

1 **Effectiveness of treatments for firework fears in dogs**

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9 **Highlights**

- 10 • An online survey on treatment options for firework fears in dogs was performed
- 11 • Feeding or playing with dogs during fireworks was associated with fear improvement
- 12 • Success was highest for ad-hoc counterconditioning, relaxation training and
- 13 medication
- 14 • Success was similar for pheromones, nutraceuticals and other alternative products
- 15 • Success rates for these alternative products are consistent with a placebo effect

16

17 **Keywords**

18 Noise fear, dog *Canis familiaris*, counterconditioning, pheromones, nutraceuticals, placebo

19 effect

20

21

22 **Abstract**

23 An online questionnaire survey investigated (1) management and (2) treatment methods for
24 firework fears in dogs employed by dog owners and their (perceived) effectiveness. A PCA on
25 data from 1225 respondents revealed four management strategies (i.e. interventions during
26 firework exposure): the principal components “*Environmental modification*” (e.g. providing a
27 hiding place, keeping windows and blinds closed, and playing music), “*Feed/Play*” (providing the
28 dog with chews, play and food during fireworks in general, as well as contingent on loud bangs),
29 “*Alternative*” (use of calming nutraceuticals, pheromones, herbal products, homeopathic
30 products, Bach flowers, and essential oils) and “*Interaction*” (allowing body contact, petting and
31 talking to the dog when loud bangs occurred). To explore possible effects of these management
32 methods on fear development, the components were correlated with a score for fear progression.
33 Of the four components, only “*Feed/Play*” was statistically associated with an improvement in
34 fear responses to fireworks. To evaluate the effectiveness of various treatment strategies,
35 owners were asked to select from a range of options which interventions they had used and
36 whether they considered them as effective. With prescription medication (N=202), improvements
37 were noted by 70% of owners. While individual products were not evaluated, the reported
38 success rates for the categories “pheromones” (N=316), “herbal products” (N=282),
39 “nutraceuticals” (N=211), “essential oils” (N=183), “homeopathic remedies” (N=250) and “Bach
40 flowers” (N=281) were all in the range of 27-35%, which is not higher than would be expected
41 based on a placebo effect. 44% of respondents (N=300) deemed pressure vests as effective.
42 Counterconditioning (providing desirable stimuli after the occurrence of noises) was the most
43 successful training technique according to the owners (N=694), with a reported effectiveness of
44 over 70%. Relaxation training (N=433) was reported to be almost as successful at 69%, while
45 noise CDs (N=377) were effective in 55% of cases. Thus, counterconditioning, relaxation
46 training and psychoactive medication appear to be the most effective strategies in the treatment
47 of firework fears in dogs. On this basis it is recommended that ad-hoc counterconditioning and
48 relaxation training should complement the standard behavioral technique of desensitization/
49 counterconditioning with noise recordings.

50 **Introduction**

51 Fear of fireworks and other loud noises represents a significant welfare problem for pet
52 dogs, both in terms of numbers affected, as well as the duration of behavioral changes
53 following a firework event. According to surveys, up to half the pet dog population react
54 fearfully to fireworks (Blackwell et al., 2013; Riemer, 2019; Storengen and Lingaas, 2015;
55 Tiira et al., 2016), and one study indicated that over 15% of fearful dogs require several days
56 or longer to recover behaviorally from a firework event, with over 3% exhibiting behavioral
57 changes for weeks or months (Riemer, 2019). Thus, identifying effective interventions to
58 prevent and treat firework fears in dogs is of wide concern. Owners' awareness of the issue
59 seems to be increasing (c.f. Riemer, 2019), and a wide range of products are marketed as
60 alleviating firework fears in dogs, ranging from pheromones to special garments and from
61 homeopathy to prescription medication. However, as has been pointed out previously, many
62 products lack scientific evidence for their effectiveness, and even most published studies in
63 the field are based on low sample sizes and often lack placebo treatments (Sherman and
64 Mills, 2008). Subsequently I give a brief overview over approaches to treating noise fears in
65 dogs.

66

67 **1) Behavioral techniques**

68 *Management*

69 In order to minimize adverse experiences for the animal, management measures are
70 important when exposure to fearful stimuli cannot be avoided (Sherman and Mills, 2008).
71 Commonly given management advice for noise fears includes providing a safe place to
72 retreat, ideally by associating it with positive experiences prior to any firework events,
73 darkening the room putting music or white noise on, ignoring fearful behavior, distracting the
74 dog with games, training or food, and refraining from any punishment (Mills, 2005; Pike et
75 al., 2015; Sherman and Mills, 2008). However, management is likely not to be sufficient to

76 generate long-lasting improvement, and behavior modification techniques, often with
77 adjunctive use of pheromones or medication, are usually recommended (Sherman and Mills,
78 2008). Given that fears and phobias can significantly compromise welfare and become
79 severe, wherever possible clinicians should aim to treat fears and attempt to resolve the
80 problem, rather than relying on management only (Horwitz and Mills, 2012).

81 *Systematic desensitization and counterconditioning*

82 The use of noise recordings for systematic desensitization and counterconditioning
83 (abbreviated as DSCC) is the most commonly advised behavioral technique in the treatment
84 of noise fears (e.g. (Horwitz and Mills, 2012; Levine et al., 2007; Levine and Mills, 2008; Mills
85 et al., 2003; Sherman and Mills, 2008). “Desensitization” can be defined as “gradual and
86 controlled exposure to the stimulus so as to extinguish the manifestations of fearful behavior”
87 (e.g. Horwitz and Mills, 2012, p. 177) “Counterconditioning” in this context usually refers to
88 pairing desirable stimuli such as food or play with the fear-eliciting stimulus (“respondent
89 counterconditioning”); although some authors also describe the process of “operant
90 counterconditioning”, defined as “reinforcing a substitute behavior that is incompatible with
91 the unwanted behavior” (Horwitz and Mills, 2012, p.217). Hereafter, I use the classic
92 definition of the term “counterconditioning” as meaning that the feared stimulus is paired with
93 an appetitive/positive outcome (e.g. food) with the goal of decreasing the fear response over
94 repeated pairings and replacing it with an appetitive response (c.f. Newall et al., 2017).

95 Studies indicate that most owners perceive an improvement in their dogs’ firework fears after
96 following a DSCC program using noise CDs (in combination with Dog Appeasing
97 Pheromone) and are very satisfied with the treatment (Levine et al., 2007; Levine and Mills,
98 2008; Sheppard and Mills, 2003), even up to one year later (Levine and Mills, 2008).

