

1 **How do drivers recall positive and negative driving events? A quantitative approach to**  
2 **analysing driving diaries.**

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6 1. Abstract

7 Whilst diary studies are often analysed in a qualitative manner, quantitative methods which  
8 analyse the percentage of different types of language used in diary entries, now exist. From a  
9 driving perspective, this could arguably tell us more about the underlying psychological  
10 processes occurring when drivers reflect on their on-road experiences. As part of a larger  
11 project, the current study used a quantitative method of language analysis, known as word  
12 count analysis, to compare driver diaries in which positive and negative driving events were  
13 reflected upon. Results suggested that when describing positive events, drivers discuss them  
14 with more elaborate and descriptive language and focus on certainty and goal-driven  
15 processes. Negative events, however, had more of a social focus as indicated by an increased  
16 use of function words. These findings provide insights into the ways in which positive and  
17 negative driving events may be appraised. Additionally, drivers used more words indicating  
18 control and reward when describing positive driving events; this is discussed in consideration  
19 of how word count analyses can provide further insight into psychological process associated  
20 with emotion, such as appraisals.

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23 Keywords: Word count analyses, emotion, control, appraisals

## 24 2. Introduction

25 Drivers are reported to be happier than those who walk or use public transport (Morris &  
26 Guerra, 2015). Based on previous theories of material possession (Dittmar, 1992), it has been  
27 demonstrated in the transportation literature that owning and using a car can be due to  
28 affective, as well as symbolic and instrumental, motivations (Steg, 2005). Affective values,  
29 such as enjoying driving a car and feeling a sense of freedom and independence, have been  
30 shown to be the most important of the three in cross-cultural research (Byosiere, Tanaka,  
31 Luethge, & Vas, 2016); this highlights the importance of investigating the roles that emotions  
32 and motivations have when we are driving.

33

34 When investigating the affective reasons for car use, several themes often emerge. For  
35 example, drivers value the flexibility and freedom of using a car (Kent, 2014), or that the idea  
36 of having a driver's licence and driving their own car results in a positive self-image and  
37 increases opportunities for socialisation (Birna, Birna Sigurdardottir, Kaplan, & Møller,  
38 2014). One value in particular that drivers often comment on is the fact that it increases  
39 perceptions of control over their method of transportation (Gardner & Abraham, 2007).  
40 Owning a car can increase a driver's control by allowing them to their destinations on their  
41 own timetables, and avoid problematic traffic situations by planning alternative routes,  
42 whereas with public transport these opportunities are limited (Beiraõ & Cabral, 2007).  
43 Simulator research also demonstrates that losing control over the environment can lead to an  
44 increased feeling of risk when driving (Saffarian, Happee, & de Winter, 2012). In a world  
45 where the use of self-driving cars is becoming increasingly prevalent, the issue of

46 maintaining individual driver control may still be of importance, not just for increases in  
47 positive emotion but also for the mitigation of feelings of risk or discomfort..

48

49 With the exception of the simulator studies and Saffarian et al's (2012) research, the  
50 aforementioned studies have used qualitative methods to investigate how people feel when  
51 they drive. It has been argued that the complexity of the research into affective motivations  
52 for driving choices and behaviours makes the use of qualitative data desirable. This is  
53 because it can help to deepen our understanding of the topic by giving participants the  
54 freedom to express why they act a certain way when driving in a more in-depth manner  
55 (Grosvenor, 2000). For example, in the literature on anger, content analysis has been used on  
56 driver diaries to establish the most common reasons for encountering offensive or negative  
57 driving behaviours (Wickens, Roseborough, Hall, & Wiesenthal, 2013). However, whilst  
58 qualitative research and analysis can be interpreted as a complementary measure to  
59 quantitative analysis (Bolger, Davis, & Rafaeli, 2003), there still remains the issue of  
60 subjectivity of linguistic interpretation, which means that the literature must be interpreted  
61 with caution.

62

63 Recent technological developments have allowed researchers to analyse qualitative data in a  
64 quantitative fashion, using methods known as word count analysis. Whilst qualitative  
65 methods are able to identify common themes based on the literal meaning of words, it has  
66 been suggested that words are processed unconsciously (Chung & Pennebaker, 2007). Thus  
67 word count analyses are performed on the assumption that word selection conveys  
68 psychological meaning above word's specific meaning (Pennebaker, Mehl, & Niederhoffer,  
69 2003). This allows for a more detailed analysis of content words (such as verbs, adjectives

70 and adverbs), which communicate *what* someone is saying, and function words (such as  
71 pronouns, articles and conjunctions), which convey *how* someone is communicating. One  
72 example of technology that can perform word count analyses with these linguistic dimensions  
73 is the Linguistic Inquiry and Word Count (LIWC- (Tausczik & Pennebaker, 2010). The  
74 LIWC is a piece of software that analyses text entries against its own bank of over 6400  
75 words and calculates the percentage of words that fall within each of around 90 dictionary  
76 and linguistic word categories. The exceptions to this are total word count and the average  
77 amount of words per sentence.

