

1 **Investigating attentional processes in depressive-like**  
2 **domestic horses (*Equus caballus*).**  
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38 **Abstract**

39 Some captive/domestic animals respond to confinement by becoming inactive and  
40 unresponsive to external stimuli. Human inactivity is one of the behavioural markers of  
41 clinical depression, a mental disorder diagnosed by the co-occurrence of symptoms including  
42 deficit in selective attention. Some riding horses display ‘withdrawn’ states of inactivity and  
43 low responsiveness to stimuli that resemble the reduced engagement with their environment  
44 of some depressed patients. We hypothesized that ‘withdrawn’ horses experience a  
45 depressive-like state and evaluated their level of attention by confronting them with auditory  
46 stimuli. Five novel auditory stimuli were broadcasted to 27 horses, including 12 ‘withdrawn’  
47 horses, for 5 days. The horses’ reactions and durations of attention were recorded. Non-  
48 withdrawn horses reacted more and their attention lasted longer than that of withdrawn horses  
49 on the first day, but their durations of attention decreased over days, but those of withdrawn  
50 horses remained stable. These results suggest that the withdrawn horses’ selective attention is  
51 altered, adding to already evidenced common features between this horses’ state and human  
52 depression.

53 Key words: horses; attention; cognition; welfare; depression;

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65 **1. Introduction**

66 One of captive/domestic animals' responses to confinement is to become inactive and  
67 unresponsive to external stimuli (Fuchs & Flügge, 2002), as reported for many lab/farm  
68 species experiencing inappropriate living conditions (*e.g.* fur-farmed mink; tethered sows;  
69 caged dogs, Cronin, 1985). Humans' inactivity is one of the behavioural markers of clinical  
70 depression (APA, 2013), a complex heterogeneous mental disorder diagnosed by the co-  
71 occurrence of affective, cognitive and behavioural symptoms (APA, 2013). Symptoms  
72 include deficits in selective attention (*i.e.* ability to focus perception on one stimulus while  
73 filtering out other simultaneous stimuli, Posner *et al.*, 1980), as evidenced *e.g.* by slower  
74 reactions in an auditory oddball task (Kemp *et al.*, 2010). Most reports of horses' impaired  
75 welfare (Burn *et al.*, 2010; Pritchard *et al.*, 2005) or pain (*e.g.* Ashley *et al.*, 2005; review in  
76 Hausberger *et al.*, in press) indicate that some horses are unresponsive to environmental  
77 stimuli. A 'withdrawn' state was recently described more formally (Fureix *et al.*, 2012):  
78 during a withdrawn bout, horses remain totally motionless (immobility with no neck, head,  
79 and ear movements); displaying a flat-necked posture; wide open, rarely blinking eyes; and  
80 backwards-pointing ears. Compared to non-withdrawn horses from the same stable,  
81 withdrawn horses react less to human approach and tactile stimulation, and consume less  
82 sucrose (Fureix *et al.*, 2015), a sign of anhedonia *i.e.* loss of interest or pleasure (Willner *et*  
83 *al.*, 1992), which is a core symptom of human clinical depression. We hypothesized that if  
84 withdrawn horses were in a depression-like condition their selective attention would be  
85 altered (Greimel *et al.*, 2015). Therefore we submitted 12 withdrawn horses and 15 non-  
86 withdrawn control horses from the same stable to unfamiliar auditory stimuli.

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88 **2. Material and Methods**

89 *2.1. Ethical note*

90 This study complied with French laws related to animal experimentation and the  
91 European directive 86/609/CEE.

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93 *2.2. Subjects*

94 Twenty-seven horses ( $N_{\text{mares}}=6$ ;  $N_{\text{geldings}}=21$ ; aged 5-20 years,  $\bar{X} \pm SE=12.7 \pm 0.9$ , 77% French  
95 Saddlebred) from the same riding school were observed in June 2012. The horses were kept in  
96 3m \* 3m individual straw-bedded stalls in a barn, allowing visual contact with conspecifics.

