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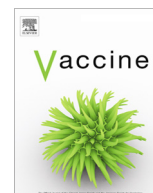
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Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine



A comparison of language use in pro- and anti-vaccination comments in response to a high profile Facebook post, ☆☆☆



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ARTICLE INFO

Article history:

Received 26 July 2016

Received in revised form 14 September 2016

Accepted 15 September 2016

Keywords:

Vaccination

Immunization

Health decision making

Perceived risk

Anxiety

Social media

Linguistic analysis

ABSTRACT

Background: Vaccinations are important for controlling the spread of disease, yet an increasing number of people are distrustful of vaccines, and choose not to (fully) vaccinate themselves and their children. One proposed contributor to this distrust is anti-vaccination misinformation available on the internet, where people search for and discuss health information. The language people use in these discussions can provide insights into views about vaccination.

Methods: Following a prominent Facebook post about childhood vaccination, language used by participants in a comment thread was analysed using LIWC (Linguistic Inquiry and Word Count). Percentage of words used across a number of categories was compared between pro-vaccination, anti-vaccination, and unrelated (control) comments.

Results: Both pro- and anti-vaccination comments used more risk-related and causation words, as well as fewer positive emotion words compared to control comments. Anti-vaccine comments were typified by greater analytical thinking, lower authenticity, more body and health references, and a higher percentage of work-related word use in comparison to pro-vaccine comments, plus more money references than control comments. In contrast, pro-vaccination comments were more authentic, somewhat more tentative, and evidenced higher anxiety words, as well as more references to family and social processes when compared to anti-vaccination comments.

Conclusion: Although the anti-vaccination stance is not scientifically-based, comments showed evidence of greater analytical thinking, and more references to health and the body. In contrast, pro-vaccination comments demonstrated greater comparative anxiety, with a particular focus on family and social processes. These results may be indicative of the relative salience of these issues and emotions in differing understandings of the benefits and risks of vaccination. Text-based analysis is a potentially useful and ecologically valid tool for assessing perceptions of health issues, and may provide unique information about particular concerns or arguments expressed on social media that could inform future interventions.

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1. Introduction

Vaccinations are important for preventing the spread of disease through a population. However, concerns about possible adverse effects and the safety of new vaccines are prevalent [1] and linked

to lower vaccination rates [2]. Vaccine concerns and refusals are increasing [3–5], and refusals are linked to outbreaks of preventable illnesses. For example, in 2014 the United States experienced a record number of measles cases [6,7]; in developed countries a large proportion of these infections occur among the intentionally unvaccinated [8].

Even when vaccination rates are generally high, clusters of un- or under-vaccinated children have been linked to disease outbreaks [9]. These outbreaks also affect children with compromised immune systems precluding vaccination and those too young to be vaccinated—at a large cost to individuals and the public-sector. Vaccine refusal is not evenly distributed in the population – it occurs predominantly in public charter and private schools, and in schools in high socioeconomic areas [5,10], which also have a

* Author contributions: KF was primarily responsible for conception and design, as well as contributing substantially to acquisition, analysis, interpretation, and write-up; LRM contributed to design, analysis, interpretation, and write-up; and CJC contributed to acquisition, analysis, and critical revision. All authors approve this submitted manuscript.

☆☆ This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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higher proportion of parents with concerns about the safety and health risks of vaccines [11]. This is consistent with other studies linking vaccine-resistance with education levels [12]. While the proportion of internet users on Facebook does not differ substantially by either income or education level [13], internet users themselves are more likely to have both higher levels of education and household income [14]. This makes the internet a useful domain within which to examine vaccine hesitancy, and Facebook provides a forum in which such views are discussed and information disseminated [15].

One hypothesised reason for heightened concern about vaccine safety is anti-vaccination misinformation readily available on the internet [16,17]. People increasingly consult the internet on a range of health issues, and discuss their health perspectives online [18]. Online health-related information is often inaccurate or incomplete [19]. Anti-vaccination webpages contain particularly low quality information, and much of the provided critique is also mediocre [20]. The impact of exposure to such information is striking; for example, viewing a website containing anti-vaccination information for 10 min or less increased perceived risk of vaccination, and decreased the perceived risk of vaccine refusal [21].

