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# Childhood socioeconomic deprivation, but not current mood, is associated with behavioural disinhibition in adults

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There is evidence to suggest that impulsivity is predicted by socioeconomic background, with people from more deprived backgrounds tending to be more impulsive, and by current mood, with poorer mood associated with greater impulsivity. However, impulsivity is not a unitary construct, and previous research in this area has focused on measures of 'waiting' impulsivity rather than behavioural disinhibition. We administered a standard measure of behavioural disinhibition, the stop-signal task, to 58 adult participants from a community sample. We had measured socioeconomic background using participant postcode at age 16, and assigned participants to receive either a neutral or a negative mood induction. We found no effects of mood on behavioural disinhibition, but we found a significant effect of socioeconomic background. Participants with more deprived postcodes at age 16 showed longer stop-signal reaction times, and hence greater behavioural disinhibition. The pattern was independent of participant age and overall reaction time. Greater behavioural disinhibition may be a consequence of experiencing childhood socioeconomic deprivation, and could play a role in maintaining social gradients in outcomes such as addiction.

2 **Childhood socioeconomic deprivation, but not current mood, is associated with behavioural disinhibition in**  
3 **adults**

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22

23 **ABSTRACT**

24 There is evidence to suggest that impulsivity is predicted by socioeconomic background, with people from  
25 more deprived backgrounds tending to be more impulsive, and by current mood, with poorer mood associated  
26 with greater impulsivity. However, impulsivity is not a unitary construct, and previous research in this area has  
27 focused on measures of 'waiting' impulsivity rather than behavioural disinhibition. We administered a standard  
28 measure of behavioural disinhibition, the stop-signal task, to 58 adult participants from a community sample.  
29 We had measured socioeconomic background using participant postcode at age 16, and assigned participants  
30 to receive either a neutral or a negative mood induction. We found no effects of mood on behavioural  
31 disinhibition, but we found a significant effect of socioeconomic background. Participants with more deprived  
32 postcodes at age 16 showed longer stop-signal reaction times, and hence greater behavioural disinhibition. The  
33 pattern was independent of participant age and overall reaction time. Greater behavioural disinhibition may be  
34 a consequence of experiencing childhood socioeconomic deprivation, and could play a role in maintaining  
35 social gradients in outcomes such as addiction.

36  
37 Keywords: impulsivity, behavioural inhibition, stop-signal, social gradients, socioeconomic deprivation,  
38 addiction

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## 41 INTRODUCTION

42 Impulsivity is an important psychological trait, because it has been linked to a number of outcomes which are  
43 problematic from both individual and societal perspectives, such as addiction and criminal behaviour (Pratt &  
44 Cullen, 2000; Perry & Carroll, 2008; Moffitt et al., 2011; Sharma, Markon & Clark, 2014). Recent evidence  
45 suggests that socioeconomic position and negative affect may be two important determinants of impulsivity. A  
46 substantial number of studies have presented evidence that individuals of lower socioeconomic position tend  
47 to be more impulsive than those of higher socioeconomic position (Lawrance, 1991; Green et al., 1996; Adams  
48 & White, 2009). Though causality is difficult to establish definitively, the relationship is thought to be at least  
49 partly causal (Haushofer & Fehr, 2014). That is, experiencing socioeconomic hardship makes people become  
50 more impulsive, rather than, for example, more impulsive people being downwardly economically mobile.  
51 Other studies have shown that negative mood can also make people more impulsive (Lerner, Li & Weber,  
52 2012). Here, the causality is much easier to demonstrate, since negative mood can be induced experimentally,  
53 and the consequent increase in impulsivity measured. The socioeconomic and mood effects on impulsivity may  
54 well be linked; part of the reason that people of lower socioeconomic position are characterised as more  
55 impulsive may be that their mood is more negative much of the time (Haushofer & Fehr, 2014). However,  
56 whether there is also a 'mood-independent' effect of socioeconomic position on impulsivity is not at present  
57 well understood.

