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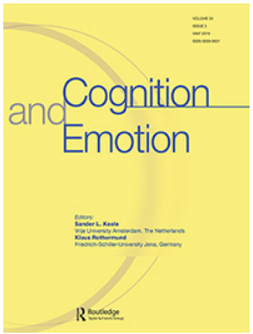

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Terror in time: extending culturomics to address basic terror management mechanisms

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ABSTRACT

Building on Google's efforts to scan millions of books, this article introduces methodology using a database of annual word frequencies of the 40,000 most frequently occurring words in the American literature between 1800 and 2009. The current paper uses this methodology to replicate and identify terror management processes in historical context. Variation in frequencies of word usage of constructs relevant to terror management theory (e.g. death, worldview, self-esteem, relationships) are investigated over a time period of 209 years. Study 1 corroborated previous TMT findings and demonstrated that word use of constructs related to death and of constructs related to patriotism and romantic relationships significantly co-vary over time. Study 2 showed that the use of the word "death" most strongly co-varies over time with the use of medical constructs, but also co-varies with the use of constructs related to violence, relationships, religion, positive sentiment, and negative sentiment. Study 3 found that a change in the use of death related words is associated with an increase in the use of fear related words, but not in anxiety related words. Results indicate that the described methodology generates valuable insights regarding terror management theory and provide new perspectives for theoretical advances.

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Terror management; culturomics; history; big data; collective representations

A few decades ago, terror management theory was introduced as an attempt to unify seemingly diverse phenomena and lines of thought within social psychology by identifying existential anxiety as a key driver underlying social behaviour (Greenberg, Pyszczynski, & Solomon, 1986). Among the boldest claims of the theory was that it would address the inattention to historical, cultural, affective, and motivational diversity inherent to the field of that time. Since then, several hundred studies have examined and empirically supported terror management theory (Burke, Martens, & Faucher, 2010). Given the original claims of the theory, however, it is remarkable that few of these studies have explicitly addressed the cross-historical applicability of terror management processes. In part, this may be due to the discipline of social psychology. It is located on the fault line of the arts and sciences, and typically more strongly identifies with the latter, seeking to isolate factors and variables from the historical and cultural context in which they operate. This oftentimes occurs at the expense of insights from the liberal arts (Gergen, 1973). It may also be due to the tendency within the humanities to shy away from formal, quantitative analysis, yielding highly subjective and context-dependent accounts of human behaviour (Schlenker, 1976, 1977). Recent developments involving Google's digitisation of millions of books, however, has the potential to bridge the divide between the arts and sciences' perspectives on social behaviour. This digitisation of books, coined by its primary advocates "culturomics" (Michel et al., 2011), allows researchers to identify frequency trajectories of word usage over hundreds of years and perform statistical analyses to identify

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patterns and relationships between constructs. To the extent that words are expressive of mental states, a common assumption in behavioural sciences (Pinker, 1999), culturomics represents an opportunity to formally investigate basic social psychological mechanisms in a historical context.

Examining social psychological processes in a historical context is the premise of this article. It considers findings from terror management theory's primary research instrument, the mortality salience paradigm (Greenberg et al., 1986), in the American historical context by analyzing a dataset of word frequencies of approximately 40,000 of the most commonly occurring words in American literature from 1800 to 2009. It examines the following: (1) the cross-historical validity of the relationship between mortality salience and nationalism and the appeal of romantic relationships (Study 1); (2) the strength of the relationships between death and nationalism/relationship appeal relative to relationships between mortality and other commonly occurring words (Study 2); (3) the relationship between mortality salience and affect (Study 3); (4) the extension of culturomics by analyzing a dataset derived from the Google digitisation project rather than relying on the so-called "Ngram viewer" (https://books.google.com/ngrams) that is typically used in culturomics articles. Unlike the digitisation project, The "Ngram" viewer only allows for the analysis of a limited number of words and lacks facilities for extensive statistical analysis.

The socio-cognitive processing of mortality concerns

Comprehensive reviews of terror management theory and research are available elsewhere (Burke et al., 2010; Pyszczynski, Greenberg, & Koole, 2004). This article primarily concerns terror management theory's central assertion that human's unique ability to meaningfully contemplate their own life and mortality creates the potential for paralysing existential anxiety. The solution to such distress is investing in symbolic structures, such as cultural worldviews, that allow humans to feel as though their life is infused with meaning, order, and permanence, and as though they are part of an enduring entity that transcends humans' temporal physical presence (Pyszczynski, Greenberg, & Koole, 2004).

There is now abundant evidence that mortality salience predicts increased attachment to various symbolic structures that define socially sanctioned and valued behaviours, such as patriotism and romantic attachment (Arndt, Greenberg, & Cook, 2002; Pyszczynski, Greenberg, & Koole, 2004). Initially, reminders of mortality were primarily induced by having participants in the experimental condition respond to open-ended questions about death (Greenberg et al., 1990; Rosenblatt, Greenberg, Solomon, Pyszczynski, & Lyon, 1989), but there are also various publications reporting other techniques to induce mortality salience, including subliminal priming (Arndt, Greenberg, Solomon, Pyszczynski, & Simon, 1997), having participants walk past a funeral parlour (Pyszczynski et al., 1996), and having participants fill out a fear of death questionnaire (Greenberg et al., 1995). These manipulations have shown that mortality salience enhances positive evaluations of in-groups (Greenberg et al., 1990; Greenberg, Pyszczynski, Solomon, Simon, & Breus, 1994) and the self (Dechesne et al., 2003), intensify behaviours that enhance or bolster positive self-conceptions (Ben-Ari, Florian, & Mikulincer, 1999), increase positive appraisal of worldview-consistent behaviour (Pyszczynski, Rothschild, & Abdollahi, 2008), increase negative appraisal of worldview-inconsistent behaviour and worldview threatening exclamations (Pyszczynski et al., 2008), as well as bolster the desire for romantic attachment (Pyszczynski et al., 1996), the desire for offspring (Mikulincer & Shaver, 2004), and consensual validation by (significant) others (Pyszczynski et al., 1996).

Conceptual and empirical work by Jamie Arndt, Jeff Greenberg, Tom Pysczszynski, and colleagues (Arndt, Cook, & Routledge, 2004; Pyszczynski, Greenberg, & Solomon, 1999) sheds light on the cognitive mechanisms underlying mortality salience effects. Building on initial findings demonstrating that reminders of mortality only impact patriotic engagement after a delay (Greenberg et al., 1994), Pyszczynski et al. (1999) subsequently developed a model of how individuals cognitively process death. The dual-process model posits that different defensive processes are activated when individuals are consciously and unconsciously aware of mortality, which create distinct mortality salience effects. When death-related thoughts are in focal awareness, participants may reduce existential anxiety by engaging in *proximal* defenses that rationally suppress death-related thoughts by pushing them into the distant future by denying one's vulnerability to mortality or seeking distraction. Once these defenses have pushed death thoughts to the fringe of focal awareness, they become highly cognitively accessible and engage unconscious *distal* defenses

to subdue existential concerns. Distal defenses defend against unconscious (as opposed to conscious) thoughts of death by investing in and defending cultural worldviews that are defined by symbolic conceptions of the self and one's cultural reality, such as patriotic sentiments and romantic affiliation (Arndt et al., 2002). Research suggests that death-thought accessibility varies when unconscious and conscious death-thoughts are present, which plays an integral role in the dual-process model of defense (Arndt et al., 2002, 2004). Accessibility of death-related thoughts is higher when death-thoughts are unconscious and on the edge of focal awareness compared to conscious reflection (i.e. after a distraction task or a subliminal prime), which engages symbolic defense (Arndt et al., 1997).

There is considerable evidence corroborating this dual-process model of defense against conscious and unconscious death-related thoughts (Arndt et al., 2004 Burke et al., 2010; Pyszczynski, Greenberg, Solomon, & Hamilton, 1990). Research has demonstrated that immediately after mortality is made salient individuals engage in psychological defense by attenuating their perceived vulnerability to death (i.e. increased intention to apply sunscreen, a conscious form of defense) whereas after a delay they engage in symbolic defenses (i.e. increased intention to tan to achieve internal and cultural standards of attractiveness, an unconscious form of defense) (Routledge, Arndt, & Goldenberg, 2004).