Misinformation spreads readily over the internet, and is often resistant to correction [22]. This is compounded by an “echo chamber” effect whereby people self-select into groups and seek out sources of information that reinforce pre-existing beliefs, including beliefs about vaccination [23,24]. Occasionally, however, people with opposing viewpoints are brought together in one (virtual) location. This happened in January 2016, when Mark Zuckerberg (co-founder of Facebook) posted a photo of himself holding his baby daughter, captioned “Doctor’s visit – time for vaccines!” As of May 2016, the post had received approximately 3.4 million ‘likes,’ and 84,000 comments. Commenters addressed the risks of vaccination and vaccine refusal, resulting in a discussion between individuals unlikely to engage with one another under different circumstances and providing a unique opportunity to compare the emotional and cognitive components of broadly pro- and anti-vaccination comments using linguistic analysis.

The words that people use can provide important insights into their thoughts and emotions [25,26]. Within the health domain, language use has been linked to successful weight loss, determining expert versus lay health advice, and public anxiety and online health-information seeking behaviour during an illness outbreak [27–29]. The Linguistic Inquiry and Word Count (LIWC) text analysis program’s [30] dictionary comprises psychologically meaningful word categories, and output includes the percentage of words within a given text that belongs to each category. Applying this technique allows for a direct comparison of emotional content, cognitive processes, and areas of particular importance in pro- and anti-vaccination (and unrelated, control) comments.

It is important to note that the characterizing individuals as “pro-vaccine” or “anti-vaccine” greatly oversimplifies. Yes, some people are universally supportive or critical of vaccines, but many others occupy a middle-ground in which the value of vaccines is recognized but potential dangers pose real concerns [31]. The focus of the present study, therefore, is the content of the actual statements, claims, and comments that individuals make rather than the classification of their personal beliefs more generally.

Because the scientific data clearly support the safety and efficacy of vaccines, we hypothesized that comments expressing opposition to vaccinations would have less evidence of analytic thought. Because vaccine hesitancy is often associated with heightened perceptions of risk and concerns about safety, we hypothesised that anti-vaccination comments would also use more risk-related, anxiety, and health words. Finally, because vaccine-sceptical websites often include arguments about responsible parenting, possible vaccine-caused harm to the immune system, and

profit-related conspiracies [17], we hypothesized that anti-vaccine comments would contain more family-, biological-, money-, and work-related (the category including medical, scientific, government, and corporate references) words.

The aim of this study was to investigate the types of arguments and language used by pro- and anti-vaccination individuals within the same conversational context in an effort to better understand underlying thought processes and inform future attitude- and behaviour-change attempts.

2. Method

We monitored responses to the original “time for vaccines” photograph post on Facebook over the subsequent week. One particularly popular comment (which garnered over 49,000 likes) and the 1489 replies to that comment which were posted within one week, were selected for analysis. This presented the largest number of related comments (i.e. forming the ongoing conversation) available, enabling a direct comparison of language use in pro- and anti-vaccination comments under the same circumstances. Similar to many of the earliest comments on the photograph, the selected comment was in favour of vaccination. The one-week time period was chosen because of the generally rapid spread and subsequent decay of interest in social media content [32], which was seen in the current study where the number of comments posted each day diminished quite rapidly from 790 comments on day one (with 277, 149, 129, 61, and 60 comments posted on days two through six, respectively) to only 24 comments on day seven.

This research was conducted with the approval of the University of New South Wales Behavioural Sciences Human Research Ethics Advisory Panel (UNSW HREAP Approval Number 2694). All data collected for this study were publicly available through Facebook, thus informed consent was not required.

2.1. Facebook comment data

All identified comments (index comment, plus 1489 response comments) were aggregated into a single Excel spreadsheet. Commenters’ names and names of other Facebook users to whom statements were directed, were removed from the dataset. In addition, all image files (most often ‘meme’ images) and html tags were removed. Meme image text was not retained for analysis because the focus of the current research was on the language people chose to use when discussing vaccination. While meme images are interesting in their own right, and represent varying opinions, the language contained within them was not generated by the commenter themselves. Data indicating the date and time that comments were posted was retained, and each comment was assigned a number between 1 and 1490 indicating its chronological appearance. Number of ‘likes’ for each comment were also retained. Facebook ‘reactions’ (love, haha, wow, sad, and angry) were not globally available until late February 2016 [33], and thus were not available at the time the original photo and subsequent comments were posted.

