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Review

Contribution to the special issue on
***CLINICAL ETHOLOGY*:**

On the applicability of eye movement desensitization and reprocessing (EMDR) as an intervention in dogs with fear and anxiety disorders after a traumatic event

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Abstract
Fear and anxiety disorders are prevalent in dogs. These disorders are not adequately resolved by current interventions, which urges exploration of additional interventions. In humans, fear and anxiety disorders such as post-traumatic stress disorder (PTSD), are effectively treated by Eye Movement Desensitization and Reprocessing (EMDR). EMDR is a non-invasive and non-pharmacological intervention involving bilateral sensory stimulation while memorizing the traumatic event, resulting in decreased emotionality of the memory. We argue EMDR might be applied as an intervention for fear and anxiety disorders in dogs, adding to the currently available interventions for the field of Clinical Ethology. Particularly nonverbal EMDR protocols used in preverbal children can be applied and the setup can be adapted for dogs. Future research should focus on the development of nonverbal EMDR protocols including proper controls, and on clinical effectiveness of such EMDR protocols for dogs. Apart from behavioural measures, psychophysiological variables should be incorporated as well.

Keywords
EMDR, fear, anxiety, dogs, *Canis familiaris*, clinical ethology, trauma.

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1. Introduction

Fear and anxiety are reported as increasingly common behavioural disorders in dogs (Bamberger & Houpt, 2006; Puurunen et al., 2020) with a prevalence ranging from 26.2 to 44% (Tiira et al., 2016; Chung et al., 2016; Dinwoodie et al., 2019; Salonen et al., 2020). Fear and anxiety disorders seriously compromise the welfare of dogs and may lead to chronic stress, relinquishment by the owner and euthanasia (Wells & Hepper, 2000; Flannigan & Dodman et al., 2001; Fatjo et al., 2006; Sherman & Mills, 2008; Dale et al., 2010; Dreschel, 2010; Blackwell et al., 2013; Salonen et al., 2020). Clinical symptoms of fear and anxiety disorders in animals seem to correspond with Post-Traumatic Stress Disorder (PTSD)-like symptoms in humans, such as psychophysiological stress response to cues associated with the traumatic experience, avoidance behaviour, and hyperreactivity and arousal (Foa et al., 1992; rats: Cohen et al., 2012; laboratory rodents: Goswami et al., 2013). In humans, PTSD is defined by the American Psychiatric Association (APA, 2013) as a trauma and stress related disorder that occurs after exposure to a traumatic experience such as threatened death, serious injury, sexual violation or even to exposure to aversive details of traumatic events experienced by close family members or friends. According to the APA (2013) the adult PTSD criteria requires: exposure to a traumatic event and intrusion symptoms (recurrent dreams or memories), avoidance, negative alterations in cognition and mood, alterations in arousal and reactivity in response to cues related to the traumatic event, for more than 1 month. In children the same criteria are used, except it requires either avoidance or negative alterations in cognition and mood (APA, 2013). In an unpublished study on dogs offered to the behavioural clinic of Utrecht University due to fear and anxiety after a specific life event, 17% of the population fitted the criteria of the Child PTSD matrix and showed two or more of the PTSD criteria. Due to similar pathological behavioural symptoms, dogs are suggested as animal models of human psychiatric illnesses like generalised anxiety disorder, trauma and PTSD (Overall, 2000; Abrar Ul Haq, 2017). Some examples of PTSD-like symptoms in canines are anecdotally found in literature, for example Mallonee & Joslin (2004) reported PTSD-like symptoms in a wolf that was captured from the wild in a traumatic way, through darting and translocation with a helicopter. The wolf showed long term symptoms like hypervigilance, exaggerated startles, generalized fear, avoidance and arousal. In dogs that experienced an earth quake, PTSD-like symptoms such as lower

trainability and attachment to caretakers and increased urine cortisol levels were found even after 10 weeks, which are comparable to impaired learning and ability to bond in human PTSD patients (Nagasawa et al., 2012). Current interventions of fear and anxiety treatment in dogs consist of a combination of behavioural and pharmacological interventions (Sherman & Mills, 2008; Ibanez & Anzola, 2009). However, a successful treatment of fear and anxiety disorders is not always possible. Pharmacological intervention (fluoxetine and diazepam) in combination with behavioural intervention did not lead to clinical signs of improvement in 24% of the dogs and a positive correlation between achieved improvement and owner compliance was found (Ibanez & Anzola, 2009). The compliance of the dog owners in the treatment of fear of fireworks with a pharmacological and behavioural intervention may be low, since 48% stated that instructions were not clear and 90% reported that they would not consider using the programme again (Levine et al., 2007). Furthermore, the down side of pharmacological interventions is drug dependence, adverse effects and eventually loss of efficacy (Engel et al., 2019). For a more successful treatment of fear after a traumatic event in dogs additional interventions are needed. As PTSD is effectively treated by Eye Movement Desensitization and Reprocessing (EMDR) in humans, it is worth investigating if this non-invasive intervention could potentially be a useful tool to treat fear and anxiety disorders after a traumatic event in dogs as well.