Arndt and colleagues have used these findings and ideas to provide an outline of the "cognitive architecture of terror management" (Arndt et al., 2002, 2004) that suggests that over time, co-occurrence of death-related experiences (e.g. the death of a loved one, or watching a violent TV show) and psychological defenses (e.g. funeral rituals, or patriotic deeds in combat) strengthens associations between death as a cognitive construct and constructs related to distal psychological defenses. Once the construct of death is activated through answering questions on the topic or through brief exposure to the word "death", associative linkages will cause symbolic psychological defense constructs to co-activate and direct behaviour. An extensive set of studies by Arndt et al. (2002) found that reminders of mortality and subliminal exposure to death related words heightened accessibility to constructs central to participants' worldview. For example, they found that when mortality salience was induced romantic accessibility increased for women but not men, and that death thoughts increased accessibility of nationalistic constructs for men but not for women. The accessibility of patriotic sentiments and of romantic relationships was measured with a word completion task. Participants with heightened accessibility of patriotism, for instance, were more likely to complete word stems (e.g. PATR _ _ _) with patriotism related words (PATRIOT) as opposed to words unrelated to patriotism (e.g. PATROLS).

Uncovering collective representations of mortality using culturomics

This associative model of cognitive representations and word stem completions are of particular interest because they can inform the extension of terror management processes across a time span of multiple centuries. The word stem completions demonstrate that the activation of mental constructs influences subsequent judgment and perception of ambiguous constructs (Higgins, Rholes, & Jones, 1977; Kruglanski, Dechesne, Orehek, & Pierro, 2009). This means the way in which one uses words to describe events or experiences can provide insight on what mental constructs are active (Nisbett & Wilson, 1977). This suggests that one can examine a large sample of words that describe events at a given point in time and make inferences about which mental constructs are active during that time. When, for example, the construct of death is activated, one can expect that death-related worlds are more likely to appear in speeches and writing. Similarly, when words related to death occur more frequently at a particular time compared to a control condition or a different time period, one can infer that at that particular time, the construct of death is mentally activated to a greater extent relative to the control condition or a different time period.

The recent emergence of the culturomics movement provides access to a database of words that can be used to examine such psychological constructs over time. Building on Google's effort to digitise several million of books that were published from the end of the Middle Ages to present, culturomics represents an attempt to perform computational analysis on these texts to "observe cultural trends and subject them to quantitative investigation" (Michel et al., 2011, p. 176). This investigation oftentimes involves plotting a word's frequency of occurrence to identify its salience in different historical contexts. For example, Michel et al. (2011, p. 177)

depicted a graph showing the occurrence of the word "slavery" from 1800 to 2000, revealing that the word "slavery" was most frequently used during the American Civil War (1861–1864) and, less saliently, during the Civil Rights movement (1955–1968). The quantitative investigation may also involve more linguistically interesting developments, such as the simple increase of the English lexicon over time (Michel et al., 2011, p. 178) and the rise and fall of the use of particular labels (e.g. "1973"), concepts (e.g. "Spanish flu"), and names (e.g. "Marc Chagall"). For example, Michel et al. (2011) reported that as a collective, year labels (e.g. "1973") that are closer to the present tend to have a shorter half-life than years prior.

The potential of Google's digitisation effort has been well-recognized within social psychology. Twenge, Campbell, and Gentile (2013), for example, have used the database to show that in the American literature in the period from 1960 to 2008, plural pronoun use (we, us) is declining whereas the use of singular (I) and second person pronouns (you) is increasing. Furthermore, a substantial percentage of virtue terms (e.g. honesty, patience) are currently used less frequently than they were in the past, suggesting that morality has become a less salient issue in public discourse (Kesebir & Kesebir, 2012). Greenfield (2013) found that both American and British literature indicate a decline in word use reflective of cultural priorities associated with rural environments (i.e. social obligation and duty, giving to other people, social belonging, religion in everyday life, authority relations, and physical activity) and an increase in word use reflective of cultural priorities associated with urban environments (i.e. individualistic and materialistic values: personal possessions, child-centered socialisation, development of psychological mindedness and the unique self).

These studied have all been completed using the nGram viewer that is available online (https://books.google.com/ngrams). This nGram viewer allows one to enter specific words, and generates plots depicting the frequency of a given word's occurrence. While these analyses provide valuable insights, nGram is unable to comprehensively observe cultural trends in language because they are only tracking specific words over time. To optimise the potential of Google's digitisation of books and examine cognitive representations in texts, it is pertinent that we are able to analyze the occurrence of millions of worlds, not a select few, and examine their interrelationships and development over time. Downloading and conducting analysis of the complete data set of digitised American books published between 1800 and 2009 that is available to download at the nGram viewer website allows us to do this. We can conduct factor analysis to cluster words and compute correlations to identify their co-occurrence in frequency of use over time, which provides insight on collective representations and associations between constructs across time.

The current study

The goal of the present study is to utilise this analytical technique to address the issue of cross-historic validity of terror management processes over 200 years and investigate the collective representation of mortality and its associative constructs. Replication has become a priority in the realm of social psychology (Open Science Collaboration, 2015), and the digitalised input of roughly a million authors can be used to corroborate or refute findings in social psychology typically obtained using samples of college students. In Study 1, we use the experimental materials of the studies by Arndt et al. (2002) that examined the effect of mortality salience on accessibility of patriotism and romantic affiliation to assess the co-occurrence of these constructs over time. Arndt et al. (2002) suggests that reminding individuals of their mortality can increase accessibility of worldview constructs such as patriotism and romantic affiliation, which indicates there is a strengthened association between the construct of death and these constructs. To the extent that these associations exist, significant co-variation of language concerning death and patriotism/romantic affiliation should be observed over 209 years. In Study 2, we use an inductive, pattern matching procedure to create a ranking of the words, which frequencies most strongly co-vary over time with the usage of the word "death". In Study 3, we examine the relationship between word usage related to death and related to affect in a cross-historical context.

The mortality salience studies that inspired Study 1 and Study 3 (i.e. respectively, the research by Arndt et al., 2002, and the research on mortality salience and affect by Lambert et al., 2014) were deliberately chosen because these studies used materials and analysis techniques that could be applied to the present research context. For example, the wordstem completion task by Arndt et al. (2002) allows one to specify which frequencies of death-related words

and frequencies of words related to worldview and romantic relationships are expected to co-vary over time. The analyses by Lambert et al. (2014) have been inspired by Linguistic Inquiry and Word Count (LIWC; Pennebaker, Booth, & Francis, 2007) and could also be used in the present research context. The database consists of 40,000 words with frequencies over 209 years, so the number of possible correlations are immense. By focusing on these specific studies and narrowing our focus, we both can avoid the dangers of data phishing and directly examine if previous experimental studies theoretically replicate in a historical context.

Importantly, this database has the potential to both examine whether established psychology theories can replicate in an alternative paradigm and uncover previously unforeseen relationships between constructs to make theoretical advances. The top-down analyses of Study 1 and Study 3 emphasise the advantage of this methodology in terms of theoretical replication, and the bottom-up approach in Study 2 illustrates its potential to advance the field. Study 2 should thus be considered a deliberate attempt to explore the most significant relationships between usage of the word death and usage of other words that can be identified with this database.

It is important to note that in translating effects that are typically observed in the laboratory to the present database of word frequencies, we encountered the dilemma of whether to analyze the absolute annual frequencies of the words or the changes of word frequencies from one year to another. We reasoned that if the current research were to be conducted in the form of an experiment, the dependent variables would pertain to patriotism and romantic affiliation in Study 1 and affect in Study 3, while in Study 2 the interest would lie in the identification of potentially relevant dependent variables. In the present dataset, however, there is no mortality salience induction to serve as independent variable. We reasoned that in history there are events that increase death-construct accessibility, which, according to terror management theory, activates the accessibility of wordview, self-esteem, and affect related constructs. In this sense, the frequencies of the word "death" and words associated with death can be considered mediators of the effect of a death-thought provoking event on social and affective behaviour. Events that happen during a particular year are assumed to increase the frequency of the use of death related words, which is assumed to coincide with increases in the frequency of patriotism and romantic affiliation related words (Study 1) and increases in affect (Study 3). This reasoning led us to correlate changes of one year relative to the previous year in word frequencies of words related to worldview, romantic affiliation, and affect, as well as changes in the frequency of the use of the word "death" or death related words of that same year relative to the previous year. Therefore, across the studies we correlated the *change scores* rather than the absolute word frequencies. This means that when there is a significant correlation of change scores between word frequencies, these words and their underlying constructs are considered to co-vary over time.

