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Dog training alleviates PTSD symptomatology by emotional and attentional regulation

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ABSTRACT

Background: Post-Traumatic Stress Disorder (PTSD) symptoms include re-experiencing, avoidance, hyperarousal, and cognitive deficits, reflecting both emotional and cognitive dysregulation. In recent years, non-pharmacological approaches and specifically animal-assisted therapy have been shown to be beneficial for a variety of disorders such as Attention-Deficit/Hyperactivity Disorder, Autism Spectrum Disorder, and PTSD. However, little is mentioned in the literature about the reciprocal effects of the animal–human interaction.

Objective: To evaluate the effects of a one-year dog training programme on PTSD symptomatology in youngsters with PTSD and on dogs' behaviour.

Methods: Fifty-three adolescents, previously exposed to interpersonal trauma, were clinically diagnosed with PTSD and assigned to a dog-training programme group ($n = 30$) and a control group ($n = 23$) that engaged in other training programmes (e.g. cooking, hairstyling, etc.). Both groups were evaluated at baseline and following 12-months by The Clinician-Administered PTSD Scale for DSM-5 in Children and Adolescents (CAPS-CA-5) and Beck-Depression Inventory (BDI). Additionally, we physiologically measured both emotional and attention dysregulation.

Results: Post-12-months training, a significant alleviation of PTSD symptomatology accompanied by lower depression severity was observed in the dog-training group, compared with a insignificant recovery in the control group. Furthermore, improved emotional and attentional regulation was observed in the dog-training group. Measuring the dogs' behaviour revealed increased anxiety and decreased selective attention performance, which was inversely correlated with the beneficial effects observed in the dog-training programme group.

Conclusions: Our findings emphasize the role of emotional and attentional regulations on the dog–handler interface, as evidence-based support for the beneficial effects of the dog-training programme, as either a non-pharmacological intervention or as complementary to anti-depressants treatment of PTSD. Though pharmacological treatments increase the patients' well-being by treating certain PTSD symptoms, our suggested dog-training programme seems to influence the PTSD diagnostic status, thus may be implemented in civilians and veterans with PTSD.

HIGHLIGHTS
• One year of dog-training programme alleviated PTSD symptoms, defined as a change in CAPS-CA-5 diagnostic status, underlined by physiologically measured attention and emotional regulation.
• However, dog–human interaction resulted in the dogs' elevated anxiety and decreased attention.

El adiestramiento canino alivia la sintomatologia de tept mediante la regulacion emocional y de la atencion

Antecedentes: Los síntomas de trastorno de estrés postraumático (TEPT) incluyen re-experimentación, evitación, hiperalerta y déficits cognitivos, reflejando desregulación tanto emocional como cognitiva. En los últimos años, se demostró que los enfoques no farmacológicos y específicamente la terapia asistida por animales son beneficiosos para una variedad de trastornos como el Trastorno por Déficit Atencional e Hiperactividad, el Trastorno del Espectro Autista y el TEPT. Sin embargo, poco se menciona en la literatura acerca de los efectos recíprocos de la interacción animal-humano.

Objetivo: Evaluar los efectos de un programa de adiestramiento canino de un año en la sintomatología de TEPT en los jóvenes con TEPT y en el comportamiento de los perros.

Métodos: Cincuenta y tres adolescentes, previamente expuestos a trauma interpersonal, fueron diagnosticados clínicamente con TEPT y asignados a un grupo de programa de adiestramiento canino ($n = 30$) y a un grupo control ($n = 23$) que participaron en otros programas de adiestramiento (ej., cocinar, peluquería, etc). Ambos grupos fueron evaluados al inicio y después de 12 meses mediante la Escala de TEPT administrada por el Clínico del DSM-5 en niños y adolescentes (CAPS-CA-5 por sus siglas en inglés) y el Inventario de Depresión de Beck (BDI). Adicionalmente, medimos fisiológicamente la desregulación emocional y de la atención.

Resultados: Después del entrenamiento de 12 meses, se observó un alivio significativo de la sintomatología de TEPT junto con una disminución de la severidad de la depresión en el grupo

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de adiestramiento canino, comparado con una recuperación insignificante en el grupo control. Además, se observó una mejoría en la regulación emocional y de la atención en el grupo de adiestramiento canino. La medición del comportamiento de los perros reveló un aumento de la ansiedad y disminución del rendimiento de la atención selectiva, que se correlacionó inversamente con los efectos beneficiosos observados en el grupo del programa de adiestramiento canino.

Conclusiones: Nuestros hallazgos enfatizan el rol de la regulación emocional y de atención en la interfaz del entrenador de perros, como soporte basado en la evidencia para los efectos beneficiosos del programa de adiestramiento canino, tanto como tratamiento no farmacológico como complementario al tratamiento antidepresivo del TEPT. Aunque los tratamientos farmacológicos fomentan el bienestar de los pacientes al tratar ciertos síntomas del TEPT, nuestro programa de adiestramiento canino sugerido parece influir en el estado diagnóstico de TEPT, por lo que puede implementarse en civiles y veteranos con TEPT.

训犬通过情绪和注意力调节缓解 PTSD 症状

背景: 创伤后应激障碍 (PTSD) 症状包括再体验, 回避, 高唤起和认知缺陷, 反映了情绪和认知失调。近年来, 非药物方法和特别是动物辅助疗法被证明对多种疾病有益, 例如注意力缺陷/多动障碍, 自闭症谱系障碍和创伤后应激障碍。然而, 文献中很少提及动物与人类交互的相互影响。

目的: 评估为期一年的训犬计划对 PTSD 年轻患者 PTSD 症状和狗行为的影响。

方法: 53 名早先遭受人际创伤并被临床诊断为患有 PTSD的青少年被分配到训犬计划组 (*n = 30*) 和参与其他计划 (例如, 烹饪, 发型设计等)。两组均在基线和 12 个月后通过儿童和青少年版临床DSM-5 PTSD 量表 (CAPS-CA-5) 和贝克抑郁量表 (BDI) 进行评估。此外, 我们在生理上测量了情绪和注意力失调。

结果: 训练 12 个月后, 训犬组的 PTSD 症状显著减轻且同时抑郁程度降低, 对照组相比之下恢复不显著。此外, 在 训犬组中观察到情绪和注意力调节得到改善。测量狗的行为显示焦虑增加和选择性注意力表现降低, 这与在 训犬计划组中观察到的有益效果呈负相关。

结论: 我们的发现强调了情绪和注意力调节对训犬者交互的作用, 作为对训犬计划有益效果的循证支持, 作为一种PTSD的非药物治疗或抗抑郁药治疗补充。虽然药物治疗通过治疗某些 PTSD 症状来增加患者的幸福感, 但我们建议 训犬计划似乎会影响 PTSD 的诊断状态, 因此可能会在患有 PTSD 的平民和退伍军人中实施。

1. Introduction

DSM-5 classifies Post-Traumatic Stress Disorder (PTSD) as a psychiatric disorder induced by exposure to traumatic/stressful events. The experience can be either a single isolated event or chronic exposure. PTSD is defined by the coexistence, for at least one month, of re-experiencing, avoidance, hyperarousal, and is no longer classified in the DSM-5 as an 'anxiety disorder' but as a 'Trauma and stressor-related disorder' (American Psychiatric Association, 2013).