97 Each stall was cleaned every morning, and was equipped with an automatic drinker. Animals  
98 were fed hay once a day (13:00 h), and commercial pellets three times a day (07:00 h, 12:00  
99 h, 19:00 h). Groups of 7-8 horses were released (allowing contact) into barren paddocks for  
100 two days at the week-end. Horses worked in riding lessons for 6–10 hours a week (two rest  
101 days). The time each horse spent being withdrawn in its stall was determined using  
102 instantaneous scan sampling (Altmann, 1974) every 2 minutes for 1h periods, repeated daily  
103 at different times of day (from 6:00 a.m. to 9:00 p.m.) over 15 days (average number of total  
104 scans per subject:  $907 \pm 11.14$ ) (Fureix *et al.*, 2015). Twelve of the 27 horses ( $N_{\text{mares}}=3$ ;  
105  $N_{\text{geldings}}=9$ ; called withdrawn horses hereafter) displayed the previously described withdrawn  
106 state at least once.

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### 108 2.3. Test settings

109 Five stimuli, all initially novel for the subjects, were broadcasted within the stable: three  
110 vocalizations of different species (baboon, barnacle goose and whale), one vocalization of an  
111 unfamiliar conspecific, and one non-biological sound (piano music). Horses were randomly  
112 exposed by groups of 4-6 in neighbouring stalls, following Noble *et al.*, (2013), to one of the  
113 five auditory stimuli, which differed for each group on a given day (*e.g.* the 1<sup>st</sup> test day, the 1<sup>st</sup>  
114 group heard the baboon, the 2<sup>nd</sup> the whale etc; the 2<sup>nd</sup> test day the 1<sup>st</sup> group heard the piano,  
115 the 2<sup>nd</sup> the baboon etc). The loudspeaker (Nagra Kudelski HP monitor®) was at equal  
116 distances (2 m) from each horse. Stimuli were broadcast for 3 seconds at 80db, always  
117 between 13:00h and 14:00h and for 5 consecutive days. Data collected on the fifth test day  
118 were discarded, due to a different (from the other test days) horses' management (*i.e.* no  
119 riding activities). Proportions of non-withdrawn and withdrawn horses were balanced within  
120 each group. Observations focused on small groups because we could not isolate subjects, or  
121 observe all the 27 horses simultaneously in the barn.

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### 123 2.4. Behavioural measurements

124 Tests were videotaped (Sony HDR-XR105®) and standard measures of attentional states  
125 were extracted from videos using continuous focal sampling (Altmann, 1974). We recorded  
126 the presence or absence of reaction (*i.e.* change in behaviour interrupting the ongoing activity  
127 after a broadcast, characterized by any ear, head, neck or whole body movement) to estimate  
128 attentional capture. We recorded the total duration of attention (*i.e.* standing motionless with

129 eyes, ears, head or neck oriented towards the loudspeaker (Waring, 2003)) during the 5  
130 minutes following a broadcast. Three horses (1 non-withdrawn, 2 withdrawn) were scared by  
131 the stimuli on the 1<sup>st</sup> and 2<sup>nd</sup> test days (*i.e.* alarm posture associated with dilated nostrils and  
132 snorting and active walking in the box; Kiley-Worthington, 1976, Wolff *et al.*, 1997). As  
133 these horses did not show any attention patterns, they were excluded from the analyses, so our  
134 analyses included only 24 horses.

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## 136 *2.5. Statistical analyses*

137 Normality and homogeneity of variances were assessed by inspection of residuals and  
138 Shapiro–Wilk W tests (Ha and Ha, 2011). Because our data were not normally distributed, we  
139 applied non-parametric statistical tests (Siegel and Castellan, 1988). Fisher’s exact and Chi-  
140 square tests were used to evaluate the influence of test day on the proportion of reactive  
141 *versus* non-reactive horses. Friedman tests, followed by multiple pairwise comparisons using  
142 Wilcoxon signed rank t-tests applying a False discovery rate correction (Benjamini and  
143 Hochberg, 2000) were used to evaluate relationships between duration of attention, stimulus  
144 type and test day. Kruskal-Wallis tests were used to assess relationships between duration of  
145 attention and group observation. Mann-Whitney U-tests (for each test day) compared  
146 durations of attention between non-withdrawn (NW) and withdrawn (W) horses, and  
147 gelding/mares. Analyses were conducted using R software (accepted two-tailed p level at  
148 0.05). Descriptive statistics are means ( $\bar{X}$ ) followed by standard errors (SE).

149

## 150 **3. Results**

151

152 Neither sex nor type of stimulus nor observation group influenced reactions and durations  
153 of attention significantly (*sex*: Mann-Whitney U-tests,  $P > 0.05$ ; *stimuli*: Friedman tests,  
154  $1.2 < F < 7.2$ ,  $P > 0.05$ ; *group*: Kruskal-Wallis tests,  $6.8 < H < 10.2$ ,  $P > 0.05$ ), therefore data were  
155 pooled for subsequent analyses.