78

79 Function words are of interest in word count analysis, as these are used in 55% of written and  
80 verbal communication despite making up less than 1% of the English vocabulary (Tausczik  
81 & Pennebaker, 2010). For example, an increased use of function words such as personal and  
82 first person pronouns is reflective of an increased focus on the self (Alexander-Emery,  
83 Cohen, & Prensky, 2005; Stirman & Pennebaker, 2001). Psychological constructs have also  
84 been established as valid in understanding behaviour; for example, the use of emotional  
85 language changes according to situational valence (Eid, Johnsen, & Saus, 2005), and an  
86 increased use of cognitive language has been related to a need to understand the causes and  
87 meanings of traumatic events (Cohn, Mehl, & Pennebaker, 2004).

88

89 The LIWC itself has been developed and refined since the early 1990s (Tausczik &  
90 Pennebaker, 2010), and the use of such word count analysis programs has not previously  
91 been considered in transportation. Nonetheless, research has demonstrated that the LIWC  
92 shows good evidence of validity and reliability. For example, evidence of its construct  
93 validity has been shown through an increased use of negative and positive language after

94 experiencing sad and amusing mood inductions respectively (Kahn et al., 2007).  
95 Additionally, the program has been shown to have better convergent and discriminant  
96 validity than other word count analysis programs (Bantum & Owen, 2009), good cross-  
97 cultural reliability (Boot et al., 2017), and excellent test-retest and good interrater reliability  
98 (Heering and Volbert, 2017). From a transportation research perspective, this suggests that  
99 there is potential to further explore the ways in which drivers recall their experiences using a  
100 valid and reliable method of word count analysis such as the LIWC. A potential first  
101 application of this suggestion could be towards analysing the linguistic properties of emotion-  
102 based driving diaries, which have had significant focus in the driving literature.

103

104 Taken together, this evidence highlights the relevance and importance of, and potential for,  
105 using quantitative methods to analyse written and verbal communication. In terms of  
106 understanding the ways in which drivers discuss positive or negative events, these analysis  
107 methods may allow us to understand how individuals process these events; whilst analysis of  
108 linguistic dimensions such as personal pronouns may provide further insight into attentional  
109 focus, analysis of psychological categories (such as cognitive, perceptual, and motivational  
110 processes) may also enable us to understand whether events are appraised in the same way  
111 that they are discussed in diaries and interviews.

112

113 The aim of this study was to explore the potential for word count analysis to explore the areas  
114 of self-focus and the linguistic prioritisations of those experiencing positive and negative  
115 driving events. However, this study constituted part of a larger project into driving  
116 technology and self-reflection, and as such the time at which self-reflection was conducted  
117 was also considered. Halfway through the project, participants visited a high-fidelity driving

118 simulator, and diary entries describing driving experiences were taken one week before and  
119 one week after this simulator visit. Evidence from the literature suggests that drivers already  
120 introspect on issues such as attitudes towards violations (Özkan, Lajunen, & Summala, 2006)  
121 and eye movement prioritisation (Konstantopoulos & Crundall, 2008); additionally, we know  
122 that providing self-generated commentaries can potentially lead to safer behaviours such as  
123 improved hazard perception skills (Isler, Starkey, & Williamson, 2009) and safer approaches  
124 to hazards (Crundall, Andrews, van Loon, & Chapman, 2010). What is not known, however,  
125 is whether the experience of receiving feedback on driving behaviours after visiting a driving  
126 simulator results in a change in self-reflection, which subsequent impact word count analysis  
127 scores. If changes in self-reflection, particularly those that are positive, are found in the time  
128 period after simulator exposure, this could lead to implications for the use of such  
129 technologies to aid positive introspection and improve both the driver experience, and  
130 potentially driver safety.

131

132 Over a seven-day period, participants were asked to report and describe the best and worst  
133 aspects of each journey they had completed as the driver of their car, and provide ratings of  
134 positivity and control. These entries were also compared to a second set of diaries completed  
135 after visiting a high-fidelity driving simulator, using the LIWC. Based on the previous  
136 literature into affective motivations for car use, it was predicted that positive driving events  
137 would be associated with higher ratings of both positivity and control. However, the literature  
138 into the LIWC has not so far, to our knowledge, compared how language changes as a result  
139 of describing events of different valences, nor has it investigated word count analysis within  
140 road user research. Thus, this was an exploratory study, and no specific predictions were  
141 made regarding the language content and style of positive and negative driving events.