2. What is EMDR and what's in it for the fearful dog?

EMDR is an effective non-invasive and non-pharmacological intervention to treat humans with PTSD and trauma (van der Kolk et al., 2007; Courtney, 2016; Navarro et al., 2018). During an EMDR session the therapist applies bilateral sensory stimulation through visual, auditory or tactile stimuli to induce changes in the memory networks in the patient that were altered by trauma (Greenwald, 1994; Oren & Solomon, 2012; Shapiro, 2012; APA, 2013; Navarro et al., 2018). EMDR is based upon the theory that traumatic memories are not adequately processed and stored in the brain (Oren & Solomon, 2012). EMDR targets these memories, integrates them within adaptive networks and hence reconsolidates them (Oren & Solomon, 2012).

Bilateral sensory stimulation plays an important role in this treatment and through a standardized procedure consisting of 8 phases (Shapiro, 2014) the targeted memory is linked to alternative information and is subsequently

stored in a more adaptive way. This allows the patient to perceive the traumatic event from a different perspective without the previous negative connotation (Oren & Solomon, 2012; Navarro et al., 2018). In a clinical trial study ($N = 88$) that compared EMDR treatment to a fluoxetine treatment or placebo, EMDR seems to be more effective after 8 weeks of treatment and after 6 month follow-up (van der Kolk et al., 2007). In total 29% of EMDR, 15% of fluoxetine and 12% of placebo treated individuals became asymptomatic (CAPS scores <20) and after six months the EMDR group continued to improve mildly in contrast to the other groups (van der Kolk et al., 2007). In another study on 67 individuals diagnosed with PTSD, EMDR treatment showed a significant greater improvement on measures of PTSD with a more rapid onset and used fewer medication and psychotherapy appointments compared to a standard treatment group with PTSD (Marcus et al., 1997).

Furthermore, a controlled study ($N = 21$) indicated that EMDR treated sexual assault victims improved significantly on PTSD and depression from pre- to post treatment compared to a no-treatment control group that was on a waiting list (Rothbaum, 1997). Reviews of randomized controlled trials demonstrate positive effects of EMDR therapy in the treatment of trauma, with part of the studies reporting EMDR to be more rapid and/or more effective than trauma-focused cognitive behavioural therapy (Navarro et al., 2018: $N = 15$; Shapiro et al., 2014: $N = 29$).

The neuroanatomy of fear and anxiety in dogs and humans is quite similar (Vermeire et al., 2011). The amygdala is responsible for impulsive, rapid and primary emotional responses (the unthinking fear response) and the prefrontal cortex is able to analyse the situation and restrain the amygdala (thinking fear response) (Vermeire et al., 2011). When sensory information enters the thalamus two pathways can be followed; the high road and low road (see Figure 1). For a more detailed function block diagram see Vermeire et al. (2011). The low road goes directly to the amygdala, whereas the high road goes through the prefrontal cortex before reaching the amygdala (Vermeire et al., 2011). The low road response will have an inhibitory effect on the prefrontal cortex and the high road will inhibit the amygdala mediating the limbic response (Vermeire et al., 2011). Human studies on PTSD indicate that increased amygdala activation is the most consistent result while processing emotional cues (Rousseau et al., 2019). Increased amygdala volume

