Clickbait; A/B Testing; Text Analysis

'I was talking to students a couple of days ago about the question, "How do you make something go viral?" And it really struck me that this is not a question for me, this is a question for God.'

– Sara Critchfield, Upworthy Editorial Director, quoted in Fipps (2011)

Online media consumption has continued to rise in the US. According to the Pew Research Center, 87% of the population access news on their mobile phones and laptops/computers, with 72% of the population having at least one account in a social media site. When people engage with online content, such as by clicking on a page, sites can typically deliver multiple sponsored ads, putting pressure on sites to maximize the clicks on their links (Stanford News 2018). However, online platforms have limited means, such as headlines and brief descriptions, with which to attract people's attention and persuade them to engage (Guadagno & Cialdini 2005; Matheson & Zanna 1989). Thus, firms face pressure to efficiently motivate viewers and readers to engage with their content, driven by websites' reliance on advertising, which is used by the majority (82% of the top 50 news sites) of sites and brings in approximately $2 billion of gross revenues (Hsu 2019).

The question facing online content providers is how to present the content in a way that persuades people to click on it. Attempts to attract attention result in headlines like "Somebody Looked At This And Thought It Was OK To Sell. WTF Were They Thinking?!" While such headlines have been derided as "click-bait," and associated with scams (Kaufman 2013), online marketing and journalism increasingly rely on such tactics to optimize engagement through the language of their advertisements and headlines (Frampton 2015). Click-optimizing messaging has become increasingly common in both advertising and content delivery online, including by mainstream sites (Munger 2018; Stein 2019; Scammell 2018; Suciu 2020). In particular, Upworthy has used a strategy of using emotional appeals to promote popular and uplifting content to become one of the most successful purveyors of engagement-optimizing content online (Karabell 2017; O'Donovan 2013), attracting 90 million people a month at its peak (Sanders 2017).

A small research literature has compared headlines from early content providers attempting to optimize engagement with mainstream sources that had not yet adopted such practices, identifying a variety of language differences as potential descriptive markers of "click-bait" (Agrawal 2016; Chen et al. 2015; Wojdynski 2016). However, little is known about what generalizable factors in headlines and other promotional messages are actually effective at increasing engagement. As we discuss next, a large academic literature has studied factors that relate more generally to people's attention, persuasion and action, but the theories have generally been developed in very different contexts and it is often unclear whether and how the findings generalize specifically to strategies for optimizing engagement.

Rather than relying on academic theories or general principles, some practitioners of engagement optimization have leveraged the breakthroughs in online experimentation that have transformed online marketing more generally (Christian 2012). These tactical "A/B tests" are designed to identify the best-performing policy in each specific setting, such as which of multiple possible headlines will generate the most clicks on an article. Making decisions this way requires large-scale experimentation (e.g., separately testing headlines for each article, one at a time), which has been widely adopted by many online content providers, due to the relatively low cost per experiment. This approach can be contrasted with a "consumer insights" strategy, in which firms attempt to identify general principles that can guide better decisions, including how to write effective headlines. Large-scale industry experimentation, despite the potential for identifying causal drivers of consumers' behavior, has tended to not vary factors strategically in a way that would foster drawing such broader conclusions. As a result, there is little evidence that firms have used large-scale experimentation for discovery of general principles, such as the key factors underlying successful headlines, that would build institutional knowledge and improve best practices.

We attempt to provide insight into the question of what makes messages effective at driving engagement, by bridging the gap between the numerous specific results from a large-scale set of experiments and academic behavioral theories of how people generally interact with messages and textual cues. We introduce an approach that we believe is useful both for testing the generalizability of academic research to field experiments and for firms to generate valuable additional insights from their existing

experimental data. We use data from thousands of experiments conducted by Upworthy, which each varied the language used in headlines for a given piece of content to find the most effective version. We use natural language processing tools and factor analysis to generate constructs capturing the difference between headlines and map those constructs to testable predictions in the prior academic literature. Unlike some recent work on text analysis in marketing, our goal is more focused on theory testing than optimizing prediction, which is why we use measures that map to psychological constructs, rather than using more flexible but potentially less interpretable machine learning approaches.

We model within-experiment differences in click-through rates as a function of the features of headlines, to test the impact of these features on engagement and to draw general conclusions. We find that the constructs identified as potentially relevant in the prior literature do collectively have a substantial impact on the effectiveness of headlines. However, the literature generally does not provide good guidance as to the direction of the effects, when it makes unambiguous predictions, as some predictions are validated by our results but many are unsupported and some are directly contradicted. We identify specific informational, cognitive, linguistic and affective factors that make headlines more engaging.

Theoretical Development and Proposed Framework

Our goal in this research is to use Upworthy's archive of experiments to shed light on a very general question: what cues effectively motivate people to engage with content? A great deal of prior research, across different aspects of the behavioral sciences, is potentially relevant to this question. The process of evaluating a message (in this case, a headline) yields a wide array of potential cues to the person making the evaluation, including the directly stated and implied components of the message, the experience of processing the message, and the affective and motivational consequences. When the message precedes a relevant choice, these cues can all potentially impact the decision, e.g., of whether to click on the link and engage with the content described by the headline.

Despite the ubiquity of these experiences and the importance of such decisions for people's consumption of content and for marketers' and firms' outcomes, little research has attempted to

holistically understand the broad set of factors impacting consumers' content engagement choices. Instead, most relevant research has focused narrowly on how specific factors impact people's experiences and decisions. In the following sections, we organize this literature, identifying psychological factors that could be operationalized in a brief headline, and deriving predictions from prior research. Our goal is to map out the informational, cognitive, linguistic and affective cues that may make one headline more effective than another in motivating consumers to engage with given content.

Informational Factors

As a baseline, we can think of our question in terms of rational models of information processing, which posit that when people are presented with information, they process all cues to reach optimal decisions and that, particularly in repeated interactions such as with a repeatedly visited website, providing misleading cues is then disincentivized (Lord & Maher 1990; Becker 1976; Friedman 1970; Lucas 1983). In this view, headlines will not differ in the substantive signals they send readers about the content and non-substantive cues (e.g., "framing") will not impact decisions. As a result, the baseline normative equilibrium will be a world in which the kinds of differences in headlines that appear in the market will not affect consumers' choices.

A great deal of research has established that this extreme version is often not the case in practice. For example, holding information constant, decisions are affected by message framing (Tversky & Kahneman 1981; Levin & Gaeth 1988). A "boundedly rational" viewpoint, accounting for people's limited cognitive capacity, predicts decision processes that are optimized relative to the cognitive costs (Simon 1955; Tversky & Kahneman 1974; Ferreira & Patson 2007), and therefore potentially affected by a variety of cues implicated in cost-efficient heuristics. This also suggests that signals sent to consumers may vary substantively in the information sent (within some reasonable range) about the implied content, since consumers will not necessarily react optimally to punish mildly inaccurate representations in a message. The phrasing of a descriptive message, such as a headline, can then have a substantial impact on

consumers' decisions and firms face the risk of suboptimal outcomes due to promoting their content with ineffective messages.

Information-seeking and specific topics

At its most basic level, a descriptive message about content is an attempt to motivate the recipient to seek the described content. Information-seeking is the pervasive human behavior of pursuing more information to satisfy some need, such as problem solving (Xu et al. 2006; Vancouver & Morrison 1995). Thus, cues communicating that the content will satisfy informational needs in general (e.g., by answering a question or telling the person how to do something) can motivate engagement.

More specifically, messages can convey the particular information gap that will be addressed, resulting in more interest and engagement when people find the specific anticipated information more compelling. Conversely, engaging with content that does not meet one's informational goals is boring (Westgate & Wilson 2018). A wide range of research has identified specific topics about which people are motivated to seek out information. One of the most broadly important motivators for information seeking is health anxiety (So et al. 2016; Eastin & Guinsler 2006). Thus, messaging involving bodily concerns and health risks can induce people to seek information, motivated by people's self-protection motives (Hovick et al. 2020; Levanthal 1970; Levanthal 1971; Rogers 1975; Rogers 1983).

A wide variety of other content topics, particularly those relating to fundamental human drives, can be of particular interest to people as well. People are motivated to pay attention to information relating to monetary incentives or rewards (Rose et al. 2007; Ariely et al. 2009), to hedonic rewards such as relaxation or leisure (c.f. Hawes 1979; Bernecker & Becker 2020) or sex (Griskevicius & Kenrick 2013; Griskevicius et al. 2009; Reichart 2002), to issues related to meaning in life, including religion (Mathras et al. 2016; Longkumer 2017; Meyer 2010) and mortality (Arndt et al. 2004), and to orienting information such as spatial or location-related area cues (Rushton 1969; Cadwallader 1975).

Temporal focus

Human decision making is often marked by insufficient attention to and weight on future outcomes relative to those closer to the present (Urminsky & Zauberman 2015), suggesting that people may be less motivated by information focusing on the future or past, compared to the present. However, people do engage in spontaneous thinking about the past, present and future (Warden, Plimpton and Kvavilashvili 2019). The temporal horizon may also change what people focus on and are persuaded by, more so than having a direct effect (Chang & Lee 2009; Mogilner et al. 2012; Kim et al. 2009).

Information gaps

While conveying information about what specifically to expect from content may be persuasive, the lack of sufficient information may also be an effective tactic. Information gaps are defined as the discrepancy between what one knows and what one wishes to know, and the desire to resolve such gaps, characterized by curiosity (Loewenstein 1994), can be a powerful motivator, including in advertising (Ruan, Hsee & Lu 2018).

Forward-referencing (Jenkins 1990) is a particular linguistic approach for creating information gaps. This involves language which references omitted or to-be-specified events or persons in the message (Blom & Hansen 2015; Yang 2011; Halliday & Hasan 1976). For example, in the sentence, "This is what happened when he said sorry!", both the underlined words 'this' and 'he' are forward-referencing forthcoming information that is not currently present, using unresolved pronouns (Lex et al 2010) that lack a clear referent. More generally, information gaps can be conveyed in a variety of ways, including by some form of expectation incongruity that motivates sense-making, by inducing a sense of ambiguity (Loewenstein 1994), or by conveying uncertainty either directly or by hedging.

It is important to note, however, that information gaps are only motivating when people want to engage with the resolution, but not when the resolution is expected to be aversive (Golman & Loewenstein 2018), suggesting that the motivating effect of uncertainty may depend on the content. Ambiguity may also have mixed effects, as people may find messages lacking certainty to be less credible and confident (Corley & Wedeking 2014; Price & Stone 2004), although conveying uncertainty specifically by hedging is often viewed positively (Jensen 2008; Gaertig & Simmons 2020).

Cognitive Factors

As people extract the kinds of informational cues discussed above from messages, they are engaged in cognitive processing of the content of the message, and the experience of extracting information can in turn generate experiential and meta-cognitive cues that can shape attitudes (Barden & Tormala 2014). In this section, we identify content-based differences in message composition that can result in different cognitive cues that may impact consumers' motivation to engage. The content of a message, especially in an online context, is important in determining what persuades people to learn more about the message (Guadagno & Cialdini 2005; Duthler 2002; Sagarin et al. 2003).

Deliberation

Reading web-based messages (e.g., as opposed to face-to-face communication) invokes a greater sense of personal self-awareness, motivating central processing of cues via deliberation (Matheson & Zanna 1989). Such deliberative thinking is important in the effects of messages on persuasion and attitude change, as depicted by the Elaboration Likelihood Model (Petty & Cacioppo 1986; Petty et al. 2002; Petty & Cacioppo 2012; Petty et al. 1999). In particular, people typically comprehend information in terms of causal relationships (Murphy and Medin 1985), and find insight rewarding (Skaar & Reber 2020), and objective arguments can be an effective tool (e.g., in television advertising, Deighton et al. 1989). Messages conveying deliberation-relevant cues are likely to be motivating, to the degree they suggest that the content will provide an opportunity for meaningful deliberation. However, if the implied deliberation is perceived as not meaningful or as too demanding relative to the available mental resources, then the content may be perceived as boring (Westgate & Wilson 2018) and avoided.

Evaluability

Evaluability refers to the ease of making comparisons, such that when a product has attributes that are difficult to evaluate in isolation, the attributes become more interpretable and meaningful when shown relative to those for another product, often shifting preferences (Hsee 1996). Evaluability reduces decision-making effort (Alba et al. 1997; Park & Kim 2003), and higher comparability in word-of-mouth

advertising enhances product sales (Zhang et al. 2013). Messages that indicate comparable quantifiability would therefore signal easier cognitive processes during comprehension and evaluation, potentially motivating engagement.