99 However, one study reports that no effect of treatment could be discerned using objective
100 behavioral measures when dogs were exposed to a novel CD recording in the clinic setting
101 (Levine et al., 2007), and this finding was similar to that of a previous study on the use of
102 noise CDs (in combination with medication) on thunderstorm fear in dogs: Despite owner-

103 reported improvement, no change in behavioral signs was noted during post-treatment
104 exposure to a thunderstorm recording in the clinic (Crowell-Davis et al., 2003).

105

106 *Relaxation training*

107 Training animals to relax on cue is a less commonly recommended tool in behavior
108 modification (but see Mills, 2003; Overall, 2013a; Talegón and Delgado, 2011). Relaxation
109 may be achieved by different approaches. Horwitz and Mills (2012) suggest to firstly, induce
110 relaxation by massage or long strokes. Secondly, this can be associated with a word in order
111 to classically condition a calm physiological state. After successful conditioning, this cue can
112 then be used to induce relaxation during stressful events even without the need to massage
113 continuously (Horwitz and Mills, 2012). While this method relies on classical conditioning, an
114 operant “protocol for training relaxation” is given in Overall (2013b). Here, the dog is
115 progressively rewarded for behaviors, facial or bodily expressions consistent with relaxation,
116 and for remaining still for increasing amounts of time and in the face of gradually increased
117 distractions (Overall, 2013b).

118

119 **2) Pharmacological interventions**

120 *Prescription medication*

121 While benzodiazepines (e.g. Alprazolam), MAOIs, SSRIs, trazodone and the α 2-
122 adrenoceptor agonist clonidine can be indicated in the medical management of noise fears
123 in dogs (Horwitz and Mills, 2012; Overall, 2013a), only a handful of studies have investigated
124 the effects of medications on noise fears in dogs, and surprisingly few were placebo-
125 controlled. Two small open-label studies indicated that trazodone and clonidine, respectively,
126 were effective in alleviating storm or noise phobia in dogs where other treatments (including
127 other medications) had failed (Gruen and Sherman, 2008; Ogata and Dodman, 2011). A
128 small prospective open clinical trial investigated the effect of a combination of daily

129 clomipramine, added alprazolam before storms, and desensitization/ counterconditioning at
130 home with a thunderstorm audio recording on the behavior of dogs affected by fear of
131 thunderstorms. While almost all caregivers indicated an improvement in their dogs, this
132 could not be confirmed when exposing dogs to the audio recording in the clinic, although it is
133 not clear whether post-treatment recordings were made under the influence of alprazolam
134 (Crowell-Davis et al., 2003). Another small retrospective study indicated that diazepam was
135 considered very or somewhat effective by 67% of owners, but many owners discontinued the
136 treatment due to the occurrence of side effects (Herron et al., 2008). None of the above-
137 mentioned studies included a placebo group. Currently, the best evidence exists for Sileo ©
138 Dexmedetomidine oromucosal gel that is specifically licensed for noise fears in dogs in the
139 European Union (European Medicines Agency, 2015). A placebo-controlled study indicated
140 that the treatment effect was good or excellent according to owner reports in 72% of dogs
141 affected by noise fears compared to 37% in the placebo group (Korpivaara et al., 2017).
142 Additionally, a pilot study on the effect of imepitoin on cortisol levels of beagle dogs during
143 thunderstorm recordings yielded promising results (Engel et al., 2018).

144

145 **3) Alternative products**

146 *Pheromonatherapy*

147 Pheromonatherapy utilizes analogues of animal pheromones, chemical signals normally
148 involved in intraspecific communication that are processed by the vomeronasal organ and
149 are assumed to have an intrinsic effect on the emotional processing of animals (Mills et al.,
150 2012). Dog appeasing pheromone (DAP, Adaptil®) mimics a pheromone produced by
151 lactating bitches after parturition that is believed to instill a sense of well-being in the
152 puppies. It is used in veterinary behavioral medicine as a calming agent also for adult dogs
153 (Mills et al., 2012).

154 An open-label follow-up study indicated that the use of Dog Appeasing Pheromone plug-in
155 diffusers resulted in a high owner satisfaction level and reported improvement in dogs'
156 clinical signs during firework exposure (Sheppard and Mills, 2003), although the inclusion of
157 behavioral advice in the treatment plan does not allow to distinguish effects of behavioral
158 modification and pheromones (c.f. Frank et al., 2010). DAP was also used as in the above-
159 cited studies in combination with noise CDs (Levine et al., 2007; Levine and Mills, 2008).
160 One study suggested that the use of DAP and noise CDs in combination had higher owner-
161 reported success rates than when either intervention was used alone (Mills et al., 2003).
162 While the above studies were unblinded and did not include a placebo group, a blinded
163 parallel-group placebo controlled study on the effects of DAP collars on the behavior of
164 laboratory beagles during playbacks of thunderstorm recordings concluded that DAP is of
165 potential benefit as an adjunct to a behavior management program (Landsberg et al.,
166 2015a). In this study, observations of active (such as startling, scanning, bolting, pacing,
167 running, circling, digging, climbing, jumping and barking) and global fear scores were
168 significantly lower in the pheromone-treated group compared to the placebo group. No
169 significant group differences emerged in passive scores (such decreased activity, freezing,
170 lower body postures, panting, trembling, salivating, lip licking etc.). Hiding in a hiding box
171 occurred significantly more in placebo-treated subjects (Landsberg et al., 2015a).

172 *Neutraceuticals*

173 Given that neutraceuticals do not underlie the same stringent approval processes as
174 medications and therefore enter the market much more easily, many non-prescription
175 neutraceuticals are available for treating fear and anxiety in dogs (Orlando, 2018). However,
176 little published research on their effects exists, especially in regard to noise fears. For
177 example, Zylkene (alpha-casozepine) may be recommended to aid with noise fears although
178 it has not specifically been tested for this indication (Horwitz and Mills, 2012). The effect of L-
179 theanine on fear of thunder in dogs was investigated in a small open-label trial. However, a
180 high drop-out rate (eight of originally 26 subjects could not be included in the analysis due to

181 early withdrawal or failure to complete the paperwork) hinders drawing valid conclusions. For
182 the remaining 18 dogs, a highly significant reduction in owner-reported global anxiety scores
183 and time to return to baseline following a storm was found, and treatment success (defined
184 as “an improvement in the behavior score after the 5th storm compared with baseline of at
185 least 1 in 50% of the behaviors identified, with no behavior getting worse” was achieved in
186 12 of the 18 dogs (Pike et al., 2015). A fish protein supplement appears to have beneficial
187 effects on cortisol reactivity in dogs exposed to a thunderstorm recording (Landsberg et al.,
188 2015b).