In the common urban population, 39.1% of young adults aged 21–30 reported at least one exposure to a traumatic event, and 23.6% of them were diagnosed with PTSD (Breslau, Davis, Andreski, & Peterson, 1991). More recently, the lifetime prevalence of PTSD was estimated to be more than 7% (Hoppen & Morina, 2019; Kessler et al., 2017).

Following the focus on PTSD in Vietnam's war veterans, the diagnosis of PTSD was considered to be irrelevant for children and adolescents (American Psychiatric Association, 1980). However, nowadays, the notion that children and adolescents can develop PTSD symptoms after being exposed to traumatic events is commonly accepted. Major advances in this field were made in 2013 when the DSM-5 included the first developmental subtype of an existing disorder,

PTSD, for children six years and under (De Young & Landolt, 2018).

Although estimates of PTSD prevalence in children and adolescents who have experienced trauma vary, most studies have reported a prevalence of 30–40% (Fergé et al., 2021). Studies indicate that children can develop PTSD after exposure to a range of traumatic stressors, including violent crime, sexual abuse, natural disasters, and war (Hoppen & Morina, 2019; Kessler et al., 2017).

Further focusing on the age factor, the prevalence of exposure to traumatic events is also high in adolescents and young adults and reported to be ~22% among 14–24 years old (Perkonig, Kessler, Storz, & Wittchen, 2000). The age factor is essential for acknowledging that youngsters' exposure to traumatic events can lead to developing PTSD. Moreover, childhood abuse is associated with emotional dysregulation (Dvir, Ford, Hill, & Frazier, 2014).

Since the first acknowledgement that traumatic events may cause an adverse reaction, significant efforts were made to examine possible treatments. To ease the symptoms of PTSD, several pharmacological treatments were implemented to improve patients' daily functioning and quality of life (Asnis, Kohn, Henderson, & Brown, 2004; Davidson et al., 2006;

Schoenfeld, Marmar, & Neylan, 2004). However, in an assessment to determine their efficacy for veterans suffering from PTSD, medications such as Anti-depressants (SSRI and others), alpha-adrenergic blockers, antipsychotic medications, and benzodiaze-pines, the results were found to be inconclusive (Committee on Treatment of Posttraumatic Stress Disorder, 2008). Though these pharmacological treatments increase the patients' well-being by treating certain symptoms, their effects over the disorder itself were found to be insufficient.

Non-pharmacological psychotherapeutic methods such as Cognitive Behavioural Therapy (CBT) and Prolonged Exposure (PE) (Foa, Rothbaum, & Furr, 2003; Foa, Rothbaum, & Murdock, 1991) allow patients to face the memory of their traumatic experience in a gradual and controlled manner (Jaycox, Zoellner, & Foa, 2002). Although both intervention methods are commonly used and frequently shown to be effective (Bryant & Friedman, 2001; Cohen, Mannarino, Perel, & Staron, 2007), the exposure of patients to their trau-matic experiences can be intimidating, and therefore may reduce compliance (Lefkowitz, Prout, Bleiberg, Paharia, & Debiak, 2005).

In recent years, there has been a growing interest regarding complementary and alternative approaches for the treatment of PTSD (Wynn, 2015). For example, exercise augmentation to usual care was shown to reduce PTSD and depressive symptoms (Fetzner & Asmundson, 2015; Powers et al., 2015). Recreational therapy, like participation in group outdoor recrea-tional programmes such as fly-fishing (Vella, Milligan, & Bennett, 2013) and horsemanship activities (Lanning & Krenek, 2013), was shown to improve the quality of life of veterans suffering from PTSD and reduce symp-toms of depression (Wynn, 2015).

Animal-assisted therapy (AAT) was shown to be ben-eficial as a complementary intervention for treating PTSD in veterans (O'haire & Rodriguez, 2018). The benefits of introducing psychiatric service dogs to the homes of military veterans' families were recently shown (Nieforth, Craig, Behmer, MacDermid Wadsworth, & O'Haire, 2021; Rodriguez, LaFollette, Hediger, Ogata, & O'Haire, 2020). In general, dog ownership was pre-viously suggested to improve mental health by decreas-ing social isolation and increasing physical activity (Hoisington et al., 2018). In a recently published meta-analysis examining the effectiveness of AAT of PTSD symptoms in both children and adults, AAT was found to be as effective as traditional psychotherapy (Hediger et al., 2021). In addition, incorporating animals in therapy was shown to enhance collaboration and decrease the number of therapy sessions required (Dietz, Davis, & Pennings, 2012; Lefkowitz et al., 2005).

AAT was also found to be helpful for autism spectrum disorder (Bass, Duchowny, & Llabre, 2009; O'Haire, 2013; Sams, Fortney, & Willenbring, 2006) and

depression (Beetz, 2017; Holcomb, Jendro, Weber, & Nahan, 1997). In children with pervasive developmental disorders, exposure to a living dog during treatment made the patients more focused and more aware of their environments than when exposed to a ball or a stuffed dog (Martin & Farnum, 2002), emphasizing the possible role of attention and emotional regulation. In support, AAT is also suggested to be highly beneficial for treating attention deficit. In a controlled experiment investigating the effects of animal therapy on children suffering from ADHD, symptoms seemed to improve in a magnitude comparable to stimulant medication for ADHD (Katcher & Teumer, 2006). Another study using CBT and canine-assisted intervention reported a greater reduction of ADHD symptoms severity com-pared with children who received CBT without an AAT (Schuck, Emm-erson, Fine, & Lakes, 2015). Although the benefits of AAT over attention deficit are addressed by several studies, the lack of unified theoretical foun-dation impairs the ability to achieve strong empirical support (Busch et al., 2016; Geist, 2011) that can be generalized to other psychopathology such as PTSD.