Sensory cues

While the kinds of messages we investigate are communicated via text processed visually, the content of the message can refer to other senses, either in relation to how the content will be delivered (visually and/or auditorily) as well as by evoking sensory associations or images. Research on sensory marketing has identified benefits of auditory and visual content on learning, recall and brand attitudes (Costley et al. 1997; Chattopadhyay et al. 2003), as well as of cues relating to touch (Peck & Childers 2008; Klatzky & Lederman 1992). Moreover, combining multiple sensory cues positively impacts perceptions (Elder & Krishna 2009), as long as the person has sufficient available processing resources. Thus, messages that include sensory appeals may increase engagement.

Linguistic Factors

Beyond the cognitive cues conveyed by message content, specific linguistic features of the message (e.g., the number or type of words used) can also convey meta-cognitive cues, such as the fluency or concreteness of the message. These cues may impact an individual's decision whether or not to engage, either via beliefs about the content (e.g., a difficult to read headline suggesting that the article will be difficult to read) or via a change in the person's psychological state (e.g., a difficult to read headline making the reader tired or bored and therefore less interested). In this section, we review a range of linguistic features and describe how they are theorized to impact the reader and the implications for engagement.

Linguistic Fluency

Fluency relates to the ease of cognitive processing, with consequences for learning and beliefs (Reber & Greifeneder 2017). In the context of textual messages, fluency is affected by the recognizability of individual words (*lexical fluency*), the ease of decoding grammatical structures in sentences (*syntactic*

fluency), and the ease of understanding the meaning (*semantic fluency*; Okuhara et al. 2017; Sperber & Wilson 2002).

Messages that use individual words that are verbose (e.g., "big words") or uncommon or unfamiliar reduce the reader's lexical fluency, typically leading to negative attitudes towards the message source (Oppenheimer 2006). Like short words, round numbers are also easier to process, more lexically fluent and hence are preferred more (Jansen & Pollmann 2001; King & Janiszewski 2011; Coulter & Roggeveen 2014). Messages with simpler grammatical structure (e.g., fewer words, shorter sentences with fewer conjunctions, more common words and greater readability) have better syntactic and semantic fluency (Rennekamp 2012; Kincaid 1975). More syntactically fluent advertisements are more persuasive (Lowrey 1998) and people have more favorable evaluations and reactions toward firms with more readable annual reports (Rennekamp 2012; Tan et al. 2014; Miller 2010).

Even though the literature suggests that higher fluency generally has positive effects, disfluency can have benefits in particular settings. Disfluency provides a cognitive roadblock that may enable people to engage more with the content of the text (Diemand-Yauman et al. 2011) and can convey importance (Labroo, Lambotte and Zhang 2009). Specific linguistic factors that contribute to fluency may also have separate effects as well like grammatical structures that make sentences more complex – e.g., the use of conjunctions and different verb categories. Also, while unfamiliar words are less fluent, they are more distinctive and hence have more positive effects on memory (Pogacar et al. 2018; Hulme et al. 1991; Lerman & Garbarino 2002; Meyers-Levy 1989).

Concreteness

Construal Level Theory distinguishes between higher-level (abstract) and lower-level (concrete) modes of reasoning (Trope, Liberman, and Wakslak 2007). Messages involving more specific and practical language are more concrete (Johnson & Fornell 1987). For example, when a concept is discussed in terms of desirability, the language used tends to be more abstract, while discussions of feasibility tend to use more concrete language (Lee et al. 2010). Similarly, intangible states (e.g., services

in the consumer setting) are represented with abstract language and tangible states (e.g., physical products) are represented with concrete language (Dube-Rioux et al. 1990).

Overall, more concrete text has been shown to be higher in comprehensibility, recall, and interest (Sadoski et al. 2000) and perceived as more true (Hansen & Wanke 2010). However, a key element of Construal Level Theory is the relation between concreteness (vs. abstraction) and psychological proximity (vs. distance). People tend to think of concepts that are in the present, physically near, certain and relating to the self or close others more concretely than when the concept is psychologically distant in terms of risk or physical, temporal or social distance (Liberman & Trope 1998). Thus, whether concreteness or abstractness is preferred may also vary depending on psychological distance, such as how close a consumer is to making a product purchase (Lambrecht & Tucker 2013; Horsky et al. 2004). In the setting of headline reading, the proximity to consuming the content suggests that concrete headlines would foster more engagement, although perhaps less so when cues in the headline signal psychological distance.

Formality

The language used to convey the same information varies across people and contexts in terms of the degree of formality (Morand 1995; Irvine 1979). Formality has been typically used to establish a sense of professionality and impersonality, reducing emotionality (Weber 1947; Morand 1995), whereas informality is associated more with closeness and personalization (Peters & Waterman 1982; Kanter 1983).

Even though informal language has historically been viewed negatively as less professional and lower status, it has been shown to be persuasive in both political contexts (Reyes 2014) and learning environments (Isbell 2018). For example, swearing, which is a form of informality, increased the persuasiveness of policy advocacy (Scherer & Sagarin 2006).

However, using informal language can also backfire. For example, while swearing increased favorable impression of politicians it also reduced the perceived persuasiveness of their message (Cavazza & Guidetti 2014), college counselors that used informal language were seen as less of an expert

(Haberstroh 2010), people had a negative reaction to brands with which they were not familiar when the brands used informal styles of communication (Gretry et al. 2017), and speakers using filler words – another form of informality – were judged to be less pleasant, less self-confident and less communicatively competent (Von Tilling 2011) . Thus, this literature provides mixed predictions about whether informal language will have positive effects.

Narrative persuasion

Personal narratives about self or others are an important tool in overcoming resistance to persuasion (Dal Cin, Zanna and Fong 2004; Deighton et al. 1989) and fostering trust (Clementson 2020). For example, people find a trip more appealing if details are described in a narrative rather than a list (Adaval & Wyer 1998). The persuasive effect of narratives often involves social engagement in the experiences of others (Van Laer et al., 2014), identification with a perspective promoted by the narrative (De Graaf et al 2012), and reflection on how one's own life relates to the narrative (Hamby et al. 2017). In particular, narrative persuasion techniques can leverage grammatical features, such as using the first-person pronoun "I" to prompt readers to take the perspective of the narrator (Oatley 1999; deGraff et al. 2012) or the second-person pronoun "you" to encourage people to think about someone in their own lives (Packard & Berger 2020). Linguistic cues relating to social relations, using pronouns to establish the reader's perspective and promoting empathy and trust (Clementson 2020) in the context of a narrative can all therefore help persuade readers to engage.

Affective Factors

Beyond the objective information conveyed and the meta-cognitive cues transmitted, messages can invoke affective reactions in readers, which in turn may impact whether or not they choose to engage with them. While these affective constructs appear highly relevant to people's motivations to engage, either via changes in attitudes or changes in perceptions, and have often been used as persuasion tactics (Aaker & Bruzzone 1981; Braun 1999), this literature makes mostly mixed predictions, suggesting that general affective consequences may not be clearly predicted and may be context dependent.

Affect and Emotion

Emotions differ in valence, such that people experiencing positive versus negative emotions making different economic decisions (Pertl & Urminsky 2020). A large literature has found that framing the same information in positive versus negative terms (e.g., as gains or losses) shifts people's decision-making, and people behave as if they pay more attention to and put more weight on negative outcomes (Levin & Gaeth 1988; Rothman & Salovey 1997; Tversky & Kahneman 1981). However, this may be countered by people's general preference for positive experiences and general tendency to perceive and express positive assessments (Dodds et al 2015). For example, ads with positive valence outperformed ads with negative valence (Williams & Aaker 2002).

Beyond valence, emotions differ in arousal and intensity. For example, emotions differing in arousal but not valence differentially impact participants' behavioral intentions (Kim et al. 2010) and decisions (Keltner et al. 1993; Raghunathan et al. 2006). In particular, more active and intense emotions (e.g., anger) would be predicted give rise to different action tendencies, which may prompt greater engagement with corresponding content, although some intense emotions (e.g., sadness) can also prompt avoidance goals that may demotivate engagement (Lerner et al 2015).

Motivational language

Language can convey motivational messages, particularly in social communication (Searle 1969; Sullivan 1988). In particular, greater use of motivating language by managers predicts positive workplace outcomes, including employee's job satisfaction (Sharbrough et al. 2006, Mayfield & Mayfield 2012). Messages communicating motivational content may therefore be more appealing and promote engagement.

Authority

The principle of authority posits that conveying authority is generally persuasive, because people defer to the opinions of experts (Cialdini 2001; Cialdini & Goldstein 2002; Page et al. 1987), particularly when the message source is seen as effective (Eagly et al. 1978). However, the effectiveness of authority-based appeals varied with perceived argument strength and the recipients' decision style (DeBono &

Klein 1993; Boehner et al 2002). Thus, while authority would generally be expected to have positive effects on message credibility, and therefore engagement, conveying authority could also backfire.

Data

Background

Upworthy.com is an online media platform, founded in 2012, that has been called the fastest-growing media company in the world (Sanders 2017). Upworthy develops a package for each story on their website consisting of a headline, a subheading, and an image (e.g., see Fig. 1). Viewers access the content (article or video) by clicking on its link.

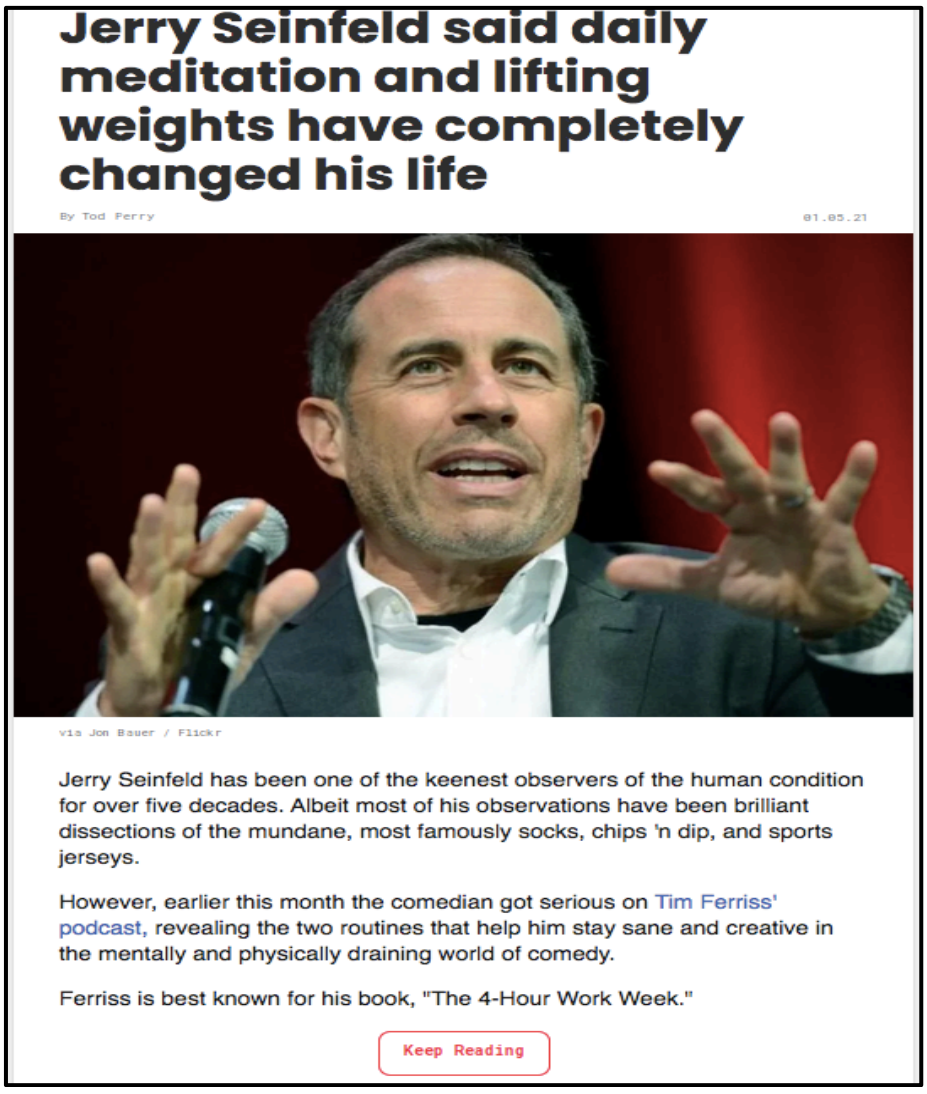

Fig 1: Example of an Upworthy package comprising of a headline, a picture, and a sub-heading

To determine which package would be most successful, Upworthy adopted A/B testing practices to run numerous experiments. Matias & Munger (2019) describe Upworthy's experimentation processes:

> (Upworthy's) content management infrastructure was optimized to deploy packages, measure responses, and compare the probability of a viewer clicking on different potential packages for the same story. Upworthy conducted its experiments on the homepage and article pages of Upworthy.com, randomly assigning different readers to see different packages for the same story in recommendations to readers. Site engineers and editors reported in interviews that they allowed only one experiment per page to limit interference between experiments. The content management system recorded the number of participants that were shown a given package (impressions) and the number that clicked on the package (clicks). After a period of time, an editor would review a dashboard that reported the results and either conduct an additional experiment (potentially with new packages) or choose which package to finalize for a given article. Editors sometimes finalized a package other than the best performing one. From that decision point, Upworthy would only display the final chosen package.