156

### 157 *3.1. First test day*

158 More NW horses (93%) than W horses (50%) reacted (Fisher exact Test,  $P=0.02$ ) (Fig. 1).  
159 Reaction times ranged from 0.41 to 4.48 seconds ( $\bar{X}=1.8\pm0.2$  seconds), but did not differ  
160 between NW and W horses (Mann-Whitney U-test:  $N_{NW}=14$ ,  $N_W=10$ ,  $\bar{X}_{NW}=2.0\pm0.2s$ ,  
161  $\bar{X}_W=1.2\pm0.2s$ ;  $U=28$ ,  $P=0.27$ ).

162 Durations of attention in reactive horses varied between subjects (from 1.0 to 10.8  
163 seconds,  $\bar{X}=4.2\pm0.7$ ) and were longer for NW horses than for W horses (Mann-Whitney U-  
164 test:  $N_{NW}=14$ ,  $N_W=10$ ,  $\bar{X}_{NW}=5.6\pm0.8s$ ,  $\bar{X}_W=2.4\pm1.1s$ ;  $U=38$ ,  $P=0.01$ ) (Fig. 2).

165

### 166 3.2. Changes of response to auditory stimuli in relation to time

167 Although all horses paid attention to the auditory stimuli at least once, patterns of  
168 response of W and NW horses differed in relation to time. The proportion of reactive W  
169 horses increased significantly on day 2 ( $X^2=10.5$   $p=0.0002$ ) and remained high on the  
170 following days, contrary to NW horses (Fig. 1). Durations of attention of NW horses  
171 decreased on day 2 compared to day 1 (Friedman test ( $N=14$ ,  $df=4$ )= $12.4$   $p=0.01$ ; Wilcoxon  
172 signed-rank test  $\bar{X}_{D1}=5.6\pm10.8s$ ,  $\bar{X}_{D2}=2.9\pm0.6s$ ,  $\bar{X}_{D3}=3.1\pm10.7$ ,  $\bar{X}_{D4}=3.7\pm0.5$ ,  $p<0.05$   
173 for all), whereas they did not vary significantly for W horses (Friedman test ( $N=10$ ,  $df=4$ )= $1.3$   
174  $p=0.85$ ) (Fig. 2).

175

## 176 4. Discussion

177 Playback of unfamiliar auditory stimuli elicited reactions of non-withdrawn horses but of  
178 only half of the withdrawn horses on the first day. Durations of attention of reactive non-  
179 withdrawn horses were longer than those of reactive withdrawn horses. Non-withdrawn  
180 horses' durations of attention decreased on the following days, but those of withdrawn horses  
181 did not vary significantly.

182 On the first test day, withdrawn horses seemed to have "switched off" auditory stimuli  
183 compared to non-withdrawn horses. This result is in accordance with Fureix *et al.*'s (2012)  
184 study reporting withdrawn horses' lower levels of reactions towards humans and tactile  
185 stimuli. This "switch off" might reflect the withdrawn horses' lack of selective attention  
186 towards unusual stimuli. Several hypotheses have been proposed to explain the depressed

187 human patients' lowered selective attention: 1) negative emotional states draw attention and  
188 thus interrupt associated behaviour: the more intensive a negative emotional state, the more it  
189 can disrupt attention to anything else (Smith et al., 1985; Williams, 2002); and 2) the resource  
190 allocation hypothesis postulates that because the depressed patients' cognitive capacity is  
191 reduced, they have deficits in engaging in effortful cognitive processes such as focusing on  
192 relevant stimulations (Ellis & Ashbrook, 1988, cited by Gotlib & Joormann, 2010). In this  
193 study, both hypotheses may apply. The complete immobility, the backward ears and lack of  
194 eye blinking (Fureix *et al.*, 2012) argue in favour of inward oriented attention more than  
195 attention oriented towards the environment. This hypothesis is confirmed by our data on  
196 attention for novel auditory stimuli. Thus, horses with impaired welfare may not perform  
197 cognitive tasks well (Hausberger *et al.*, 2007).

198 With time, the subjects' reactions to our tests varied. More withdrawn horses reacted on  
199 the second day and this proportion remained similar subsequently, while a reverse pattern was  
200 observed for the non-withdrawn horses. Withdrawn horses could have difficulties to detect or  
201 differentiate novel or relevant stimuli in their environment, and this could be related to  
202 cognitive control deficits affecting individuals' ability to disengage attention from irrelevant  
203 material, a common feature of human depressed patients (Gotlib and Joormann, 2010; Kemp  
204 *et al.*, 2010).