The pattern of symptoms comprised of high anxiety following chronic stress and attention vigilance, is suggested to exacerbate the emergence of post-trau-matic stress symptoms (Wu & Wei, 2020). In PTSD, survival mechanisms are characterized by a transi-tional state of heightened arousal and hypervigilance, aimed at coping with an immediate threat (Cantor, 2009). Emotional (anxiety) and attentional dysregula-tion may reflect individual differences in top–down attentional control, which influence the expression of attentional bias such as in PTSD (Schoorl, Putman, Van Der Werff, & Van Der Does, 2014). Recently, we reported that emotional and attentional dysregulation, measured by the auditory sustained attention test (ASAT) and acoustic startle reflex, can indicate emer-gence of PTSD (Dolev et al., 2021).

The Auditory Sustained Attention Test (ASAT) was previously suggested by us as a systematic method that measures a neurological phenomenon based on the well-known Pre-Pulse inhibition (Avital, Dolev, Aga-Mizrachi, & Zubedat, 2011; Dolev et al., 2021; Engel-Yeger et al., 2021; Zubedat et al., 2015) that reflects both modulations of sustained attention and emotional dys-regulation. The acoustic startle reflex is associated with emotional dysregulation (Dvir et al., 2014; Ebner-Priemer et al., 2005; Morgan, Grillon, Southwick, Davis, & Charney, 1995), which is a major symptom of PTSD (Morgan, Grillon, Southwick, Davis, & Charney, 1996). War veterans suffering from PTSD were shown to exhibit exaggerated acoustic startle reflex (Morgan et al., 1996), which was also observed in adults who were abused as children (Jovanovic et al., 2009). Therefore, startle reflex measurements can allow a systematic method for evaluating emotional dysregulation in PTSD as well as the efficacy of AAT intervention.

Flashbacks or re-experiencing of the traumatic event considered as a core symptom of PTSD according to the ICD-11 diagnostic criteria (Brewin, 2015). Unlike typical extraction of episodic memories, during a flashback, patients suffering from PTSD re-experiencing the traumatic memory as if it was happening here and now, with little to no attention focused on their actual surroundings (Ehlers, Hackmann, & Michael, 2004). Difficulties in focusing attention are not the only link between PTSD and attentional functioning. Both PTSD and ADHD have been shown to have significantly associated symptoms (Adler, Kunz, Chua, Rotrosen, & Resnick, 2004) and have a high degree of comorbidity (Antshel et al., 2013; Cuffe, McCullough, & Pumariega, 1994). In addition, ADHD was suggested to increase vulnerability for developing PTSD (Adler et al., 2004).

Together, measuring attentional dysregulation in a physiological manner may subserve as a prism to PTSD symptomatology and its modulation following AAT intervention.

Utilizing the physiologically measured ASAT, we aim to evaluate the possible beneficial effects of AAT accurately and objectively (i.e. dog therapy) on PTSD symptomatology. Secondly, we also aim to evaluate the consequences of the human–dog interaction on the dogs' attention and anxiety-like behaviour.

2. Methods

2.1. Human subjects

Participants were recruited from the Manof youth-village in Acre, Israel. Sixty adolescents (age 16 ± 1), previously exposed to interpersonal trauma, were referred to our study by social workers and teaching staff. Each participant was first evaluated for PTSD symptomatology using the Clinician-Administered PTSD Scale for DSM-5 in Children and Adolescents (CAPS-CA-5, approved to be used by the NIMH). The evaluations were made by a psychiatrist and a psychologist that were blind to the physiological measurements and the subjects' course of study.

Following sortation of the students to their main course of study according to personal choice and compatibility, our test group contained 30 participants with PTSD (14 males and 16 females) to be trained as dog-handlers and 23 participants with PTSD (12 males and 11 females) from a variety of other courses which constituted the control group. The study's sample size was calculated to provide more than 85% statistical power. According to the Technion – Israel Institute of Technology IRB's approval, all participants and their parents signed an informed consent form.

The participants in both experimental and control groups reported domestic abuse and/or criminal violence to be the most common traumatization. In addition, the majority of the female participants reported

sexual abuse. Moreover, all participants had access to mental health professionals, including social workers and a psychiatrist. The chief social worker of the youth village examined the participants in both experimental and control groups and found no differences in their usual treatment.

2.2. Dogs

Twelve dogs (7 males and 5 females; age 1.4 ± 0.5 years) from the Manof youth village's kennel participated in our study. All dogs were from medium-large size breeds (Malinois/German-Shepherd) with no previous training record. The participants were divided into teams of 2–3, each assigned to a specific dog. The dogs' initial training was first done by professional dog trainers, and specific dog-handler assignments were made after evaluating the compatibility between each participant team and their canine counterparts.

After learning the basics of dog handling, the participants' responsibilities over their canine partners were gradually increased over the school year. Initial responsibilities were over the dogs' well-being, and only later permission was given to take the dogs out of the kennel for walks and start with 3 h daily behavioural training sessions 3–5 times a week along the following 12 months. Each interaction with a dog, on a specific working day, was made by a single team member, while observed by other team members and an instructor. Before any discipline or actual training exercises started, the handlers attended 42 h of theoretical course by the chief trainer. During this course the handlers learned the principles of dog training, classical and operant conditioning, the effectiveness of various reinforcement schedules and ethical guidelines regarding treatment and training dogs. The basic discipline exercises with the dogs include responding to verbal commands by using a positive reinforcement incentive such as food or a training ball, according to each dog's individual incentive preference. The participants were also learning to get familiar with different dog training methods such as using a clicker, different types of reinforcements, and leading styles. If needed, negative feedback was allowed to be given verbally ('Bad Boy') and only with the approval of the instructors. The use of nonverbal punishments was prohibited.

Next, the future dog handlers work with the dogs on following footprints on different surfaces. Each participant first left their own footprints, and 30 minutes later, they sent their dog to trace them. The footprint was left on three types of surfaces: sand, grass, and asphalt. At this stage of the training programme the handler positively reinforced the dog when tracking the target footprint by using food incentive that was later on replaced by a training ball as positive reinforcer. During the school year, the participants went through three practical tests to evaluate satisfactory functioning. In these

tests, an external examiner evaluated the dog handler team performance while tracking footprints that were gradually more difficult to detect, between the first and the final test.

2.3. Procedure

All human participants were assessed using the CAPS-CA-5, Beck Depression Inventory (BDI-II) questionnaires and physiologically examined by the ASAT and Startle measurements. All the samples were taken during morning classes (8 am–2 pm) twice, once at the beginning of the school year and post 12 months. The dogs were assessed using the Canine objective evaluation task at the same time points.