58 Impulsivity, however, is not a unitary trait (Reynolds et al., 2006; Sharma, Markon & Clark, 2014; Stahl et al.,  
59 2014). Although a number of typologies of impulsivity have been proposed, a common distinction is between  
60 the unwillingness to wait for a deferred outcome ('waiting impulsivity' or impulsive choice) and the inability to  
61 stop oneself from making a response that has been cued or initiated by the context ('stopping impulsivity',  
62 impulsive action, or behavioural disinhibition) (Reynolds et al., 2006; Perry & Carroll, 2008; Brevers et al.,  
63 2012). Although both types are often referred to as impulsivity in the literature, measures of waiting  
64 impulsivity do not tend to be substantially correlated with measures of behavioural disinhibition (Reynolds et  
65 al., 2006). Almost all of the evidence on socioeconomic position and current mood as predictors of impulsivity  
66 comes from waiting impulsivity tasks. For behavioural disinhibition, one study found no socioeconomic  
67 patterning in a large community sample of children and adolescents (Crosbie et al., 2013). Beyond this, there is  
68 little research looking for a socioeconomic gradient, and there have been no experimental studies  
69 manipulating mood to examine the consequences for behavioural disinhibition. In this study, we therefore  
70 administered a standard measure of behavioural disinhibition, the stop-signal task (SST), to adults from a

71 community sample, having first measured their socioeconomic background, and randomly assigned them to  
72 receive either a negative mood induction or a control procedure.

73 In the SST, participants complete many trials where they must respond with a key press to a go-cue displayed  
74 on a computer screen. On a minority of trials, and unpredictably, a stop-cue is also displayed. In these trials,  
75 the participant is instructed not to press the key. By varying the temporal offset between the appearance of  
76 the go-cue and the appearance of the stop-cue on the stop trials, it is possible to estimate the participant's  
77 stop-signal reaction time (SSRT). This is the characteristic time required for the person to successfully make an  
78 inhibitory response. A longer SSRT equates to poorer behavioural inhibition (or, equivalently, greater  
79 behavioural disinhibition). The theoretical assumptions underlying the task have been confirmed (Logan &  
80 Cowan, 1984; Logan, Cowan & Davis, 1984), and SSRT scores have been externally validated in studies of drug  
81 addiction (Fillmore et al., 2002). As well as the SSRT itself, the SST yields for each participant an average  
82 reaction time for the go trials (the GRT). This is a potentially important covariate, since individual differences in  
83 SSRT may simply reflect variation in reaction time to the go-cue rather than inhibition abilities *per se*. It is also  
84 important, when analysing SSRT and GRT, to control for participant age, since both reaction times have been  
85 shown to increase with age in adulthood (Williams et al., 1999; Bedard et al., 2010).

86 There are multiple ways of conceptualizing and assessing socioeconomic position. Recent studies have  
87 suggested that exposure to deprived neighbourhoods across childhood may be a key predictor of psychological  
88 outcomes (Sampson, Sharkey & Raudenbush, 2008; Sastry & Pebley, 2010; Sharkey & Elwert, 2011). We thus  
89 chose to focus on neighbourhood socioeconomic deprivation rather than individual socioeconomic status, and  
90 measured at the end of childhood rather in adulthood. We therefore decided to use residential postcodes from  
91 age 16 to obtain a neighbourhood deprivation score. The UK has high-quality deprivation data resolved to a  
92 small spatial scale, based on the average of indices across multiple domains of deprivation. For the mood  
93 induction, we used the Velten procedure, a widely-used technique where the participant reads a sequence of  
94 either neutral or negatively-valenced statements according to the condition they have been assigned to  
95 (Velten, 1968). The negative condition induces a global negative mood.

96 Our predictions were that participants from more deprived backgrounds, and participants assigned to the  
97 negative condition, would show relatively longer SSRTs, once appropriate control was made for age and GRT.  
98 We noted the possibility that there might also be interactions between socioeconomic background and mood  
99 condition, since some recent studies have suggested that people from different socioeconomic backgrounds  
100 react differently to cues of current adversity (Griskevicius et al., 2013). We thus included interactions between  
101 mood condition and socioeconomic background in our models.