Dataset preparation

Creating a dataset that can be analyzed using SPSS from the files that are available for download at the Google Ngram viewer website constitutes a laborious task. To bring the data set to manageable proportions, only the American English data (version 20120701) were included in further analyses. Each file of the American English dataset, presented per letter of the alphabet, was downloaded and analyzed for irregularities. Some files (e.g. the "a" file, and "p" and "s" files) contain over 80 million words and word fragments/symbols. Closer inspection revealed that many of the words are represented at least twice in the dataset, with the data associated with a word (i.e. frequency of occurrence per year) showing considerable similarities for the different representations of the same word. In the absence of an explanation of the origins of this multiplicity, it was decided to average the data of the different word representations for one word, in one year, as an indication of the frequency of occurrence. A second reduction measure was to include only data from the years of 1800 till 2009 (and thereby to exclude the data from before 1700). Note that in analyses reported for the separate studies below, the focus was primarily on the word frequencies between 1800 and 2009, because the analysis of this timeframe yields the most reliable results (Michel et al., 2011). A third measure was to put all words in capital letters, summing the (partially) capped and non-capped versions of the same words. Finally, a total frequency of occurrence per word was computed by summing up the frequencies for all years from 1700 until 2009, and this total was used to select the 40,000 most frequently occurring words. With close to a billion estimated total

occurrences, the words "AND" (962596814.98 estimated occurrences) and "ARE" (912779902.77) were the two most frequently occurring words in the database. The words "XY" (82105,69) and "BEIGE" (82095,55) closed the list at positions 39,999 and 40,000 respectively. The database containing the 40,000 words was subsequently adapted into various versions that allowed us to address substantive questions. The primary interest for the following studies is the co-*variation* of constructs over time (i.e. similarities in increases or decreases of constructs over time). To obtain this score, the word frequencies per word per year were divided by the total frequency per year to control for the general increase in word frequencies as time progresses. This adjusted score was then used to compute an index of change by dividing, per word, the adjusted frequency of one year by the adjusted frequency of the preceding year.

Study 1

In this study, experimental procedures described by Arndt et al. (2002) were utilised to identify the word stems and associated words related to death, relationships, and patriotism. The identified words per category were submitted to factor analysis, and the resulting factors were then correlated to assess the merits of Arndt et al.'s hypotheses that there is co-variation between the usage of death-related words and of relationship-related words as well as between the usage of death-related words and the usage patriotism-related words.

Method

Database

The analyses were based on the changes in word occurrence of the 40,000 most frequently occurring words in the American literature (see above for details on the dataset preparation).

Procedure and materials

We used Arndt et al. (2002) materials to identify 10 words related to nationalism: flag, patriot, states, senate, law, anthem, cash, congress, America, national. We used the same materials to identify 10 words related to relationships: wife, lover, marry, sex, romance, date, bride, husband, engaged, marriage. A terror management theory website hosted by the University of Missouri (http://www.tmt.missouri.edu) contains multiple lists of words and word stems used to measure death construct accessibility that have been used in numerous studies (e.g. Pyszczynski, Solomon, & Greenberg, 2015, for review). Eight words were taken from the website to measure death as a construct: buried, dead, grave, killed, skull, coffin, corpse, and murder. Co-variation in occurrence of the words from these three categories (nationalism, relationships, and death) constituted the primary interest for the analyses.

Results

Factor analysis

As a first step in the data analysis, separate principal component factor analyses with Varimax rotation were conducted for the three categories of words. When the separate words are found to be part of an underlying latent factor, it indicates that their word usage increase and decrease in a similar way along with the latent factor. For the patriotism related words, four factors were extracted with Eigenvalues > 1, with only the first factor yielding an Eigenvalue > 2, at 2.32. Only the first two factors clustered a clearly interpretable set of words, and were therefore considered for further analyses. In particular, the first factor clustered the words: states (factor loading, .72), senate (.82), congress (.69), national (.35), and law (.31), suggesting that this factor indicates the political/institutional component of the United States. The second factor appears to cluster more symbolical components of the United States: flag (factor loading, .77), patriot (.45), cash (.34), and national (.65). For the relationship related words there was also a four factor solution. The first factor was with an Eigenvalue of 3.13 and the second and third factors were with Eigenvalues > 1. Only the first and second factor allowing meaningful interpretation. The first factor consisted of lover (factor loading, .83), marry (.64), romance (.79), bride (.66), and husband (.41). This factor may reflect a romantic component of romantic relationships. The second factor consisted of wife (.62), marry (.47), sex (.54), husband (.72), and marriage (.65), suggesting this factor is associated with a marriage component of romantic relationships. The death-related words could be also divided along three factors of Eigenvalue > 1. The first two factors can be interpreted. The first factor, Death Factor 1, grouped together grave (.76), coffin (.55), corpse (.58), and murder (.60). The second factor, Death Factor 2, grouped together killed (.82), buried (.72), and corpse (.41).

Correlations

For the six constructs identified by the factor analyses (i.e. political/institutional nationalism, symbolical nationalism, romantic components of relationships, marital components of relationships, Death Factor 1 and Death Factor 2) indicators were computed by averaging the scores of the relevant items. These indicators were then entered into a correlation analysis. The correlations observed for Death Factor 1 were similar to the effects observed in the Arndt et al. (2002) experiments. Death Factor 1 correlated positively and significantly with symbolical nationalism, $r = .14$, $p < .05$, but not with political/institutional nationalism, $r = -.012$, $p > .86$. Furthermore, there was a strong positive correlations between Death Factor 1 and the romantic component of relationships, $r = .44$, $p < .001$, and a positive correlation between Death Factor 1 and marital components of relationships, $r = .20$, $p < .003$. Thus, these results support the experimental effects reported by Arndt et al. For Death Factor 2, significant correlations were also observed. There were positive correlations between this factor and the romantic components of relationships, $r = .22$, $p < .002$, as well as the marital components of relationships, $r = .14$, $p < .05$. The only unexpected correlation concerned the relationship between Death Factor 2 and the symbolic components of nationalism, which was unexpectedly negative at $r = -.17$, $p < .02$ (the correlation between this death factor and the political/institutional aspects of nationalism was not-significant, $p > .05$.)

Discussion

Study 1 sought to replicate findings obtained by Arndt et al. (2002), which demonstrates that inducing mortality can increase activation of death related constructs (e.g. patriotism, relationships). To do so, we utilised digitised versions of millions of books to track the associations between the changes in usage of death-related words and changes in usage of patriotism and relationship related words over 209 years. Despite this substantial departure from a laboratory setting, the results of our study corroborate the findings of Arndt et al. (2002). Greater occurrence of death-related words was associated with a greater occurrence of words related to symbolical nationalism and of words related to romantic and marital components of relationships.

Factor analysis on the present dataset revealed that it is important to distinguish between different types of nationalism (political/institutional and symbolical) and relationships (romantic and marital). The finding that usage of death-related words is only associated with symbolic, as opposed to political/institutional nationalism, can be interpreted as consistent with existing literature. Prior research (e.g. Greenberg, Simon, Pyszczynski, Solomon, & Chatel, 1992) indicates that death transcendence is primarily derived from a sense of meaning and value that symbolic aspects of a nation provide (i.e. belonging to a large, enduring entity), but not institutional designs (i.e. states, laws, congress). The finding that usage of the death-related words is associated with usage of words related to the romantic components of relationships to a greater extent than the marital components of relationships is also consistent with this notion. Whereas both romantic and marital components may infuse one's life with meaning and value, the self-esteem derived from romantic relationships may be greater than that of institutionally arranged marital relationships (consider here the many romantic stories of true love being disturbed by family arranged marriages, e.g. "Los Amantes de Teruel", Spain's most famous love story).

Amidst these converging findings, it should be noted the death-related words could also be divided into two factors, and the second factor (comprised of the words buried, killed, and corpse) yielded expected positive correlations between both components of relationships, but an unexpected negative correlation between the symbolic components of nationalism. At present, it is difficult to find a satisfactory explanation for this finding. Overall, however, Study 1 does provide evidence for the correlations between death-related constructs and constructs related to symbolic nationalism and relationships in a historical context.