2.4. Clinician-administered PTSD scale for children and adolescents for DSM-5

The Clinician-Administered PTSD Scale (CAPS) is a structured interview for assessing PTSD symptomology severity (Blake et al., 1995). The CAPS-CA-5 (Pynoos et al., 2015) is a version for Child/Adolescent revised by the DSM-5. The CAPS-CA-5 contains a 30-item clinician-administered PTSD scale suitable from the age of 7 and above. It assesses a total of 20 PTSD symptoms providing standardized questions and probes for each symptom. Additional questions target the onset and duration of the symptoms, subjective distress, impact on social functioning, and more. Scoring was made according to the DSM-5 criteria using item clusters for each criterion. The scores summarized by both frequency and intensity rate of each cluster indicate the criterion's severity in addition to a single total severity score. The measured PTSD-related criteria are: re-experiencing, avoidance behaviour, cognition and mood, hyperarousal and dissociation. After the scoring is made, the PTSD diagnostic status is calculated if at least 1 of each criterion B and C, in addition 2 of each criterion D, E, F and G are met. An informed consent was granted from the US-NIMH to the study's PI for using CAPS-CA-5.

2.5. Beck Depression Inventory (BDI-II)

The BDI (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) is a multiple-choice self-report questionnaire for measuring the severity of depression. The inventory's most current version (BDI-II) was designed for DSM-4 and from the age of 13. Since our study's participants are Israeli adolescents, we used the Hebrew version of the BDI-II questionnaire. The questionnaire contains 21 multiple-choice questions, each with 4 (0–3) levels of scoring.

2.6. Auditory sustained attention test and emotional dysregulation

The Auditory Sustained Attention Test (ASAT) measures a neurological phenomenon based on the Pre-Pulse Inhibition (PPI) in which weaker acoustic pre-pulse inhibits the reaction to a subsequent strong startling pulse (Zubedat et al., 2014b). A computerized human startle response monitoring system (SR-HLAB startle reflex, San Diego Instruments, San Diego, CA) was used to deliver acoustic startle stimuli via headphones and record the corresponding electromyography activity. Two disposable electrodes (sensor area 12 mm^2) were placed approximately 0.75–1 cm below the pupil on the orbicularis oculi muscle, and a 3rd reference electrode was placed on the mastoid bone. The skin area at the electrode site was cleaned, and a small amount of EEG & ECG Prepping Gel (Signa Gel – Parker Laboratories Inc., Fairfield, New Jersey, USA) was applied on dry skin before placing the electrodes.

The session started with a 1-minute acclimatization period with a 60 dB background noise level that was delivered continuously throughout the session. Then a total of 60 trials were delivered pseudo-randomly with an average of 4.55 sec (3–7 sec) inter-trial-interval (ITI). The trials included 10 no-stimulus trials, 30 trials of single 30 ms 102,108,114 dB (10 trials each) 'pulse alone' startle stimuli to evaluate individual startle response, and 20 'pre-pulse' trials that consisted of a single 108 dB pulse preceded by a 20 ms pre-pulse of 12 or 24 dB (10 trials each) above background noise (i.e. 72 or 84 dB). The synchronization between the auditory stimuli and EMG recordings, as well as the signals analysis, was conducted by the Mindtension software (Israel). The ASAT was calculated as the percent of the habituated/inhibited response as follows: 100-(max response to 'pre+pulse' trial/max response to 'pulse alone' trial X 100) (Dolev et al., 2021; Zubedat et al., 2014a).

2.7. Canine objective evaluation task

Dogs were individually inserted into the same room (4 × 4 m) in three different trials for 5 min each (ITI 30 min). In the first trial, the room was empty, and the dog's behaviour was monitored to measure: (i) distance moved (m); (ii) velocity (m/sec); (iii) anxiety index (distance in the periphery*100 *(total distance)-$^{-1}$); (iv) freezing duration (sec). For the second trial, four identical objects were placed one in each corner of the room before allowing the dog to enter and explore them. At the third trial, one of the identical objects was replaced by a novel object different in shape, size, and colour before allowing the dog to enter and explore the room one last time. The dog's behaviour was monitored to measure: (v) foraging-like

behaviour (sec); and (vi) selective attention (latency to novel object). To prevent smell trails, the room was cleaned using soap water between each trial. The dogs' movement was recorded from a downwards facing GoPro HERO 5 camera (GoPro Inc., San Mateo, Calif.) fixed to the room's ceiling. The video footage was analysed using Ethovision XT software (Noldus Inc., The Netherlands) reconfigured to measure dog movement.

2.8. Statistical methods

A mixed design (2 × 2) was utilized with two groups as between subject's factor (dog programme versus control) and testing time points as a within-subject factor (baseline and post 12-months). Results were analysed with two-way ANOVA for mixed design with interaction analysis and post hoc t-tests. For all the tests, we added effect size calculations (i.e. partial η^2 for ANOVA). To associate human measurements with those of the dogs, a Pearson's correlation was computed.

The statistical tests were conducted blind to the group identity, using Bonferroni adjusted alpha levels for multiple comparisons. Results were considered statistically significant if P-value < 0.05. Results are displayed as mean± S.E.M.

3. Results

3.1. Human subjects

The dog programme group (age 16.5 ± 1 years) was comprised of 16 females and 14 males with PTSD, while the control group (age 16.1 ± 1 years) included 11 females and 12 males with PTSD.

Using CAPS-CA-5 assessment, we evaluated differences in PTSD symptomatology between the dog programme and the control group:

3.1.1. Re-experiencing

A significant effect was found for time [$F(1,58) = 110.05$, $P < 0.0001$; $\eta^2 = 0.655$], group [$F(1,58) = 18.36$, $P < 0.0001$; $\eta^2 = 0.24$] and for the test time × group interaction [$F(1,58) = 17.25$, $P < 0.0001$; $\eta^2 = 0.229$]. While at baseline both groups showed similar re-experiencing scores, post 12 months the dog programme group had a significant lower score [$t(29) = 6.28$, $P < 0.0001$; Figure 1(a)].

3.1.2. Avoidance

A significant effect was found for time [$F(1,58) = 99.01$, $P < 0.0001$; $\eta^2 = 0.631$], group [$F(1,58) = 4.74$, $P < 0.034$; $\eta^2 = 0.076$] and for the test time × group interaction [$F(1,58) = 23.51$, $P < 0.0001$; $\eta^2 = 0.288$]. While at baseline both groups showed similar avoidance scores, post-12 months the dog programme group scored significantly lower [$t(58) = 4.64$, $P < 0.0001$; Figure 1(b)].

3.1.3. Hyperarousal

A significant effect was found for time [$F(1,58) = 91.55$, $P < 0.0001$; $\eta^2 = 0.612$], group [$F(1,58) = 28.34$, $P < 0.0001$; $\eta^2 = 0.328$] and for the test time × group interaction [$F(1,58) = 12.01$, $P < 0.001$; $\eta^2 = 0.172$]. The controls showed increased hyperarousal level at baseline [$t(57) = 2.29$, $P < 0.025$] and post-12 months compared to the dog programme subjects, which decreased their hyperarousal score significantly more [$t(27) = 6.35$, $P < 0.0001$; Figure 1(c)].