## 102 **METHODS**

### 103 **Ethics and Participants**

104 The study was authorised by the Newcastle University Faculty of Medical Sciences Ethics Committee under  
105 approval number 00655/2013. Participants were an opportunity sample of individuals who had grown up in  
106 the UK, recruited by means of the Institute of Neuroscience participant pool, Newcastle University. This is a  
107 large database of email addresses of people who have shown an interest in taking part in neuroscience or  
108 medical research. It includes students, staff of the university, and other residents of the city, and is thus  
109 reasonably diverse in terms of ages and socioeconomic backgrounds. A compensation of £5 was offered in  
110 exchange for participation. The data includes two samples gathered in separate years by TC and TP  
111 respectively. All procedures were identical in the two sub-samples. We have repeated all analyses in this paper  
112 with experimenter as an additional random effect, and none of the results is altered. A total of 58 people  
113 participated (65.5 % female; age (in years)  $M = 32.77$ ,  $SD = 14.8$ ).

### 114 **Procedure**

115 Participants were tested individually in a single session in a curtained cubicle within a computer laboratory. The  
116 experimenter withdrew from the cubicle during the tasks. On a desk in front of the participant was a desktop  
117 computer with speakers and keyboard. Standard computer keyboards have slow polling rates that render them  
118 unsuitable for tasks requiring highly accurate timing (Plant, Hammond & Whitehouse, 2003; Verbruggen, Logan  
119 & Stevens, 2008), and so we used a Razer 'Lycosa' games keyboard with a specified polling rate of 1000Hz. The  
120 sequence of steps was as follows: participants read the study information sheet and signed a consent form;  
121 completed a computerised demographic questionnaire and baseline mood measure; completed the mood  
122 induction task; completed the SSRT; and finally completed another mood measure as a manipulation check.  
123 On completion, each participant was debriefed and received the compensation payment.

124 *Demographic questionnaire and baseline mood measure.* The initial questionnaire, delivered via the Qualtrics  
125 survey platform ([www.qualtrics.com](http://www.qualtrics.com)), asked participants to report their age, sex, the postcode of the address  
126 that they had lived in at age 16, and their current mood on a scale of 1-100, where 1 was the most negative  
127 possible and 100 the most positive.

128 *Mood induction procedure.* On completion of the initial questionnaire, Qualtrics pseudorandomly assigned  
129 participants to either the negative or neutral conditions. The experimenter was thus blind to the experimental  
130 condition. Those in the negative condition saw a sequence of 50 statements from the negative Velten mood  
131 induction (Velten, 1968). These describe negative sentiments, and their severity increases as the sequence of

132 statements goes on. Participants in the neutral condition saw a sequence of 50 statements matched to the  
133 neutral ones for linguistic properties but devoid of any emotional valence. Each statement was presented on  
134 the screen for six seconds, and the participants were instructed to try to memorise them. After the sequence  
135 had finished, the participants alerted the experimenter, who started up the SSRT programme.

136 *Stop signal task.* We delivered the SST using STOP-IT software (Verbruggen, Logan & Stevens, 2008). In this  
137 implementation, the go-cue is a square or circle displayed in the middle of the screen; two response keys on  
138 the keyboard were marked with a square and circle respectively, and the participant instructed to press the  
139 correct one as quickly as possible. The stop signal is an audible tone. STOP-IT was run in full-screen mode, with  
140 system volume set to full and speaker volume at 2/3. The default task parameters were used: 1 practice block  
141 of 32 trials, followed by 3 experimental blocks of 64 trials each. Each trial begins with a 250ms fixation cue,  
142 followed by the go-cue, which is displayed until the participant responds, with a maximum limit of 1250ms. The  
143 inter-trial interval is 2000ms. Stop-trials constitute 25% of all trials; the difference in onset time of stop-cue  
144 relative to go-cue on these trials is automatically titrated dependent on performance to provide an estimate of  
145 the delay at which that participant has a 50% chance of inhibiting successfully. The participant's SSRT is  
146 calculated from the value of this delay.