The present findings represent a relevant asset for terror management theory. They demonstrate that the mortality salience effects observed in the laboratory can be generalised to the American collective memory of the last two centuries. This provides further support for the theoretical tenets of terror management theory in an alternative paradigm and suggests that it may be fruitful to further pursue terror management processes using historical and contemporary texts. Furthermore, the database consists of work by hundreds of thousands of authors. The convergence of findings with such a large number of "participants" (i.e. authors of books) used in the present study strongly testifies to the

robustness of mortality salience effects, which is of considerable importance in light of the increasing value attached to replications within social psychology (Gilbert, King, Pettigrew, & Wilson, 2016; Nosek, Spies, & Motyl, 2012; Open Science Collaboration, 2015).

In transposing the Arndt et al. (2002) laboratory findings to the current research canvas, two issues require further scrutiny. First, in a laboratory setting, it takes minutes before reminders of death induce symbolic defenses, so considering the relationship between usage of death related-words and the usage of nationalism/relationship-related words within a one-year timespan is reasonable. It may be, however, that increases in the usage of death-related words in one year affect the increases or decreases of usage of particular words in the following years. Conversely, variation in word frequencies indicative of symbolic defenses (i.e. relationship or nationalism-related words) may affect the usage of death-related words in the subsequent years. This issue will be further investigated in Study 2.

Second, in Study 1 we adapted a deductive approach to developing our hypotheses. Psychological theory was used to derive hypotheses, which were then used to assess relationships among specific variables. While our hypotheses were supported, this approach fails to examine how usage of words that are unrelated to nationalism and relationships may co-vary over time with the usage of death-related words. The database showing the occurrence over time of 40,000 words provides the opportunity to adopt a more inductive approach to address terror management mechanisms. Rather than investigating correlations between specific word occurrences, the database allows to assess how each of the usage of 40,000 words co-vary with the usage of the word "death", and to rank the words that are specified by terror management theory among a broader set of words than expected on the basis of TMT.

Study 2

In this study, the changes in the annual frequencies of the word "death" were correlated with the changes of the annual word frequencies of each of the other words in the database, to examine the strongest temporal associations between the usage of death and the usage of each of the other words in the database. Following the reasoning outlined in the introduction and the corroborative findings of Study 1, further support of terror management theory would imply not only that the changes in frequency of words related to patriotism and relationships significantly co-vary over time with the changes in frequency of words related to death (as observed in Study 1), but that the changes in frequencies of words related to patriotism and relationships, relative to other words, also show the strongest co-variation with death-related words. If changes in the usage of words other than those related to patriotism and relationships are found to co-vary more strongly with the usage of the word death, it suggests that hypotheses other than those provided by terror management theory regarding the ways in which death affects social language merit consideration. Study 2 not only considered the specific word "death" and its temporal correlates, but also the words "terror" and "horror" and their temporal correlates. The word "terror" was chosen because of its role in the name "terror management theory" and the potential for existential-induced terror. The word "horror" was taken as a contrast to "terror". Whereas "terror" refers to the anticipation of something horrifying, "horror" refers to the actual experience after a horrific event has occurred. From the angle of terror management theory, the usage of both words should co-vary with the usage of words related to worldview-striving, self-enhancement, relationships, etc. Moreover, to assess the impact of the occurrence of the relevant words from one year to another, three types of correlational analyses were conducted. Changes in the frequencies of the three words of primary interest (i.e. "death", "terror", and "horror") were related to changes in each of the approx. 40,000 other words in the database: (1) when the changes in frequencies of the three words occurred a year earlier than the changes in frequencies of each of the 40,000 other words; (2) when changes in use of the three words occurred in the same year as the changes in each of the 40,000 other words; and (3) when the changes in use of the three words occurred a year after changes in use of each of the 40,000 other words.

Method

Database

As in Study 1, the analyses were based on the changes in word use of the 40,000 most frequently used words in the American literature.

Procedure and materials

A SPSS syntax file was written that automatically computed the correlations between the changes in frequencies in the words "death", "terror", and "horror", and the changes in frequencies of the remaining words in the database. The three words of primary interest were adjusted for year: in the first run, changes in word frequency at year X were correlated with changes in word frequency of each of the (approx.) 40,000 remaining words at year X+1; next, changes in frequency of the three words at year X were correlated with the changes in frequency of each of the remaining words at the same year; and in the final run, changes in frequency of the three words at year X were correlated with the changes in frequency of each of the remaining words at year X-1. In this way, it is not only possible to assess co-variation in word use, but also to determine which word frequencies change following a change in frequency of either the word "death", "horror", or "terror", and usage of which words precede a change in the usage of one of these three words under investigation.

Results

Table 1 depicts the 20 words with the strongest correlations. We first examined the words that co-vary with "death" within the same year. Of the words used in Study 1 to examine the accessibility of patriotism and romantic relationships, only "wives" ranked within the 20 most strongly co-varying words related to death. When looking at words that co-vary with the word "death" at year X+1 (i.e. when changes in the usage of the word "death" precede changes in the usage of a particular word the year after the change in the word "death" has occurred), only "bride" can be traced back to the words used in Study 1. For the words that co-vary with death (in the same year, the year before, or the year after), it appears difficult to find particularly meaningful interpretations. The presence of six medical terms in the top 10 of "same-year" correlations (i.e. "hepatocytes", "monoclonal", "immunoglobulins", "prostaglandins", "intraoperative", and "interleukin") suggests that "death" is most strongly tied to the medical domain.[1]

The words found to co-vary in the same year with the word "horror" seem more readily interpretable. The words "despair", "struggling", "frantic", "trembling", "terror", "ruin", are intuitively related to "horror", whereas other words such as "struggling", "silence", or "rage" may also be tied to "horror" with minimal additional narrative. A striking feature of the results for "horror" at year X-1 and year X+1 is that, unlike for "death" and "terror", the associated words are predominantly negatively correlated. When there is an increase in the word "horror" in a particular year, words such as "compared", "incurs", and "unfolding" tend to decrease in frequency in the following year. Furthermore, when there is an increase in the use of the words "furiously", "safety", and "cope" (among others) in a particular year, the word "horror" is less likely to occur in the following year. In the absence of a particularly (intuitively) meaningful relationship between "horror" and the listed words at year X-1 and X+1, one can only speculate about the nature of this finding.

Meaningful pairs were identified when examining words that co-vary with the word "terror". The word "terror" covaried with "courage", "terrified", "fury", "cruel", "triumph", and "rage". These words can be considered appropriate keywords to summarise Ernest Becker's (1973, 1975) analysis of the human condition, the anthropological work that terror management theory stemmed from. His analyses links human heroism ("courage" and "triumph") involving considerable ardour ("fury", "rage") to existential terror ("terrified", "cruel"). As with "death" and "horror", the analyses of year X-1 and year X+1 did not yield easily interpretable results.

Auxiliary analysis

The primary aim of Study 2 was to investigate the most important co-variation of the word death relative to the words "horror" and "terror". The findings of Study 2 are therefore focused on the most important insights to be gleaned from comparing the three constructs. The primary finding is that whereas the words "horror" and "terror" generate correlates that can be quite readily interpreted from the angle of terror management theory (i.e. that courage and triumph are related to terror). The word "death" showed the strongest correlations with medical words, which was derived from the Top 20 of most strongly correlating words. A closer examination of the words that co-vary with the word "death" over time may provide some insights into the associations that death elicits and thereby may inform terror management theory regarding the types of responses elicited by death. Clearly, there are many elements of the data that are worthy of further examination. But we deemed the analysis of the words that are most strongly associated

Table 1. Words with the strongest temporal associations with the target words "DEATH", "HORROR", and "TERROR". Reported are correlations of changes when changes in target words are preceded by one year by the reported words (left column), changes in these words and the target words occur during the same (middle), and changes in these words follow changes in the target words by one year (right column).