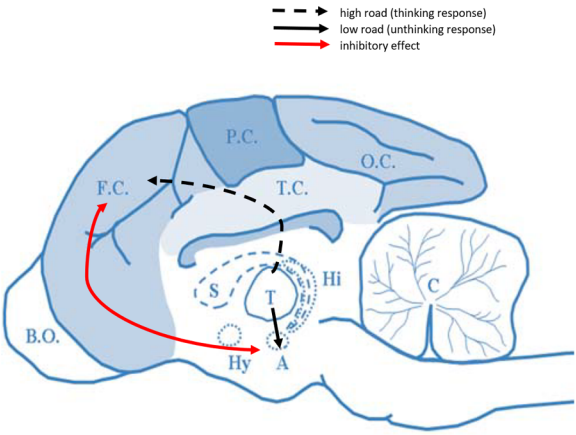

Figure 1. The canine brain with the main regions involved in anxiety, B.O., bulbus olfactorius; F.C., frontal cortex; P.C., parietal cortex; T.C., temporal cortex; O.C., occipital cortex; C, cerebellum; S, striatum; T., thalamus; Hi, Hippocampus; A, amygdala; Hy, hypothalamus and indicating the excitatory an inhibitory effects (adapted from Vermeire et al., 2011).

and overactivation, may account for exaggerated fear responses and persistence of traumatic memories as well as altered emotional regulation (Milad et al., 2009; Morey et al., 2012). Besides an increase in activity and volume of the amygdala, neuroimaging data of PTSD patients also showed a decrease in activity and grey matter volume in the ventral medial pre-frontal cortex (vmPFC) and other areas of executive functioning (Vyas et al., 2003; Boukezzi et al., 2017). The amygdala is interconnected with the vmPFC and the vmPFC is involved in top-down regulation of the amygdala due to its role in fear extinction (Phelps et al., 2004; Carrion et al., 2010). Some studies have also found decreased control of the vmPFC over the amygdala leading to a dysregulation of emotional processing and enabling amygdalar hyperresponsivity (Garfinkel & Liberzon, 2009; Pitman et al., 2012). The neuroanatomy and basic brain structures of the dog are comparable to other mammals. However, the dog brain is relatively small compared to the human brain; moreover, the cortex shows less folds so relatively the surface area is smaller including the relative size of the frontal lobe (33.3% of the brain in humans and 10% in dogs) (Figures 1 and 2). Brain imaging in dogs with anxiety disorders demonstrated altered blood flow levels in the brain and increased amygdala activation due to absence of inhibition of the prefrontal cortex (PFC), that are similar in humans suffering from PTSD, panic disorder and social anxiety disorder (Vermeire et al., 2009). In humans, the brain

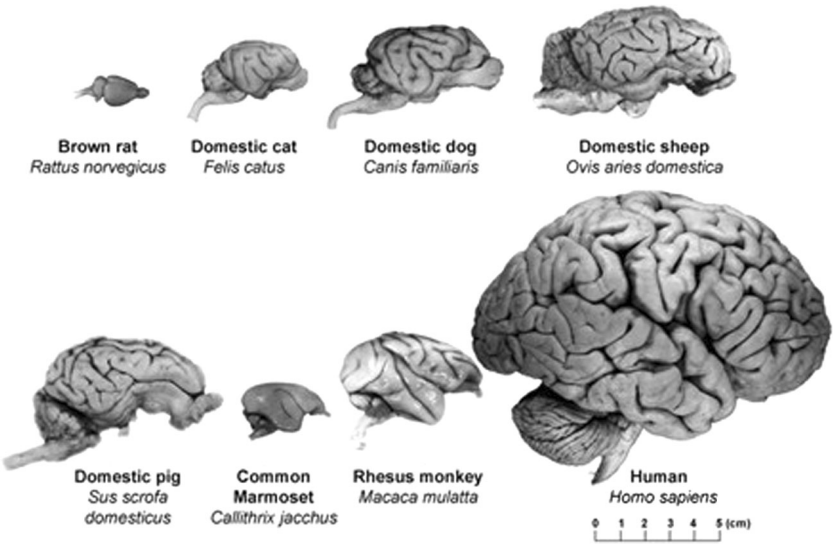

Figure 2. Comparative gross neuroanatomy of various mammal animal species. Images reproduced from the University of Wisconsin and Michigan State Comparative Mammalian Brain Collections and National Museum of Health and Medicine. Preparation of images and specimens funded by the National Science Foundation, as well as by the National Institutes of Health. University of Wisconsin and Michigan State Comparative Mammalian Brain Collections website (http://neurosciencelibrary.org/index.html).