142

143 3. Methods

144 3.1. Participants

145 All participants were required to hold a full driver's licence. This study involved two sessions  
146 of simulated driving, so participants were screened for simulator sickness. For this,  
147 participants completed a practice simulated drive of 10 minutes and those who did not show  
148 signs of sickness, as measured by a simulator sickness questionnaire (Kennedy, Lane,  
149 Berbaum, & Lilenthal, 1993) were included in the remainder of the study. A total of 36  
150 participants were tested in this phase, and after screening for simulator sickness 29  
151 participants took part. Seventeen were female and 12 were male. They were aged between  
152 21-64 years old ( $m=36.17$ ,  $sd=13.22$ ). All of them had a full UK driver's licence and reported  
153 driving at least 2-3 times per week. On average, participants reported driving an average of  
154 156.4 miles ( $sd=136.5$ ) over the course of 9.3 hours ( $sd=8.88$ ) per week. During the course of  
155 the study, a total of 598 journeys were recorded across participants; they reported driving an  
156 average of 21.78 miles ( $sd=19.56$ ) during every journey recorded, which took an average of  
157 40 minutes ( $sd=27.76$ ) to complete. Ethical approval for the study was obtained from the  
158 University of Nottingham's ethics committee, and an inconvenience allowance was provided  
159 for participation.

160

161 3.2. Design

162 Two within-subjects factors are reported for the current study. The first of these was the  
163 affective nature of the diary content. Participants were asked to report the best and worst parts  
164 of the journey they had just completed. In both cases, they were asked to describe the event

165 and provide ratings of feeling and control. The instructions provided were the same for best  
166 and worst event entries.

167

168 Secondly, as this was part of a larger study looking at the effects of feedback on self-reported  
169 feelings regarding driving, the time at which diary entries were recorded was also treated as a  
170 within-subjects variable. Participants completed a series of diary entries for seven days prior  
171 to completing a series of routes in a driving simulator; after receiving feedback on their  
172 driving behaviour in the simulator, participants recorded driving diaries for another seven  
173 days.

174

175 The dependent variables chosen for the current study were primarily based on variables that  
176 can be extracted from the LIWC. For the purposes of this paper, only summary language  
177 variables, linguistic dimensions (including content and function words), and words associated  
178 with psychological processes believed to be relevant to driving were selected. This included  
179 words related to affective, cognitive, perceptual and motivational processes, the latter of  
180 which is also referred to as ‘drives’. A summary of these variables is available in Table 1 (see  
181 (Pennebaker, Boyd, Jordan, & Blackburn, 2015) for a summary of all outputted variables  
182 from the LIWC). All variables except for word count and words per sentence (which were  
183 expressed as absolute numbers) were expressed as percentages. In addition to this, the  
184 average amount of words per entry were calculated by the researcher, to reflect the degree of  
185 verbal fluency and insight associated with best and worst driving events.

186

187 Participants were also asked to provide two ratings after describing each driving event. The  
188 first of these asked the participant to rate how the event made them feel. This rating was



189 based on a 5-point Likert scale ranging from 1-5. A score of ‘1’ indicated the participant felt  
 190 very negative about the event, whilst a score of ‘5’ suggested they felt very positive about the  
 191 event. The second of these ratings asked the participant to rate how much control they felt  
 192 they had over the event. This rating was based on another 5-point Likert scale. This time, a  
 193 score of ‘1’ indicated no perceived control over the event, whilst a score of ‘5’ indicated the  
 194 participant felt they had complete control over the event.

195

196 **Table 1: LIWC variables and examples of each (Pennebaker, Boyd, Jordan, &**  
 197 **Blackburn, 2015)**

	Examples
<b>Summary language variables</b>	
Word Count	-
Words per sentence	-
Words > 6 letters	-
<b>Linguistic dimensions</b>	
Function words	it, to, no, very
Total pronouns	I, them, itself
Personal pronouns	I, them, her
Impersonal pronouns	it, it's, those
Articles	a, an, the
Prepositions	to, with, above
Auxiliary verbs	am, will, have
Common adverbs	very, really
Conjunctions	and, but, whereas
Negations	no, not, never
<b>Other grammar</b>	
Verbs	eat, come, carry
Adjectives	free, happy, long
Comparisons	greater, best, after
Interrogatives	how, when, what
<b>Psychological processes</b>	
<b>Affective processes</b>	
Positive emotion	happy, cried
Negative emotion	love, nice sweet
Negative emotion	hurt, ugly, nasty
<b>Cognitive Processes</b>	
Insight	cause, know, ought
Causation	think, know
Discrepancy	because, effect
	should, would

Tentativeness	maybe, perhaps
Certainty	always, never
Differentiation	hasn't, but, else
<b>Perceptual processes</b>	look, heard, feeling
See	view, saw, seen
Feel	feels, touch
<b>Drives</b>	ally, friend, social
Achievement	win, success, better
Power	superior, bully
Reward	take, prize, risk
Risk	danger, doubt

198

199

200        3.3.Materials

201    In order to complete the diaries, participants were given an Olympus WS-853 Digital Voice  
202    Recorder. This recorder had a built-in microphone and could record 8GB, or up to 2080  
203    hours, of audio. The recorder also contained a retractable USB connector, which was used to  
204    attach the device to a computer and extract the relevant .wmv files after each week of diary  
205    entries had been completed. Participants were also provided with two A4 laminated sheets.  
206    The first of these provided instructions that reminded them how to use the recorder, whilst the  
207    second provided instructions on how the diary entries should be completed.