	WORD	*r*	WORD	*r*	WORD	*r*
DEATH	1. BIBLIOLIFE	,4009441	1. BIBLIOLIFE	−.7683939	1. BIBLIOLIFE	−.6665988
	2. ÏŒ[1]	.3941497	2. AUTOCAD	.4632283	2. CENGAGE	.4609985
	3. ENCRYPTION	.3446091	3. HEPATOCYTES	.3927440	3. WWW.BIBLIOBAZAA	.4281968
	4. HYPERLINKS	.3330095	4. MONOCLONAL	.3741965	4. HYPERLINKS	.3827492
	5. SAS	.3241681	5. IMMUNOGLOBULINS	.3589604	5. QAEDA	.3715979
	6. PENICILLINS	.3187920	6. PROSTAGLANDINS	.3576424	6. ANTIFUNGAL	.3608464
	7. AUTOCAD	−.3115078	7. INTRAOPERATIVE	.3472669	7. PARAMEDICS	.3571210
	8. INALIENABLE	.3086061	8. HYPERLINKS	−.3264650	8. BIBLIOBAZAAR	.3457239
	9. AEROSOLS	−.3066719	9. INTERLEUKIN	.3227304	9. PREDICTABLY	−.3398676
	10. BILL	.3051114	10. DISPLEASE	.3226063	10. MODEL	−.3260435
	11. LYSOSOMAL	.3047975	11. PAGEANTS	.3209420	11. ÏŒ°	−.3215460
	12. HEAVE	.3001697	12. UNIVARIATE	−.3205348	12. I	−.3200612
	13. BRIDE	−.2997295	13. CFCS	.3190867	13. BENZODIAZEPINES	.3127346
	14. CFCS	−.2966872	14. PLEASED	.3185402	14. ADSORBENT	.3110174
	15. INNS	.2959749	15. LIMITS	−.3152774	15. AUTOCAD	−.3103115
	16. CPU	.2938907	16. WIVES	.3075549	16. NGOS	.3084177
	17. EIGENFUNCTIONS	.2937762	17. SEEING	.3059204	17. IDLE	−.3073384
	18. MONOLAYERS	−.2928351	18. OBLIGES	.3054635	18. SAFEGUARDS	.3060839
	19. WARHEADS	.2905212	19. AGREEABLE	.3054331	19. DONATION	−.3041450
	20. POSTSECONDARY	.2876027	20. PETROCHEMICAL	.3033915	20. DISHONOUR	.3036235
HORROR	1. COMPARED	−.4525613	1. DESPAIR	.7158093	1. BIBLIOLIFE	−.5879261
	2. INCURS	−.4508718	2. HUNG	.6813131	2. FURIOUSLY	−.4388369
	3. UNFOLDING	−.4507165	3. STRUGGLING	.6584338	3. SAFETY	−.4382011
	4. HAPPIER	−.4319303	4. SILENCE	.6485524	4. COPE	−.4335618
	5. SOOTHING	−.4279211	5. IMPATIENCE	.6481309	5. DESPERATE	−.4328872
	6. SESSION	.4245234	6. FRANTIC	.6375494	6. UNWIELDY	−.4226724
	7. FINDS	−.4234808	7. INSULT	.6345211	7. EXPERIMENTAL	.4134815
	8. CAUGHT	−.4219286	8. FLUNG	.6307285	8. FURIOUS	−.4093049
	9. DRAWS	−.4189225	9. TRIUMPH	.6210307	9. AWED	−.4081615
	10. PIED	.4185604	10. TREMBLING	.6142657	10. MUTINY	−.4064917
	11. PLUNGE	−.4182436	11. RAGE	.6142499	11. ÂŽª	.4023743
	12. PICNICS	−.4155286	12. TREMBLED	.6031088	12. FEARING	−.4015610
	13. AFFORDABLY	.4132809	13. TERROR	.5979663	13. RUIN	−.4015138
	14. WWW.BIBLIOBAZAA	.4118517	14. SUSPICIONS	.5971708	14. REUNITE	−.3978972
	15. DREAMING	−.4109081	15. RUIN	.5970796	15. MEDICAL	.3973982
	16. PLUNGED	−.4039652	16. TEARS	.5950254	16. FURY	−.3952182
	17. SURPRISING	−.4037919	17. AMAZEMENT	.5939515	17. STUNNED	−.3926291
	18. SHRINK	−.4002754	18. RUINED	.5932698	18. PROFESSOR	.3922969
	19. BIBLIOLIFE	.4000489	19. SILENT	.5920370	19. CRUSH	−.3888007
	20. MUSED	−.3997927	20. SNATCHED	.5913541	20. OMINOUS	−.3880733
TERROR	1. ITEM	.4930873	1. COURAGE	.7668292	1. KITTENS	.4946186
	2. PATHOLOGISTS	.4856035	2. TERRIFIED	.7560478	2. BIBLIOLIFE	−.4923568
	3. EXACERBATION	.4828093	3. FURY	.7447682	3. KELLOGG	.4851278
	4. MEDIEVAL	.4741187	4. CRUEL	.7343820	4. HORSEBACK	−.4787075
	5. CONVENIENT	.4732152	5. TRIUMPH	.7291710	5. FREIGHTER	.4769030
	6. TREMBLING	−.4679374	6. RAGE	.7265075	6. FRECKLES	.4766290
	7. ISABELLE	.4663976	7. THREW	.7256876	7. RESIDUES	.4747701
	8. WWW.BIBLIOBAZAA	.4647338	8. DREW	.7101672	8. ÂŽª	.4723282
	9. IDIOPATHIC	.4623153	9. CRUELTY	.6924605	9. MICHELE	.4702115
	10. SYNOVIAL	.4554801	10. EAGER	.6893732	10. STEFANO	.4662109
	11. ROMEO	.4545478	11. DESPAIR	.6885634	11. MAGNETS	.4656784
	12. UNWELCOME	−.4501688	12. TREMBLED	.6791582	12. YARNS	.4620845
	13. RABIES	.4491885	13. IMPATIENT	.6763533	13. PHOSPHATES	.4564541
	14. CONDYLE	.4465897	14. VENGEANCE	.6748674	14. DIABETES	.4547728
	15. SERUM	.4461338	15. BIBLIOBAZAAR	.6745291	15. COMIN	.4537353
	16. EVERYWHERE	.4451388	16. FRANTIC	.6730148	16. FURIOUSLY	−.4530679
	17. DISTENSION	.4430193	17. HOPES	.6725538	17. SLAG	.4507323
	18. PERITONITIS	.4429442	18. ALARMED	.6685631	18. RASPED	.4497584
	19. SWEATING	.4406356	19. FLED	.6680624	19. SPORADIC	.4495625
	20. ANEURISM	.4400082	20. RUSHED	.6534942	20. OUTLAY	.4494676

with death to be the most pertinent for the general aims of this research.

In order to examine these associations, the 1000 words that most strongly (positively or negatively) correlated with death were subjected to closer scrutiny. On the basis of a preliminary scanning, seven categories of words were identified. There were 7 words that pertain to the category "death". There were 26 that relate to "violence". A total of 48 words relate to "medicine." For the category "religion", 14 words could be identified. The category "positive valence" contained 27 words, while there were 61 words with "negative valence". The category "relationships" contained 29 words. A total of 212 out of 1000 could be thus assigned to the one of the seven categories. Appendix A provides an overview of the words associated with each category. We also searched for nationalism and patriotism related words, but found only the words "national" on the 894th position of most strongly correlating words.

To examine whether particular categories were more strongly associated with death than other categories, we counted the number of words per category within rank-ordered units of 100 words. The rank-ordering implied that the first unit contained the 100 strongest correlating words, the second unit the words that ranked between 101 and 200 in terms of the strength of correlation with death, etc. Figure 1 graphically depicts the outcome of this procedure. The figure shows that the majority of words related to the medical, violence, and relationship categories have relatively strong correlations with death as indicated by a high prevalence of these words in the first and secondly highest ranked units relative to their prevalence in the lower ranked units. In contrast, words related to the death, religion, and positive valence categories have relatively high prevalence in less highly ranked units. Negative words are prevalent in both the highly ranked and less highly ranked units. Taken together, these analyses provide further insight in the patterns of co-variation of the word death with other categories of words that are relevant in the context of terror management theory. The Top 20 of words that most strongly co-vary with death contains many words that relate to medicine. Analysis of the Top 1000 words shows that there also other categories of words that co-vary over time with the word death, including words related to violence, relationships, religion, positive sentiment, and negative sentiment. These analyses have the potential to provide guidance for further studies on the nature of collective representations in response to confrontation with death.

Discussion

The goal of Study 2 was to investigate terror management processes by employing an open-vocabulary method for word analysis (Park et al., 2015). In Study 1, terror management theory and previous experimentation were used to investigate temporal relationships between the usage of death-related words and the usage of words related to patriotism and romantic relationships. The words were derived from previous experimental studies. While the significant correlations found in Study 1 corroborate the basic premises of terror management theory, it is possible that other constructs that co-vary with the usage of words related to death, but that are currently not implicated in the theory. Accordingly, the open-vocabulary method used in Study 2 potentially enables conceptual expansion of TMT.