2.2. Data coding

To assess differences between comment types, two independent raters coded all comments as ‘pro-vaccination,’ ‘anti-vaccination,’ or ‘unrelated or unclear.’ A third independent rater (who was unaware of study hypotheses) resolved disagreements, and 14 cases where all three raters disagreed were resolved through discussion between the two initial raters. Commenter names were removed from the dataset prior to coding to reduce potential rater bias from emerging. See [Supplementary Materials](#) for examples of comments coded into each category and those that

were challenging to code. Interrater reliability was assessed using Cohen's kappa ($\kappa = 0.77$, $p < 0.001$, 95%CI[0.75,0.80]), and substantial agreement was established [34]. A total of 486 (32.6%) comments were classified as pro-vaccination (e.g. "thank you for being a smart person and doing what's best for your child and the community"), 330 (22.1%) as anti-vaccination (e.g. "injecting newborns and infants with disease and neurotoxins is disgusting science that injures millions every year"), and 674 (45.2%) as unclear or unrelated control comments (e.g. "Holy crap this convo is still going on? Imfao!").

2.3. LIWC analysis

To compare language use across comment categories, all pro-vaccination, anti-vaccination, and unrelated comments were aggregated into three separate Word files and processed as 100-word segments (as suggested by Mehl and Gill [35] for reliability of analysis in low frequency categories) using the Linguistic Inquiry and Word Count text analysis program, LIWC2015 [30], and a procedure similar to that used for blog data in response to an infectious disease outbreak [29]. LIWC is an automatic text analysis program that counts and calculates the percentage of words in a variety of linguistically and psychologically meaningful categories, including categories relating to specific topics (e.g. body and health-related language), emotions (e.g. anxiety), and social relationships (e.g. family-related word use). The program uses a comprehensive dictionary with subjective categories (e.g. emotion words) derived from a systematic rating procedure carried out by three experienced independent judges, as well as categories reflecting dimensions of language (e.g. articles and prepositions) [36]. LIWC has demonstrated reliability and validity as a method for assessing psychological constructs, particularly those related to emotion [36]. For the analyses, the percentage of words in each category was computed.

The following linguistic categories are computed: summary variables (analytical thinking, authenticity); affective processes (positive emotion, anxiety, anger); social processes (social, family); cognitive processes (causation, tentative, certainty); biological processes (body, health); drives (risk); personal concerns (work, money, death) – see Table 1. Summary variables of analytical thinking and authenticity are new additions to LIWC 2015, and

Table 1
Examples and number of words in examined LIWC categories.

Category	Examples	Words in category
Analytical thinking	–	–
Authenticity	–	–
Positive emotion	Good, smile, happy	620
Anxiety	Worried, scary, alarming	116
Anger	Hate, kill, attack	230
Social processes	Talk, they, together	756
Family	Baby, parent, family	118
Causation	Activated, caused, outcome	135
Tentative	Doubtful, ambiguity, incomplete	178
Certainty	Definitely, always, proven	113
Body	Brain, blood, womb	215
Health	Injury, poison, health	294
Risk	Safety, danger, concern	103
Work	Doctor, research, government	444
Money	Profit, compensation/payouts ^a , economic	226
Death	Kill, fatalities, plague/murder ^b	74

^a Interestingly, the word 'compensation' is used exclusively in anti-vaccination comments, while 'payouts' only appears in pro-vaccination comments.