208

209        3.4.Procedure

210    The procedure was completed over a time period of approximately three weeks. Participants  
211    initially completed a screening phase for the simulator aspect of the study. After this, the  
212    researcher gave verbal instructions on how the diary entries should be completed. Participants  
213    were told that over the next seven days, they were to complete a series of diary entries every  
214    time they completed a journey as the driver of the car. They were told that after each journey,

215 they needed to record how many miles they had driven and how long they had been driving  
216 for. They were then told that they would need to describe the best and worst parts of the  
217 journey; after describing each event they were to provide ratings of how the event made them  
218 feel and how much control they believed they had. Whilst participants were asked to  
219 complete these diary entries immediately after completing their journey, for safety reasons it  
220 was also emphasised that the diary entries should only be completed after the car was parked  
221 and the keys had been taken out of the ignition. Participants were made aware of the risks  
222 associated with using a recording device whilst driving and were required to sign a consent  
223 form prior to receiving the initial recorder.

224

225 Diary entries were then recorded over the next seven days. After this point, participants  
226 returned to the driving simulator with their recorders and completed two 10-minute drives  
227 around a simulated version of Nottingham city centre. After receiving feedback on their  
228 driving, the diary recording process was then repeated for another seven days, after which  
229 participants returned to the University to return the second recorder, be debriefed, and receive  
230 an inconvenience allowance.

231

## 232 4. Results

### 233 4.1. Data preparation

234 Audio files were extracted from the recorder and were sent to an external company, who  
235 transcribed the files (Dragon Virtual Assistants™) and sent the associated word documents  
236 back to the researcher. Prior to analysis, the files were then visually inspected. Timestamps  
237 were removed, as well as references to journey times and mileage. For processing purposes,  
238 the document was then segmented into best and worst journey events by typing ‘XX’ after

239 each diary entry; the researchers specified in the programme that any instance of ‘XX’ in the  
240 word document represented a separation between entries. In each segment, any phrasing  
241 which either repeated the questions outlined on the provided instruction card, or contained  
242 ratings of feeling and control, were removed. To avoid any bias in scores, clauses such as  
243 ‘The best part of the journey was...’ or ‘The worst part of the journey was...’ were also  
244 removed.

245

246 All files were then processed using the LIWC to extract the linguistic categories outlined in  
247 the methods section and averaged across recorded driving events to obtain average scores for  
248 positive and negative events across week one, and across week two separately. Any  
249 linguistic dimensions or psychological categories where less than half of the participants had  
250 produced a response were removed from analysis. Linguistic dimensions where this was the  
251 case included first person plurals as well as second and third person words. For affective  
252 processes this included words associated with anger anxiety and sadness. For perceptual  
253 processes this included words associated with hearing and for motivational processes, this  
254 included words related to affiliation.

255

256 As the data was part of a larger project looking into the effects of feedback from a simulator  
257 drive on driver speech, data were initially analysed as part of the 2x2x2 mixed design  
258 ANOVA with factors of affect (positive or negative event) x time of diary entry (week 1 or  
259 week 2) x whether feedback was received (control group versus feedback group). However,  
260 findings for the feedback factor, both main effects and interactions with this factor, were non-  
261 significant once alpha corrections had been taken into consideration (all  $ps > .002$ ), and are  
262 also not the focus of this study; thus only within-subjects effects are reported in this paper.

263 Due to incomplete or inconsistent recordings across the two weeks, data from four  
264 participants were removed prior to this, leaving a total of 25 in the final analysis. Effect sizes  
265 are reported as partial eta squared, and error bars represent standard error of the mean. Each  
266 dependent variable was analysed separately, thus, in order to correct for multiple criterions,  
267 an alpha criterion of .0005 was established for significance, on the basis of the 112  
268 observations presented in this paper. As none of the analyses yielded significant main effects  
269 of time, nor interactions of time and diary affect, were significant (all  $p_s \geq .003$ ), only main  
270 effects of diary entry affect are reported in this paper.