One striking feature of the open-vocabulary analysis is that the usage word "death" tends to most strongly co-vary with words related to health, and more specifically, technical medical terms. Out of the Top 10 words that most strongly co-vary with the word "death", six were medical terms. This suggests that linking mortality salience to health-related behaviours may be a particularly fruitful avenue of study (Arndt et al., 2009; Goldenberg & Arndt, 2008; McCabe, Vail, Arndt, & Goldenberg, 2014).

When the correlations for same-year co-variation are considered, it is striking that the word "death" has markedly weaker correlations than "horror" and "terror". For the top 20 correlations of both "horror" and "terror", all correlations were $r > .59$. In contrast, for "death" only "biblolife", a publisher of religious books, had a (negative) correlation larger than .59, and most were $r < .40$ (positive, reversed for negative correlations). Perhaps this is the case because the construct of "death" just has much weaker connections to other words. An additional interpretation for this finding is that the meaning of death is diluted relative to "horror" or "terror" because it is readily used in diverse contexts. In expressions such as "smoking causes death", "till death do us part", "scared to death", the construct of death is considered in very different contexts. Similar to the fan effect (Anderson, 1983), this may result in weaker connections between death to each associative link than words with less diversity in meaning (i.e. "death", "horror"). The

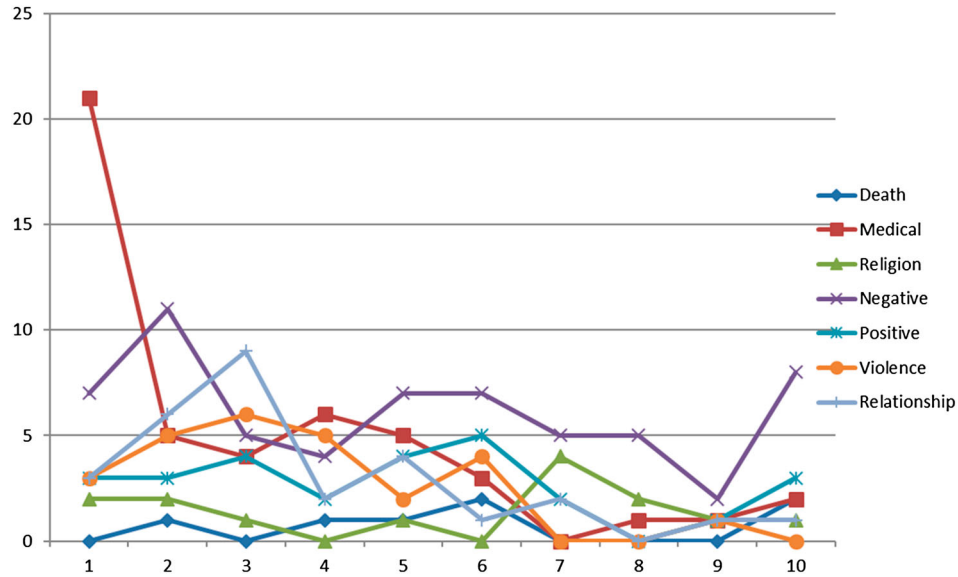

Figure 1. Number of relevant word for the n-th 100 most strongly correlating words. The y-axis indicates the number of words per category, the x-axis indicates the ranking with 1 indicating the 100 strongest correlating words, 2 indicating the 101–200 strongest correlating words, etc.

notion that the extent of associative strength between constructs depends on their diversity in meaning is particularly relevant for studies founded on assumptions about semantic networks and spreading activation (Greenwald et al., 2002; Smith & DeCoster, 1998). This suggests that priming constructs with greater diversity in meaning may produce differential effects compared to those with lesser diversity.

For "death", "horror", and "terror", there were few readily interpretable results for the year X-1 and year X+1 analyses. Clearly, these analyses were only exploratory. There is no theoretical basis to assume that a change in usage of either the word "death", "horror", or "terror" would be related to a change in usage of a specific word or class of words *in the subsequent year*, although it may be that when the lag between words or classes of words are based on shorter intervals (e.g. seconds, or minutes) meaningful patterns may be observed. These type of analyses may be more meaningful for datasets with shorter time intervals (e.g. seconds, or minutes) rather than years.

Study 3

In Study 3 we took advantage of using such a large dataset to examine the validity of the narrow effects of mortality salience. According to Lambert et al. (2014) the reason why the mortality salience manipulation typically shows no effects on mood is that these mood-effects are "extremely narrow" (p. 656) rather than non-existent as is typically assumed in the terror management literature (Arndt, Allen, & Greenberg, 2001). Lambert et al. (2014) reviewed 336 published studies and conducted four experiments to illustrate that death-thoughts elicits negative affect, especially fear and terror-related sentiments. In one experiment, the authors used Linguistic Inquiry and Word Count (e.g. Pennebaker et al., 2007) to analyze short, open-ended responses to questions about death. The responses reflected a greater presence of fear-related words but not a greater presence of anxiety-related words relative to open-ended responses to questions about mundane activities. Given the specificity of the words used to analyze the presence of fear and anxiety in Lambert, et al., the study was deemed particularly suitable to test whether in 209 years of American literary history, the construct of death significantly co-varies with fear and anxiety.

For the methodology outlined in this article, there is a considerable risk of confirmation bias (Mynatt, Doherty, & Tweney, 1977) when seeking to replicate laboratory findings in the context of 209 years of American literature. A dubbing of previously established findings in historical context may be considered a corroboration, but a lack of correspondence in findings may be much more difficult to interpret because the materials (i.e. words) and circumstances are quite

distinct. There also may be biases stemming from the analyses because the words studied here (particularly in Study 1), are contemporary words that may be more frequently used now than in the past. Because the Lambert et al. (2014), findings involve both a significant effect of death thought on fear *and* a null-effect of death-thought on anxiety, a replication of these findings may be considered particularly encouraging for the examination of laboratory findings in the context of American literature.

In Study 3, we also have an interest in different methods to assess changes in the construct of death over time. In Study 1, we used the death-construct accessibility measure developed by Arndt et al. (2002) to assess the construct of death. A factor analysis performed on the separate words that have been included in this measure separated two clusters of death related words. In Study 2, we investigated changes in frequency of the word "death" rather than the two clusters of death related words identified in Study 1 because the single word "death" would serve as a more adequate comparison for the words "terror" and "horror" for which there is no equivalent construct accessibility measure reported in the literature. In Study 3, we analyzed changes in both the composite scores derived from the death-construct accessibility measure and the single-word-'death'- measure to investigate potential differences between these measures.

Method

Database

The same database was used as in the previous studies.

Procedure and materials

To create indicators of fear and anxiety, the words used by Lambert et al. (2014, see Table 4, p. 663) were taken and slightly modified. Whereas Lambert et al. (2014) used word stems to allow for grammatical variations of the semantic core construct, for the present purposes only complete words were used. This means that the word stem "fright*" was completed as the word "frighten", and "horr*" as "horror". Moreover, the constructs "terrified" and "ambiguous" and "tensing" that were used by Lambert et al., were not included in the database used in the current study, and therefore were not considered. Accordingly, in the present study, a fear-composite score was calculated by averaging the annual change scores of the following words:

AFRAID, FEAR, FEARED, FEARFUL, FEARING, FEARS, FRANTIC, FRIGHTEN, HORROR, PANIC, SCARE, SCARING, SCARY, TERRIFIED, TERRIFYING, TERROR

An anxiety-composite score was created by averaging the annual change scores of the words:

AMBIVALENT, ANXIOUS, ANXIETY, APPREHENSIVE, NERVOUS, SHAKE, SHAKING, SHAKY, JITTERY, TENSE, TENSION, UNCERTAINTY, UNSURE, UNEASY, WORRY

To examine the relationship between changes in these scores for anxiety and fear and changes in occurrences of the construct of "death", three indicators of changes in usage of "death" were used. The first indicator involved only the word "death". The second indicator involved the first factor of death-related words as identified in Study 1 (i.e. the composite of "grave", "coffin", "corpse", and "murder"). The third indicator involved the second factor of death-related words identified in Study 1(i.e. the composite of "killed", "buried", "corpse").