^b Similarly, 'murder' is only seen in anti-vaccination comments, while 'plague' references appear only in pro-vaccine comments.

are the only non-transparent dimensions, in that they are derived from algorithms (based on previous research) reflecting a particular balance of word usage across a number of categories [30]. Authenticity scores enumerate linguistic markers of deception [37]. Higher scores reflect more authentic (less deceptive) language use. Deception comprises a cluster of linguistic markers: fewer first-person singular (I, my, me) and third-person (she, their, them) pronouns, fewer exclusive words (but, except, without), and more negative emotion words (hate, worthless, enemy) and motion verbs (walk, move, go). Higher analytical thinking scores are indicative of categorical versus dynamic language use, with greater use of the former being related to academic success [38]. High scores reflect greater use of articles (a, an, the) and prepositions (to, with, above), and lower use of personal (I, them, her) and impersonal (it, it's those) pronouns, auxiliary verbs (am, will, have), conjunctions (and, but, whereas), adverbs (very, really), and negations (no, not, never). Examples of comments from the current study that score highly on authenticity and analytical thinking can be found in the [Supplementary Materials](#). Each variable is derived from previously published findings and standardized scores from comparison samples enable the generation of percentile information.

Categories in LIWC are generally arranged hierarchically, with all words in a subcategory also present in the parent category [30]; therefore, parent categories were not analysed where their subcategories were of more interest, with the exception of social processes. The social processes category comprises not only subcategory words (family, friends, male, female) but also includes words relating to human interaction (e.g. talking, sharing).

2.4. Statistical analyses

Analyses were carried out using SPSS version 23. The percentage word use within the selected LIWC categories was not normally distributed within the comment groupings, and non-parametric statistical tests were employed. Kruskal-Wallis Independent Samples tests were used to compare language use across the three groups, and pairwise comparisons with a Bonferroni correction were conducted to further investigate significant main effects. An alpha level of 0.05 was used.

3. Results

Before completing linguistic analysis, Kruskal-Wallis comparisons were made across groups for word count, comment number (indicating distribution of comments throughout the week), and number of 'likes' received. All three outcomes differed significantly across the three groups, $ps < 0.05$. Bonferroni-corrected pairwise comparisons were used to further investigate these differences. Unrelated comments were more frequent earlier in the week than were anti-vaccination comments ($p = 0.04$). There were no distribution differences between pro- and anti-vaccination comments, or between unrelated and pro-vaccination comments ($ps > 0.48$). Pro-vaccination comments received significantly more 'likes' ($Med = 4$, $IQR = 6$), than unrelated ($Med = 1$, $IQR = 3$; $p < 0.001$) and anti-vaccination comments ($Med = 2$, $IQR = 3$; $p < 0.001$). Anti-vaccination comments, in turn, garnered more 'likes' than did unrelated comments ($p < 0.001$). Both pro- ($Med = 39.5$, $IQR = 56$) and anti-vaccination comments ($Med = 40$, $IQR = 60$) contained more words per comment than unrelated comments ($Med = 14$, $IQR = 22$; $p < 0.001$), but did not differ from one another ($p = 0.35$).

When examining word use categories, anti-vaccination comments were significantly higher in analytical thinking than either the unrelated ($U = 83.51$, $p < 0.001$) or pro-vaccination ($U = 85.11$,

$p < 0.001$) comments (see Table 2). See Table 3 for examples of comments scoring highly in each of the examined LIWC categories across pro-vaccination, anti-vaccination, and control comments. Pro-vaccination comments evidenced greater authenticity than anti-vaccination comments ($U = -48.23$, $p = 0.013$). Both pro- and anti-vaccination comments had significantly fewer positive emotion words than control comments ($U_{\text{pro}} = -92.61$, $p < 0.001$; $U_{\text{anti}} = -122.21$, $p < 0.001$). Pro-vaccination comments contained more anxiety-related words than either control ($U = 58.56$, $p = 0.001$) or anti-vaccination comments ($U = -33.57$, $p = 0.047$), but there were no differences found for anger words, $p = 0.50$. Anti-vaccination comments contained fewer social and family-related words than either control ($U_{\text{soc}} = -103.20$, $p < 0.001$; $U_{\text{fam}} = -56.66$, $p = 0.005$) or pro-vaccination comments ($U_{\text{soc}} = -55.75$, $p = 0.001$; $U_{\text{fam}} = -67.56$, $p < 0.001$).