271

#### 272 4.2. Rating of positivity and control

273 Main effects of diary affect were found for subjective ratings of perceived affect  
274 ( $F(1,22)=150.2, p<.00001, \eta_p^2=.872$ ) and control ( $F(1,23)=20.94, p=.0001, \eta_p^2=.477$ ). Best  
275 event entries were associated with more positive ratings of feeling on the Likert scale  
276 ( $m=4.14$ ;  $m$  for worst events= $2.38$ ), as well as a higher degree of perceived control ( $m=2.99$ ;  
277  $m$  for worst events= $2.22$ ).

278

279

#### 280 4.3. LIWC dimensions

281 Firstly, it is worth noting that significant main effects of diary entry valence were found for  
282 the use of affective language when talking about driving events ( $F(1,22)=75.13, p=.00004,$   
283  $\eta_p^2=.535$ ). Positive driving events were associated with a higher use of affective language  
284 ( $m=5.03\%$ ) than negative driving events ( $m=3.26\%$ ). Significant main effects were also  
285 found for the amount of positive language used ( $F(1,19)=88.7, p<.00001, \eta_p^2=.824$ ), and the

286 amount of negative language used ( $F(1,14)=34.88, p=.00003, \eta_p^2=.714$ ). Positive driving  
 287 events were associated with a higher use of positive language ( $m=4.49\%$ ;  $m$  for negative  
 288 events= $1.37\%$ ), and negative driving events were associated with a higher use of negative  
 289 language ( $m=1.74\%$ ,  $m$  for positive= $0.88\%$ ).

290

291 Main effects of diary entry valence were also found for summary language variables and  
 292 linguistic dimensions outlined in the LIWC. Main effects of diary entry valence were found  
 293 for the amount of words used per diary entry ( $F(1,23)=29.87, p=.00001, \eta_p^2=.565$ ), the  
 294 amount of words greater than six letters used ( $F(1,23)=17.43, p=.0003, \eta_p^2=.431$ ), the  
 295 amount of function words used ( $F(1,23)=16.86, p=.0004, \eta_p^2=.423$ ), and the amount of  
 296 adjectives used ( $F(1,22)=26.58, p=.00003, \eta_p^2=.547$ ). The recall of positive driving events  
 297 was associated with a greater use of words larger than six letters ( $m=18.33\%$ ;  $m$  for negative  
 298 events = $16.16\%$ ) and a greater use of adjectives ( $m=5.51\%$ ;  $m$  for negative events= $3.89\%$ ).  
 299 The recall of negative driving events was associated with a greater number of words per diary  
 300 entry ( $m=50.86$ ;  $m$  for positive events = $37.38$ ) and greater use of function words ( $m=58.39\%$ ;  
 301  $m$  for best= $55.23\%$ ) (See Fig. 1).

302

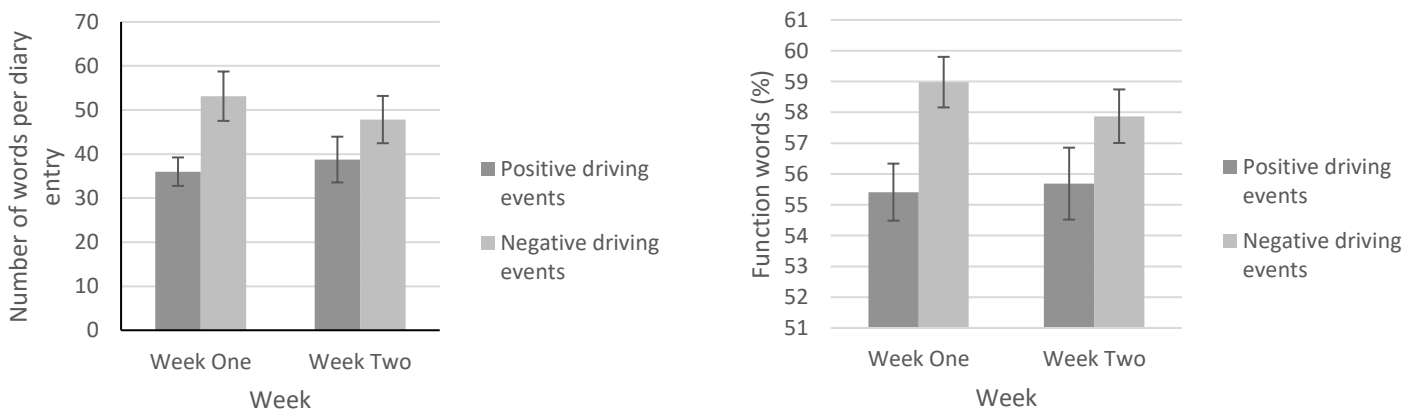


Figure 1: (a) Number of words per entry, and (b) Percentage of function words used, as a function of diary affect and week of diary entry.