Results

Regression analyses were used to examine the relationships between the indicators of changes in death and in the composites of fear and anxiety. Table 2 summarises the key statistics for these analyses. In general, the findings strongly corroborate the findings by Lambert et al. For all three death measures, highly significant, positive β-values were found for the Fear-composite, but not for the Anxiety-composite. This indicates that as the usage of death increases during a particular year, one can also expect that the usage of fear-related words but not anxiety-related words, will also increase in the same year. The only significant relation between one

Table 2. Summary of regression analysis results of Study 3.

Word "Death"	*B*	*SE B*	*β*	*t*	*p*<
Fear	.445	.123	.249	3.63	.001
Anxiety	−.018	.068	−.018	−.26	.79
Note. $R^2 = .061$.					
Death Factor 1[a]	*B*	*SE B*	*β*	*t*	*p*<
Fear	.375	.055	.435	6.87	.001
Anxiety	.026	.030	.056	.879	.381
Note. $R^2 = .201$.					
Death Factor 2[b]	*B*	*SE B*	*β*	*t*	*p*<
Fear	.485	.065	.468	7.48	.001
Anxiety	−.096	.036	−.167	−2.67	.009

Note: $R^2 = .220$.

[a]This factor is a composite of the words: grave, coffin, corpse, and murder.

[b]This factor is a composite of the words: killed, buried, and corpse.

of the death measures and the Anxiety-composite was for the second Death-factor. A negative relation between Death and Anxiety was observed, indicating that increases in death salience may be associated with decreases in anxiety. Because this effect was only observed with this specific death measure and not for the others, it is difficult to interpret this relationship.

Discussion

Study 3 used prior findings by Lambert et al. (2014) to examine the co-variation of the construct of death and constructs related to fear and anxiety. Consistent with the findings by Lambert et al, changes in constructs related to death were found to co-vary with constructs related to fear, but not constructs related to anxiety. As such, Study 3 also provides evidence for the replicability of terror management findings using the words from a sizable part of 200+ years of American literature. Thus, these findings significantly contribute to the credibility of terror management effects, and place these findings – using quantitative analysis – in historical context. Study 3 was also effective in demonstrating that the current approach to terror management processes not only converges with the experimental approach in identifying phenomena that relate to death (in this case, fear) but also in the identification of phenomena that do not relate to death (in this case, anxiety).

General discussion

The goal of the present set of studies was to investigate laboratory findings derived from terror management theory using Google's initiative to scan millions of books. This digitisation allows us to create a database specifying the annual frequency per word for the 40,000 most frequently occurring words in the American literature from 1800 to 2009. With this database, it becomes possible to investigate empirically validated terror management processes in a historical context. Consistent with the laboratory findings (Arndt et al., 2002), Study 1 showed a significant co-variation of the usage of death-related constructs and usage of constructs related to patriotism and romantic relationship such that an increase in the frequency of the usage of death related words coincided with increases in the usage of words related to nationalism and words related to romantic relationships. Study 3 showed that increases in the frequency of the usage of death related words coincided with increases in usage of fear-related words but not anxiety-related words, which also supports laboratory findings (Lambert et al., 2014).

Study 2 used a pattern-recognition procedure, computing the degree of co-variation between changes in the usage of the word death and the usage of each of the remaining approx. 40,000 other words in the database to identify possible linkages that are not implicated by terror management theory. The study showed that changes in the usage of the word death coincided with changes in the usage of several medical constructs. There are few words linked to worldview defense or self-esteem present in the top 20 of most strongly co-varying words. Furthermore, the associative links between death and other words were considerably weaker (as reflected in weaker correlations) than words related to either "horror" or "terror". Also, the words "horror" and "terror" generated an intuitive and narrower set of co-varying words compared to "death". For "death", "terror", and "horror", there was not a clear pattern of associated words between the target words and words that preceded or followed them by a year. Regarding these latter findings, it is quite remarkable that the majority of words that correlated (one year prior or after) with "horror" are negatively correlated, while words associated with "death" and "terror" are positively correlated. Although the pattern is striking, any straightforward explanation is currently difficult to formulate.

The value for terror management theory

The present results provide considerable support for terror management theory. To begin, our results demonstrate that laboratory findings that lend empirical support to TMT can be replicated in a drastically different research context. In particular the results of Study 1 corroborate Arndt et al. (2002), which demonstrated that mortality salience increased the accessibility of worldview-related words. Similarly, the current finding that changes in the usage of death-related words co-vary over time with the usage of fear-related words but not with anxiey-related words also supports previously reported findings based on laboratory research (Lambert et al., 2014). In the light of the salient concern about the replication of social psychological experimentation (Nosek et al., 2012), the current findings are noteworthy. Some years ago, it was rumoured that the mortality salience

effect was "only observed in the desert", referring to the dominance of terror management articles from the University of Arizona in social psychological literature (Martin & van den Bos, 2014). The current findings refute the claims surrounding terror management theory's limited generalizability.

Furthermore, the inductive, rather than deductive approach, to identify constructs and processes related to death reported in Study 2 provides an important innovation to mortality salience research and psychology in general. Rather than relying on theoretically derived relationships between constructs, the inductive approach simply assesses which constructs co-vary over time with the word death. The finding that many of the constructs specified by terror management theory (wordview, self-esteem) are not among the most strongly co-varying with death, suggests there is still considerable room for theoretical innovation in terror management theory. The prominence of medically related constructs in the top 20 words that are most strongly co-varying with death suggests that the study of terror management processes in a medical context may be a fruitful avenue for further research (Goldenberg & Arndt, 2008).

Furthermore, the pattern of findings obtained in Study 2 bear relevance to the dual process model of terror management theory (e.g. Arndt et al., 2004; Pyszczynski et al., 1999). The findings demonstrate that words related to medicine, violence, and to a lesser extent romantic relationships are more strongly associated with death, whereas words related to religion and positive valence are also related to death, but the degree of co-variation between these latter categories and death appears to be less pronounced. According to the dual process model of terror management theory, the processing of death related thoughts occurs on both conscious and unconscious levels. When thoughts of death are conscious, individuals will respond with *proximal defenses* to remove the death-related thought from focal attention and attenuate the perceived vulnerability mortality that are rationally oriented and threat focused. In contrast, however, when death thoughts are cognitively accessible, but outside of conscious awareness, individuals respond with *distal defenses* that maintain self-esteem and uphold cultural standards of worth. The findings obtained in Study 2 may suggest that the present method of scanning co-variation between death related words and other words over time is more effective in detecting rationally processed death concerns, because violence related words (presumably one of the cause of death) and medical words (presumably a solution for the threat of death) were found to be more strongly associated with death, than words with affective valence and words related to religion (typically associated with more experiential processing and cultural worldviews). However, the findings of Study 1 and 2 that show that death-related constructs also co-vary over time with patriotism related constructs (although weakly) and words related to romantic relationships, which are typically associated with unconscious defenses against death. This suggest that the method used can also detect the unconscious forms of defense against death-related thoughts.

Given these findings, it would be of interest to examine whether analyses other than the simple linear correlations and regressions that were used in the present studies would yield others patterns that would pertain to other aspects of terror management theory. For example, it would be interesting to explore whether alternative methods are stronger at detecting symbolic defenses against death anxiety. In this context, topological cosine similarity methods that are currently applied in text mining (e.g. Park et al., 2016) may reveal different patterns than the one's currently reported. Using these different text mining methods may further our understanding of the various mechanisms used to defend against existential concerns.

Implications for culturomics

The inductive approach correlating changes in word frequencies over time presents a unique contribution to culturomics. Although there is a facility called "Google Correlate" available on the internet (www.google.com/trends/correlate), that allows one to conduct similar computations within a time span of several years, the present research used a timespan of two centuries and one-year intervals. Our ability to observe theoretically significant correlations between variables over two centuries, as opposed to a limited number of years, illustrates the strength of the current methodology. It is also important to note culturomics research typically analyzes single variables, rather than correlations between multiple variables.

