



Geomagnetic Variables and US Market Descriptors as Predictors of the Frequency of Use of the Google Search Terms *Anxiety, Depression, Peace* and *Dow Jones*

Marco G. Di Feo

Psychology Department, Laurentian University

Lyndon Juden-Kelly

Psychology Department, Laurentian University

Stan Koren

Psychology Department, Laurentian University

Cynthia Whissell

Psychology Department, Laurentian University

ABSTRACT

This research examines relationships between Google search behaviours (frequency of searches) and world geomagnetic and US market variables. Frequency of searches for the terms *Anxiety, Depression, Peace*, and *Dow Jones* were predicted with moderate success ($p < .001$, R values between .31 and .46) from the combination of variables. For example, more searches involving *Anxiety* were performed when geomagnetic activity along the East-West axis and trading volume were both high.

Keywords: Google searches, geomagnetism, market performance

INTRODUCTION

Research has provided convincing evidence of relationships between changes in the earth's geomagnetic field and human behaviour. Weekly geomagnetic variability was associated with an increase in first aid mining accidents (Persinger & Nolan, 1984) and geomagnetic storm activity with an increase in suicide rates (Gordon & Berk, 2003). Artificial magnetic fields were shown to affect emotional states (Tsang, Koren, & Persinger, 2009) and increased geomagnetic storm activity predicted increases in psychiatric admissions (Friedman, Becker & Bachman, 1963). Krivelyova & Robotti (2003) demonstrated that the behaviour of the stock markets was related to the presence of geomagnetic storms, and suggested that the relationship between geomagnetic activity and market behaviours was likely mediated by changes in people's moods. The mechanisms by which geomagnetic variables have their effects is not entirely known, but dysregulation of melanin and the pineal gland, with ensuing changes in the autonomic nervous system, have been thought to be involved (Krivelyova & Robotti, 2003; Gordon & Berk, 2003).

Instead of dealing with extreme and rare events such as suicide attempts, psychiatric admissions, and geomagnetic storms, this research examines their day-to-day counterparts - the use of emotionally negative search terms on Google and daily levels of geomagnetic activity. Google search data have been applied to the study of both mental health phenomena (Nutti et al, 2014) and market behaviours (Preis, Moat, & Stanley, 2013). Because of the

demonstrated relationship of geomagnetic activity to mood, *Anxiety* and *Depression* were two of the search terms examined, and because of the relationship of geomagnetism to stock market behaviours, the search term *Dow Jones* was also included. Weekly frequency of Google searches for these terms, provided by Google Trends, was predicted from several variables reflecting ongoing levels of geomagnetic activity and from two market variables – the Dow Jones Index and Dow Jones trading volume.

METHOD

Weekly worldwide data for Google search frequencies were obtained from Google Trends¹ for 261 weeks beginning May 27th, 2012 to May 21st, 2017. Google Trends publishes relative rather than absolute values. Data were requested for all search terms entered simultaneously: *Depression*, *Anxiety*, and *Dow Jones*. Initially, the search term *Suicide* had also been included, but its frequencies were extremely low (in comparison to the other terms), and markedly skewed (beyond the point of correction by transformation), making it an inappropriate variable for correlational analyses. Because the terms *Depression*, *Anxiety*, and *Dow Jones* were all assumed to reflect negative mood, the search term *Peace* was included in the same request as a comparative term. It was expected that this term would have of a pattern of relationships to geomagnetic activity different from those of the negative terms.

Weekly geomagnetic data for the Earth were obtained from a site in Finland.² Data were available for strength of activity in three dimensions, X (South to North), Y (West to East) and Z (up to down),³ as were estimates of r (overall activity) and ϕ (measure of the earth's magnetic dipole), and an estimate of the variability of each of these over the week, resulting in 10 measures of geomagnetic activity (Table 1). Weekly Dow Jones data were obtained reflecting price (the Index) and trading volume.⁴ Time was represented by a variable indicating the number of the week (1 to 261).