303 Main effects of diary entry valence were found for psychological dimensions associated with  
304 cognitive and motivational processes. Specifically, main effects were found for the use of  
305 words associated with certainty ( $F(1,21)=23.57, p=.00008, \eta_p^2=.529$ ) and reward  
306 ( $F(1,18)=52.67, p<.00001, \eta_p^2=.745$ ). Positive driving events were recalled with a greater  
307 use of words associated with both certainty ( $m=2.72\%$ ;  $m$  for negative events= $1.72\%$ ) and  
308 reward ( $m=3.47\%$ ;  $m$  for negative events= $1.66\%$ ) (See Fig. 2).

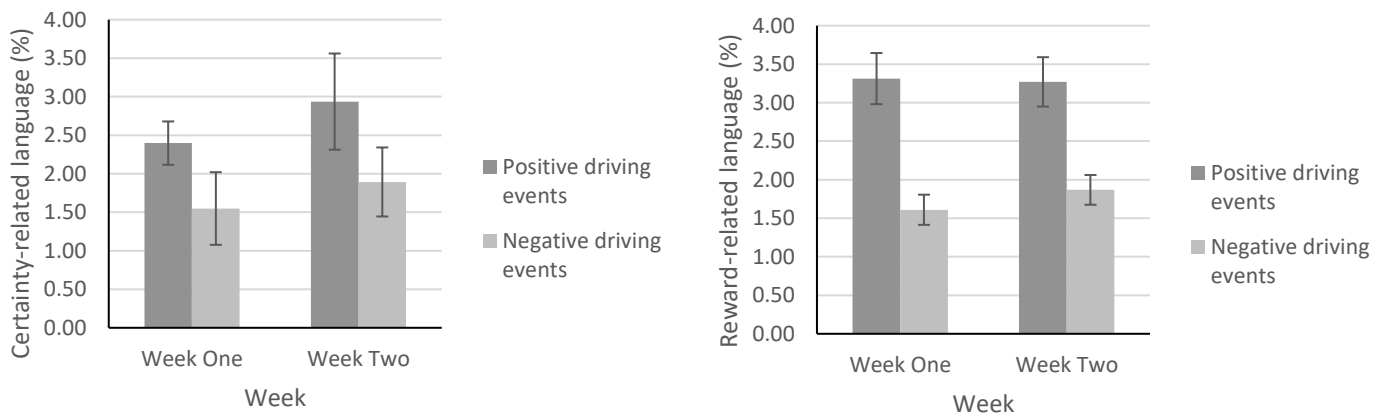


Figure 2: Use of (a) certainty-related, and (b) reward-related language, according to diary affect and week of diary entry.

309

310

311

312 5. Discussion

313 To our knowledge, this is the first study of its kind to perform a quantitative analysis on  
314 driving diaries. As would be expected, drivers used greater amounts of positive language  
315 when discussing the best events from their journey, and more negative language when  
316 describing the worst events. This indicates that the language drivers used to describe their  
317 best and worst driving genuinely reflected positive and negative events respectively.

318 Moreover, analyses suggested that drivers use different language categories when recalling  
319 positive and negative events; this in itself may reflect different attentional priorities and  
320 communication styles according to event valence, and provide more insight into how  
321 differently appraised driving events are discussed.

322

323 The discussion of positive driving events was associated with a greater use of six-letter words  
324 and adjectives, and language associated with certainty and reward. It has been demonstrated  
325 in previous research that an increased use of words greater than six letters is associated with  
326 increases in cognitive complexity as demonstrated by research into online medical advice  
327 (Toma & D'Angelo, 2015) and descriptions of more abstract categorical emotions (Darbor,  
328 Lench, Davis, & Hicks, 2016). Additionally, we know that adjectives are content words that  
329 provide descriptive context to nouns presented in the same sentence. Recent research into the  
330 use of adjectives highlights their emotional association, which can provide differential tones  
331 onto the same noun (Skillicorn & Leuprecht, 2013), or even levels of subjectivity (Pang &  
332 Lee, 2008). For the current study, this indicates that people use more complex and descriptive  
333 language when describing the positive driving events that have occurred to them. If we accept  
334 the theory that the use of six-letter words is also an indicator of higher intelligence (Lee, Rui,



335 & Whinston, 2015; Tausczik & Pennebaker, 2010), then it could imply that drivers think  
336 about positive on-road events in a deeper manner than negative ones.