189 Many owners tend to prefer to try “natural treatments” – such as herbal remedies,
190 homeopathy or essential oils – in the management of behavioral problems first, with
191 medication being regarded as only a last resort (Notari and Gallicchio, 2008). However, for
192 most of these products, there is either no peer-reviewed research at all, results are
193 inconclusive or negative.

194 *Herbal formulations*

195 A placebo-controlled crossover study investigated the effect of Harmonease Chewable
196 Tablets, containing a blend of extracts of *Magnolia officinalis* and *Phellodendron amurense*,
197 on inactivity duration during thunder storm recordings in 20 beagle dogs (with higher
198 inactivity interpreted as reflecting greater fear intensity). While an analysis of variance
199 indicated no significant treatment or order effect, the number of dogs reducing levels of
200 inactivity during thunderstorm recordings was higher in the treatment group (60%) than in
201 the placebo group (25%)(DePorter et al., 2012). Note, however, that later studies found that
202 many individuals react with an increase, rather than a decrease, in activity to thunderstorm
203 recordings (Gruen et al., 2015; Landsberg et al., 2015a, 2015b).

204 *Homeopathy*

205 A double-blind placebo-controlled study on the use of a homeopathic remedy in the
206 treatment of firework fears in dogs showed high owner-reported improvement rates in both

207 the placebo group (65%) and the verum group (71%), with no significant differences in any
208 measures between the two groups. While the owners were also given simply management
209 advice on how to react during firework exposure, this is unlikely to explain the perceived high
210 rates of success, with substantial placebo effects being more likely (Cracknell and Mills,
211 2008). As such, open-label studies should be interpreted with caution.

212 *Aromatherapy (essential oils)*

213 Odors, in particular essential oils, may be used in a therapeutic context to alleviate stress in
214 animals (Mills et al., 2012). As pointed out in the BSAVA Manual of Canine and Feline
215 Behavioral Medicine, there are suggestions that lavender and chamomile may promote
216 calmness in shelter dogs, but no evidence is available in relation to noise fears (Horwitz and
217 Mills, 2012).

218 *Bach flowers*

219 Although there is no science-based evidence for their effectiveness, Bach flowers may be
220 advised by some animal behavior professionals based on owners' preferences (Notari and
221 Gallicchio, 2008). Moreover, like Dog Appeasing Pheromone, herbal formulations,
222 homeopathic products and essential oils, Bach flowers are freely available over the counter
223 and so do not require a consultation with a professional.

224

225 **4) Pressure vests**

226 Studies on humans and on cattle indicate that deep pressure and weighted vests, or
227 pressure in a squeeze chute, respectively, have calming effects. While the mechanism of
228 action is not clear, it is suggested that peripheral oxytocin in response to the skin contact
229 may contribute to relieving stress, reducing blood pressure and heart rate (reviewed in
230 Pekkin et al., 2016). So-called pressure vests, tight-fitting vests for dogs exerting deep
231 pressure when worn, utilize this principle and are postulated to exhibit calming effects on pet
232 dogs. While the available evidence is inconclusive, there are some indications of effects on

233 some behavioral parameters and heart rate during thunderstorm or firework recordings that
234 could be interpreted as reflecting lowered anxiety when wearing a vest (Fish et al., 2017;
235 Pekkin et al., 2016). Also owners considered the vest to be of benefit during real-life
236 thunderstorm events (Cottam et al., 2013). A review concluded that “pressure vests may
237 have small but beneficial effects on canine anxiety and that habituating the dog to the vest,
238 assessing for comfort and using repeatedly may improve the likelihood of any benefit”
239 (Buckley, 2018). Several vests are commercially available, such as the Thundershirt, Anxiety
240 Wrap and Lymed Animal™ Supporting Garments.

241

242 To conclude, there is a lack of high-quality evidence for the majority of commonly
243 recommended interventions in the treatment of noise fears in dogs. Since almost all existing
244 studies suffer from very low sample sizes, it was decided to take a cross-sectional approach
245 here using an online internet survey targeting a variety of different interventions. Like most
246 previous studies, the study is based on the owners’ assessment of their dogs’ wellbeing
247 during noise exposure and the effectiveness of behavioral techniques or products used.

248

249 **Methods**

250 An online questionnaire survey (in an English and a German version) was distributed to dog
251 owners via our research group’s website and social media. The questions covered the
252 owners’ consent for the use of their data, demographic data about the dogs (date of birth,
253 sex, neuter status, breed, country, source of dog, age at acquisition), dogs’ health problems
254 and other potential behavioral problems (Riemer, 2019). Two scores were used to rate the
255 severity and progression of firework fears, respectively (see below). Furthermore, owners
256 were asked to indicate which management and treatment options they had used by selecting
257 a number of options and, for the latter, whether they considered these as effective.

258

259 *Welfare impaired score*

260 As a measure of the severity of firework fears, participants were asked “Please rate your
261 level of agreement with the following statement: The overall welfare of my dog is strongly
262 compromised by fireworks”. This was rated on a 5-point Likert scale ranging from “disagree
263 strongly”, “tend to disagree”, “partly/partly”, “tend to agree” to “agree strongly”. The ensuing
264 “Welfare Impaired” score was converted into a numerical score from 1 (“disagree strongly”) to 5 (“agree strongly”) for the analysis.

266 *Fear progression score*

267 The “Fear progression” score was based on the question “How has your dog’s fear of
268 fireworks progressed in the last years?”, with the following response options “My dog was
269 never afraid of fireworks”, “The fear has improved greatly”, “The fear tends to have
270 improved”, “The fear has remained the same”, “The fear tends to have become worse”, “The
271 fear has become much worse” or “I don’t know”. For analysis, this was converted into a
272 score ranging from 1 (“The fear has become much worse”) to 5 (“The fear has improved
273 greatly”), with “I don’t know” treated as missing data.

274 *Management strategies*

275 Owners were asked to select which management approaches (i.e. strategies during firework
276 exposure, independent of any preparatory interventions) they had used to help their dogs
277 cope with fireworks from a list of options (Table 1). They were also asked to select how they
278 responded to their dogs when hearing loud bangs (Table 1).

279 *Effectiveness of interventions*

280 Owners were asked to select from a number of options which interventions to prevent or
281 treat their dog’s fear of fireworks they had tried and whether they considered these as
282 effective (response options: effective - not effective - not used; Table 2).