With regard to word use reflecting cognitive processing, certainty words did not differ across groups ($ps > 0.29$) but causal word use did differ, with both pro- ($U = 74.53$, $p < 0.001$) and anti-vaccination ($U = 61.79$, $p = 0.007$) comments evidencing more causal language than control comments. Anti-vaccination comments showed a trend toward less use of tentative language than pro-vaccination comments ($U = -39.26$, $p = 0.055$). Anti-vaccination comments used significantly more body-related words than did pro-vaccine comments ($U = 95.41$, $p < 0.001$), which also used fewer body words than control comments ($U = -50.39$, $p = 0.019$). Similarly, anti-vaccination comments contained more health-related words than either control ($U = 127.49$, $p < 0.001$) or pro-vaccination comments ($U = 42.63$, $p = 0.032$), which in turn contained more health words than control comments ($U = 84.86$, $p < 0.001$). Both pro- and anti-vaccination comments contained more risk-related words than control comments ($U_{\text{pro}} = 83.97$, $p < 0.001$; $U_{\text{anti}} = 68.58$, $p = 0.001$). Anti-vaccination comments also referenced significantly more work-related words than pro-vaccine comments ($U = 52.45$, $p = 0.005$), and more money-related words than control comments ($U = 27.06$, $p = 0.025$). Death references did not differ across the comment groups, $p = 0.13$.

4. Discussion

Efforts have focused, albeit with less-than-spectacular success, on changing the attitudes and behaviours of vaccine-hesitant

individuals [39]. Because the scientific evidence regarding vaccines appears clear, the anti-vaccine viewpoint is often viewed as overly emotional, irrationally suspicious, and angry – and anecdotal illustrations of these qualities certainly exist. The current findings indicate, however, that such irrational and emotional qualities do not typify the argument-style or language of Facebook users who make comments indicating opposition to vaccinations. Instead, the anti-vaccination comments contained linguistic markers of analytical thinking, characterised by categorical language use, often appearing as factual (or in this case, pseudo-factual) and logically structured statements that mimic valid scientific information. This, as well as relatively lower use of anxiety-related words (giving the impression of confidence in one's correctness), may make anti-vaccination arguments particularly compelling for uncertain parents seeking information about childhood vaccinations. Such language use gives the appearance of certainty and analytical thinking, even though the conclusions that have been reached are not scientifically based. Contrary to expectations, the anti-vaccination comments not only showed evidence of more linguistic markers of analytical thinking than either the pro-vaccination or unrelated comments, they also contained fewer anxiety-words than did the pro-vaccination comments and were no different from the pro-vaccination comments in positive emotions, or in anger. Although the anti-vaccination comments did contain more body and health-related words, there was no difference in death-related words.

The significantly more anxious nature of the pro-vaccination posts, along with their greater family-related content, is also worth noting. It may be that these individuals have a greater awareness and understanding of the scientific data (the non-significant trend toward their use of more tentative language is consistent with this view) and thus a greater cause to worry, especially about their own families whom they believe may be harmed by the failure of others to accept vaccinations. Similarly, the relative absence of anxiety word use in anti-vaccination comments may reflect a Dunning-Kruger type effect [40], whereby commenters express less anxiety because they do not realise the erroneous nature of their beliefs, their flawed interpretation of the scientific evidence, nor the health risks to themselves and society inherent in their refusal of vaccinations.

The summary variables of analytical thinking and authenticity are new to LIWC 2015. Higher values for analytical thinking are

Table 2
Group differences in percentage of word use in LIWC categories.