3.1.4. Cognition and mood

A significant effect was found for time [$F(1,58) = 94.44$, $P < 0.0001$; $\eta^2 = 0.62$], group [$F(1,58) = 18.44$, $P < 0.0001$; $\eta^2 = 0.241$] and for the test time × group interaction [$F(1,58) = 13.97$, $P < 0.0001$; $\eta^2 = 0.194$]. While at baseline both groups showed similar cognition and mood scores, post-12 months the dog programme group exhibited significantly better cognition and mood evaluations [$t(32) = 6.6$, $P < 0.0001$; Figure 1(d)].

3.1.5. Dissociation

A significant effect was found for time [$(1,58) = 66.98$, $P < 0.0001$; $\eta^2 = 0.536$], group [$F(1,58) = 8.17$, $P < 0.006$; $\eta^2 = 0.123$] and for the test time × group interaction [$F(1,58) = 6.74$, $P < 0.012$; $\eta^2 = 0.104$]. While at baseline both groups showed similar dissociation scores, post-12 months the dog programme group had a significantly lower score [$t(22) = 3.93$, $P < 0.001$; Figure 1(e)].

The overall Caps-CA-5 dimensions are summarized by the following methods.

3.1.6. Total symptom severity

A significant effect was found for time [$F(1,58) = 125.2$, $P < 0.0001$; $\eta^2 = 0.683$], group [$F(1,58) = 27.31$, $P < 0.0001$; $\eta^2 = 0.32$] and for the test time × group interaction [$F(1,58) = 19.37$, $P < 0.0001$; $\eta^2 = 0.25$]. While at baseline both groups showed similar total symptom severity scores, post 12-months the dog programme group showed significantly less severity of symptom [$t(29) = 7.22$, $P < 0.0001$; Figure 2(a)].

3.1.7. PTSD diagnostic status

To examine the change in PTSD diagnostic status at baseline compared with post-12-months, a Chi-Square test was conducted. However, the baseline rate of PTSD subjects was higher in the dog programme group compared with the controls [$\chi^2(1) = 4.92$, $P < 0.026$], following 12 months, the number of dog programme PTSD subjects significantly decreased [$\chi^2(1) = 41.366$, $P < 0.0001$] while the control showed no significant improvement (Figure 2(b)).
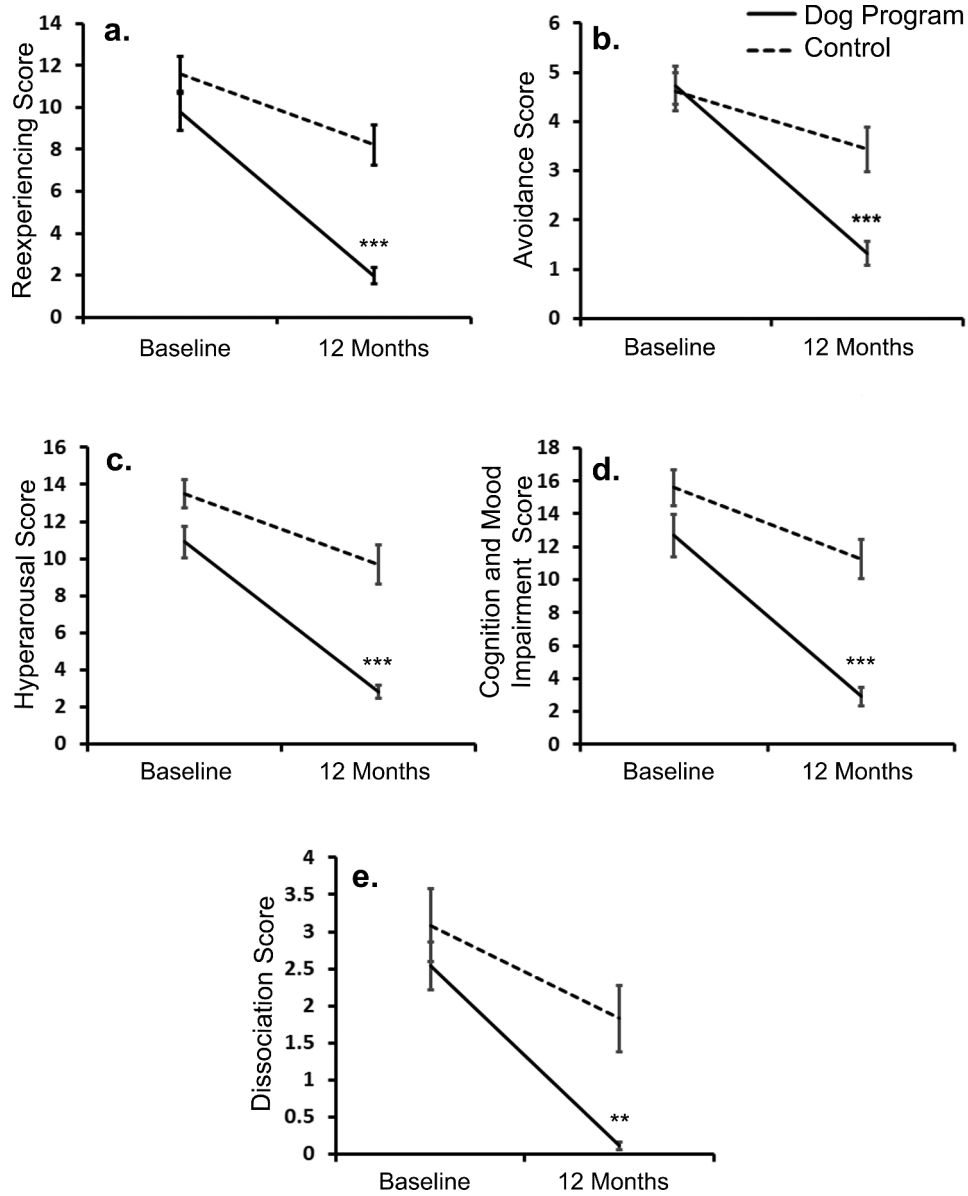
Figure 1. Caps-CA-5 scores. Comparing the dogs' programme to the control group, statistically significant improvements were observed in all measured PTSD criteria scores following 12 months: (a) Re-experiencing; (b) Avoidance; (c) Hyperarousal; (d) Cognition and Mood Impairment score and (e) Dissociation. Error bars are SEM; $n = 60$ (**$P < 0.001$; ***$P < 0.0001$).
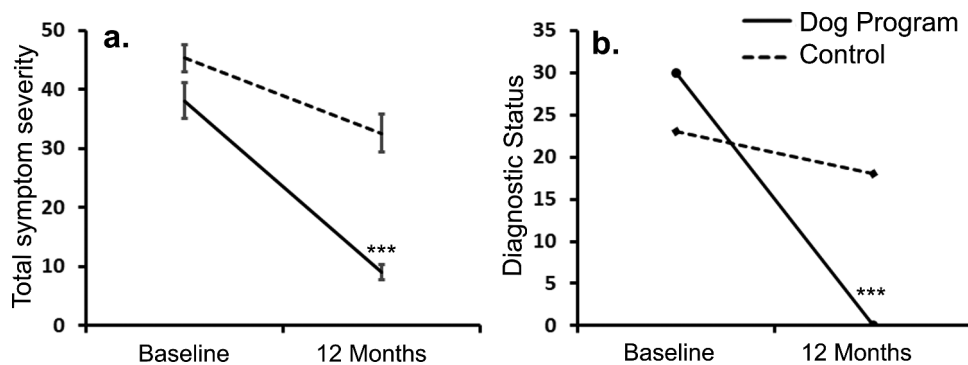