283

284 Table 1. Questions related to owners' management of firework fears (i.e. strategies during

285 firework events).

Which measures do you take on New Year's eve/ on days with fireworks? (Please select all applicable answers).	
	Nothing
	I create a safe hiding place for my dog
	I close the curtains/ window shutters
	I play loud music to drown out the noise
	I put a thundershirt/ anxiety wrap on my dog
	I offer chews to my dog
	I play with my dog
	I give food to my dog
How do you react yourself (to your dog) when hearing loud bangs? (Please select all applicable answers).	
	I ignore him or her/ I don't pay attention to him or her
	I pet him or her
	I give him or her a treat
	I play with him or her
	I allow him or her to maintain body contact
	I speak to him or her in a calming way
Have you administered medication	Yes - No

or other calming products to your dog during the last firework event?	
If yes, which ones? (Please select all applicable products).	
	Neutraceuticals (e.g. Zylkene, tryptophan etc.)
	Pheromone products (Adaptil diffuser, spray or collar)
	Herbal products
	Homeopathic products
	Bach flowers
	Essential oils
	Drugs (prescription medication available only from a veterinarian)
	Other

286

287 Table 2. Question on the perceived effectiveness of interventions for management or

288 training.

Which measures to treat or prevent firework fears did you consider as effective?	Response options: effective - not effective - not used
	Noise CD
	Pheromone products (such as Adaptil diffuser, collar or spray)
	Herbal products
	Homeopathic products
	Neutraceuticals (e.g. Zylkene, tryptophan etc.)
	Bach flowers

	Essential oils
	Drugs (prescription medication available only from a veterinarian)
	Counterconditioning (for example, giving a treat or playing with the dog after a noise has occurred)
	Relaxation training
	Thundershirt/ anxiety wrap
	Other

289

290 **Analysis**

291 In order to identify patterns in management strategies, a non-linear principal components
292 analysis (Linting et al., 2007; Linting and van der Kooij, 2012) or Categorical Principal
293 Components Analysis (CATPCA) in IBM SPSS Statistics Version 23 (© IBM Corporation and
294 its licensors 1989, 2015) was performed over the questions on owners' management
295 strategies during fireworks, including measures taken during New Year's eve/ on days with
296 fireworks (e.g. creating a hiding place, closing windows, playing music etc.), how owners
297 reacted to loud bangs themselves (e.g. ignoring the dog, petting the dog, giving the dog a
298 treat etc.), and which types of products they had administered (e.g. pheromone products,
299 prescription medication, pressure vests etc.). To assess relationships of management
300 factors and fear development, the ensuing components were correlated with the Fear
301 Progression Score using Spearman rank correlation tests, as requirements for parametric
302 analysis were not met, using Statistica 6.1 (Statsoft Inc. 1984–2004).

303 For the specific questions on different products and training techniques used, the percentage
304 of respondents considering a given intervention as effective was calculated from the total
305 number of respondents that indicated having used this intervention.

306

307 **Results**

308 A total of 1225 responses were analyzed, including 527 responses in English and 699 in
 309 German. Dogs were of various breeds or crosses and included 588 females (of which 430
 310 neutered, 157 intact and one of unknown neuter status) and 637 males (of which 424
 311 neutered, 207 intact and 6 chemically castrated). Over half the dogs in the survey (N=639)
 312 were given a rating of 3 or higher on the Welfare Impaired score and so are considered as
 313 fearful of fireworks (see (Riemer, 2019) for more details).

314 **Management strategies**

315 Regarding owners' management during firework exposure, the CATPCA yielded four factors
 316 (based on Eigenvalues >1 and Cronbach's Alpha >0.7) that had no cross-loadings and
 317 accounted for 49% of the variance (Table 3).

318 **Table 3.** Results of a CATPCA on management strategies employed by owners during
 319 fireworks, with Varimax rotation. Loadings >0.4 are bolded.

		Environmental Modification	Feed/ Play	Alternative	Interact	Total
Measures during firework events	No measures	-0.718	-0.210	-0.087	-0.256	
	Hiding place	0.654	0.049	0.148	0.217	
	Windows closed	0.803	0.104	0.100	0.100	
	Music	0.722	0.131	0.164	0.030	
	Thundershirt	0.351	0.077	0.400	0.044	
	Chews	0.238	0.684	0.038	0.003	
	Play	0.130	0.751	-0.064	0.081	
	Food	0.074	0.749	0.071	0.086	
	Reaction to bangs	Ignore	-0.057	-0.071	-0.021	-0.629
Pet		0.040	0.208	0.104	0.760	
Feed		-0.001	0.658	0.035	0.323	

	Play	-0.035	0.718	-0.005	0.193	
	Body contact	0.313	0.115	0.092	0.585	
	Talk	0.257	0.189	0.083	0.701	
Products used	Neutraceuticals	0.244	0.024	0.443	0.030	
	Pheromones	0.248	0.005	0.586	0.021	
	Herbal products	0.123	0.059	0.729	0.000	
	Homeopathy	0.078	-0.036	0.748	0.051	
	Bach flowers	0.112	-0.057	0.645	0.094	
	Essential oils	-0.044	0.053	0.580	0.086	
	Prescription medication	0.394	-0.048	0.213	0.066	
	Cronbach's alpha	0.769	0.731	0.726	0.708	0.948b
	Eigenvalue	2.795	2.735	2.693	2.112	10.335
	% of variance	13.309	13.021	12.825	10.058	49.214

320

321 The first component, termed “**Environmental modification**” had high positive loadings for
 322 providing a hiding place, keeping windows and blinds closed, and playing music and a high
 323 negative loading for not taking any measures. The use of a thundershirt or anxiety wrap and
 324 prescription medication also loaded > 0.35 on this component. The second component,
 325 “**Feed/Play**”, had high positive loadings for providing the dog with chews, play and food
 326 during fireworks in general, as well as for feeding and playing with the dog in response to
 327 loud bangs. The third component, labelled “**Alternative**” had high positive loadings for the
 328 use of calming neutraceuticals, pheromones, herbal products, homeopathic products, Bach
 329 flowers, and essential oils. The fourth component, “**Interaction**”, had high positive loadings
 330 for allowing body contact, petting and talking to the dog when loud bangs occurred, and a
 331 high negative loading for ignoring the dog.