Variable	Pro-vaccination (%)				Anti-vaccination (%)				Unrelated (%)				χ^2	p
	Rank	Mdn	IQR	M (SE)	Rank	Mdn	IQR	M (SE)	Rank	Mdn	IQR	M (SE)		
Analytical thinking	306.65 ^a	42.90	35.41	44.90 (1.36)	391.76 ^b	57.10	42.71	56.32 (1.71)	308.25 ^a	40.12	38.09	45.58 (2.04)	29.45	<0.001***
Authenticity	359.29 ^a	25.24	37.83	32.54 (1.39)	311.06 ^b	20.24	36.67	27.90 (1.57)	341.25 ^{a,b}	25.24	40.87	30.92 (2.05)	8.22	0.016*
Positive emotion	329.71 ^a	2.00	3.00	2.56 (0.11)	300.12 ^a	2.00	2.00	2.24 (0.11)	422.33 ^b	4.00	3.00	3.76 (0.22)	36.79	<0.001***
Anxiety	362.29 ^a	0.00	1.00	0.57 (0.05)	328.73 ^b	0.00	1.00	0.43 (0.05)	303.73 ^b	0.00	0.00	0.29 (0.05)	13.88	0.001**
Anger	346.60	1.00	1.00	0.90 (0.06)	328.06	0.50	1.00	0.81 (0.07)	337.65	1.00	1.00	0.88 (0.09)	1.40	0.498
Social	348.55 ^{a,+}	11.00	6.00	11.20 (0.27)	292.79 ^b	10.00	7.00	9.91 (0.29)	396.00 ^{a,b,+}	13.00	6.00	12.14 (0.39)	26.48	<0.001***
Family	364.46 ^a	1.00	2.00	1.07 (0.09)	296.89 ^b	0.00	1.00	0.52 (0.05)	355.55 ^a	0.00	2.00	0.99 (0.11)	21.03	<0.001***
Causation	357.99 ^a	3.00	3.00	2.76 (0.11)	345.25 ^a	2.00	3.00	2.65 (0.12)	283.46 ^b	2.00	2.00	2.11 (0.13)	14.77	0.001**
Tentative	352.00 ^{a,+}	3.00	3.00	2.97 (0.11)	312.75 ^{a,+}	2.00	2.25	2.63 (0.13)	353.48 ^a	3.00	2.00	3.04 (0.19)	6.71	0.035*
Certainty	343.76	2.00	2.00	2.06 (0.09)	338.64	2.00	2.00	2.04 (0.10)	324.85	2.00	2.00	1.88 (0.13)	0.93	0.629
Body	292.85 ^a	0.00	1.00	0.58 (0.06)	388.26 ^{b,+}	1.00	2.00	1.23 (0.10)	343.24 ^{b,+}	0.00	1.00	0.99 (0.13)	38.04	<0.001***
Health	339.94 ^a	2.00	3.00	2.71 (0.12)	382.57 ^b	3.00	2.00	3.22 (0.15)	255.08 ^c	1.00	2.00	1.94 (0.16)	39.00	<0.001***
Risk	360.90 ^a	1.00	2.00	1.08 (0.07)	345.51 ^a	1.00	1.00	0.97 (0.07)	276.93 ^b	0.00	1.00	0.63 (0.08)	20.47	<0.001***
Work	311.27 ^a	2.00	2.00	2.04 (0.11)	363.72 ^b	2.00	3.00	2.67 (0.15)	348.26 ^{a,b}	2.00	2.00	2.36 (0.17)	10.48	0.005**
Money	331.46 ^{a,b}	0.00	1.00	0.42 (0.05)	358.52 ^a	0.00	1.00	0.61 (0.07)	315.33 ^b	0.00	0.00	0.35 (0.07)	7.84	0.020*
Death	346.23	0.00	1.00	0.45 (0.04)	341.47	0.00	1.00	0.45 (0.05)	314.68	0.00	0.00	0.30 (0.05)	4.09	0.129

^{a,b,c} Cells with different superscripts are significantly different at $p < 0.05$ (Bonferroni corrected).

* Indicates groups where differences did not reach statistical significance but demonstrated a trend at $p < 0.10$.

Table 3

Examples of comments scoring highly on examined LIWC categories in pro-vaccination, anti-vaccination, and neutral/unclear control comments.