Figure 2. PTSD severity and diagnosis status. (a) Total severity score of the Caps-CA-5 criteria revealed a statistically significant improvement in the dog programme group post-12-months; Similarly, (b) the number of positive PTSD diagnostic status was dramatically decreased in the dog programme group post-12-months. (***$P < 0.0001$).
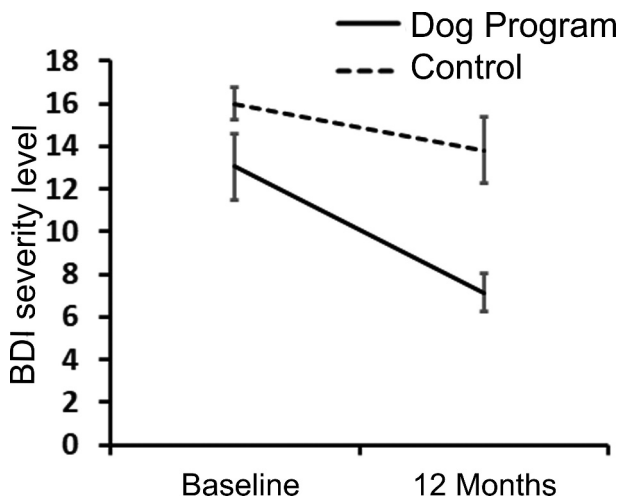
Figure 3. BDI depression severity level. Post 12 months, the dog programme subjects reported on lower depression level compared to the high level at baseline that was shared with the control subjects.

3.2. Beck Depression Inventory (BDI)

A significant effect was found for time [$F(1,24) = 7.592$, $P < 0.011$; $\eta^2 = 0.24$] but not for group [$F(1,24) = 3.483$, $P > .074$; $\eta^2 = 0.127$] and the test time × group interaction [$F(1,24) = 1.586$, $P > .22$; $\eta^2 = 0.062$; Figure 3].

3.3. Startle response

A significant effect was found for time [$F(1,27) = 11.60$, $P < 0.002$; $\eta^2 = 0.318$], group [$F(1,27) = 7.52$, $P < 0.011$; $\eta^2 = 0.218$] and for the test time × group interaction [$F(1,27) = 6.88$, $P < 0.014$; $\eta^2 = 0.203$]. Though at baseline both groups showed similar startle response, post-12 months the dog programme group showed a significant decrease of their startle response [$t(27) = 6.7$, $P < 0.0001$; Figure 4(a)].

3.4. Auditory Sustained Attention Test (ASAT)

A significant effect was found for group [$F(1,27) = 5.35$, $P < 0.029$; $\eta^2 = 0.165$] and for the test time × group interaction [$F(1,27) = 16.71$, $P < 0.0001$; $\eta^2 = 0.382$] but not for the test time [$F(1,27) = 2.51$, $P > .124$]. At baseline both groups showed similar attention performance, however, following 12 months the dog programme group presented a marked increase of atten-tion performance, while the control group deteriorated [$t(27) = 16.46$, $P < 0.0001$; Figure 4(b)]. Representative signals of the physiologically measured ASAT are presented in Figure 4(c).

3.5. Dogs' evaluation

Utilizing paired t-test we found that interacting for 12-months with the youngsters from the dog-programme have yielded decreased activity [$t(11) = 3.64$, $P < 0.004$] an-d velocity [$t(11) = 2.18$, $P < 0.05$], accompanied by an increase in freezing [$t(11) = 2.2$, $P < 0.05$] and anxiety-index [$t(11) = 3.42$, $P < 0.006$]. The behavioural parameters at baseline were higher than standard working dogs' performance (i.e. red line; unpublished data based on 230 dogs). However, after 12-months of training, the behaviours were normalized to the standard performance (Figure 5(a–c)). Nonetheless, the anxiety-index, which was similar to the standard level at baseline, significantly elevated post-12-months (Figure 5(d)).

Furthermore, post 12-months of training, the dogs decreased both their foraging-like behaviour [$t(11) = 3.76$, $P < 0.003$; Figure 6(a)] and selective attention performance [$t(11) = 4.52$, $P < 0.001$; Figure 6(b)]. When compared with the behavioural standard performance (red line), the decrease in foraging-like behaviour falls within standard values, while the selective attention performance deviates from it.

3.6. Associating dog–human measurements

Calculating Pearson's correlations, we aim to associate the various measurements coming from the dog programme subjects and their specific dogs. At Post 12-months of intensive dog–handler interaction, we found significant inverse correlations between the CAPS-CA-5 cognition and mood scores and dogs' selective attention performance [$R_p = -0.79$, $P < 0.02$].

4. Discussion

The goal of the current research is to examine the influence of non-pharmacological intervention methodologically and physiologically over PTSD severity. Specifically, we found a statistically significant improvement in PTSD symptoms in adolescents who were exposed to a dog training programme vs. adolescents trained in other programmes.