structures affected by PTSD are reversibly altered after EMDR, mirroring treatment benefits. Studies indicate that after treatment with EMDR, patients with PTSD demonstrate a restored increase in prefrontal cortex activity as demonstrated by cerebral blood flow (Levin et al., 1999; Lansing et al., 2005; Oh & Choi, 2007) and electrical brain activity (Pagani et al., 2007), indicating a restored inhibition of limbic system activity. The effect of EMDR in dogs with fear and anxiety disorders has not been investigated but considering the analogy similar effects of EMDR-like treatments are to be expected in dogs with fear and anxiety after a traumatic event. Brain imaging to substantiate this is feasible since dogs can be trained to voluntarily enter the fMRI by positive reinforcement training (Berns et al., 2012). In humans with traumatic memories that do not reach the criteria for PTSD, EMDR still helps in the reconsolidation of a traumatic memory into adaptive memory networks and a reduction of PTSD symptoms (Cvetek, 2008; Frustaci et al., 2010). Therefore, even without a PTSD diagnosis in dogs similar effects of EMDR-like treatments are to be expected.

3. Practical application of EMDR-like techniques in dogs

Challenges may arise in the practical application of EMDR techniques in dog. In humans, EMDR involves verbally asking the patient to memorize the traumatic experience while being bilaterally stimulated and associate it to positive emotions. In dogs a therapist cannot verbalize what is requested and the regular adult protocol cannot be applied. However, the reliving of PTSD symptoms after trauma does not depend on the attainment of language per se. This is only a method that is easily applicable in adult humans who are verbally oriented. The ''representational memory'' can be evoked in different ways, making the technique more applicable to dogs. Interesting solutions might be available in the literature on the treatment of traumatised (preverbal) children. Young (preverbal) children can develop PTSD with comparable symptoms to adults (Gaensbauer & Siegel, 1995; Egger & Angold, 2006; Coates & Gaensbauer, 2009; Fleming, 2012; Coates, 2016). Although EMDR was initially developed for adults, the technique has been found to be effective in treating adolescents, (younger) children, children with mental and physical impairments and children who do not have a formal PTSD diagnosis, but show PTSD-like symptoms (Adler-Tapia & Settle, 2009; Hensel, 2009; Kemp et al., 2010; Lichtenstein & Brager, 2017). For children the protocol to conduct EMDR is less focused on verbally induced cognition and emotions, and more on imagery and sensations to induce the traumatic memory and establish a positive memory that will replace it (Fleming, 2012). The activation of the child's memory of the traumatic experience is adjusted to the child's mental age; an image can be drawn of a negative memory as opposed to verbally describe it or caregivers can use story telling methods to describe verbal details of the traumatic experience (Lovett, 1999; Mevissen et al., 2011; Adler-Tapia & Settle, 2017). To provide bilateral sensory stimulation, a therapist can place stickers on their fingers or move a toy to facilitate eye tracking or can replace eye movements with tapping, or auditory stimulation through headphones or audio speakers (Ahmad et al., 2007; Mevissen et al., 2011; Addler-Tapia & Settle, 2017). Getting the child to connect to positive things such as play, imagining a safe place or think about positive sensations, enables it to reprocess the trauma and link the traumatic memory with more positive information (Shapiro, 2001; Wizansky, 2007). In young children who do not have the verbal skills to express themselves, the traumatic experiences can be processed through play (Beckley-Forest & Monaco, 2020). EMDR can be incorporated into play therapy for example

by bilaterally tapping the child's shoulders, arms, or knees, body locations whereby the child can still engage in their play activities (Coates & Gaensbauer, 2009; Courtney, 2016; Beckley-Forest & Monaco, 2020). This can be relevant when bilateral sensory stimulation is incorporated into already existing therapeutic interventions in dogs with fear and anxiety after a traumatic event.

The methods of conducting EMDR in preverbal children shows application-possibilities to conducting EMDR non-invasively in dogs as well, as both are nonverbal and procedures have similarities. In dogs, a therapist could present a (weakened) stimulus that induces sensations related to the traumatic experience and associate them to positive sensations through classical conditioning during bilateral sensory stimulation. For example, in dogs with fear and anxiety of firework noises the current treatment protocol uses systematic desensitization with counterconditioning (Levine et al., 2007). In practice this means that a weakened sound stimulus is played back and associated with a pleasant experience such as receiving a toy and/or food in order to establish a more positive association. The protocol of bilateral sensory stimulation could be easily incorporated in this procedure by letting the dog visually follow a food reward or toy with left-right movements in front of the dog before actually giving it to the dog (see also Figure 3). Bilateral sensory