	Pro-vaccination	Anti-vaccination	Control
Analytical thinking	<i>Since the introduction of vaccines the American life expectancy nearly doubled</i>	<i>Vaccines cause death! Look up the vaccine injury court! It's a disgusting sham but it exists! Every disease was in the decline before the vaccine</i>	<i>Actually, that's an example of your limited intellect and reliance on the comic book of the internet for your information ...</i>
Authenticity	<i>When the West is too rich and caught up in their own woo to remember or appreciate the fear in being deathly sick</i>	<i>So im suppose to inject myself with poison in order to protect other people? That doesnt really seem fair</i>	<i>I think your daughter is lovely I remember when my grandaughter was that age enjoy every moment</i>
Positive emotion	<i>Thank you for the intelligent choice! Great father!</i>	<i>Oh thank goodness for this guy. He changed my mind. Lol #vaccineskill #neverpumpingpoisonintomykids</i>	<i>Hahaha man, I love comment sections</i>
Anxiety	<i>I don't think parents should have a right to spread deadly diseases based on their own irrational fears and gullibility, being fooled by propagandists to believe that vaccines are "cocktails."</i>	<i>Shame on him and any person who shoots toxins into a body bypassing the gut!</i>	<i>Don't be afraid. ... just be more aware!</i>
Anger	<i>If you believe that vaccines cause autism then frankly you are a f**king idiot</i>	<i>F**k all of you, this vaccines are full of s**t and make you stupid and sick. Open your eyes</i>	<i>Go play in traffic dumbass</i>
Social	<i>Thank you to all of you who have gotten yourselves and your children vaccinated</i>	<i>Everyone who says there kid has autism says they are also vaccinated. Not one said they werent. Pretty evident</i>	<i>Well said! Thanks for sharing your perspective</i>
Family	<i>My son a kid in my sons class died of a disease long iradicated polio. Bet those parents wish they vacinated</i>	<i>I think parents should have a right to say yes or No. I don't think we should be giving vaccine cocktails to babies either</i>	<i>I think that is his daughter not son. ...</i>
Certainty	<i>YES!! Vaccines do NOT cause autism! Complete myth! Vaccinate children, everyone!</i>	<i>Ur an idiot vaccinations kill an undeniable fact</i>	<i>Disagree what? everyone is in positive agreement in all comments!!!!</i>
Causal	<i>That's because vaccines don't cause autism</i>	<i>...Because autism is the only reason people don't vaccinate. Riiiiight</i>	<i>Organic food causes autism</i>
Tentative	<i>Even if vaccines DID cause autism, the belief that autism is somehow a worse fate than painful, crippling disease and/or DEATH is beyond me</i>	<i>You probably have autism/asbergers because of the vaccines not any other reason</i>	<i>You may want to read this. ...</i>
Body	<i>There is more research linking early use of antibiotics killing gut flora being linked to autism than vaccines</i>	<i>Shame on him and any person who shoots toxins into a body bypassing the gut!</i>	<i>Took the words right out of my mouth (keyboard? fingers?)</i>
Health	<i>Yes pro-disease. If you reject vaccines you are actively promoting preventable disease</i>	<i>...Our bodies are made to deal with disease. Its called an immune system. And an uncompromised immune system works bloody well. Keep your vaccines</i>	<i>When doctors started telling women to quit caffeine when pregnant that's when autism became more rampant</i>
Risk	<i>There are risks to all medicines and all vaccinations but there are bigger risks by not getting vaccinated</i>	<i>Vaccination can be a very dangerous act... vaccins can cause autism and other dangerous reactions ...</i>	<i>You are a dangerous idiot</i>
Work	<i>I trust the government because of one reason: The have good researcher with certificate from a university. And I mean real university - not the You-Tube-University</i>	<i>If you trust what this government tells you, you really need to research</i>	<i>The temple of Scientism?...Science isn't a religion. Nor is capitalism</i>
Money	<i>Sure sounds like vaccines are profitable *eye roll*</i>	<i>BIG PHARMACY, BIG PROFIT, BIG BUSINESS, Do u trust the FDA.Check ingredients in your food supply. Good luck</i>	<i>Toyota, 1 company, is worth \$230 billion</i>
Death	<i>Chances of injury or death from vaccine are one in one point two million, if an unvaccinated baby suffering injury or death is one in one thousand</i>	<i>Unfortunately big Pharma and big Chem are combined to a toxic power of death to our species!</i>	<i>Like Peter Pan? Everyone dies</i>

indicative of categorical language use, cognitive complexity, and abstract thinking, and associated with success in tertiary education [38]. This finding is broadly consistent with recent literature indicating that highly educated parents hold more negative attitudes towards vaccination and report lower intentions to have their children vaccinated [41]. The results also suggest that pro-vaccination comments are more authentic, or less deceptive, than comments that are distrusting of vaccination [37]. The reasons for this are unclear, and it would be premature to assume that these linguistic markers necessarily indicate deception in this context. It may be that communication style directed towards persuading others shares some similarities with deceptive language, particularly because, much like deliberate deception, persuasive communication is an attempt to present information in such a way as to be compelling to the reader. Additionally, mean authenticity scores in the current sample (ranging from 28 to 33%) are all markedly lower than base rate usage across blogs (61%) and Twitter (50%) from a large comparison dataset [30].