337

338 Within transportation research, emotions have previously been investigated within an  
339 appraisal framework, albeit this has been focused on the relationship between negative  
340 emotions and goal blocking events (Mesken, Hagenzieker, Rothengatter, & de Waard, 2007;  
341 Roidl, Frehse, Oehl, & Höger, 2014). The current findings extend this previous research into  
342 the relationship between driving and goal pursuit by finding an increased use of reward-  
343 related language in everyday speech when describing positive events. Furthermore, language  
344 associated with psychological processes also provides insight into how natural language may  
345 be reflective of previous hypotheses into the causes of emotions. When describing positive  
346 events, drivers used an increase level of language associated with certainty and reward.  
347 Certainty is a factor that has been implicated in appraisal theories of emotion, and greater  
348 levels of certainty have been associated with positive categorical emotions (Smith &  
349 Ellsworth, 1985). From this, it could be suggested that our data provides support for such  
350 theories that include certainty as an appraisal dimension, at least within the context of  
351 driving. Furthermore, an increased use of reward-related language has been associated with  
352 the pursuit of goals within the LIWC literature (Vaughn, 2018). This indicates that the use of  
353 such language when discussing positive driving events could be an indication of the driver  
354 acknowledging goal promotions as a result of that event.

355

356 Additionally, it should be noted that positive driving events were associated with a higher  
357 degree of control, which supports previous research (Beiraõ & Cabral, 2007; Gardner &  
358 Abraham, 2007). This in conjunction with increased use of reward-related language implies

359 that fulfilling the goal of maintaining control can make the driver feel happier; this has  
360 implications regarding the use of autonomous vehicles.

361

362 The recall of negative driving events, on the other hand, was associated with a difference in  
363 attentional focus. Firstly, the discussion of negative driving events was associated with a  
364 greater number of words per diary entry. This could reflect an increase in talkativeness or  
365 processing of the situation (Tausczik & Pennebaker, 2010). If this is the case then this could  
366 imply drivers ruminate more on negative events, without necessarily trying to understand the  
367 cause or meaning of those events (as indicated by no significant differences in the use of  
368 cognitive language for negative events). Additionally, there was an increased use of function  
369 words when describing negative driving events. Previous literature suggests that the use of  
370 function words is often overlooked in research, and in fact reflects levels of social skills or  
371 attention towards social characteristics (Chung & Pennebaker, 2007). Whilst the current  
372 study did not find significant differences in specific function word categories, these findings  
373 nonetheless suggest an attentional focus towards social characteristics, such as the self or  
374 others, when describing negative driving events.

375

376 If we accept that the language used when recalling positive driving events could reflect some  
377 of the core proposals made by appraisal theories, then something similar could be argued for  
378 the recall of negative events. If function words reflect an orientation towards social  
379 characteristics, then it is possible drivers are trying to evaluate who is responsible for the  
380 event occurring (Roseman, 1996). Despite the fact the current study focused on general  
381 negative emotion, these findings would support research into the attributions made in anger-  
382 provoking driving events. In these cases, it is often noted that drivers actively seek to

383 determine other-person responsibility for the events that have occurred (Britt & Garrity,  
384 2006; Mesken et al., 2007; Roidl et al., 2014; Zhang & Chan, 2014). Recent content analyses  
385 into road rage based tweets has made similar conclusions, with drivers using the social media  
386 environment to openly blame others for events occurring on the road (Stephens, Trawley, &  
387 Ohtsuka, 2016).

388

389 Taken together, the findings from both positive and negative events could therefore reflect  
390 the use of language that supports important components of appraisal theories. This in turn  
391 could extend Chung and Pennebaker's (2007) argument that words are processed  
392 unconsciously, to suggest that the appraisal dimensions such as goal pursuit and  
393 responsibility evaluation are processed by the driver in an unconscious manner. From a  
394 practical perspective this could then lead to the argument of providing drivers with a style of  
395 unconscious bias training, that makes them aware of their tendencies to process different  
396 types of driving events in different ways. This would be particularly useful for negative  
397 driving events such as those that elicit anger, in order to reduce rates of road rage. However,  
398 it is also acknowledged that no significant increases in personal pronouns were found for  
399 negative driving events, which would provide further strength to the arguments made. Further  
400 word count analysis research into the use of personal pronouns when describing negative  
401 driving events of different emotional categories (such as anger, sad, and disgust) could  
402 provide further insight into these suggestions.

#### 403 5.1. Suggestions for future research

404 What can be surmised from the current study's findings is that use of word count analyses, or  
405 software programs such as the LIWC could provide further insight into people's motivations  
406 or attentional focuses whilst driving. This may allow us to further our understanding of

407 different driving issues. Based on the current study, further research into emotions whilst  
408 driving, and appraisal components associated with these, could be beneficial from theoretical  
409 and practical perspectives. This could also be extended into other established transportation  
410 issues, such as understanding the processes underlying the negative attitudes of drivers  
411 towards more vulnerable road users such as cyclists (Paschalidis et al., 2016). Extending the  
412 use of word count analysis to other issues, examples could include understanding the  
413 attentional choices made by novice drivers, or gaining insight into the travel choices made by  
414 older drivers.