A second novelty of the present findings is the use of theory to specify which words are expected to co-vary over time. Typically, data-driven techniques in

social psychology use the opposite approach. Our methodology utilised social psychological theory to inform deductive analytical techniques, which suggests that culturomics can be used to test relationships between constructs previously observed in the laboratory. Corroborating these relationships using millions of books provides a new ways of testing theoretically relevant correlations and effects, next to experimental research. In this respect, the present approach can be considered a meaningful contribution to efforts to systematically investigate the replicability of previously reported social psychological findings. The use of theory to make sense of patterns can also be considered an important contributions to culturomics. Clearly, large amounts of data can potentially uncover new insights in social processes. The interpretation of news insights as meaningful, rather than coincidental or spurious, requires a theoretical framework that makes sense out of the identified relationships (Mikulincer & Shaver, 2004). Oftentimes, the frameworks currently used in culturomics are based on a rudimentary understanding of history. For instance, the finding that the words "slavery" shows peaks in frequency of use during the American Civil War and the early days of the civil rights movement (Michel et al., 2011) suggests that frequency scores can be used to trace historical processes, but what if these peaks were not observed during these time periods but during others? Established social psychological theorising can thus provide a useful tool for the meaningful interpretation of quantitative historical data.

Big data may serve to bridge social psychology and history

This research illustrates the potential for a new research paradigm in social psychology that can provide insight on human social behaviour and processes in historical contexts. Social psychology and history have often been considered antagonists. Social psychologists predominantly argue that social behaviour can be captured in universal regularities while historians tend to emphasise the importance of specific contexts and places in time. Examining word frequency trajectories over a prolonged period of time enables the analysis of both universal regularities and specific points in time, and how these regularities transition from one temperospatial context to another. In this respect, big data may serve to bridge social psychology and history and allow for the analysis of psychological theory in a range of historical contexts (Van den Bosch, Van den Herik, & Doorenbosch, 2013).

The present contribution is only a preliminary exploration in this novel research paradigm. There are numerous limitations in the present study. To begin, the Google database has been known to contain various types of errors, including errors that results from the specific scanning method and messy meta-data (see e.g. Zhang, 2015). For instance, the letter "f" was printed in the past in a way that it is now read by a contemporary scanner as an "s", leading e.g. "café" to be counted as "case" in the database. The messy meta-data imply for instance that "Obama" would occur in the database prior to the rise of Barack Obama, simply because of a miscoding of the year of publication. These errors may be problematic when it comes to tracking the meaning of particular constructs or names over time, as some of these errors may yield spikes or decreases in word use irrespective of actual historical events. Because the present studies, however, were primarily focused on assessing theory-derived relationships between constructs over time, these errors of the Google database may be considered less problematic. The errors contribute to noise and would make it more likely that a hypothesis that is based on existing theory would be disconfirmed rather than corroborated. Still, in the present studies, the relationships between constructs that were previously observed in the laboratory could also be observed using this database, indeed far more likely *despite* rather than *because* of the noise.

Another potential pitfall of the database is that is contains very limited information on the sources of the language that is included in the database. For example, the database contains both fiction and non-fiction publications (Michel, personal communication, September 2015), and the words and themes used in fiction and non-fiction bear distinct relations to their realities in a given time period. Moreover, the representation of the literature genres has been noted to vary across time periods. For example, scientific literature is being more prominently represented relative to other genres in more recent years (Zhang, 2015). Furthermore, there is an unspecified and varying time lag between the psychologically relevant time of writing and the less psychologically relevant time of publication that is actually analyzed (Zhang, 2015). Furthermore, changes in word frequencies are examined in year intervals, whereas psychological analysis typically involves trial-intervals of seconds or

minutes. There is also the risk of selection bias (Smart, 1966) because the present dataset only contains information about people who are able and willing to write books and documents that are considered to be of sufficient quality for Google to scan. This is a narrow sample, and databases consisting of other psychologically relevant materials from other sources (i.e. natural language use) that are ordered along temporal intervals could also provide relevant insights. Similarly, datasets that document behaviour (e.g. purchasing behaviour) and reflect direct action as opposed to rumination, could also reveal patterns of temporal developments to inform social psychological theory. It may be of interest for future research to combine various datasets that include various types of language use to examine how words and actions co-vary over time. The use of datasets containing information about word search behaviour, rather than words written in books, may also help to avoid the risk of selection bias and help create more psychologically realistic time intervals to analyze psychological processes.

Conclusion

The present studies introduce a novel research paradigm that can substantially progress the field of social psychology. It can be utilised to replicate and explore the validity of existing theory and to establish previously unforeseen relationships between variables. Furthermore, the current studies provide support for the cross-historical applicability of terror management theory and suggest that important facets of social psychology can be examined in historical contexts.

Note

1. The word "bibliolife" that most strongly co-varies with "death" is a publishing company of religious texts.

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Appendix A: Coding categories and associated words.

Death

DYING
MISCARRIAGES
GRAVE
CASUALTIES
FUNERAL
OUTLIVED
LOSS

Medical

ALLERGENS
NONSTEROIDAL
HEPARIN
HEPATOCYTES
MONOCLONAL
IMMUNOGLOBULINS
PROSTAGLANDINS
INTRAOPERATIVE
INTERLEUKIN
CFCS
GERIATRICS
MALIGNANCIES
ANTICHOLINERGIC
OPERATE
ADENOSINE
PHARMACOKINETIC
CORTICOSTEROIDS
POSTOPERATIVE
NEPHROTIC
IMMUNOLOGICAL
SUBCLINICAL
AXONAL
NUCLEOTIDES
CORTISONE
IMMUNODEFICIENC
DIAZEPAM
NONSURGICAL
IMMUNOLOGY
PRECLINICAL
MUSCARINIC
HYPOPLASTIC
LYSOSOMAL
LIPOPROTEINS
ALLERGY
ESTROGEN
DYSPLASIA
IMMUNOL
BACTERIOL
LEUKOCYTES
BIOSYNTHESIS
TRIGONOMETRIC
PENICILLINS
ADENOCARCINOMA
PHOSPHORYLATED
ALLERGIES
CEREBROSPINAL
NEUROSCIENCE
GLYCOPROTEINS

Religion

BIBLIOLIFE
HASIDIC
REPENT
SPIRITS
ACCURSED
PRIEST
NEHEMIAH
NOAH
SACRILEGIOUS
GOD
VOWING
RELIGIOSITY
CURSED
PRAY

Negative

DESPAIR
BAD
DISPLEASE
GRIEF
MEANEST
VILLAINY
SLOTHFUL
BLOODY
SUFFER
ANGRY
DECEIVING
FEARED
SWEARING
ALIENATED
PITIED
CRUEL
MADLY
DISTRESSED
WRONGED
GRIEVOUSLY
RAGE
TORMENT
SUFFERED
DIVERTED
DOOM
WEEPING
VILLAINOUS
SCANDALOUS
HATED
ENVY
MALICE
DISPLEASURE
THOUGHTLESS
MISERIES
CONDEMNING
STINK

CRUELTY
GARRULOUS
DECEIVED
BRUTE
UNPARDONABLE
MALADY
UNEASY
TREACHEROUS
DISTASTEFUL
DISOBEDIENCE
WANTON
FRICTION
OBJECTIONABLE
HORRORS
GRIEVOUS
HORROR
DISDAIN
HOSTILITY
ALARMED
HUMILIATED
SUFFERS
MISERABLY
FEARS
SUFFOCATED
BETRAYING

Positive

CELEBRATING
TENDERLY
SPLENDOUR
PLEASED
AGREEABLE
PASSION
COURAGE
OVERCAME
PLEASANTRY
LEISURE
KINDLY
NOURISHED
MIRTH
UNCONCERNED
PLEASURE
VALIANT
KINGLY
CARESS
FEASTED
MAGNIFICENCE
PROMINENT
FEASTS
COURTESY
LOYALLY
BRAVE
WARMLY
GRACIOUS

Violence

INCEST
POSITION
MURDER
FIGHT
WARHEADS
MURDERER
MURDERING
HOSTAGE
STONED
HANDGUNS
MURDERED
BLOODSHED
KILL
POISONED
FORCED
EXPLODED
TORTURES
SOLDIERS
SLAIN
THEFT
INFLICTION
SWORDS
WEDDING
OUTLAWS
TORTURED
SLAUGHTER
MASSACRE
STABS

Relationships

MAID
DAUGHTERS
NULLITY
LOVER
PATRIARCHS
HUSBAND
WIVES
SISTER
BRIDE
NEPHEW
WIFE
STRANGER
BRIDAL
SERVANTS
SENATOR
GRANDFATHER
BETROTHED
MARRIES
STRANGERS
TUTOR
TEAM
SISTERS
MISTRESSES
BONDAGE
BROTHERS
ROOMMATES
PEDIGREE
FATHERLY
SONS