205  
206 This study reveals that a horses' 'withdrawn state' corresponds to a multifaceted  
207 syndrome including lower reactivity to environmental stimuli suggesting selective attentional  
208 impairments, a common trait of human depressed patients (Gotlib and Joormann, 2010).  
209 Replication and further research on withdrawn horses' attentional processes are needed,  
210 before validating it for a spontaneous model of depression.

211

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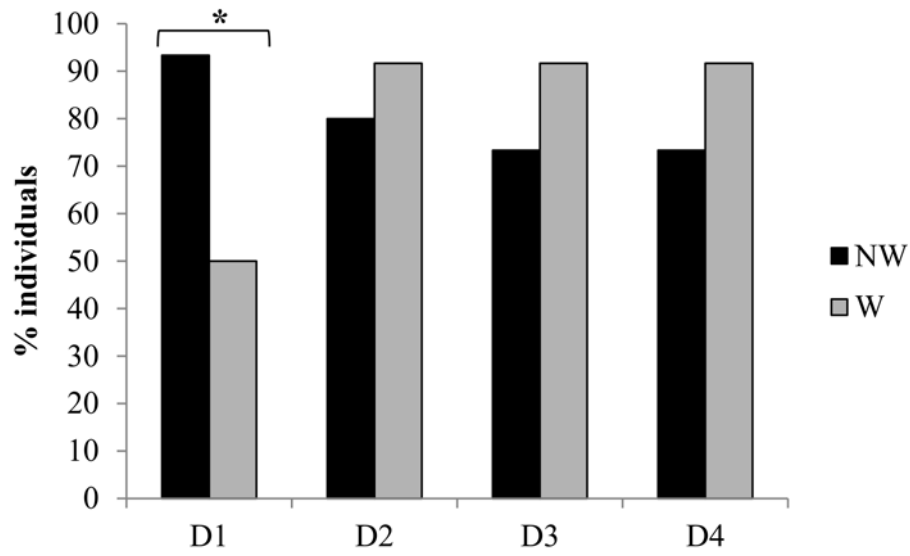
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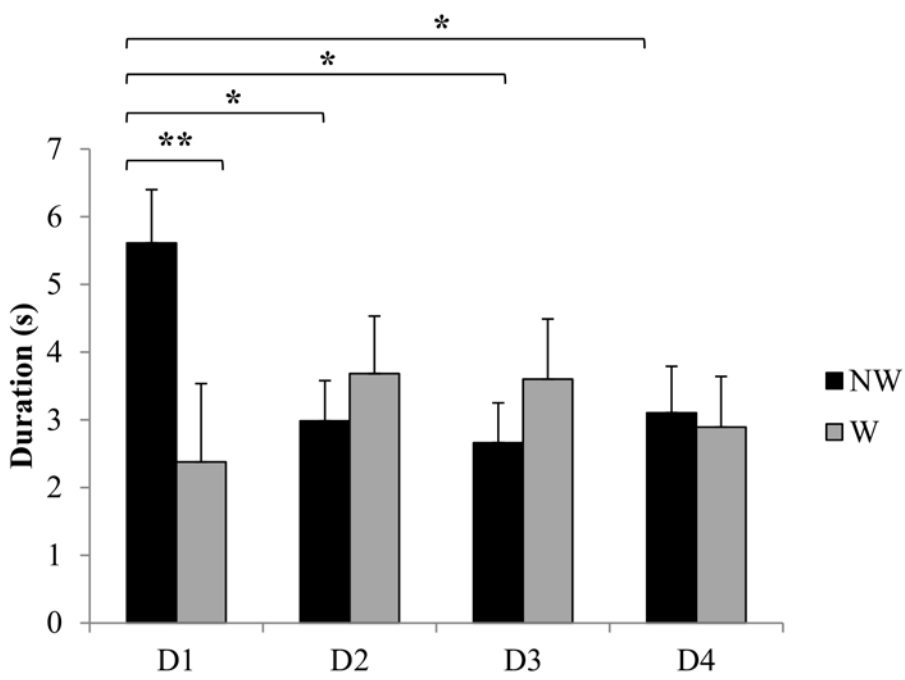


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Figure 1

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Figure 2

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