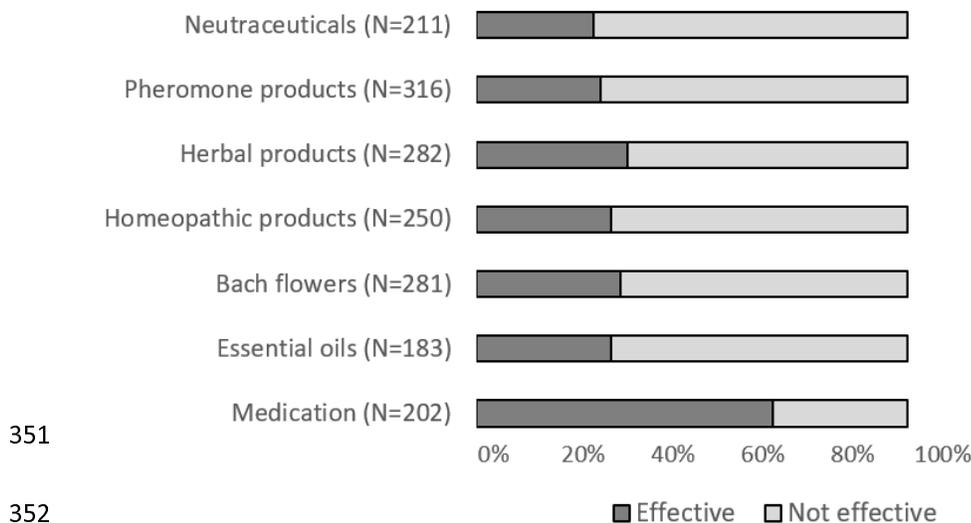
332 Within those dogs with Impaired Welfare scores of 3 or higher, the principal component
 333 “Environmental Modification” was significantly positively correlated with Fear Progression
 334 (i.e. an increase in severity of firework fears, Spearman rank correlation test, $Rho=0.181$,
 335 $N=566$, $p=0.00001$) whereas the component “Food/ Play” was significantly negatively

336 correlated with Fear Progression (Spearman $Rho=-0.16$, $N=566$, $p=0.00008$). There was no
337 relationship between Fear Progression and the components “Alternative” (Spearman
338 $Rho=0.026$, $N=566$, $p=0.527$) and “Interaction” (Spearman $Rho=-0.03$, $N=566$, $p=0.357$).

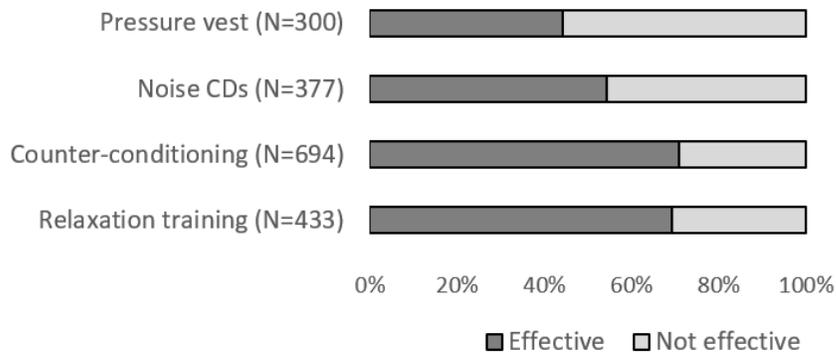
339

340 ***Owner-reported efficacy of products used and training techniques***

341 Of those owners who had used pheromone products (Adaptil diffuser, spray or collar,
342 $N=316$), 28.8% considered these to be effective in alleviating their dogs' firework fears. The
343 reported success rate was 27.0% for nutraceuticals ($N=211$), 35.1% for herbal products
344 ($N=282$), 31.2% for homeopathic products ($N=250$), 33.5% for Bach flowers ($N=33.5$) and
345 31.1% for essential oils ($N=183$). Prescription medication had a much higher reported rate of
346 effectiveness at 68.9% ($N= 202$; Figure 1). A success rate of 44% was indicated for the use
347 of a thundershirt/ anxiety wrap ($N=300$). Noise CDs were considered as effective by 54.4%
348 of those who had used them ($N=377$). The most effective training techniques according to
349 the survey were counterconditioning (70.8% success rate, $N=694$) and relaxation training
350 (69.3% reported effectiveness, $N=433$; Figure 2).



353 Figure 1. Owner reported success rates of calming nutraceuticals, pheromones, herbal
354 remedies, homeopathic products, Bach flowers, essential oils and prescription medication.



355

356 Figure 2. Owner reported success rates of pressure vests and different training approaches.

357

358 Since the question on which specific products were used were optional, data on the type of
 359 prescription medication used were available for 103 dogs. Of those, 86 received one type of
 360 drug, 13 received a combination of two drugs and four received three drugs. Alprazolam
 361 (N=32) and Dexmedetomidine (N=19) were the most frequently prescribed single drugs. The
 362 most frequent combination was Trazodone & Alprazolam (N=7). Other combinations
 363 included Dexmedetomidine combined with Diazepam or Alprazolam. Table 4 shows the
 364 reported effectiveness of the drugs in the sample, bearing in mind that the sample size was
 365 very small for most types of medication.

366

367 Table 4. Owner reported effectiveness of different prescription medications

	N	Effective	Effective (%)
Alprazolam	32	29	90.63
Dexmedetomidine	19	14	73.68
Diazepam	8	4	50
Trazodone	8	6	75
Acepromazine	4	4	100
Benadryl	3	3	100

Fluoxetine	3	3	100
Clomipramine	2	2	100
Clonidine	2	0	0
Sertralin	1	1	100
Tramadol	1	1	100
>1 drug	17	13	76.47
Trazodone & Alprazolam	7	7	100

368

369 **Discussion**

370 An online survey was performed to explore how owners managed potential firework fears in
371 their dogs and which interventions they perceived as effective in improving dogs' firework
372 fears.

373 *Management*

374 In order to gauge whether management measures can affect the progression of firework
375 fears in dogs, the four management factors were correlated with the Fear progression score.
376 The results indicated that "Environmental modification" (providing a hiding place, keeping
377 windows and blinds shut, and playing music) was associated with a significant deterioration
378 of firework fears, whereas provision of chews, play and food during fireworks in general, as
379 well as deliberately providing these rewards when loud bangs occurred (principal component
380 "Feed/Play") was associated with a significant improvement. No association was found
381 between fear progression and the "Alternative" component (use of nutraceuticals,
382 pheromones, herbal products, homeopathic products, Bach flowers, and essential oils) or
383 the "Interaction" component (allowing body contact, petting and talking to the dog when loud
384 bangs occurred).