147 After the experimenter had explained the instructions, participants pressed a key when they were ready to  
148 start the task. The experimenter observed the participant during the practice block to see whether they were  
149 responding correctly. The participant then completed the 3 experimental blocks, which the experimenter did  
150 not observe. Following the practice block and each one of the trial blocks, a summary screen showing the  
151 participant's response suppression rate, trials missed and errors made was displayed during a 10-second delay  
152 until the participants could press a key to begin the next task. After the final block, the participants alerted the  
153 experimenter.

154 *Manipulation check mood measure.* As the final step of the experiment, the participants were asked to rate  
155 their mood again on a scale of 1 to 100 via the Qualtrics survey window on the computer. The experimenter  
156 was careful not to observe, or be seen to be observing, the answer to this question.

## 157 **Data Analysis**

158 Raw data are available as Supplementary Material. SSRT was calculated using the ANALYZE-IT programme  
159 supplied with STOP-IT (Verbruggen, Logan & Stevens, 2008). All participants provided data that met the  
160 assumptions required by STOP-IT to generate a valid SSRT and GRT. Postcode at age 16 was converted to a  
161 deprivation score via the Neighbourhood Statistics database (<https://neighbourhood.statistics.gov.uk/>).



162 First, we extracted for each postcode a deprivation rank; this is the rank in terms of multiple deprivation of the  
163 lower super output area corresponding to the postcode, from 1 (most deprived in UK) to 32482 (least  
164 deprived). We converted this into a more intuitively interpretable deprivation score using the formula:

$$165 \quad \text{Deprivation score} = 1 - (\text{deprivation rank} / 32482)$$

166 Thus, the median UK neighbourhood would have a deprivation score of 0.5, the most deprived a score of 1,  
167 and the least deprived a score of 0. Once the measures had been calculated, data were analysed in R (R Core  
168 Development Team, 2013), using general linear models and t-tests as appropriate. SSRTs were mildly right-  
169 skewed. All models reported below were also run using log-transformed SSRT, which corrects the right skew.  
170 Since results were essentially identical, the non-transformed results have been reported. Residuals were  
171 checked in all cases, and there were no major violations of parametric model assumptions.

## 172 **RESULTS**

### 173 **Descriptive statistics**

174 Table 1 shows the descriptive statistics by condition for variables other than performance in the stop-signal  
175 task. There were no significant differences by condition in age, deprivation, or baseline mood, as there should  
176 not have been, since condition was randomly assigned. Average deprivation scores were close to the UK  
177 median neighbourhood (0.45), but with a good range (0.11 – 0.98). Deprivation score was not significantly  
178 associated with baseline mood ( $r_{56} = 0.07$ ,  $p = 0.62$ ).

### 179 **Mood manipulation check**

180 The mood induction produced a modest decrease in mood between baseline and final rating in the negative  
181 condition ( $M = -3.23$ ;  $SD = 5.27$ ), and a modest improvement in mood in the neutral condition ( $M = 2.78$ ;  $SD =$   
182  $13.31$ ). The condition difference in mood change was statistically significant ( $t_{56} = -2.29$ ,  $p=0.03$ ). However, the  
183 final mood ratings were not significantly different between the negative and neutral conditions (Negative:  $M =$   
184  $77.1$ ,  $SD = 18.1$ ; Neutral:  $M = 74.5$ ,  $SD = 17.3$ ,  $t_{56} = 0.56$ ,  $p=0.58$ ). This is due to variation in initial mood diluting  
185 the modest effect of the mood manipulation. For this reason, in all subsequent analyses, we include both  
186 experimental condition and baseline mood as independent variables. We also repeated the analyses using final  
187 mood in place of condition and baseline mood, but no conclusions were changed.