These experiments were used not only to decide which version of the package to use on their own webpage, but also to determine the content for related Facebook advertising (Fitts 2011).

Dataset

The Upworthy Research Archive (https://upworthy.natematias.com/index) is a dataset of headline A/B tests conducted by Upworthy, hosted by researchers at Cornell University (Matias & Munger, 2019). The current dataset consists of 32,488 tests conducted from January 24, 2013 through April 14, 2015, just after the company announced editorial shifts. For each test, the dataset includes the content of each of the packages included in an experiment for a specific item of content. The dataset includes over 150 thousand packages with a median of 4 packages per experiment. Together, these packages received over 538 million impressions and over 8 million clicks. Each test included a median of 14,342 impressions and a median of 201 clicks per test.

This research archive includes valid tests conducted by Upworthy in the study period, excluding tests that were never shown to viewers (zero impressions) and packages that had missing test IDs. Given that our research focuses on cues readers extract from headlines, we excluded all packages in an experiment which were accompanied with *different images*, to isolate the causal effects of headlines only. In some experiments, this resulted in keeping the experiment but dropping specific packages with differing images, while in other cases the entire experiment needed to be dropped (i.e., if no two packages had the same image).

Exploratory and Confirmatory Datasets

The terms for using the Upworthy Archive for academic research require that any publication using the data be done as a "registered-report". The goal of a registered-report is both that the authors make all analysis decisions independently of the final dataset that conclusions will be drawn from as well as to promote peer review of research that selects on research questions and methods rather than specific results (Chambers et al 2015). The analysis reported in the current draft of the paper is based on Upworthy's exploratory dataset, a random sub-sample of 22,666 packages from 4,873 tests, of which 3346 tests meet our inclusion criteria. Should the paper be accepted for publication, code comprising all the analyses reported in the accepted version of the paper will be sent to Upworthy Archive team, who would then independently run the analysis on the remaining data, the confirmatory dataset, which includes 105,551 additional packages from 22,743 tests. These results from the confirmatory dataset would be reported in the final paper, and the results from the exploratory dataset would be reported in an Online Appendix, for full transparency. The analysis code would also be made public, but the confirmatory data could not be made publicly available.

To get a sense of the statistical power in our initial analysis, consider the simplified case in which each experiment has only two conditions. If all experiments had relevant variation, we would have 90% power to detect an effect of r = .012. However, in many of the experiments the two headlines may not differ on a given factor. In the case where only 15% of the experiments have variation in the factor of interest, we would have 90% power to detect r = .031. Furthermore, given that we will be correcting for

multiple comparisons, as we describe next, the statistical power will be lower. In our primary analyses, we estimate that we will have 90% power (after Bonferroni correction) for a typical item (based on a median rate of variation in 66% of experiments) to detect r = .042. In the confirmatory dataset, we anticipate substantially higher power given the larger sample size (e.g., 90% power, after Bonferroni correction, for a typical item to detect r = .019).

Analysis Plan

Primary Variables

The dependent variable in our analysis will be the click-through rate (clicks divided by impressions) on a given headline, relative to the click-through rate for the other headlines tested for the same content in the same experiment, as a measure of engagement with a headline.

Unlike in a typical academic experiment, conditions in the Upworthy experiments were not necessarily designed to isolate the causal impact of specific factors, but instead were designed for the tactical goal of identifying the most effective version. As a result, the experiments often involved testing headlines that differed from each other in multiple ways. This is a common circumstance in large-scale industry experimentation and can limit firms' ability to draw broader conclusions across experiments. To address this, we need a method for extracting theoretically relevant constructs from the content of the headlines themselves, to test theories of which factors that can be implemented in headline writing drive engagement.

We use Natural Language Processing (NLP) tools to create variables from the text of the headlines that represent theoretically relevant constructs. Most of our independent variables will be computed using Linguistic Word Count 2015 (LIWC2015; Pennebaker et al. 2015) as well as some additional variables from Text Analyzer (Berger et al. 2020) software. While recent research has shown that flexible machine learning approaches to text analysis can be highly informative and predictive (Tirunillai & Tellis 2014; Anderson & Simester 2014; Netzer et al 2019; Buschken & Allenby 2016), we will use pre-specified measures due to the importance of being able to map the measures back to theoretical constructs.

The potential variables for inclusion are based on linguistic features (e.g., pronouns, verbs, adjectives), grammatical structure and word lists to capture psychological measures such as concreteness, readability and emotions (refer to the Online Appendix A for the full list of variables, examples, and additional details), enabling us to test a wide range of theory-driven hypotheses with the dataset. The development of the LIWC variables involved validation studies (e.g., in relation to subjective ratings of the concept being measured, Pennebaker and King 1999; Tausczik & Pennebaker 2010). LIWC variables have been used in over 120 studies (Tausczik & Pennebaker 2010) and the updated 2015 version we use has been cited by 2745 articles, some of which provide further independent validation. For example, Eichstaedt et al. 2018 showed that sad and negative emotion words used by people on Facebook – as identified by LIWC –predicted their depression in medical records. Text Analyzer is a recent NLP tool with individual items validated in text analysis research on marketing insights (Berger et al. 2020).

We also used Python to create custom dictionaries for two additional variables, suspense and tutorial words, which we had identified as potentially relevant but were not included in LIWC2015 or Text Analyzer. Headlines that include text such as, "You won't believe what happened next!" are commonly observed online and our dictionary for suspense focused on common synonyms and negations of the word "believe." We coded tutorial words to capture instructional text and headlines about learning (e.g., "Learn how to file your taxes easily").

Factor Analyses and Inclusion Criteria with the Exploratory Dataset

For any variable that was measured in both LIWC2015 and Text Analyzer (e.g., the percentage of words that are pronouns), we kept the LIWC version, leaving a total of 112 variables capturing various aspects of the headlines in the dataset. We z-scored all independent variables as they are measured on different scales. Next, we grouped these variables based on our review of the literature review into 29 groups of potentially related measures.

Factor analysis was used to combine highly correlated variables that are suggested by the literature to measure the same construct into theory-relevant indices measuring constructs (see Online Appendix B for details of the procedure). For example, the literature in fluency suggests that reading

difficulty, word count, and words per sentence in a given text should indicate disfluency and a factor analysis on these three variables validated that assumption by loading them onto a single factor. However, other potential indicators of disfluency (e.g., verbosity or unfamiliarity of words) were less correlated and were not found to load onto the same factor and were therefore kept as separate constructs. We identified 42 distinct constructs that are identifiable via text analysis and are calculated from the 112 variables, which we use in the current analyses and which will also be used in the confirmatory data analysis.

The fact that we can identify a psychologically relevant construct using text analysis does not mean that the causal impact of the construct is well-identified in the Upworthy experiments. For an Upworthy experiment to test the effectiveness of a particular headline aspect, the headlines within an experiment need to vary in that construct and we can only draw generalizable conclusions if that aspect varies across headlines within multiple independent experiments. We excluded any constructs that did not vary within an experiment for at least 15% of the total experiments in the exploratory dataset. For example, since 96% of the experiments had no variation across the headlines in the use of words associated with religion, religion was not considered in our analysis. In the analysis of the confirmatory dataset, this will be re-assessed using a lower threshold (5%), given the larger number of experiments.

Table 1: Constructs, corresponding variables, and literature predictions

Construct	Items	Predicted impact on engagement	Experiments
Informational Factors			
Information-seeking	Interrogative and tutorial words, question mark	Positive	58%
Body-related	Biological words, body/health/ingestion related words	Positive	41%
Health-Anxiety	Fear/Risk/Anxiety/Disgust related words	Positive	72.5%
Incentive	Work/Money/Reward related words	Positive	55%
Relaxation	Leisure/Home related words	Positive	34%
Location	Relative area words, spatial words, prepositions	Positive	72%
Present vs Past	Present/Past focus words	Mixed	72%
Future	Future focus words, time related words	Mixed	62%
Forward-Reference	Function words, pronouns, impersonal pronouns	Positive	72%
Incongruity	Anticipation & surprise words, internet abbreviations, unusual punctuations	Positive	72%
Certainty	Certainty-denoting words	Mixed	42%
Hedges	Discrepancy words, tentative words, differing words	Mixed	66%
Cognitive Factors			
Deliberation	Words indicating cognitive processes, causation, or insight	Positive	71%
Evaluability	Adjectives, comparison words, quantifiers	Positive	67.5%
Visual	Perception words, sight-related words	Positive	54%
Auditory	Hearing-related words	Positive	25%
Other Senses	Feeling-related words	Positive	15%
Linguistic Factors			
Disfluency	Word count overall & per sentence, reading difficulty	Negative	72%
Verbosity	Six+ letter words	Negative	72%
Numeric	Numbers	Positive	41%
Common words	Dictionary words, familiar words	Positive	72%
Conjunctions	Conjunctions	Unclear	63%
Verb Categories	Verbs, adverbs, auxiliary verbs	Unclear	72%
Concrete	Concreteness, articles	Positive	73%
Formality	Analytic words, informal words, informal assent words	Mixed	71%
Social (singular)	Personal pronouns, he/she, social words, male/female-related words	Mixed	71.5%
Social (plural)	They, affiliation words, family/friend-related words	Mixed	55%
First Person	I	Mixed	25%
Writer to Reader	We, you	Mixed	50%
Trusting	Trust-related words	Positive	69%
Affective Factors			
Positive Emotion	Positive emotion/sentiment words, joy-related words	Positive	73%
Negative Emotion	Negative emotion/sentiment words, sadness/anger related words	Mixed	73%
Presence of Emotion	Sentiment/Valence scores	Mixed	73%
Emotional Intensity	Emotionality, extremity, arousal, affect	Mixed	73%
Motivational Language	Words about drives and achievements	Positive	69%
Authority	Dominance/clout/power words	Mixed	73%

Table 1 summarizes the constructs included in the analysis (see Online Appendix B for information on the excluded constructs), specifies the component items used to quantify each factor, and tabulates the percent of experiments in which at least two headlines differ in their score for that construct. The table also indicates the predicted direction of effect of a given construct on reader engagement, as suggested by prior literature. For example, we operationalized "information-seeking" as the average of the standardized interrogative words, and the punctuation question mark from LIWC2015 and tutorial words from the hand-coded dictionary. The information-seeking score differed across headlines within the experiment for 58% of experiments and was predicted to have a positive impact on reader engagement. It is important to note that we do not know how reliable a measure of each construct these variables are. This will limit our ability to interpret null findings somewhat, as a variable may fail to predict click-through rates when it is a weakly-informative measure of the construct, even if the construct does have a causal effect.

Analysis of Experimental Effects

We will use three methods to test which of the constructs have a significant average treatment effect on headline click-through rates. First, we fit a full model, including all of the 36 identified constructs (see Table 1) as well as experiment-level fixed effects, without using any variable-selection method to account for multiple-testing:

$$P(Click \mid Impressions) = \beta_0 + \Sigma^{36}{}_{i=1}\, \beta_i X_i + \Sigma_{j=1}^{3346} \gamma_j D_j + error \qquad (1)$$

This can be thought of as a linear probability model, such that the X's denote each of the 36 constructs and D's denote the fixed effects capturing experiment-level differences (e.g., in the content being tested in an experiment). We ran a linear regression for the full model depicted by equation (1) and determined statistical significance using α=0.05.