385 The positive correlation between Fear progression and "Environmental Modification" is
386 unlikely to indicate that measures of environmental modification were *contributing* to

387 increased fear severity. Conversely it is probable that owners who perceived an increased
388 fear response in their dogs were more likely to take measures of environmental modification,
389 since these are commonly recommended measures for dogs fearful of fireworks (e.g. Mills et
390 al., 2003; Pike et al., 2015; Sherman and Mills, 2008). Of real interest, however, is the
391 significant negative association of Fear progression and the “Feed/Play” component. It is
392 reasonable to assume that this reflects a positive effect of the intervention on fear
393 progression rather than vice versa, since owners experiencing an improvement in their dogs’
394 fears should be less likely and not more likely to attempt a given intervention. It appears that
395 using appetitive stimuli during firework exposure not only helped to keep the fear at bay
396 during the event, but they may even have contributed to a longer-lasting improvement in
397 fearfulness, possibly exerting some counterconditioning effects even without a systematic
398 desensitization/ counterconditioning approach. Alternatively, it is possible that dog owners
399 who used food and toys during fireworks also performed ad-hoc counterconditioning
400 (providing these incentives contingent on occurrence of noises) in everyday life.

401 A common recommendation is to ignore the dog when it shows fearful behavior (e.g. Mills et
402 al., 2003; Pike et al., 2015; Sherman and Mills, 2008). The current study indicated that
403 interacting with the dog is neither associated with improvement nor with deterioration of the
404 dogs’ fear level over time. Similarly, Dreschel and Granger (2005) found no influence of the
405 owner’s behavior on behavior and cortisol levels in dogs after a playback of a thunderstorm
406 recordings. Whether interacting with a fearful dog has beneficial or detrimental effects on
407 fear level in the firework situation itself requires further investigation. There is, however,
408 evidence from other stressful situations that being petted and talked to is associated with
409 lower physiological or behavioral stress indicators in dogs (e.g. Csoltova et al., 2017;
410 Hennessy et al., 1998; Lynch and McCarthy, 1967), and some physiological mechanisms for
411 this have been identified (e.g. Handlin et al., 2011; Kostarczyk and Fonberg, 1982; Odendaal
412 and Meintjes, 2003; Rehn et al., 2014). Thus, there might be potential beneficial effects of
413 attending to fearful dogs also in firework situations, even if it cannot be ruled out that this

414 reinforces some behavioral actions, such as attention-seeking, by instilling some fear relief
415 (negative reinforcement).

416

417 *Behavior modification and training*

418 The above-mentioned correlation between higher scores on the “Feed/Play” principal
419 component and a more favorable fear progression has indicated that using food and play
420 during fireworks is an effective way of alleviating noise fears in dogs. This is also confirmed
421 by the owners’ own perceptions: Counterconditioning (defined in the questionnaire as “for
422 example, giving a treat or playing with the dog after a noise has occurred”) was considered
423 to be effective by 70.8% of those who had tried this technique. It is commonly believed that
424 desensitization/ counterconditioning can only be successful in achieving a lasting emotional/
425 behavioral change if pets are kept under their threshold or tolerance level (Horwitz and Pike,
426 2014, but see a critical evaluation of this assumption in Klein, 1969; Wilson and Davison,
427 1971). While this would clearly be the ideal approach, the results of the current study
428 indicate that even ad-hoc, non-systematic, counterconditioning in everyday life (such as
429 giving a treat, playing with the dog or celebrating a little ‘party’) whenever a loud noise
430 occurs, as well as during firework events, can contribute to an improvement of firework fears
431 in dogs. While some dogs may be too stressed to eat during exposure to loud noises,
432 providing high-value food after any noise occurrence is a simple strategy that can be easily
433 implemented also by inexperienced owners and was actually used by over half the
434 respondents in this study (N=694). Using this technique as a preventative measure appears
435 to be extremely effective in preventing the development of firework fears in the first place
436 (Riemer, 2019). This method is thus highly recommendable in both the prevention and
437 treatment of noise fears in dogs.

438

439 Interestingly, with a success rate of a 69.3% according to the owners, relaxation training was
440 nearly as effective as counterconditioning in alleviating firework fears in dogs. Although

441 relaxation was an inherent component of the original concept of “systematic desensitization”
442 in people sensu Wolpe, (1958, reviewed in Thomas et al., 2012; Wilson and Davison, 1971),
443 relaxation training is less prominently mentioned in the current literature on clinical animal
444 behavior. Nonetheless, a relatively high number of respondents in the sample (N=433) had
445 attempted this techniques. The current questionnaire did not go into detail about the type of
446 training protocols that were used, i.e. whether a classically conditioned approach was mostly
447 used or whether respondents achieved a relaxed state through positive reinforcement of
448 relaxed behaviors. Further research is therefore warranted on the optimal relaxation
449 protocols. Similarly as with counterconditioning, it appears that respondents did not
450 necessarily use relaxation training in a systematic way with a gradual increase in stimulus
451 intensity; nonetheless, the technique seems to have been successful in a large proportion of
452 cases, at least according to the owners’ perceptions.

453

454 The current gold standard and most studied behavioral approach in the therapy of noise
455 fears is to perform desensitization/ counterconditioning (DSCC) using noise recordings (e.g.
456 Horwitz and Mills, 2012; Levine et al., 2007; Levine and Mills, 2008; Mills et al., 2003;
457 Sherman and Mills, 2008). Nonetheless, at 54.4% reported effectiveness, the use of noise
458 recordings had a considerably lower success rate than ad-hoc counterconditioning and
459 relaxation training in the current study. The rate of success is also somewhat lower than
460 reported in previous studies on the use of noise CDs, possibly reflecting the more long-term
461 view. For example, in a follow-up study one year after the first implementation of DSCC
462 using noise CDs, 66% of owners indicated either “a moderate or great improvement” in their
463 dog’s fear of fireworks, even though only few of the respondents had continued to use the
464 CD recording (Levine and Mills, 2008), and reported success rates were even higher in the
465 short-term (Levine et al., 2007; Sherman and Mills, 2008).