### 189 **Go-reaction time (GRT)**

190 We fitted a general linear model to the GRTs, with age, initial mood, condition, deprivation score and the  
191 condition by deprivation score interaction as predictors. The model summary is shown in the upper part of

192 table 2. Age predicted GRT, with GRTs becoming slower with increasing age, but there were no significant  
193 effects of initial mood, condition or deprivation score on GRT.

194

### 195 **Stop-signal reaction time (SSRT)**

196 The general linear model for SSRT included as predictors GRT, age, initial mood, condition, deprivation score,  
197 and the condition by deprivation score interaction. The model summary is shown in the lower part of table 2.

198 There was a significant effect of GRT, with participants who were faster on the go-trials having a longer SSRT.

199 There was also a predicted effect of age, with older participants having longer SSRTs. There was a significant

200 effect of deprivation score, with participants from more deprived postcodes having longer SSRTs (figure 1). The  
201 effects of initial mood, condition, and the condition by deprivation interaction were not significant.

202

203

## 204 **DISCUSSION**

205 In a community sample of adults, we found evidence that behavioural disinhibition, as measured using the  
206 SSRT task, was related to socioeconomic background. Participants who had lived in more deprived postcodes at  
207 age 16 had longer SSRTs, and hence showed greater behavioural disinhibition, than participants who had lived  
208 in more affluent postcodes. We also measured mood, and manipulated it using a standard mood-induction  
209 procedure, but we found no evidence that current mood - either the naturally-occurring variation in baseline  
210 mood, or our experimentally-produced mood manipulation - affected SST performance in any way. Thus, our  
211 predictions concerning the relationship between socioeconomic deprivation and behavioural disinhibition  
212 were supported, whilst our predictions concerning the role of current mood were not. Our results also  
213 concurred with those of previous investigations in finding that SSRTs, as well as GRTs, increased substantially  
214 with age (Williams et al., 1999; Bedard et al., 2010). We also found that SSRT was negatively related to GRT;  
215 people who were faster to act in the go-trials were, other things being equal, slightly more disinhibited.  
216 However, the deprivation-disinhibition relationship was not explained by differences in GRT; it persisted even  
217 once variation in GRT was controlled for.

218 A number of previous studies have demonstrated socioeconomic gradients in measures of 'waiting' impulsivity,  
219 the relatively steep devaluing of future rewards compared to immediate ones (Lawrance, 1991; Green et al.,  
220 1996; Adams & White, 2009). To our knowledge, this is the first evidence that there may also be a  
221 socioeconomic gradient in 'stopping impulsivity' or behavioural disinhibition. Demonstrating the existence of

222 such a gradient is potentially important, since behavioural disinhibition predicts problematic real-world  
223 outcomes above and beyond 'waiting' impulsivity alone (Brevers et al., 2012; Sharma, Markon & Clark, 2014).

224 Why socioeconomic gradients in impulsivity should exist is not well understood. They could be driven by  
225 socioeconomic variation in general cognitive ability. In the current data, this seems unlikely to be the case,  
226 since there was no gradient in reaction times on the go trials, which one might have expected if there was a  
227 gradient in general cognitive performance. However, without more robust measurement of general cognitive  
228 ability, this possibility cannot be dismissed. Another recent proposal is that relationships between  
229 socioeconomic position and impulsivity might be mediated by differences in mood (Haushofer & Fehr, 2014).  
230 However, this cannot be the case here, since there was no socioeconomic gradient in baseline mood, and we  
231 found no evidence for any effect of mood on behavioural disinhibition. This is in contrast to a previous  
232 experimental study that found effects of mood manipulation on waiting impulsivity (Lerner, Li & Weber, 2012).  
233 Thus, our data suggest an embedded effect of socioeconomic deprivation on disinhibition that is independent  
234 of current mood. Socioeconomic position is associated with many different aspects of experience, from  
235 housing to diet to family composition, and exactly what it is about deprivation that tends to produce greater  
236 disinhibition as well as a relatively stronger preference for immediate over delayed outcomes remains to be  
237 explored.