While this analysis tests the statistical significance of each factor, controlling for the other factors, the fact that multiple tests are being conducted will increase the overall false positive rate, e.g., to an 84% chance of at least one false positive when testing 36 constructs. We use two approaches to correct for

multiple testing, doing LASSO regression and Bonferroni corrections for variable selection. For the Bonferroni correction, we set $\alpha = \frac{0.05}{n}$, where *n* is the number of hypotheses being tested. For both the Lasso and Bonferroni, we re-ran the regression on the subset of variables identified as significant by each method.

Results

In the full model (Figure 2), 21 out of the 36 constructs tested had a statistically significant effect on click-through rates, suggesting that overall, headline characteristics captured by our independent variables did impact engagement overall. While the coefficients are small, the effects could be considered modest but meaningful. Given the average click-through rate of 1.6%, most of the estimated effects ranged from a 3.1% decrease to a 3.1% increase in click-through rates for a one standard deviation change in the construct between headlines (e.g., corresponding to the range $\beta = -.0005$ to $\beta = .0005$). For example, the $\beta = .00102$ coefficient of "social (singular)" corresponds to an approximately 6.4% ($\frac{0.00102}{0.016}$) increase in click-through rate for every standard deviation increase in the "social (singular)" score of a headline.

Out of the 21 constructs for which we were able to identify clear directional predictions in the prior literature, the estimates were in the predicted direction for 7 of the constructs, of which 5 were significant. By contrast, we found the opposite of the predicted relationship for 14 of the constructs, of which 8 were significant. Thus, while many of the constructs identified in the literature have significant effects, the prior literature does not yield generally accurate predictions of the direction of these effects, as operationalized in our data.

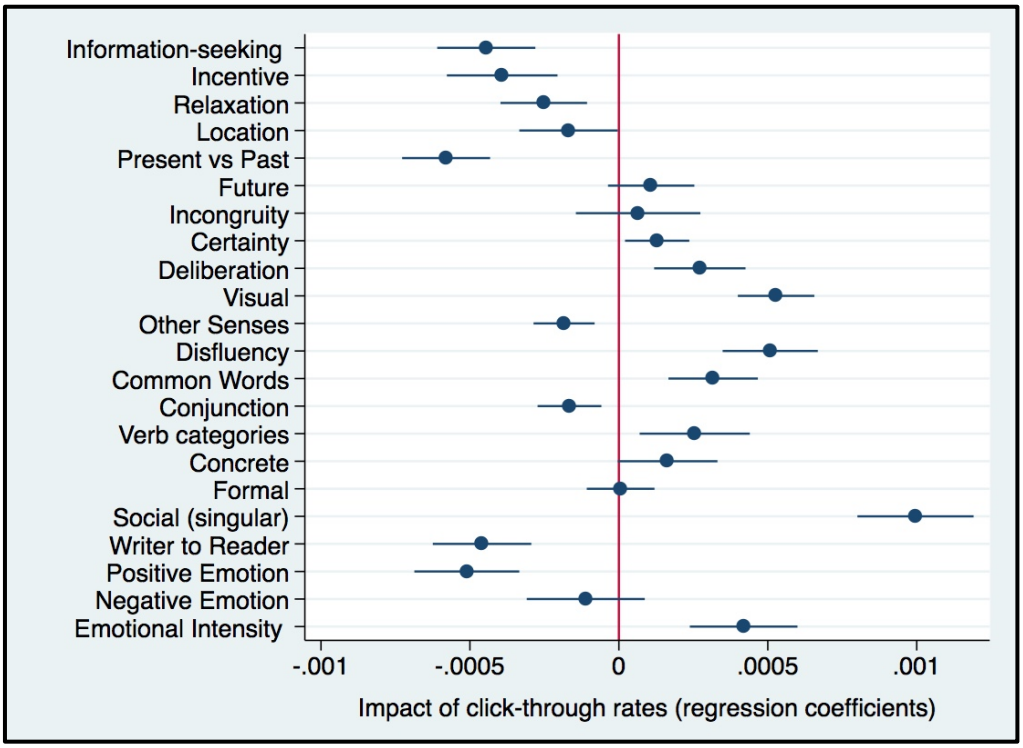

Fig 3: Regression coefficients of each construct on click-through rate; variables selected using LASSO

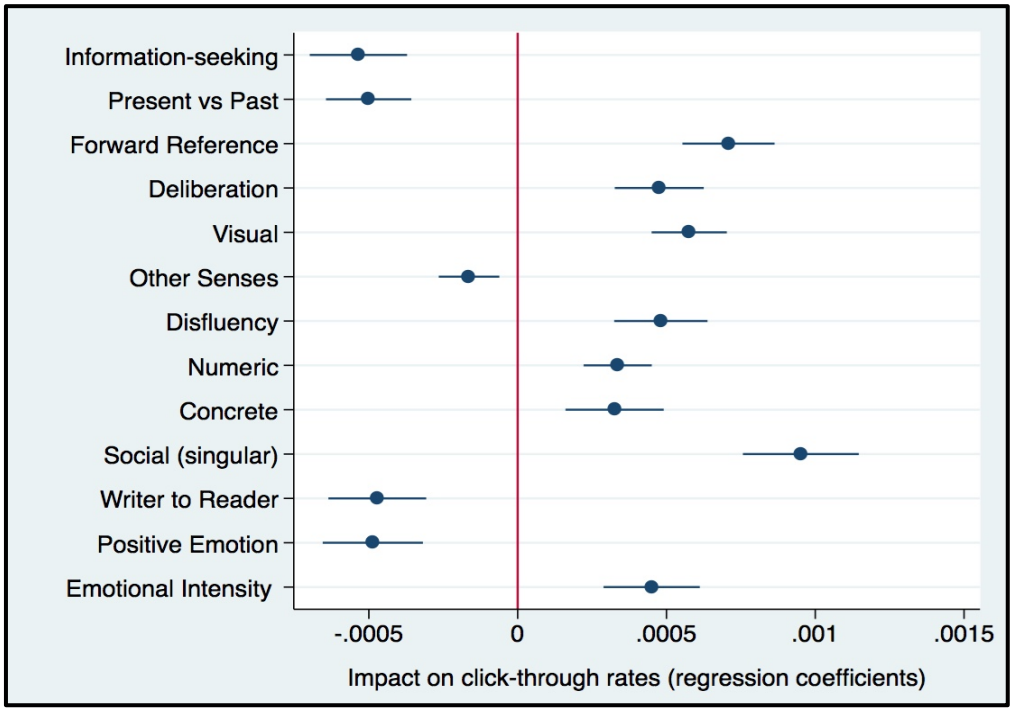

Fig 4: Regression coefficients of each construct on click-through rate; variables selected using Bonferroni correction

Correcting for multiple comparisons reduces the number of constructs with identifiable effects. The LASSO regression identifies 22 constructs (Figure 3), while Bonferroni correction preserves 13 constructs (Figure 4) as significant. These results strongly suggest that multiple textual aspects of the headlines have causal effects on engagement. However, in the Lasso model, we found fewer effects that were significant in the direction predicted by the prior literature (3) than significant in the opposite direction (6). In the Bonferroni-corrected model, a similar number of effects (5) were significant in the predicted direction as in the opposite direction (4).

We discuss the specific findings from the more conservative Bonferroni-corrected model. Among the informational factors, three were significant. Consistent with prior research, using forward reference language in headlines, which is predicted to increase curiosity, increased engagement with the headlines. For example, incorporating cues such as unresolved pronouns motivated readers to click through to see the content. Using language that focuses on the present rather than the past reduced click-through, potentially consistent with some prior research but inconsistent with the general idea of present bias in decision-making. Contrary to the implications of prior research, headlines that incorporated information-seeking cues (e.g., by suggesting that the content would answer a question or teach something) performed more poorly.

Among the cognitive factors tested, three were significant. Consistent with prior research, particularly the Elaboration Likelihood Model, including deliberation-related language increased engagement, on average. The impact of sensory cues was more mixed. Consistent with the literature in sensory marketing, highlighting the senses of perception and sight in headlines increased reader engagement with the content. However, contrary to the same literature, senses other than sight or hearing, such as touch, reduced click-through rates.

Table 2: Direction of significant impact of constructs on click-through rates, for each model, alongside predicted directions

Construct	Predicted impact on engagement	Full Model	Lasso	Bonferroni
Informational Factors				
Information-seeking	Positive	Negative	Negative	Negative
Body-related	Positive	Negative		
Health-Anxiety	Positive	Null		
Incentive	Positive	Negative	Negative	
Relaxation	Positive	Negative	Negative	
Location	Positive	Null	Null	
Present vs Past	Mixed	Negative	Negative	Negative
Future	Mixed	Null	Null	
Forward-Reference	Positive	Positive		Positive
Incongruity	Positive	Null	Null	
Certainty	Mixed	Positive	Positive	
Hedges	Mixed	Null		
Cognitive Factors				
Deliberation	Positive	Positive	Positive	Positive
Evaluability	Positive	Null		
Visual	Positive	Positive	Positive	Positive
Auditory	Positive	Null		
Other Senses	Positive	Negative	Negative	Negative
Linguistic Factors				
Disfluency	Negative	Positive	Positive	Positive
Verbosity	Negative	Null		
Numeric	Positive	Positive		Positive
Common words	Positive	Positive	Positive	
Conjunctions	Unclear	Negative	Negative	
Verb Categories	Unclear	Null	Positive	
Concrete	Positive	Positive	Null	Positive
Formality	Mixed	Null	Null	
Social (singular)	Mixed	Positive	Positive	Positive
Social (plural)	Mixed	Negative		
First Person	Mixed	Null		
Writer to Reader	Mixed	Negative	Negative	Negative
Trusting	Positive	Negative		
Affective Factors				
Positive Emotion	Positive	Negative	Negative	Negative
Negative Emotion	Mixed	Null	Null	
Presence of Emotion	Mixed	Null		
Emotional Intensity	Mixed	Positive	Positive	Positive
Motivational Language	Positive	Null		
Authority	Mixed	Null		

Linguistic factors also impacted engagement, with five significant constructs identified, two of which were predicted by the prior literature. Given the generally positive effects of syntactic and semantic fluency observed in the prior literature, it was surprising to see that greater *disfluency* in language increased click-through rates on headlines. Headlines with longer sentences, more difficult readability, and higher word count were clicked on more. However, consistent with the fluency literature, we saw that the presence of numbers in headlines increased click-through rates, while other aspects of fluency did not have significant effects. Consistent with prior literature, however, making headlines more concrete improved engagement. While most linguistic elements of narrative style did not have a significant effect, headlines implying social stories about individuals were more effective, but writing headlines directed to the reader backfired.

Lastly, the effects of affective cues were somewhat limited and mixed. Using more emotionally intense language increased engagement. However, including more positive emotion words in headlines reduced engagement, a somewhat ironic finding given Upworthy's mission of providing positively oriented content. The findings in our analyses are contrasted with the predictions from the literature in Table 2.

Robustness Checks

We perform two robustness checks to address potential limitations of our analysis approach. First, we tested whether any of the constructs that had been excluded because they did not vary in at least 15% of the experiments had significant effects. We included all 42 constructs – including the 6 constructs that were excluded in our main analysis – in a regression predicting the click-through rate. After applying the Bonferroni correction (i.e., $\alpha = .0012$), none of the excluded constructs were found to impact the click-through rate (Table 4, Online Appendix B).

Another potential concern, due to our use of factor analysis to reduce the variables to a smaller set of constructs, is that a variable that has a strong causal effect might have correlated with and therefore been averaged with other variables that did not shift engagement, resulting in a null result for the construct. To test this, we ran an additional regression using all 112 variables instead of the 36 constructs.

This analysis identified 2 variables that significantly predicted click-through rate after Bonferroni correction on their own but were not included in a significant construct in the main Bonferroni-corrected model. Mentions of money reduced engagement (ß=-.00021, t(3345)=-3.51, p<.001), as did the use of and dominating language (ß=-.00029, t(3345)=-3.73, p<.001; see Table 5 in Online Appendix B).