The high percentage of biological, health, money and work-related words contained within the anti-vaccination comments appear to link to some of the themes that Davies and colleagues identified in their analysis of anti-vaccination websites [17], namely establishing vaccination hesitancy as being scientifically valid, positioning vaccines as poisons and damaging to health

and the immune system, and assertions of a conspiracy between the medical profession, pharmaceutical industry, and government, to deny vaccine harm in order to generate continued profits. The theme of rapport building with concerned and unsure parents does not appear to be supported in the current data, with much lower social and family word use, and lower positive emotions words in comments relating to vaccination more generally. However, this may not have been the primary aim of communication in this forum, and perhaps indicates that concern for society and family is less important to the anti-vaccination position than websites might suggest.

Queries regarding thought processes, beliefs, and fears about vaccines are typically made using standard survey methods. Unstructured, self-initiated indicators of these constructs as in the present study would have been difficult to obtain prior to the advent of social media. Many people use their real names on Facebook and the medium is not anonymous, but individuals may nonetheless feel somewhat less subject to the constraints of social norms when posting online – if this is the case, an argument may be made that data of this sort are less biased than data collected using more traditional survey methods.

One important limitation, however, is that language may have been guided not only by commenters own views, but also by what they thought would be particularly persuasive to others. For

example, the higher use of social and family words in pro-vaccination comments may reflect a belief that these would be relevant to others, and foster more positive attitudes toward vaccines. Similarly, the *subject* of expressed anxiety is likely to reflect the commenters' desire to construct arguments to persuade those with opposing opinions. Higher anxiety word use in pro-vaccination comments in conjunction with social and family references may reflect an emphasis of the communal nature of vaccination as protecting vulnerable members of society – which necessitates expressing anxiety about those vulnerable individuals. In contrast, anxiety word use in anti-vaccination comments alongside health or body-related language may reflect attempts to persuade others about the perceived dangers of 'toxic' effects of vaccines. Nevertheless, the present findings provide a different perspective on vaccination views, and are particularly useful because they provide insight on the segment of the population that holds vaccine-positive views—a group that typically receives little focus.

The current research highlights a particular challenge for public health communication in the time of Web 2.0 [42]. With the increasing popularity of social media and interactive internet environments it is important to remember that pro-vaccination health messaging, much like anti-vaccination messaging and other user-generated content on the internet and in social media, is not exclusively produced by reputable sources. Given that strategies commonly used by public health agencies are not always effective and may produce backfire effects on vaccine intention [39], the influence of social media interactions with pro-vaccination messaging from members of the general population that is sometimes unclear, hostile, and inaccurate, may be particularly problematic both for those engaged in the conversation, and for viewers who choose to read but not engage in the online conversation.

Anti-vaccination comments in the current sample tended to be more analytical, with a focus on body, health, work (professions involved in research and medical care), and money-related word use. This suggests a group attempting to provide scientific explanations for an unscientifically-backed perspective, as well as broader concerns about the monetary motivations of medical professionals, scientists, pharmaceutical companies, and governments. In contrast, comments in favour of vaccination evidenced greater anxiety, as well as a greater focus on social processes and family-related language. The linguistic profile is suggestive of a group discussing their own fears and anxieties, particularly with respect to the social impact of vaccination-rejection generally, and implications for their families more specifically. This apparent mismatch between the concerns and focus of pro- and anti-vaccination comments provides insight into how we might go about reassuring pro-vaccination groups, and also indicates that the arguments that those *supporting* vaccination think are compelling may not be particularly well matched with the concerns of those *opposed* to vaccination. Education targeted toward enhancing understanding of science and the scientific method, and accurate messaging around health and biological mechanisms of vaccination, may be more effective in shifting views of the vaccine-hesitant compared to messages with a focus on the importance of immunization for protecting vulnerable members of society.

Conflict of Interest

None of the authors has any conflict of interest to disclose.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.vaccine.2016.09.029>.

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