238 Our study had a number of limitations. Our sample was not constructed in such a way as to guarantee  
239 socioeconomic representativeness. However, we were fortunate in that the mean deprivation score of our  
240 sample was roughly in the middle of the UK range, and both extremes were represented in the data. We  
241 measured deprivation through postcode at the end of childhood. We chose this as we anticipated recruiting  
242 mainly young adults, and we felt this would be the single most convenient and valid measure for this age  
243 group. In fact, we recruited more, older people than anticipated, and childhood postcode at 16 is a less ideal  
244 measure for these participants than for younger ones. For one thing, their age 16 is longer ago, and the  
245 neighbourhoods may have changed in the intervening years. We made no attempt to distinguish statistically  
246 between childhood deprivation and adult deprivation. It could be that the most important predictor of  
247 behavioural disinhibition is *current* experience of deprivation (Nettle et al., 2014), and the relationship we  
248 found with childhood deprivation might be because people with more deprived childhood backgrounds also go  
249 on to experience more deprivation in adulthood. To discriminate whether current or childhood experience of  
250 deprivation is important, the two would need to be separately measured to establish which has the greater  
251 predictive power. Our measure also did not distinguish individual-level socioeconomic characteristics such as  
252 parental income and education from neighbourhood-level deprivation. The two are likely to be highly

253 correlated, but our study does not licence inferences about which of these, if either, is responsible for the  
254 observed association. We should also be cautious about inferring causality from an association; though it  
255 seems reasonable that something about childhood deprivation might cause the development of greater  
256 disinhibition, other explanations for the correlation cannot be excluded.

257 Our mood manipulation, though it employed a standard technique that has been used in other recent studies  
258 (Smallwood & O'Connor, 2011; Scherrer, Dobson & Quigley, 2014), produced only very modest effects on  
259 participants' final mood. It is possible that a stronger manipulation of mood might have affected behavioural  
260 disinhibition. However, there was considerable variation in baseline mood, and the combination of baseline  
261 mood and the manipulation still did not explain any variation in behavioural disinhibition. This suggests that  
262 across a substantial range of mood, mood effects on behavioural disinhibition, if they exist, must be very small.

263 Despite the limitations noted above, it is striking that in a relatively small sample, and with a relatively crude  
264 measure of socioeconomic background, we found evidence of an association between the experience of  
265 deprivation and behavioural disinhibition. Childhood socioeconomic deprivation is an epidemiological predictor  
266 of a number of important outcomes such as subsequent crime (Levine, 2011), and transition to habitual use of  
267 drugs and tobacco (Legleye et al., 2011). Behavioural disinhibition plausibly plays a role in these outcomes.  
268 Thus, behavioural disinhibition could be an important psychological mechanism linking childhood  
269 socioeconomic conditions to subsequent life outcomes.

270

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337

338 **Table 1.** Descriptive statistics by condition for age, baseline mood and deprivation score.

339

	Negative	Neutral	Condition difference
Participants	30 (18 female)	28 (20 female)	
Age (years)	$M = 34.8, SD = 15.9$	$M = 30.5, SD = 13.3$	$t_{55} = 1.09, p = 0.28$
Baseline Mood (1 - 100)	$M = 80.4, SD = 17.9$	$M = 71.7, SD = 22.6$	$t_{56} = 1.62, p = 0.11$
Deprivation Score (0 - 1)	$M = 0.45, SD = 0.29$	$M = 0.45, SD = 0.25$	$t_{55} = 0.09, p = 0.93$

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344 **Table 2.** Summary of general linear models predicting GRT (upper rows) and SSRT (lower rows)