Interactions

In the preceding analyses, we have thought of each individual construct as having an isolated effect on the click-through rates, holding constant the other constructs. However, it is possible that some constructs moderate the effects of other constructs on reader engagement. For example, Tsai & Thomas (2001) show that abstract (vs. concrete) thinking about message content attenuates the effect of processing fluency. In an additional analysis, we test for evidence of interactions in which any one construct moderates another.

$$P(Click \mid Impressions) = \beta_0 + \Sigma^{N_{Lasso}}{}_{i=1}\, \beta_i X_i + \Sigma^{N_{Lasso}}{}_{i=1}\, \beta_i X_i\, X_{j\neq i} + \Sigma_{j=1}^{3346}\, \gamma_j D_j + error \quad (2)$$

We use Lasso for variable selection because the analysis would otherwise involve estimating an additional 1260 two-way interaction coefficients. We identify three significant interactions, after correcting for overfitting, suggesting that the effect of a given headline aspect may depend on other characteristics of the headline. Fig 6a-c display the specific relationships identified in the interactions.

We find that the positive effect on reader engagement of headlines suggesting deliberation is enhanced when the headline also incites curiosity ($ß_{int}$= .0003669, t(3345)=2.76, p=.006). This relationship has been suggested in prior literature, which posited that curiosity enhances critical thinking, increasing student engagement (Pusca & Northwood 2018). We also find that the average positive effect of individual social cues varies depending on other cues. Specifically, in emotionally arousing headlines ($ß_{int}$= -.0002881, t(3345)=-3.91, p<.001) and headlines with trust-related words ($ß_{int}$= -.0002514, t(3345)=-2.55, p=.011) the impact of content related to socialization by individuals is reduced. Overall, these results suggest the findings in our primary analysis estimate average treatment effects that are likely to vary to some degree with other factors as opposed to a single generalizable treatment effect.

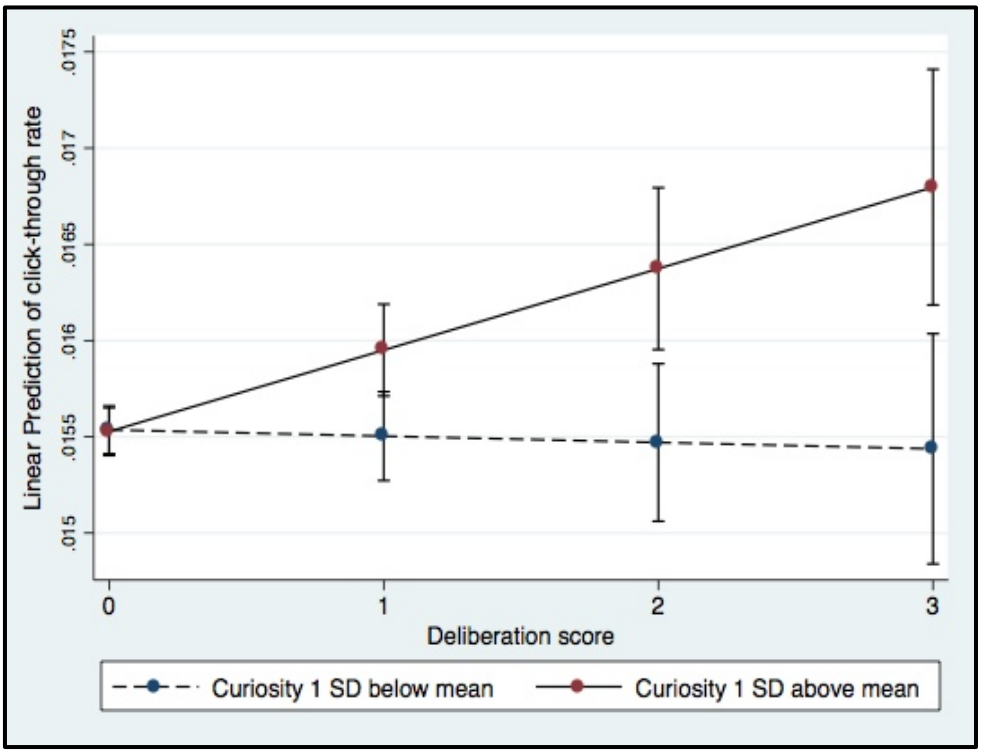

Fig 6a: Linear prediction of the click-through rates by deliberative language, moderated by curiosity-inciting language.

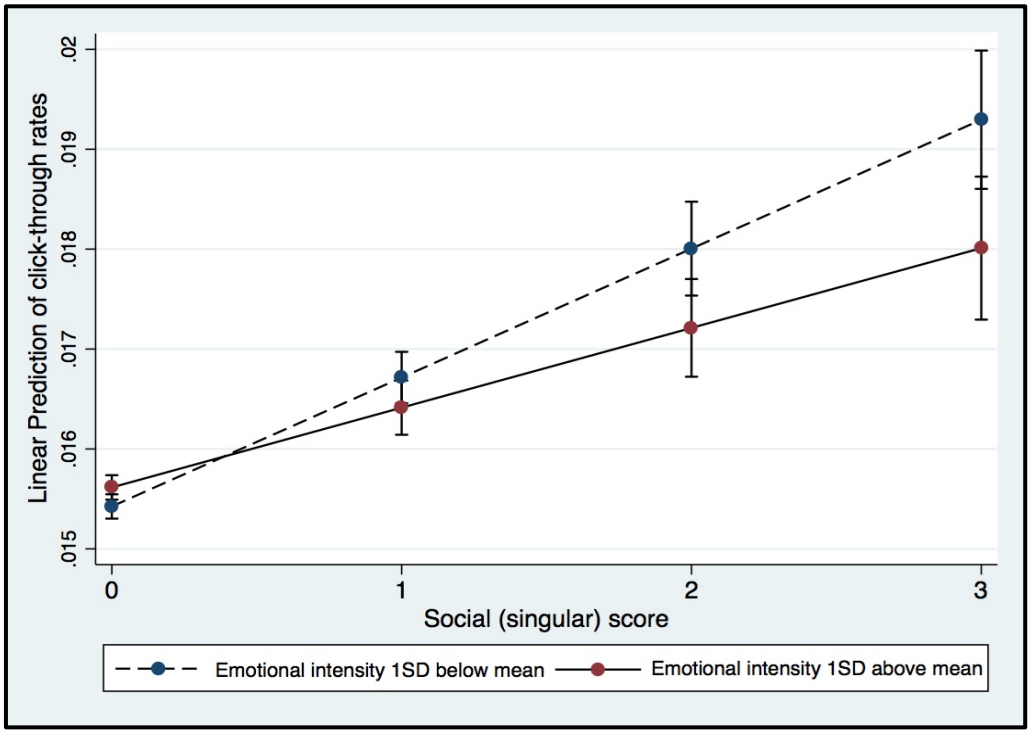

Fig 6b: Linear prediction of the click-through rates by language highlighting socializing activities of individuals, moderated by emotionally arousing language.

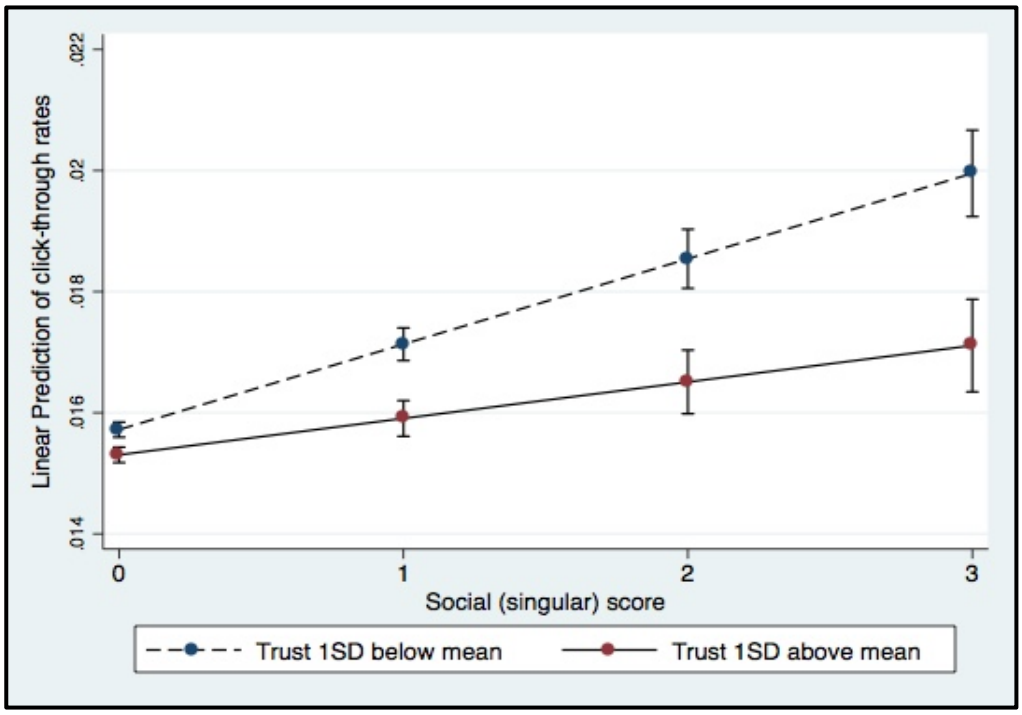

Fig 6c: Linear prediction of the click-through rates by language highlighting socializing activities of individuals, moderated by trust-related language.

Concluding Remarks

Using text analysis, we test the causal effects of rational, cognitive, linguistic, and affective factors on consumer engagement with online content, as operationalized in a diverse set of headlines in a large database of online field experiments. The textual cues we extract from the headlines using text analysis tools do predict click-through rates, overall. Our findings, which suggest that prompting curiosity through the use of forward reference and using deliberative processing, visual-sensory marketing, numeric fluency, and concreteness improve engagement, are consistent with the implications of prior research. We also identify other factors that make headlines more effective, including emotional intensity, past references, individual social cues and avoiding speaking directly to the reader, for which prior literature provided mixed predictions. However, we also find effects of other types of sensory marketing (excluding visual and auditory), positive emotion content and, perhaps most surprisingly, syntactic-semantic disfluency, that directly contradict prior research literatures.

Future research can further these findings in several ways. Researchers can use text mining to further validate and refine the specific dictionaries for those theoretical constructs that significantly predicted reader engagement in this paper, as well as potentially develop more precise text-based measures for constructs that were not significant predictors and attempt to develop new measures for any constructs from the literature that were omitted from our analyses. Despite the massive scope of the experiments we analyzed, our findings are constrained by the fact that all the experiments were conducted on the same platform. It would be beneficial to use the same approach to test the generality of the findings to the platform (e.g., such as using a headline dataset from a "hard news" site). Our approach in this paper could also be extended to test the impact of other types of text-behavior relationships, such as the effect of product description features on purchase likelihood.

More generally, our findings illustrate the lack of clear and generalizable guidance provided by many theories of cognition and behavior, including in many widely researched areas and discusses the need for more precise theories. In particular, our findings highlight both the potential and the need for broad field experimentation to inform ostensibly general theories of human behavior. However, our analysis also demonstrates the high statistical power that may be needed, especially to make general claims.

For marketers, this paper validates the proposition that seemingly small changes in wording can impact engagement. However, contrary to the common belief that the design of effective messaging is an "art" driven primarily by experience and intuition, our findings suggest that there are specific factors that systematically improve engagement, in ways that have not been reliably identified in the academic literature. These findings reinforce risk of relying on behavioral principles identified in completely different contexts for designing marketing messages and highlights the importance of testing multiple approaches and experimentally optimizing policies in the local context (Goswami and Urminsky 2020). In this paper, we develop a general approach that firms who engage in large-scale A/B testing can use to derive systematic learning, aggregated over experiments, that can contribute to institutional learning and adopting marketing best practices in their context.