Non-pharmacological interventions such as eye movement desensitization and reprocessing (Boudewyns & Hyer, 1996; Diehle, Opmeer, Boer, Mannarino, & Lindauer, 2014), trauma-focused cognitive-behavioural therapy (Diehle et al., 2014; Hinton, Hofmann, Pollack, & Otto, 2009), and more (Weathers, Keane, & Davidson, 2001), were shown to reduce PTSD symptoms measured by CAPS-CA-5. Similarly, our findings revealed that the dog programme experimental group had shown statistically significant improvement post-12-months of training in all evaluated PTSD criteria, compared with the control group. The meaningfulness of the group differences if determent by both statistical significance and effect size. Indeed, the effect size, based on Cohen's F (Cohen, 2013), indicated that all PTSD criteria showed large effect sizes (ANOVA partial eta square larger than 0.14) for the group variable, with Avoidance and Dissociation parameters showing medium effect size (partial eta square larger between 0.06 and 0.14).
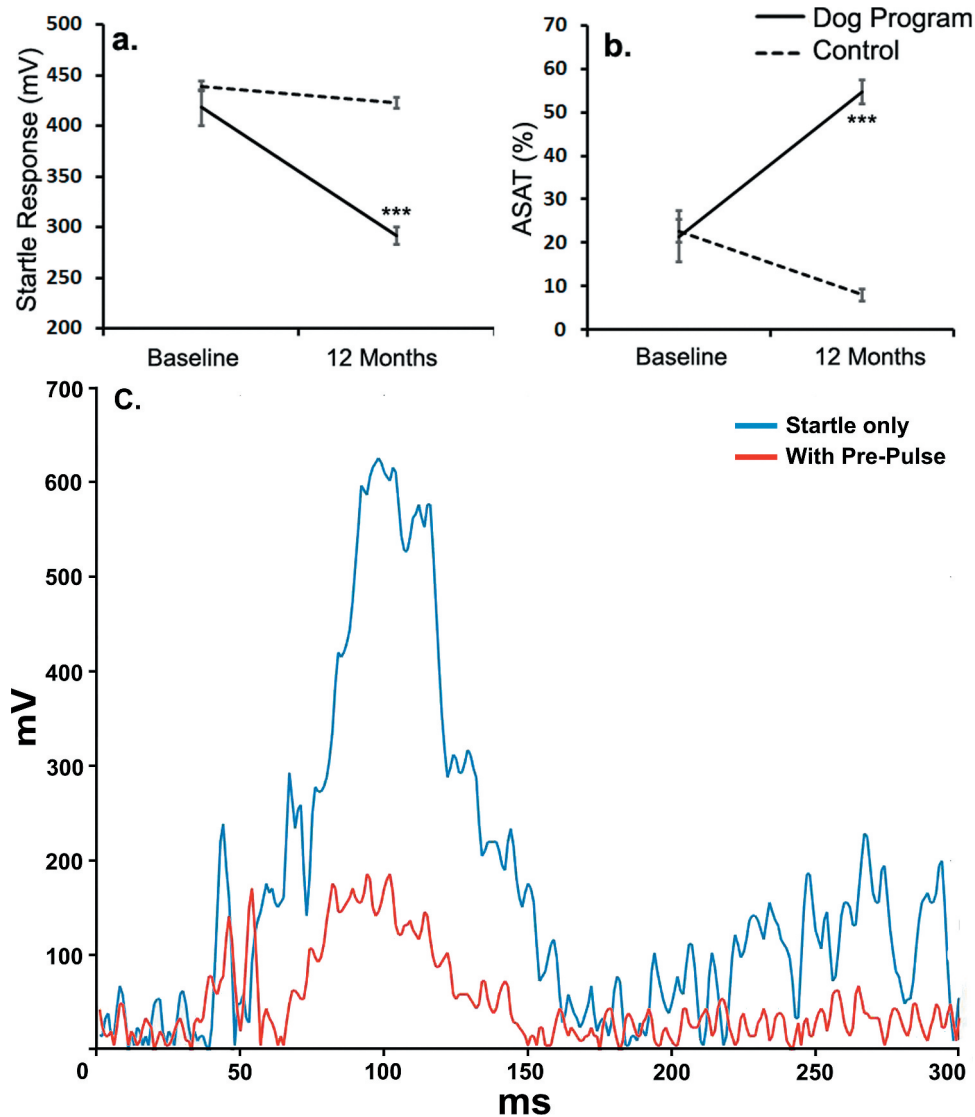
Figure 4. Startle response and Auditory sustained attention test. (a) Average startle response to auditory stimuli given at 108 and 114 decibels. (b. Average auditory sustain attention measured as the percentage of inhibition to a pre-pulse given at 72 and 84 decibels 100 ms before a pulse-alone stimulus. (***P < 0.0001). (c) A Representative physiologically measured EMG signals of ASAT. The blue line represents a startle reaction to a 108 dB auditory stimulus. The red line represents a diminished startle reaction to a 108 dB auditory stimulus when preceded by an 84 dB auditory 'pre-pulse' stimulus.

Depression is known to be prevalent in both adult PTSD patients (Shalev et al., 1998) and children/adolescents (Fan, Zhang, Yang, Mo, & Liu, 2011; Kar, Kumar Bastia, Kumar, & Associate, 2006; Kilpatrick et al., 2003). By utilizing the BDI questionnaire, we found a statistically significant decrease in depression scores among both participant groups post-12-months. No significant difference was found between the groups.

Apart from depression symptoms, PTSD is also associated with emotional dysregulation (Dvir et al., 2014), which has been shown to deteriorate various functions in maltreated children, such as increased aggression, decreased attention, social competence, and understanding of negative emotions (Maughan & Cicchetti, 2002; Shields & Cicchetti, 1998; Shields, Ryan, & Cicchetti, 2001; Shipman, Edwards, Brown, Swisher, & Jennings, 2005).

Although evidence for emotional dysregulation found in the literature is mostly based on questionnaires and other non-physiological measurements, several studies have previously utilized acoustic startle response measurements for evaluating emotional dysregulation (Ebner-Priemer et al., 2005; Jovanovic et al., 2009; Morgan et al., 1996). For example, Ebner-Priemer et al. (2005) found that borderline personality disorder patients had a significantly higher startle response as compared to controls. Similarly, we found that youngsters suffering from PTSD had exhibited emotional dysregulation at baseline. However, we showed that following 12 months of dog training the emotional dysregulation was regulated with a large effect size (Cohen, 2013).