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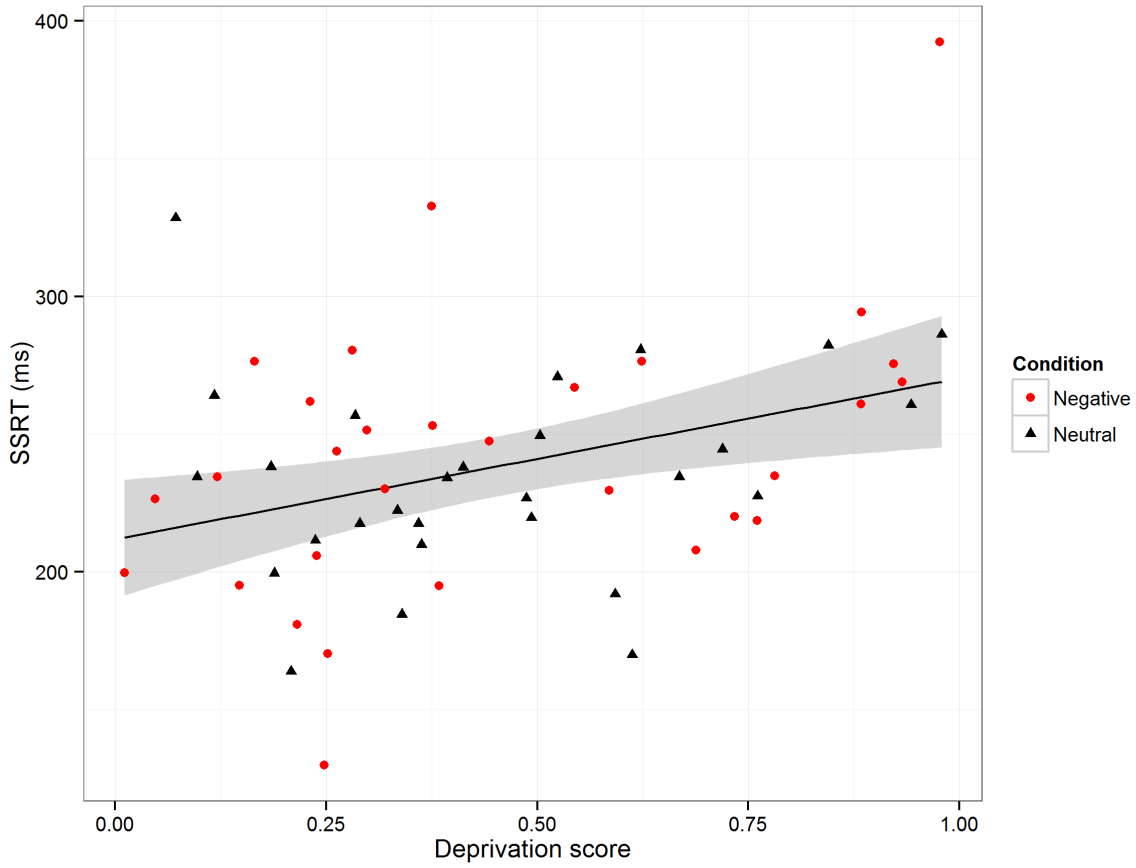
Variable	Parameter estimate	Standard error	t	p
<i>Outcome variable: GRT</i>				
Age	4.85	1.35	3.59	0.01
Deprivation score	185.20	225.82	0.82	0.42
Baseline mood	0.46	0.98	0.47	0.64
Condition	8.39	76.27	0.11	0.91
Deprivation score	-117.44	150.16	-0.78	0.44
* condition				
<i>Outcome variable: SSRT</i>				
GRT	-0.08	0.04	-2.15	0.04
Age	1.08	0.41	2.63	0.01
Deprivation score	146.65	61.83	2.37	0.02
Baseline mood	-0.40	0.27	-1.50	0.14
Condition	18.40	20.75	0.89	0.38
Deprivation score *	-65.26	41.09	-1.59	0.12
condition				

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353 **Figure 1.** Scatterplot of stop-signal reaction time (SSRT) against deprivation score, with participants labelled by  
354 condition in the mood manipulation.