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Online Appendix A

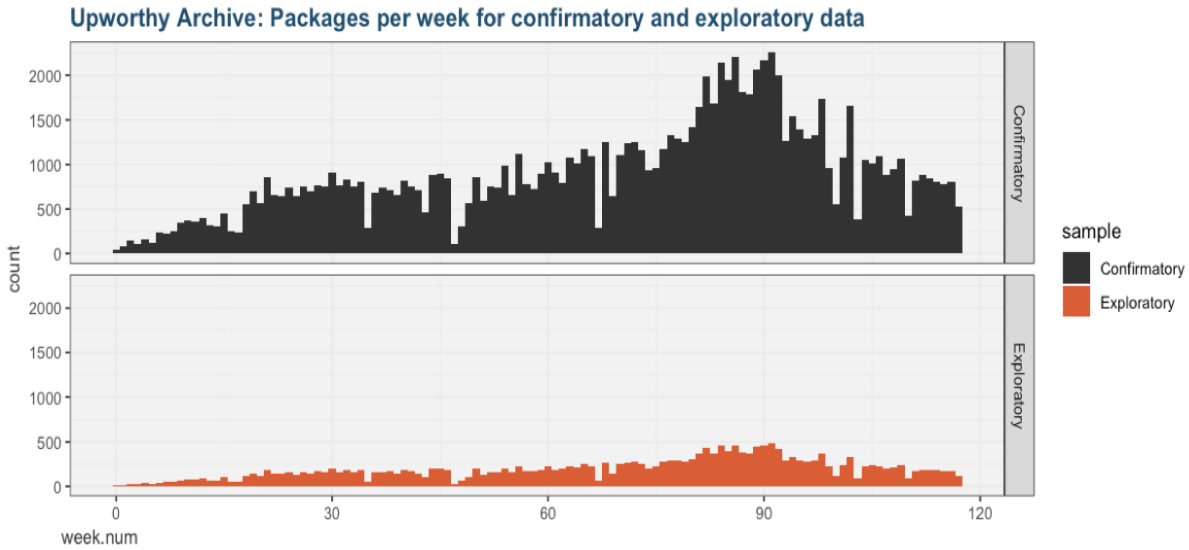
Data Description

All Upworthy Data variables

Each observation includes the following:

1. Experiment ID,
2. The time the package was created; the headline,
3. Sub-heading (and social media preview text);
4. Preview image (picture);
5. Number of impressions (i.e., total number of times it was shown)
6. Clicks received by the package during the test.

Both the confirmatory and exploratory datasets are a random sample stratifies by week number, to support time-series research, both datasets are a random sample stratified by week number, as depicted by the figure below.



Source: https://upworthy.natematias.com/index

Generated Variables

NLP TOOL	CATEGORY	EXAMPLES	DESCRIPTIONS
LIWC	Word count		Total number of words in the text
LIWC	Analytical thinking		High number reflects formal, logical, and hierarchical thinking; lower numbers reflect more informal, personal, here-and-now, and narrative thinking.
LIWC	Clout		High number suggests that the author is speaking from the perspective of high expertise and is confident; low Clout numbers suggest a more tentative, humble, even anxious style.
LIWC	Words per sentence		Number of words in a sentence
LIWC	Six+ letter words		Words containing six or more letters
LIWC	Dictionary words		Words found in dictionary
LIWC	Total function words	it, to, no, very	
LIWC	Total pronouns	I, them, itself	
LIWC	Personal pronouns	I, them, her	
LIWC	1st pers singular	I, me, mine	
LIWC	1st pers plural	we, us, our	
LIWC	2nd person	you, your, thou	
LIWC	3rd pers singular	she, her, him	
LIWC	3rd pers plural	they, their, they'd	
LIWC	Impersonal pronouns	it, it's, those	
LIWC	Articles	a, an, the	
LIWC	Prepositions	to, with, above	
LIWC	Auxiliary verbs	am, will, have	
LIWC	Common Adverbs	very, really	
LIWC	Conjunctions	and, but, whereas	
LIWC	Negations	no, not, never	
LIWC	Common verbs	eat, come, carry	
LIWC	Common adjectives	free, happy, long	
LIWC	Comparisons	greater, best, after	
LIWC	Interrogatives	how, when, what	
LIWC	Numbers	second, thousand	
LIWC	Quantifiers	few, many, much	
LIWC	Affective processes	happy, cried	
LIWC	Positive emotion	love, nice, sweet	

LIWC	Negative emotion	hurt, ugly, nasty	
LIWC	Anxiety	worried, fearful	
LIWC	Anger	hate, kill, annoyed	
LIWC	Sadness	crying, grief, sad	
LIWC	Social processes	mate, talk, they	
LIWC	Friends	buddy, neighbor	
LIWC	Female references	girl, her, mom	
LIWC	Male references	boy, his, dad	
LIWC	Cognitive processes	cause, know, ought	Words indicating cognitive processes
LIWC	Insight	think, know	
LIWC	Causation	because, effect	
LIWC	Discrepancy	should, would	
LIWC	Tentative	maybe, perhaps	
LIWC	Certainty	always, never	
LIWC	Differentiation	hasn't, but, else	
LIWC	Perceptual processes	look, heard, feeling	
LIWC	See	view, saw, seen	
LIWC	Hear	listen, hearing	
LIWC	Feel	feels, touch	
LIWC	Biological processes	eat, blood, pain	
LIWC	Body	cheek, hands, spit	
LIWC	Health	clinic, flu, pill	
LIWC	Sexual	horny, love, incest	
LIWC	Ingestion	dish, eat, pizza	
LIWC	Drives		Motivational language words
LIWC	Affiliation	ally, friend, social	
LIWC	Achievement	win, success, better	
LIWC	Power	superior, bully	
LIWC	Reward	take, prize, benefit	
LIWC	Risk	danger, doubt	
LIWC	Past focus	ago, did, talked	
LIWC	Present focus	today, is, now	
LIWC	Future focus	may, will, soon	
LIWC	Relativity	area, bend, exit	Words indicating locational area
LIWC	Motion	arrive, car, go	
LIWC	Space	down, in	Words indicating spatial area
LIWC	Time	end, until, season	
LIWC	Work	job, majors	
LIWC	Leisure	cook, chat, movie	
LIWC	Home	kitchen, landlord	

LIWC	Money	audit, cash, owe	
LIWC	Religion	altar, church	
LIWC	Death	bury, coffin, kill	
LIWC	Informal language		
LIWC	Swear words	fuck, damn, shit	
LIWC	Netspeak	btw, lol, thx	
LIWC	Assent	agree, OK, yes	
LIWC	Nonfluencies	er, hm, umm	
LIWC	Filler words	you know, i mean	
LIWC	Punctuations		
LIWC	Period		
LIWC	Question Mark		
LIWC	Exclamation Mark		
LIWC	Dash		
LIWC	Aposotrophe		
LIWC	Quotation Marks		
LIWC	Other Unusual Punctuations	* , %	
TEXT ANALYZER	Flesch-Kincaid Grade Level		The Flesch-Kincaid grade level of a piece of text based on the words per sentence and syllables per word. Higher scores mean the text requires more years of education to understand.
TEXT ANALYZER	Concreteness & Familiarity		**Concreteness** refers to how much a word refers to an actual, tangible, or "real" entity: something that arises from or appeals to immediate experience. **Familiarity** refers to how often a word is typically seen or heard.
TEXT ANALYZER	Emotionality		Quantifies the degree to which an individual's attitude or reaction is based on emotion. The words "amazing" and "excellent" are similarly positive, but the former indicates the attitude is based on a more emotional feelings-based reaction. Also gives emotional valence and extremity (how extreme the valence is).

TEXT ANALYZER	NRC Hashtag Emotion and Sentiment		Captures how much of eight specific **emotions** (anger, anticipation, disgust, fear, joy, sadness, surprise and trust) and how much **positive** and **negative** sentiment are expressed in a text.
TEXT ANALYZER	NRC VAD (Valence, Arousal, Dominance)		Produces scores for **valence**, **arousal** , and **dominance**. Valence indicates the positivity or negativity expressed in a passage of text; arousal indicates the emotional intensity of the text; dominance indicates the degree of control exerted.
HAND CODED	Suspense	unbelievable, unimaginable, guess	Words commonly used to maintain suspense
HAND CODED	Tutorial	learn, how	Words used in learning/teaching

Online Appendix B

Supplemental Statistical Information

NLP Software text coding details

Most LIWC2015 output variables are expressed as percentage of total words. There are six exceptions: word count (WC; raw word count), (WPS; mean words per sentence), and four summary variables: Analytic, Clout, Authentic, and Tone. Each of the summary variables are standardized composites based on previously published research. The composites have been converted to percentiles based on large corpora of texts described in the LIWC2015 Language Manual. Text Analyzer represents output variables as the sum of weights associated with each word in the entry (with 0 for words not in the lexicon and 1 for lexica which lack weights) divided by the number of words in that entry.

Exceptions in the Factor Analyses

Even though factor analysis is an important statistical tool for combining variables into constructs, the independent variables generated in this data are derived from the language of the headlines specific to this dataset. So, theoretically, even though some variables belong to a specific construct, those variables may not load on a single factor. In 3 (out of 41) such cases, we decided to go with the literature and combine the variables into a single construct, even though they did not load onto a single factor.

For social interactions (singular), the factor loadings for female words was .6296 for Factor 1 and -.6670 for Factor 2 and the factor loadings for male words was .5568 for Factor 1 and .7613 for Factor 2. Every other variable in this construct – personal pronouns, he/she, social words – had higher loadings on Factor 1 than 2. Since the loadings for male and female words on either factor seemed comparable (despite being higher for Factor 2), we combined them all into one factor instead of two. Similarly, for social interactions (plural) only affiliation words (i.e. interactions with reference to others) loaded onto Factor 1 more than Factor 2 (.7774 vs -.1153), but since the literature on narrative persuasion includes interactions among multiple people, we combined this variable with the others – they, family-related words, friend-related words – into a single construct. Finally, for the construct of negative emotion, negative sentiment

(from Text Analyzer) and sadness loaded higher on Factor 2 than 1 (Negative Sentiment: .3853 vs -.4523; Sadness: .4559 vs .8280). However, since the loadings are again comparable and also since in the literature, these variables are related to the concept of negative emotion, we combined them into a single construct along with negative emotion (from LIWC) and anger.

Table 1 (Full): Constructs along with inclusion criteria

Construct	Items	Number of experiments with zero variation	Percentage of experiments with zero variation	Include?
Informational Factors				
Information Seeking	§ Interrogative Words	1,410	42.14%	Yes
	§ Question Mark			
	§ Tutorial words			
Body Related	§ Biological words	1,968	58.82%	Yes
	§ Body-related words			
	§ Health-related words			
	§ Ingestion-related words			
Health Anxiety	§ Fear-related words	920	27.50%	Yes
	§ Risk-related words			
	§ Anxiety-related words			
	§ Disgust-related words			
Incentive	§ Work related words	1,493	44.62%	Yes
	§ Money related words			
	§ Reward related words			
Relaxation	§ Leisure related words	2,215	66.20%	Yes
	§ Home related words			
Location	§ Relative area words	938	28.03%	Yes
	§ Spatial words			
	§ Prepositions			
Sex	§ Sexually charged words	3,023	90.35%	No
Religion	§ Religious words	3,198	95.58%	No
Mortality	§ Death related words	3,100	92.65%	No
Present vs Past	§ Present focus words	945	28.24%	Yes
	§ Past focus words			
Future	§ Future focus words	1,273	38.05%	Yes
	§ Time related words			
Forward Reference	§ Function Words	926	27.67%	Yes
	§ Pronouns			
	§ Impersonal pronouns			
Incongruity	§ Anticipation	924	27.62%	Yes
	§ Surprise			
	§ Internet abbreviation language			
	§ Unusual punctuations			
Suspenseful	§ Suspense	3,151	94.17%	No
Certainty	§ Words denoting certainty	1,933	57.77%	Yes
Hedges	§ Discrepancy words	1,146	34.25%	Yes
	§ Tentative words			
	§ Differing words			
Cognitive Factors				
Deliberation	§ Cognitive process words	981	29.32%	Yes
	§ Words indicating causation			