466

467 Perhaps owners who received the CD from professionals in veterinary behavior medicine
468 were more motivated to follow through the procedure, or they had received better

469 instructions on how to approach DSCC – although Mills et al. (2003) and Levine et al. (2007)
470 found that many owners did not necessarily adhere to the instructions very well, and that two
471 CDs with different types of instructions appeared to be similarly effective. The published
472 studies had relatively high dropout rates. While personal reasons were mostly given (Levine
473 et al., 2007), it cannot be ruled out that those owners who perceived no success of treatment
474 were more likely to discontinue and were thus not available for reporting on the perceived
475 success (or lack thereof) at the study end. Also with relatively small sample sizes in the cited
476 studies compared to the current one, more random variation can be expected in the former.
477 Additionally, treatment success might be over-reported when personal follow-up via phone
478 calls are made as in Levine et al. (2007), Levine and Mills (2008) and Mills et al. (2003),
479 since it is suggested that patients may report positive outcomes to the treating clinician out
480 of politeness, enhancing the placebo effect (Kienle and Kiene, 1997). It is furthermore
481 possible that the advice to introduce a “safe haven” (“a location in the home in which the dog
482 had only positive experiences – not the same location to which the dog normally hid when
483 fearful” (Levine et al., 2007) and the provision of Dog Appeasing Pheromone (Levine et al.,
484 2007) enhanced the treatment success compared to the use of CD recordings alone (c.f.
485 Mills et al., 2003).

486

487 Some difficulties with using noise recordings for DSCC have been recognized. They may not
488 be realistic enough, depending on the quality of the recording or the speakers, the setup of
489 the room influencing acoustics, and lacking associated stimuli such as flashes (Sheppard
490 and Mills, 2003; Shull-Selcer and Stagg, 1991). Even under optimal conditions, some dogs
491 will not respond to the simulations (Shull-Selcer and Stagg, 1991). Moreover, DSCC using
492 noise recording is a time-consuming process, and may need to be repeated periodically to
493 prevent a relapse, which some owners may be unwilling or unable to provide (Levine and
494 Mills, 2008; Sheppard and Mills, 2003).

495

496 Thus, while noise recordings clearly have a place in the treatment of noise fears, ad-hoc
497 counterconditioning to noises and relaxation training should complement this treatment
498 strategy. In particular, using treats or other incentives whenever a (loud) noise occurs may
499 be an easier strategy to implement in everyday life for many owners, as unlike both DSCC
500 with noise recordings and relaxation training, it requires no targeted training other than
501 having some food on hand – although clearly, the more structured training can be done, the
502 better the outcome is likely to be.

503

504 *Products*

505 While the reported success rates for counter-conditioning and relaxation training were
506 relatively high, behavioral methods on their own may often not be sufficient to provide
507 adequate fear relief. Accordingly, a wide range of products with putatively calming properties
508 are on the market; however, there is a lack of good-quality evidence on their effectiveness.

509

510 In the current study, the highest success rates of all product categories was achieved for
511 prescription medication, even though it can be presumed that dogs that were medicated
512 were affected by more severe noise fears than those receiving no medication. Since
513 medications undergo a rigorous testing process (albeit not necessarily for the indication
514 “noise fears”) before they are licensed, and work at the level of the central nervous system,
515 this should be expected. While the overall sample size for users of medication was large in
516 the current study (N=202), only a smaller number of owners had indicated which
517 medications they had used. Of primary interest here are the two most commonly reported
518 medications, Alprazolam (N=32) and Dexmedetomidine (N=19). The success rate was very
519 high for Alprazolam at over 90%, while Dexmedetomidine was considered to be effective in
520 over 73% of cases. The latter figure is very similar to the published effectiveness of
521 Dexmedetomidine in a placebo-controlled study, in which a good or excellent treatment
522 effect was found in 72% in the dexmedetomidine group, compared to 37% in the placebo

523 group (Korpivaara et al., 2017). Too few respondents have named other types of
524 medications so that no definitive conclusions can be drawn regarding their effectiveness.

525

526 Overall, pharmacological treatment is no doubt recommendable for dogs with severe noise
527 fears, both as a management strategy to help them cope in the case of firework events and
528 possibly to complement training efforts and facilitate learning during behavior modification
529 treatment. Many owners, however, view medication only as a last resort and prefer to use
530 more “natural” treatments, due to concerns such as potential side effects (Notari and
531 Gallicchio, 2008; Sheppard and Mills, 2003). Unfortunately, very few of these products have
532 demonstrated any evidence of effectiveness (Landsberg et al., 2015b).

533

534 Remarkably, all types of ‘alternative’ products in the current survey – including herbal
535 products, nutraceuticals, homeopathic remedies, essential oils, but also pheromones – had
536 reported success rates in the range of 27 to 35 percent. This is approximately the rate of
537 success that would be expected based on a placebo effect. A placebo is “an inert medication
538 used for its psychological effect, or for purposes of comparison in an experiment”, with a
539 placebo effect defined as “any improvement or change in subjective discomfort or illness
540 resulting from an intervention possessing no physical effect” (Tavel, 2014). When other
541 individuals (clinicians or caregivers) rate the effectiveness of a given intervention, we may
542 observe a caregiver placebo effect, which often has even larger effect sizes than those
543 reported by the patients themselves (Rief et al., 2009). A caregiver effect in companion
544 animals has also been defined as “improved ratings of outcomes in companion animals in
545 the absence of improvement in objective measures (Gruen et al., 2017). Whether a placebo-
546 by-proxy effect exists in veterinary medicine – meaning that the caregiver’s belief alters their
547 interaction with the pet which consequentially has a true beneficial effect on the animal – is
548 not known (Gruen et al., 2017). Instead it is concerning that many interventions leading to
549 better welfare according to the owners’ subjective assessments may in fact have no benefit
550 on the animal at all.

551 In the medical literature, response rates to placebos are commonly in the range of around
552 35% (Muñana et al., 2010). In companion animals, caregiver placebo effects of up to 50-
553 70% have been reported (Gruen et al., 2017). In the study by (Korpivaara et al., 2017) on the
554 effect of dexmedetomidine vs placebo on firework fears in dogs, 37% of dogs in the placebo
555 groups had a good or excellent treatment effect as judged by their owners. In the study by
556 Cracknell and Mills (2008) evaluating the effect of a homeopathic remedy on firework fears
557 in dogs, the reported rates of improvement did not differ significantly between treatment
558 groups but were extremely high in both the placebo group (65%) and the treatment group
559 (71%), although the fact that simple behavioral advice had also been given might have
560 contributed to these high success rates in both groups (Cracknell and Mills, 2008). In a study
561 on fluoxetine in the treatment of canine separation anxiety, global separation anxiety scores
562 in the placebo-treated dogs improved in 44-51.3% of cases across the six weeks of
563 treatment (Landsberg et al., 2008).