Apart from the emotional symptoms in PTSD, the re-experiencing symptom is considered as the core symptom in PTSD (American Psychiatric Association,
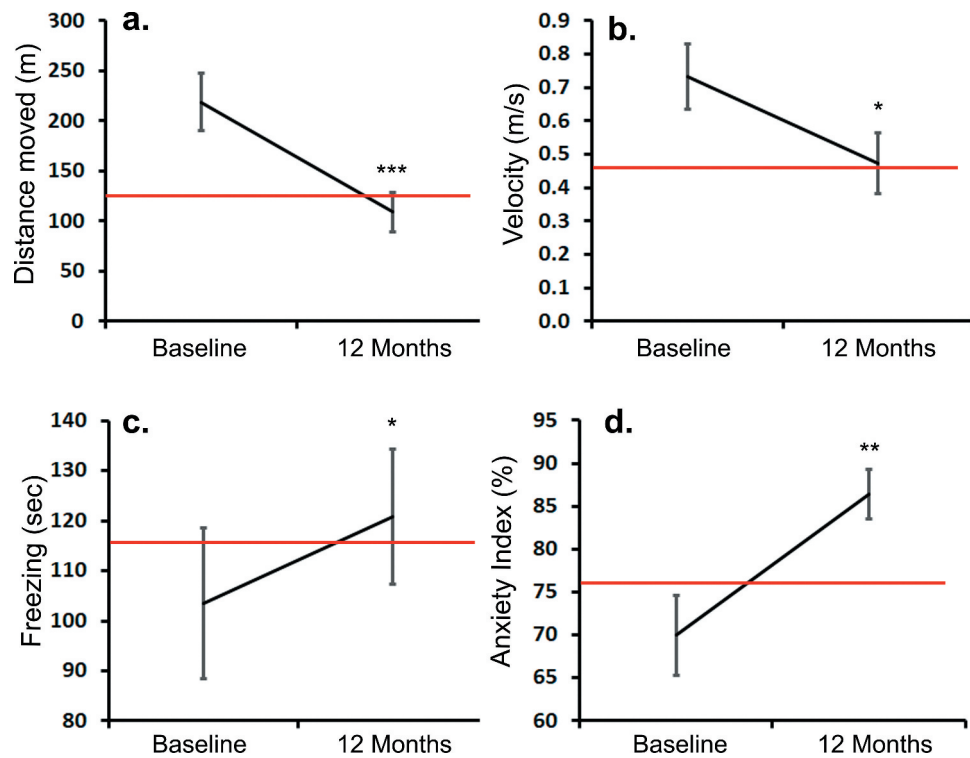
Figure 5. Dogs activity and anxiety-like behaviours. (a) Total distance moved (metres) in the entire room; (b) Average velocity (metres /second); (c) Freezing measured as the number of seconds spent without movement. The red line depicted the standard behaviour for working dogs; (d) Anxiety-index percentage calculated as distance moved in the room's periphery divided by the total distance movedX100 (*$P < 0.05$, **$P < 0.006$, ***$P < 0.005$).
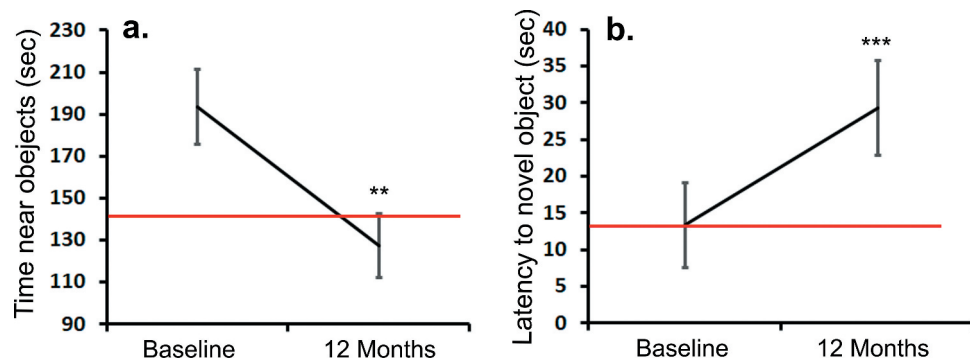

Figure 6. Dogs foraging-like and selective attention performance. (a) Foraging-like behaviour decreased to normal level post 12 months training; However, (b) selective attention performance has deteriorated post 12 months as manifested by longer latency (**$P < 0.003$, ***$P < 0.001$).

2013). Memory impairment as well as deficits in attention and learning (Qureshi et al., 2011) emphasize the possible dual role of the attention system in both cognitive and re-experiencing symptoms. Schäfer, Zvielli, Höfler, Wittchen, & Bernstein (2018) suggested that one possible mechanism through which trauma exposure may contribute to the development of PTSD is the dysregulation of attentional processing of trauma event-related cues. Thus, we postulate that attentional dysregulation may underlie the misprocessing of a neutral stimulus (i.e. condition stimulus), eliciting the re-experiencing of the trauma.

To further this hypothesis, we physiologically measured the auditory sustained attention and indeed found a statistically significant improvement in the dog-training programme subjects' attention performance with a large effect size (Cohen, 2013).

Following the beneficial effects in the dog-training programme subjects and to better understand the underlying mechanism of these effects, we also aimed to examine the dogs' emotional and attentional performance at the same time points. To the best of our knowledge, the AAT literature has mainly focused on the dog-human interaction effects on the human

subjects. Evaluation of the animal subjects' well-being is less common and mostly relies on the handler's assessment, cortisol level and behavioural observation (Glenk, 2017). Thus, the evaluation of animal subjects' well-being seems to be governed by subjective assessment. Recently, we have developed a computerized objective evaluation of various dogs' behaviours such as anxiety and selective attention (data not shown). Comparing to these standard values, we found a negative effect on the dogs' performance as their anxiety-like behaviour increased and their selective attention ability decreased.

These results suggest that the dog–handler interaction may have influenced the dogs' behaviours, either by the nature of the interaction itself and/or by the training method utilized in the programme (Rooney & Cowan, 2011).

Finally, we found a strong inverse association between the dogs' and humans' measurements suggesting a cross-species interplay, i.e. while the emotional and attentional dysregulation of the handlers was improved along with PTSD symptomatology, the anxiety and selective attention of the dogs deteriorated. Similarly, in our previous study (Zubedat et al., 2014b), we found that the exposure of handlers to stress positively affected the dogs' performance in an odour detection task. Thus, there seems to be a cross species disequilibrium between the dog and the handler emotional and attentional dysregulation. Together, our current findings emphasizing the reciprocal role of emotional and attentional dysregulations on the dog–handler interface, suggesting the dog-training program, either as a non-pharmacological intervention or as complementary to anti-depressants. Though pharmacological treatments increase the patients' well-being by treating certain PTSD symptoms, our suggested dog-training programme seems to influence the disorder itself, though a larger study with longitudinal follow-up is required. In sum, our study support previous finding (Nieforth et al., 2021; O'haire & Rodriguez, 2018; Rodriguez, Bryce, Granger, & O'Haire, 2018; Rodriguez et al., 2020) and provides evidence-based support for dog therapy to be implemented in civilians and veterans with PTSD.

Ethics statement

The Institutional Review Board (IRB) approved the study, and all participants and their parents signed an informed consent form.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author, [A.A.]. The data are not publicly available since they are containing information that could compromise the privacy of research young participants.

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