	§ Words indicating insight			
Evaluability	§ Adjectives	1,088	32.52%	Yes
	§ Comparison words			
	§ Quantifiers			
Visual	§ Perception words	1,553	46.41%	Yes
	§ Sight-related words			
Auditory	§ Hearing-related words	2,518	75.25%	Yes
Other senses	§ Feeling-related words	2,844	85.00%	Yes
Linguistic Factors				
Disfluency	§Word Count	921	27.53%	Yes
	§Words per Sentence			
	§ Reading Difficulty			
Verbosity	§ Six+ letter words	938	28.03%	Yes
Numeric information	§ Numbers	1980	59.18%	Yes
Common words	§ Dictionary words	899	26.87%	Yes
	§ Familiar words			
Conjunction		1,245	37.21%	Yes
Verb Categories	§ Common verbs	932	27.85%	Yes
	§Auxiliary verbs			
	§Adverbs			
Concrete	§ Concreteness	901	26.93%	Yes
	§ Articles			
Formality	§ Analytical words	967	28.90%	Yes
	§ Informal words			
	§ Informal assent words			
Swearing	§ Swear words	3,084	92.17%	No
Filler	§ Filler words	3,186	95.22%	No
	§ Non-fluencies			
Social singular	§ Personal Pronoun	954	28.51%	Yes
	§He/She			
	§ Social words			
	§ Female words			
	§ Male words			
Social plural	§ They	1,498	44.77%	Yes
	§ Affiliation words			
	§ Family related words			
	§ Friend related words			
First person	§ I	2,512	75.07%	Yes
Writer to Reader	§ We	1,672	49.97%	Yes
	§ You			
Trusting	§ Trust related words	1,044	31.20%	Yes
Affective Factors				
Positive Emotion	§ Positive emotion words	918	27.44%	Yes
	§ Positive sentiment words			
	§ Words denoting joy			
Negative Emotion	§ Negative emotion words	905	27.05%	Yes
	§ Negative sentiment words			
	§ Words denoting sadness			
	§ Words denoting anger			
Presence of Emotion	§ Sentiment score	897	26.81%	Yes
	§ Valence score			
Emotional Intensity	§ Emotionality	913	27.29%	Yes
	§ Extremity			
	§ Arousal			
	§ Affect			
Motivational Language	§ Words about drives	1,050	31.38%	Yes
	§ Words about achievements			

Authority	§ Dominance words	907	27.11%	Yes
	§ Clout words			
	§ Power words			

Table 3: Regression of constructs on click-through rate (all three methods)

VARIABLES	(1) Full Model	(2) Lasso	(3) Bonferroni
Information-seeking	-0.000517***	-0.000445***	-0.000535***
	(8.58e-05)	(8.40e-05)	(8.34e-05)
Body-related	-0.000215**		
	(9.26e-05)		
Health Anxiety	-6.51e-05		
	(0.000107)		
Incentive	-0.000286***	-0.000392***	
	(0.000102)	(9.47e-05)	
Relaxation	-0.000202***	-0.000252***	
	(7.53e-05)	(7.41e-05)	
Location	-0.000101	-0.000169**	
	(8.79e-05)	(8.44e-05)	
Present vs Past	-0.000562***	-0.000580***	-0.000501***
	(7.55e-05)	(7.53e-05)	(7.31e-05)
Future	0.000109	0.000108	
	(7.47e-05)	(7.40e-05)	
Forward Reference	0.000523***		0.000708***
	(9.32e-05)		(7.90e-05)
Incongruity	6.67e-05	6.45e-05	
	(0.000107)	(0.000107)	
Certainty	0.000147***	0.000129**	
	(5.56e-05)	(5.51e-05)	
Hedges	-7.49e-05		
	(8.58e-05)		
Deliberation	0.000367***	0.000272***	0.000476***
	(8.29e-05)	(7.83e-05)	(7.63e-05)
Evaluability	-4.78e-05		
	(7.41e-05)		
Visual	0.000553***	0.000528***	0.000576***
	(6.80e-05)	(6.55e-05)	(6.45e-05)
Auditory	-6.95e-05		
	(6.16e-05)		
Other Senses	-0.000173***	-0.000184***	-0.000163***
	(5.25e-05)	(5.23e-05)	(5.19e-05)
Disfluency	0.000478***	0.000508***	0.000481***
	(8.23e-05)	(8.15e-05)	(8.00e-05)
verbosity	6.49e-05		
	(6.26e-05)		
Numeric	0.000299***		0.000336***
	(6.02e-05)		(5.85e-05)
Common Words	0.000213**	0.000316***	
	(8.96e-05)	(7.66e-05)	

Conjunction	-0.000132**	-0.000166***	
	(5.53e-05)	(5.46e-05)	
Verb Categories	0.000188*	0.000255***	
	(9.75e-05)	(9.44e-05)	
Concrete	0.000355***	0.000164*	0.000326***
	(9.51e-05)	(8.54e-05)	(8.42e-05)
Formal	3.97e-05	5.87e-06	
	(5.85e-05)	(5.80e-05)	
Social (singular)	0.00102***	0.000996***	0.000952***
	(0.000108)	(9.95e-05)	(9.93e-05)
Social (plural)	-0.000352***		
	(0.000121)		
First person	-5.42e-05		
	(5.79e-05)		
Writer to Reader	-0.000412***	-0.000459***	-0.000472***
	(8.89e-05)	(8.44e-05)	(8.39e-05)
Trust-related	-0.000127**		
	(5.31e-05)		
Positive Emotion	-0.000404***	-0.000510***	-0.000487***
	(0.000100)	(8.99e-05)	(8.59e-05)
Negative Emotion	-5.18e-05	-0.000111	
	(0.000114)	(0.000101)	
Presence of Emotion	-2.96e-05		
	(0.000102)		
Emotional Intensity	0.000473***	0.000419***	0.000450***
	(9.53e-05)	(9.22e-05)	(8.26e-05)
Motivating Language	-7.84e-05		
	(7.76e-05)		
Authority	-7.73e-05		
	(0.000111)		
Constant	0.0155***	0.0155***	0.0155***
	(3.44e-05)	(3.45e-05)	(3.44e-05)
Observations	14,975	14,975	14,975
R-squared	0.049	0.042	0.043
Number of experiments	3,346	3,346	3,346

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Robustness Check including the excluded constructs

	COEF.	STD. ERR.	T	P>|T|	[95% CONF.	INTERVAL]
INFORMATION-SEEKING	-0.0005298	0.0000859	-6.17	0.000	-0.0006982	-0.0003615
BODY-RELATED	-0.0002289	0.0000945	-2.42	0.015	-0.0004142	-0.0000437
HEALTH ANXIETY	-0.0000574	0.0001074	-0.53	0.593	-0.000268	0.0001532
INCENTIVE	-0.0002746	0.0001019	-2.69	0.007	-0.0004743	-0.0000748
RELAXATION	-0.0001949	0.0000753	-2.59	0.010	-0.0003426	-0.0000472
LOCATION	-0.0000926	0.0000881	-1.05	0.294	-0.0002653	0.0000802
PRESENT VS PAST	-0.0005555	0.0000756	-7.35	0.000	-0.0007037	-0.0004074
FUTURE	0.0001096	0.0000748	1.47	0.143	-0.000037	0.0002562
FORWARD REFERENCE	0.000545	0.0000936	5.82	0.000	0.0003615	0.0007285
INCONGRUITY	0.0000643	0.0001069	0.6	0.548	-0.0001452	0.0002738
CERTAINTY	0.0001475	0.0000556	2.66	0.008	0.0000386	0.0002564
HEDGES	-0.0000762	0.0000859	-0.89	0.375	-0.0002446	0.0000922

DELIBERATION	0.00038	0.0000833	4.56	0.000	0.0002167	0.0005433
EVALUABILITY	-0.0000376	0.0000742	-0.51	0.613	-0.0001829	0.0001078
VISUAL	0.00056	0.0000681	8.23	0.000	0.0004266	0.0006934
AUDITORY	-0.0000677	0.0000616	-1.1	0.272	-0.0001884	0.000053
OTHER SENSES	-0.0001686	0.0000525	-3.21	0.001	-0.0002716	-0.0000656
DISFLUENCY	0.0004899	0.0000823	5.95	0.000	0.0003285	0.0006513
VERBOSITY	0.000062	0.0000628	0.99	0.323	-0.000061	0.000185
NUMERIC	0.0003073	0.0000603	5.1	0.000	0.0001892	0.0004254
COMMON WORDS	0.0002025	0.0000896	2.26	0.024	0.0000268	0.0003782
CONJUNCTION	-0.0001297	0.0000554	-2.34	0.019	-0.0002383	-0.0000212
VERB CATEGORIES	0.000195	0.0000979	1.99	0.046	3.14E-06	0.0003869
CONCRETE	0.0003613	0.0000951	3.8	0.000	0.0001748	0.0005477
FORMAL	0.0000587	0.0000623	0.94	0.346	-0.0000635	0.0001809
SOCIAL (SINGULAR)	0.0010312	0.000108	9.55	0.000	0.0008194	0.0012429
SOCIAL (PLURAL)	-0.000342	0.0001209	-2.83	0.005	-0.0005789	-0.000105
FIRST PERSON	-0.0000505	0.000058	-0.87	0.384	-0.0001642	0.0000633
WRITER TO READER	-0.0004063	0.0000889	-4.57	0.000	-0.0005806	-0.000232
TRUST-RELATED	-0.0001298	0.0000533	-2.43	0.015	-0.0002343	-0.0000253
POSITIVE EMOTION	-0.0004063	0.0001008	-4.03	0.000	-0.000604	-0.0002087
NEGATIVE EMOTION	-0.000059	0.000115	-0.51	0.608	-0.0002845	0.0001665
PRESENCE OF EMOTION	-6.92E-06	0.0001024	-0.07	0.946	-0.0002076	0.0001938
EMOTIONAL INTENSITY	0.0004705	0.0000956	4.92	0.000	0.000283	0.000658
MOTIVATING LANGUAGE	-0.0000812	0.0000777	-1.04	0.296	-0.0002335	0.0000711
AUTHORITY	-0.0000813	0.0001114	-0.73	0.465	-0.0002997	0.000137
SUSPENSE	0.0000404	0.0000532	0.76	0.447	-0.0000638	0.0001447
SWEARING	-0.0000112	0.0000562	-0.2	0.842	-0.0001214	0.000099
FILLER WORDS	0.0001253	0.0000693	1.81	0.070	-0.0000104	0.0002611
SEX-RELATED	0.0001071	0.000073	1.47	0.142	-0.0000359	0.0002502
RELIGION	0.0000163	0.0000601	0.27	0.786	-0.0001014	0.000134
DEATH-RELATED	0.0001385	0.0000615	2.25	0.024	0.000018	0.000259
CONSTANT	0.0155292	0.0000344	451.99	0.000	0.0154618	0.0155965

Table 5: Robustness Check with all the output from LIWC2015 , Text Analyzer and hand-coded dictionaries respectively as independent variables in a regression predicting click-through rates

	COEF.	**STD. ERR.**	**T**	**P>|T|**	**[95% CONF. INTERVAL]**	
WORD COUNT	0.0003128	0.0000833	3.76	0.000	0.0001495	0.0004761
ANALYTICAL (FORMAL) WORDS	0.000294	0.000151	1.95	0.051	-1.91E-06	0.0005899
CLOUT	0.000044	0.000115	0.38	0.702	-0.0001815	0.0002694
AUTHENTIC	-0.00018	0.000114	-1.58	0.114	-0.0004034	0.0000434
TONE	-0.0000849	0.0000999	-0.85	0.395	-0.0002807	0.0001109
WORDS PER SENTENCE	-1.13E-06	0.0000915	-0.01	0.990	-0.0001804	0.0001781
SIX+ LETTER WORDS	0.0001111	0.0000842	1.32	0.187	-0.0000539	0.0002762
DICTIONARY WORDS	0.0001874	0.0001011	1.85	0.064	-0.0000108	0.0003856
FUNCTION WORDS	0.0001547	0.0001848	0.84	0.403	-0.0002076	0.000517
PRONOUNS	-0.001561	0.0020289	-0.77	0.442	-0.005538	0.002416
PERSONAL PRONOUNS	0.1212471	0.1376873	0.88	0.379	-0.1486435	0.3911378
I	-0.0544631	0.0626945	-0.87	0.385	-0.1773549	0.0684288