415

416 However, to achieve this, future research must consider the fact that individual differences  
417 could play a role in the ways in which we choose to speak. When discussing the purposes of  
418 functions words, Chung & Pennebaker (2007) question the causal links between person and  
419 speech, asking whether the use function words reflect the person's mental state, or whether  
420 the former influences the latter instead. An additional example comes from the field of  
421 cyberpsychology, where it has been shown that levels of empathy result in individuals using  
422 fewer words greater than six letters on social networking sites (Guazzini et al., 2016). Within  
423 the field of transportation, a wide variety of individual differences are apparent in areas such  
424 as experience, age, and personality; thus it is recommended that future transportation research  
425 using word count analyses consider such differences.

426

## 427 5.2.Limitations

428 There are some limitations to the current study, or questions that arise as a result of the study  
429 that could be investigated in future research. Firstly, whilst this study focused less on the  
430 content of positive and negative events, it is still entirely possible that the nature of the events

431 described could influence the language used. For example, based on the aforementioned  
432 applications to appraisal theories of emotion, it could simply be that positive driving events  
433 only occur when individual driving goals are promoted, whilst negative driving events only  
434 occur when others are felt to be at blame for those situations. On the hand, this means we  
435 might expect there to be a greater use of personal pronouns when discussing negative events,  
436 which was not the case in this study. On the other hand, this suggestion highlights the reason  
437 why the use of a mixed methods approach may be more desirable in future research.

438

439 Secondly, the order in which events were recalled or when they took place during the drive  
440 was not considered. Previous memory research has indicated that the serial position in which  
441 emotional events take place bear little to no effect on subsequent recall (Kulas, Conger, &  
442 Smolin, 2003; Nielson & Lorber, 2009; Wirkner et al., 2018). This would imply that the order  
443 in which positive and negative driving events took place during the driving journey should  
444 not have impacted the ways in which they were subsequently recalled. Nonetheless, the  
445 possibility cannot be ruled out this could have impacted the events recalled and the language  
446 used. Additionally, it is acknowledged that a small sample of participants took part in this  
447 study. Whilst these numbers were considerably smaller than some studies using the LIWC  
448 (Cohn, Mehl, & Pennebaker, 2004; Eid, Johnsen, & Saus, 2005), it is still comparable to the  
449 participants numbers found in other papers using the same program (Stirman & Pennebaker,  
450 2001). Nonetheless, further studies using word count analyses should seek, where possible, to  
451 recruit larger samples depending on the research question of interest and anticipated effect  
452 sizes.

453

454 Whilst the current study provides interesting implications regarding driver recall, there are  
455 also still limitations with the use of word count analysis as a method in itself. Most notably,  
456 word count analysis programs are unable to consider the multiple meanings of words, and the  
457 context in which these are used (Abe, 2011); the LIWC is no exception to this criticism.  
458 However, using a qualitative approach to analysing such data can lead to subjective  
459 interpretations of diary content, meaning that results would still need to be interpreted with  
460 caution. One study that has used a mixed methods approach to analyse song lyric contents has  
461 also noted additional limitations regarding interpretation (Czechowski, Miranda, & Sylvestre,  
462 2016). The authors of the study acknowledge that different interpretations of the data could  
463 have been made by other researchers due to differences in conceptual frameworks or  
464 disciplinary perspectives, and they also noted that using descriptive coding methods may not  
465 be enough to capture more abstract or subtle variations in text. It is important at this point to  
466 note that the purpose of the LIWC is to provide an idea of what topics individuals are focused  
467 on, regardless of the context, in a way that may often be missed in methods such as thematic  
468 analysis (Ireland & Mehl, 2014). To provide an example of this, an early study into writing  
469 about traumatic events found that those who used more positive emotion words had better  
470 health outcomes in the months after writing, despite writing about traumatic events  
471 (Pennebaker, Mayne, & Francis, 1997). In the current study, whilst it may have been  
472 expected for drivers to reflect on more risky situations when discussing negative events,  
473 quantitative analysis revealed that there was not a greater use of risk-related language in the  
474 recall of negative events.

### 475 5.3. Conclusions

476 This is one of the first studies to use quantitative methods to analyse how drivers recall  
477 events. When participants were asked to recall the best and worst events associated with each  
478 journey, positive events were associated with an increased focus on affect, certainty, and

479 reward. Negative events, on the other hand, were associated with an increased focus on social  
480 aspects of the situation, as indicated by an increase in function words. The findings also  
481 provide practical implications regarding the need to make autonomous driving an enjoyable  
482 experience. Finally, the use of a quantitative method such as the LIWC has been emphasised  
483 as one which may clarify and elaborate on some of the information that may be used from  
484 more qualitative methods, making it an innovative and promising way to analyse the  
485 reflection and recall of driving events.

486

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