Variables that were extremely positively skewed (frequency of searches for *Anxiety*, *Dow Jones*, and *Peace*, and the Dow Jones trading volume) were submitted to a \log_{10} transformation to correct the skew. There was a considerable time effect in the data. For example field strength along the Y axis and weekly anxiety search frequencies were both strongly correlated with time. These values represent long-term trends that dominate the data but are not the focus of the research. In the first case the trend might be due the sun spot cycles that influence magnetic activity; sunspots were on the rise in the years studied. The second trend is likely the outcome of the increased availability of computers and a rising use of Google searches worldwide between 2012 and 2017. All terms were corrected for time by predicting each variable from time and retaining the residual. After correction, search frequencies for *Depression* and *Anxiety* were correlated ($r=.65$, $p<.001$), and search frequencies for *Anxiety* and *Dow Jones* were correlated ($r=.18$, $p<.05$). There was no relationship between search frequencies for the terms *Depression* and *Dow Jones*. The frequency of searches for *Peace* was moderately correlated with that for all other search terms (*Depression*, $r=.38$; *Anxiety*, $r=.32$; *Dow Jones*, $r=.28$, $p<.001$).

¹ <https://trends.google.com/trends/?geo=US>

² <http://www.sgo.fi/Data/Magnetometer/magnData.php> (Finland)

³ <http://www.geomag.nrcan.gc.ca/mag fld/comp-en.php>

⁴ <https://www.investing.com/indices/us-30-historical-data>

RESULTS

Relationships between geomagnetic and market variables and search frequencies are reported in Table 1. Dow Jones volume, which reflects the level of trading activity, was positively related to all four search frequencies; as trading volume rose, searches for the terms *Anxiety*, *Depression*, *Dow Jones* and *Peace* also rose (independently of time). The Dow Jones Index, on the other hand, was negatively correlated to frequency of searches for *Anxiety*, *Dow Jones* and *Peace*; as prices rose, searches for these terms, but not for *Depression*, declined. Searches for the term *Dow Jones* were weakly but consistently related to all measures reflecting the variability of the Earth's magnetic field; greater variability was associated with more frequent searches.

There were several significant relationships among magnetic variables. To allow for simpler predictive equations, all potential predictors (10 magnetic variables and two market variables) were entered into a principal components analysis with a Varimax rotation. The analysis yielded four components that explained 84% of the total variance. The first component had high loadings for all the variability measures and was labeled *Magnetic Variability*. The second component included high loadings for phi and Y activity, a high negative loading for X activity, and a moderately high loading for trade volume. It was labeled *West-East Activity and Trade Volume*. The third component had high loadings for Z activity and r (overall activity), and the final component represented only the Dow Jones Index. These two components were labeled *Up-Down Activity* and *Prices*. Component scores were then employed as predictors of search frequencies in linear regressions with simultaneous entry of all four variables (Table 2).

Prediction was moderately successful in every case and each resulting formula was unique in terms of its significant contributors. Search frequencies for *Anxiety* were best predicted, and they tended to be high when *Magnetic Variability* and *Price* were low, and when *West-East Activity/Trade Volume* and *Up-Down Activity* were high. This means that when geomagnetic activity was strong along all dimensions and steady (i.e. when variability was low), and this activity was accompanied by falling stock prices, more Google users employed the search term *Anxiety*. The only significant predictor of searches for *Dow Jones* was the *Price* component, which was negatively related to it. As stock prices fell, there were more searches for the term *Dow Jones*. Searches for *Peace* increased when *West-East Activity/Trade* was high and when *Price* was low. Searches for *Depression* were highest when *West-East Activity/Trade Volume* was high and *Magnetic Variability* was low. The components employed in prediction were orthogonal to one another (totally unrelated), so the standardized weights in Table 2 also represent the correlations between components and search term frequencies.