564 Thus, it seems likely that a placebo effect accounts for the perceived effectiveness of those
565 products where the success rates were 35% or less in the current study, which was the case
566 for pheromone products, nutraceuticals, herbal remedies, essential oils, as well as
567 homeopathic remedies. In this context it is also notable that the many promising open-label
568 trials have not been followed up by placebo controlled ones. Possibly this reflects a
569 publication bias, with positive results from open-label trials potentially being more likely to be
570 published than negative results in controlled studies.

571 Of the above-mentioned products, only Dog Appeasing Pheromone (Adaptil®) has been
572 investigated in several studies on fear and anxiety in dogs. Some open-label trials reported
573 high treatment success rates, but these were often confounded by the parallel application of
574 the pheromones and behavioral management or CCSD training (Levine et al., 2007; Levine
575 and Mills, 2008; Sheppard and Mills, 2003). One study suggested that using a combination
576 of CDs and DAP resulted in better outcomes than when only one of these treatments was
577 used (Mills et al., 2003). However, the high success rates for placebo treatments observed in

578 placebo-controlled studies on treatments for firework fears in dogs (Cracknell and Mills,
579 2008; Korpivaara et al., 2017) call for a cautious interpretation of open-label studies. One
580 parallel-group placebo controlled study using objective behavioral measures did indicate
581 some beneficial effects of DAP collars on global and active fear scores during exposure to
582 thunderstorm recordings in laboratory beagles. On the other hand, DAP treated dogs also
583 spent more time hiding, so the results are not entirely conclusive, and the sample size was
584 small (12 beagles per treatment group, Landsberg et al., 2015a). A systematic review on
585 pheromone application in dogs and cats concluded that only a single study yielded sufficient
586 evidence for of a reduction in fear and anxiety by DAP in dogs, while six studies yielded
587 insufficient evidence (Frank et al., 2010). Thus, also in view of the present study's results,
588 there is currently little evidence to support the effectiveness of dog appeasing pheromones
589 as a calming agent in dogs fearful of fireworks. Similarly, no recommendations can be made
590 for the use of nutraceuticals, herbal remedies, essential oils, and homeopathic products. Of
591 course, perhaps with the exception of pheromones where the same ingredient, Dog
592 Appeasing Pheromone or Adaptil, formed the basis of all products (diffusers, sprays or
593 collars), the study does not allow drawing conclusions for a specific product in this case, as
594 all products in a category were analyzed together.

595 Finally, the reported effectiveness for pressure vests (thundershirt, anxiety wrap) was 44%.
596 Although this could still be in a range where a placebo effect is possible, the proportion of
597 respondents considering pressure vests effective was considerably higher compared to all
598 the 'alternative' products, indicating that pressure vests may indeed have beneficial effects in
599 some dogs. Further research is needed, as previous studies indicated a possible small
600 beneficial effect but were not conclusive either (reviewed in Buckley, 2018).

601

602 *Critical evaluation*

603 Like most studies assessing the effectiveness of treatments for noise fears in dogs (e.g.
604 Cracknell and Mills, 2008; Crowell-Davis et al., 2003; Korpivaara et al., 2017; Levine et al.,

605 2007; Levine and Mills, 2008; Sheppard and Mills, 2003), the current study relied on owners'
606 assessments of their dogs' behavior. Therefore it cannot be avoided that the results are
607 affected by the owners' interpretation and may be subject to bias. However, studies
608 indicated that owners' ratings of their dogs' fear are reliable and demonstrate external
609 validity (e.g. Tiira and Lohi, 2014), although they are susceptible to caregiver placebo effects
610 (e.g. Cracknell and Mills, 2008). Based on previous placebo-controlled studies, we know
611 approximately in what range placebo effects can be expected, as discussed above. While
612 randomized double-blind placebo-controlled studies, and using video analysis to assess
613 dogs' behavior, are no doubt the gold standard for assessing the effect of a given
614 intervention, they are often limited by the costs and manpower required for both conducting
615 and administrating the study. Additionally, ethical concerns might be raised (c.f. Frank et al.,
616 2010). Using a large-scale questionnaire survey thus represents a useful approach to gather
617 data from a large sample of participants. Moreover, a broad survey like the current one may
618 be less likely than localized trials of specific products to attract volunteer participants with
619 high expectations that might lead to an overestimate of effectiveness (c.f. Muñana et al.,
620 2010), or to induce participants to over-report effectiveness of treatments out of politeness to
621 the treating doctor (Kienle and Kiene, 1997). It can thus be viewed as an advantage that the
622 prescribing clinicians and the researchers were not the same persons in the current study.
623 Owners were furthermore able to draw from their long-term experiences (i.e. not only for a
624 few weeks within a particular study). While recall biases cannot be ruled out, the possibility
625 to test a given product over a longer time period or during several firework events may lead
626 to a more accurate assessment than when owners are asked to make an assessment over
627 only a few weeks.

628 By asking owners to simply rate a given intervention as "effective" or "not effective", the
629 outcome is relatively crude. Nonetheless it is useful, since effectiveness of products is often
630 measured by the proportion in the population in which the treatment had an effect, and
631 together with the large sample size, it allows us to compare relative effectiveness of different

632 treatments – even if it does not allow conclusions in absolute numbers regarding the true
633 effectiveness of the interventions.

634

635 **Summary**

636 Owner-reported effectiveness of different treatment options for firework fears in dogs was
637 analyzed from a large-scale questionnaire survey, with over 180 respondents per treatment
638 category. Ad-hoc counter-conditioning (providing desirable stimuli after the occurrence of
639 noises) was associated with a significant improvement in the severity of firework fears and
640 was considered as effective by over 70% of owners. Relaxation training was reported to be
641 almost as successful, while noise CDs were considered effective by only 55%. 44% of
642 respondents deemed pressure vests as effective. With prescription medication,
643 improvements were noted by 70% of owners. While individual products were not evaluated,
644 the reported success rates for the categories “pheromones”, “herbal products”,
645 “neutraceuticals”, “essential oils”, “homeopathic remedies” and “Bach flowers” (all in the
646 range of 27-35%) are not higher than would be expected based on a placebo effect. Thus,
647 besides psychoactive medication, counterconditioning and relaxation training appear to be
648 the most effective strategies in the treatment of firework fears in dogs and should
649 complement the standard behavioral technique of desensitization/ counterconditioning with
650 noise recordings.

651

652

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658

659 **Conflict of interest statement**

660 The author declares no competing interests.

661

662 **Authorship statement**

663 The idea for the paper was conceived by Stefanie Riemer. The questionnaire design,
664 distribution, analysis and writing was performed by Stefanie Riemer.

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