WE	-0.0446943	0.0513139	-0.87	0.384	-0.1452781	0.0558896
YOU	-0.0741204	0.0851511	-0.87	0.384	-0.2410312	0.0927903
SHE/HE	-0.0848567	0.0976475	-0.87	0.385	-0.2762623	0.1065489
THEY	-0.0533805	0.0612804	-0.87	0.384	-0.1735006	0.0667396
IMPERSONAL PRONOUNS	0.001349	0.0014115	0.96	0.339	-0.0014178	0.0041158
ARTICLES	0.0001538	0.0001074	1.43	0.152	-0.0000566	0.0003643
PREPOSITION	-0.0002957	0.0001072	-2.76	0.006	-0.0005058	-0.0000856
AUXILIARY VERBS	-0.0000924	0.0001192	-0.77	0.438	-0.0003261	0.0001413
ADVERBS	0.0001149	0.0000925	1.24	0.214	-0.0000663	0.0002961
CONJUNCTION	-0.0000945	0.0000777	-1.22	0.224	-0.0002469	0.0000578
NEGATION WORDS	-0.0000178	0.0000735	-0.24	0.809	-0.0001619	0.0001264
VERBS	0.0001254	0.0001065	1.18	0.239	-0.0000834	0.0003343
ADJECTIVES	-0.0000472	0.0000715	-0.66	0.509	-0.0001875	0.000093
COMPARISON WORDS	0.0000371	0.000066	0.56	0.574	-0.0000923	0.0001666
INTEROGGATION WORDS	0.0000213	0.0000645	0.33	0.742	-0.0001052	0.0001478
NUMERIC INFORMATION	0.0002985	0.0000637	4.69	0.000	0.0001736	0.0004234
QUANTIFIERS	-0.0000619	0.0000646	-0.96	0.338	-0.0001886	0.0000648
AFFECT WORDS	-0.0001395	0.000521	-0.27	0.789	-0.0011608	0.0008819
POSITIVE EMOTIONS	0.000018	0.0004142	0.04	0.965	-0.000794	0.0008299
NEGATIVE EMOTIONS	0.0000597	0.0003708	0.16	0.872	-0.0006671	0.0007866
ANXIETY WORDS	0.0000491	0.0000645	0.76	0.447	-0.0000774	0.0001755
ANGER WORDS	0.0000156	0.0000812	0.19	0.848	-0.0001435	0.0001746
SAD WORDS	0.0000334	0.0000713	0.47	0.640	-0.0001064	0.0001732
SOCIAL WORDS	0.0002351	0.0001333	1.76	0.078	-0.0000261	0.0004963
FAMILY WORDS	-0.0000756	0.0000775	-0.98	0.329	-0.0002275	0.0000763
FRIEND WORDS	0.0001372	0.0000693	1.98	0.048	1.33E-06	0.0002732
FEMALE	0.0002861	0.0001223	2.34	0.019	0.0000463	0.0005259
MALE	0.0002058	0.0001131	1.82	0.069	-0.000016	0.0004275
COGNITIVE PROCESS WORDS	0.0001117	0.0001781	0.63	0.531	-0.0002374	0.0004608
INSIGHTFUL WORDS	0.0001803	0.0000921	1.96	0.050	-2.10E-07	0.0003608
CAUSATION WORDS	-0.00005	0.0000933	-0.54	0.592	-0.0002328	0.0001328
DISCREPANCY WORDS	-0.0001617	0.0000724	-2.23	0.026	-0.0003036	-0.0000198
TENTATIVE WORDS	0.0001113	0.0000793	1.4	0.160	-0.0000441	0.0002667
CERTAINTY WORDS	0.0001735	0.0000861	2.02	0.044	4.82E-06	0.0003422
DIFFERING WORDS	0.000032	0.000106	0.3	0.763	-0.0001759	0.0002398
PERCEPTION WORDS	-0.0004521	0.0002768	-1.63	0.102	-0.0009947	0.0000906
SIGHT WORDS	0.0008176	0.0002195	3.72	0.000	0.0003873	0.0012479
AUDITORY WORDS	0.000295	0.0001719	1.72	0.086	-0.0000419	0.0006319
FEELING WORDS	0.0000803	0.0001111	0.72	0.470	-0.0001374	0.0002981
BIOLOGICAL WORDS	0.0003355	0.000182	1.84	0.065	-0.0000213	0.0006924
BODY RELATED WORDS	-0.000149	0.0001001	-1.49	0.137	-0.0003453	0.0000472
HEALTH RELATED WORDS	-0.0003442	0.0001149	-3	0.003	-0.0005694	-0.000119
SEXUALLY-CHARGED WORDS	-0.0000217	0.000098	-0.22	0.825	-0.0002137	0.0001703
INGESTION-RELATED WORDS	-0.0002285	0.0001085	-2.11	0.035	-0.0004412	-0.0000157
WORDS INDICATING DRIVES	-0.0000202	0.0001879	-0.11	0.914	-0.0003886	0.0003481
AFFILIATORY WORDS	-0.0003952	0.0001286	-3.07	0.002	-0.0006472	-0.0001432

WORDS INDICATING ACHIEVEMENT	0.0000131	0.0000719	0.18	0.855	-0.0001277	0.000154
WORDS INDICATING POWER	9.81E-07	0.0001173	0.01	0.993	-0.000229	0.000231
WORDS INDICATING REWARD	-0.0000989	0.0000838	-1.18	0.238	-0.0002631	0.0000654
WORDS INDICATING RISK	-0.000119	0.0000773	-1.54	0.124	-0.0002705	0.0000325
PRESENT FOCUS WORDS	-0.0002046	0.0000917	-2.23	0.026	-0.0003843	-0.0000248
FUTURE FOCUS WORDS	-0.0000293	0.0000555	-0.53	0.597	-0.0001381	0.0000794
RELATIVE AREA WORDS	0.000223	0.0003594	0.62	0.535	-0.0004816	0.0009276
MOTION-RELATED WORDS	-0.0000686	0.0001238	-0.55	0.579	-0.0003112	0.000174
SPATIAL WORDS	4.55E-06	0.0002356	0.02	0.985	-0.0004573	0.0004664
TIME-RELATED WORDS	-6.41E-06	0.0002186	-0.03	0.977	-0.0004348	0.000422
WORK RELATED WORDS	-4.54E-06	0.0000697	-0.07	0.948	-0.0001412	0.0001321
LEISURE RELATED WORDS	-0.0001173	0.0000642	-1.83	0.068	-0.0002431	8.55E-06
HOME RELATED WORDS	-0.0000725	0.0000542	-1.34	0.181	-0.0001788	0.0000338
MONEY RELATED WORDS	-0.0002143	0.000061	-3.51	0.000	-0.0003339	-0.0000946
RELIGION WORDS	1.66E-06	0.0000607	0.03	0.978	-0.0001173	0.0001207
DEATH RELATED WORDS	0.0001805	0.0000632	2.86	0.004	0.0000566	0.0003044
INFORMAL WORDS	0.0002189	0.0001452	1.51	0.132	-0.0000657	0.0005035
SWEAR WORDS	-0.0001191	0.0000861	-1.38	0.166	-0.0002878	0.0000496
INTERNET ABBREVIATION WORDS	-0.0000724	0.0000807	-0.9	0.370	-0.0002306	0.0000859
ASSENTING WORDS	-0.0001441	0.000091	-1.58	0.113	-0.0003226	0.0000343
NONFLUENCIES	-0.000042	0.0000646	-0.65	0.516	-0.0001685	0.0000846
FILLER WORDS	0.000046	0.0000547	0.84	0.400	-0.0000612	0.0001533
ALL PUNCTUATIONS	-0.2049602	0.1295866	-1.58	0.114	-0.458972	0.0490516
PERIOD	0.1222939	0.0772956	1.58	0.114	-0.0292187	0.2738064
COMMA	0.0682926	0.0432216	1.58	0.114	-0.016429	0.1530142
COLON	0.0250423	0.0159179	1.57	0.116	-0.0061596	0.0562441
SEMI-COLON	0.003133	0.0019334	1.62	0.105	-0.0006567	0.0069227
QUESTION MARK	0.0478048	0.0304923	1.57	0.117	-0.0119654	0.1075749
EXCLAMATION MARK	0.0210131	0.0133444	1.57	0.115	-0.0051442	0.0471705
DASH	0.0412086	0.0260618	1.58	0.114	-0.0098769	0.0922941
QUOTATIONS	0.029598	0.0187205	1.58	0.114	-0.0070973	0.0662933
APOSTROPHE	0.0970019	0.061315	1.58	0.114	-0.0231858	0.2171897
PARENTHESES	0.0261984	0.0165685	1.58	0.114	-0.0062787	0.0586754
OTHER UNUSAL PUNCTUATIONS	0.0432274	0.0273555	1.58	0.114	-0.0103939	0.0968487
READING LEVEL	0.0000994	0.0000803	1.24	0.216	-0.0000579	0.0002568
CONCRETENESS	0.0000375	0.0000833	0.45	0.652	-0.0001258	0.0002009
FAMILIAR WORDS	-0.0000424	0.0000832	-0.51	0.611	-0.0002054	0.0001207
EMOTIONALITY	0.0000954	0.0001422	0.67	0.502	-0.0001834	0.0003742
EXTREMITY	0.0002256	0.0001517	1.49	0.137	-0.0000718	0.0005229
VALENCE	-0.0000749	0.0001014	-0.74	0.460	-0.0002737	0.000124

SENTIMENT	-0.0002624	0.0001102	-2.38	0.017	-0.0004785	-0.0000464
ANTICIPATION	-0.0000116	0.0000534	-0.22	0.828	-0.0001162	0.0000931
DISGUST	-0.0000257	0.0000616	-0.42	0.676	-0.0001464	0.000095
FEAR	0.0000392	0.0000582	0.67	0.500	-0.0000748	0.0001532
JOY	-0.0000629	0.0000589	-1.07	0.286	-0.0001785	0.0000526
POSITIVE SENTIMENT	-9.46E-06	0.0000736	-0.13	0.898	-0.0001538	0.0001349
SURPRISE	0.0000487	0.0000549	0.89	0.375	-0.000059	0.0001564
TRUST	-0.0001204	0.0000539	-2.24	0.025	-0.0002259	-0.0000148
AROUSAL	0.0002312	0.00007	3.3	0.001	0.0000941	0.0003683
DOMINACE	-0.0002945	0.000079	-3.73	0.000	-0.0004494	-0.0001396
VALENCE (PROPORTIONAL)	0.0002349	0.0000812	2.89	0.004	0.0000757	0.000394
NEGATIVE SENTIMENT (REVERSED)	-0.0001655	0.0000823	-2.01	0.044	-0.0003268	-4.21E-06
PAST FOCUS (REVERSED)	-0.0003388	0.0000809	-4.19	0.000	-0.0004973	-0.0001802
SUSPENSE WORDS	0.0000152	0.0000536	0.28	0.777	-0.0000899	0.0001204
TUTORIAL WORDS	-0.0001473	0.0000478	-3.08	0.002	-0.000241	-0.0000536
CONSTANT	0.0155292	0.0000342	454.56	0.000	0.0154622	0.0155961

Table 6: Using Lasso to select all two-way interactions relevant for predicting click-through rates

	COEF.	**STD. ERR.**	**T**	**P>|T|**	**[95% CONF. INTERVAL]**	
INFORMATION-SEEKING	-0.0005239	0.0000834	-6.28	0.000	-0.0006873	-0.0003605
INCENTIVE	-0.0002732	0.0000938	-2.91	0.004	-0.0004572	-0.0000893
PRESENT VS PAST	-0.0004961	0.0000731	-6.79	0.000	-0.0006393	-0.0003528
FORWARD REFERENCE	0.0005544	0.0000731	7.59	0.000	0.0004112	0.0006976
DELIBERATION	0.0003622	0.0000741	4.89	0.000	0.0002169	0.0005075
VISUAL	0.0005134	0.0000632	8.13	0.000	0.0003896	0.0006372
DISFLUENCY	0.0004628	0.0000799	5.79	0.000	0.0003061	0.0006195
NUMERIC	0.0002966	0.000058	5.11	0.000	0.0001829	0.0004103
SOCIAL (SINGULAR)	0.0010594	0.0001025	10.34	0.000	0.0008585	0.0012603
SOCIAL (PLURAL)	-0.000473	0.000115	-4.11	0.000	-0.0006984	-0.0002477
WRITER TO READER	-0.0004654	0.0000835	-5.57	0.000	-0.0006291	-0.0003017
POSITIVE EMOTION	-0.0004781	0.000086	-5.56	0.000	-0.0006466	-0.0003095
EMOTIONAL INTENSITY	0.0003903	0.0000823	4.74	0.000	0.0002291	0.0005515
INTERACTION CURIOSITY-DELIBERATION	0.0003669	0.000133	2.76	0.006	0.0001062	0.0006276
INTERACTION SOCIAL (SINGULAR)-TRUST RELATED	-0.0002881	0.0000736	-3.91	0.000	-0.0004324	-0.0001437
INTERACTION SOCIAL (SINGULAR)-EMOTIONAL INTENSITY	-0.0002514	0.0000986	-2.55	0.011	-0.0004446	-0.0000581
CONSTANT	0.0155127	0.0000346	448.17	0.000	0.0154448	0.0155805