DISCUSSION

Data reported and discussed in this paper point to the fact that common everyday behaviours such as Google searches are correlated with week to week changes in levels of geomagnetic activity and can be predicted from such activity and from the behaviours of the markets. Distinct predictive formulas suggest that different processes underlie the use of each of the search terms. All the components representing market and geomagnetic predictors entered significantly into one or another predictive formula. *West-East Activity/Trade Volume* and *Price* were the components making the strongest contributions to prediction. High *West-East Activity/Trade Volume* predicted more searches for *Depression*, *Anxiety*, and *Peace*. This might be the result of the destabilizing influence of high geomagnetic activity in this dimension which led to negative emotions and a heavier than usual amount of trading (jittery markets). High *Price* predicted fewer searches for *Anxiety*, *Dow Jones*, and *Peace*, which could suggest a greater assurance (and a lesser need to search) in times of a high Dow Jones Index.

These data rely on correlational analyses and should not be employed in reaching conclusions about causation. They do, however, point to the existence of multiple systematic relationships between the frequency with which people searched Google using various key terms and world geomagnetic and US market variables. Such relationships warrant continued study.

Table 1 Significant relationships between search variables and US market and world geomagnetic variables ($p < .001$, variables corrected for time)

<u>Market and Geomagnetic Variables</u>	Google Search Frequencies			
	<u>Depression</u>	<u>Anxiety</u>	<u>Dow Jones</u>	<u>Peace</u>
DJ ^a Volume	.31	.43	.28	.19
DJ Price	---	-.27	-.38	-.38
X	-.17	-.26	---	---
Y	---	.21	---	---
Z	---	.15	---	---
r	---	---	---	---
Phi	.13	.25	---	---
sdX ^b	---	---	.12	---
sdY	---	---	.12	---
sdZ	---	---	.14	---
sdr	---	---	.14	---
sdPhi	---	---	.13	---

^a DJ stands for "Dow Jones"

^b sd indicates a standard deviation for a variable across the week.

Table 2 Standardized regression formulas for the prediction of the frequency of Google searches for four search terms from four component scores representing world geomagnetic and US market activity

<u>Predictive Components</u>	Criteria (Search Terms)			
	<u>Depression</u>	<u>Anxiety</u>	<u>Dow Jones</u>	<u>Peace</u>
Magnetic Variability	-.15*	-.12*	.07	-.08
West-East Activity/ Trade Volume	.26*	.38*	.06	.17*
Up-Down Activity	.05	.12*	.09	.04
Prices	.03	-.19*	-.28*	-.32*
$R_{4,255} (p < .001)$.31	.46	.31	.37

*significant individual predictor within the formula, $p < .05$

References

- Friedman, H., Becker, R. & Bachman, C. (1963) Geomagnetic parameters and psychiatric hospital admissions. *Nature*, 200, 626-628.
- Gordon, C. & Berk, M. (2003) The effect of geomagnetic storms on suicide. *South African Psychiatry Review*, 6, 24-27.
- Krivelyova, A. & Robotti, C. (2003) Playing the field: geomagnetic storms and international stock markets. *Federal Reserve Bank of Atlanta, Working Paper No. 2003-5a*, Federal Reserve Bank of Atlanta, Atlanta, GA.
- Nuti, S., Wayda, A., Ranasinghe, I., Wang, S., Dreyer, R. P., Chen, S., & Murugiah, K. (2014) The use of Google Trends in health care research: a systematic review. *PLOS ONE*, 9, 1-49, e109583.
- Persinger, M. & Nolan, M. (1984) Geophysical variables and behavior: XX. Weekly numbers of mining accidents and the weather matrix: the importance of geomagnetic variation and barometric pressure. *Perceptual and Motor Skills*, 59, 719-722.
- Preis, T., Moat, H. & Stanley, E. (2013) Quantifying trading behavior in financial markets using Google Trends. *Scientific Reports*, 3:1684.
- Tsang, E., Koren, S., & Persinger, M. (2009) Specific patterns of weak (1 microTesla) transcranial magnetic fields differentially affect depression, fatigue, and confusion in normal volunteers. *Electromagnetic Biology and Medicine*, 28, 365-373.