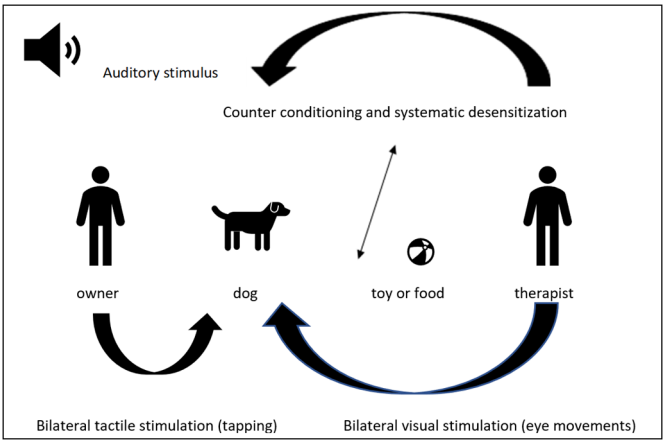

Figure 3. Schematic representation that suggests how to practically apply EMDR in dogs with fear of an auditory stimulus such as fireworks. Bilateral tactile stimulation can be applied by a repeatedly left-right tapping on the shoulders of the dog by the owner. Bilateral visual stimulation through eye movements can be applied by showing and moving a toy or food by the therapist.

stimulation can also be applied through tapping the dog bilaterally on both shoulders (left and right) by the owner. However, this should only be applied if the dog experiences the touching as something neutral or positive. Preferably the owner should be present to create a safe situation for the dog and provide social support, comparable to the protocol in children that promotes the presence of the parent during EMDR procedures (Adler-Tapia & Settle, 2017). Designing a double blinded experiment is impossible in this context. To exclude effects of the owners much as possible the owner should be placed behind the dog and asked not to speak, to prevent visual and/or verbal cues towards the dog. By blinding the owner or using a one way screen reducing the view on the experimenter the owner can be blinded to the treatment method to some extent. The experimenter should not be involved in data analysis and the researcher should be blinded to the treatment method when analysing the results. Another example where EMDR can be applied is in dogs with fear or anxiety towards conspecifics which started after a traumatizing previous bite incident (see for consequences dog-dog biting incidents; Schilder et al., 2019). Dogs with fear or anxiety of conspecifics could be presented with a stimulus dog at a certain distance to induce fear. Besides a live stimulus dog alternative, more standardized visual stimuli can be considered such as stuffed/artificial dummy dog or a picture of a dog. However, studies indicate that dummy dogs might have limited predictive validity for fear and aggression during behavioural testing (Barnard et al., 2012; Shabelansky et al., 2015). A picture of a dog on a screen was used in a study that investigated whether dogs are able to discriminate between positive and negative emotions (Albuquerque et al., 2016). Future research should focus on developing and optimizing nonverbal EMDR protocols on dogs that demonstrate fear after a (non-induced) traumatic experience, subsequently, the effect of the protocols should be evaluated. Furthermore, the effects of the type of stimulus (live dog, dummy dog, visual representation of dog) on EMDR treatment of dogs with fear of conspecifics should be investigated. This study could use a combination of counterconditioning (which is the usual intervention) and bilateral sensory stimulation.

Furthermore, well-designed control groups are essential to be able to validate the effectiveness of the EMDR as a useful intervention tool. Control groups should consist of dogs with comparable background and behavioural expressions of fear and anxiety after a traumatic experience to a comparable

stimulus. The first control group should be treated with a (weakened) stimulus (systematic desensitization) and associate them to positive sensations through classical conditioning (counterconditioning) without bilateral sensory stimulation. The entire context and treatment is comparable except the aspect of bilateral sensory stimulation. This may indicate whether bilateral sensory stimulation has an additional effect compared to regular cognitive behavioural therapeutic interventions. The dogs of the second control group should be presented with the stimulus in the presence of the owner and experimenter, without any form of therapeutic intervention. This control group functions as a no-treatment group and controls for possible habituation to the stimulus.

4. Validation of EMDR intervention

Animal studies of EMDR so far have been limited to induced-PTSD in laboratory rodents in controlled experiments with invasive treatment interventions such as electrical stimulation of the eye-lid (Kodiyan, 2016; Wurtz et al., 2016). Wurtz et al. (2016) developed an animal model for long-lasting fear recovery using auditory cued fear condition and extinction learning in mice. The model was validated by using a translational approach based on identifying a therapeutic intervention to reduce conditioned fear response in human PTSD patients and implementing it into the animal model. The fear conditioning was established by pairing a neutral stimulus (auditory stimulus) to an electric shock (unconditioned stimulus). The study tested the model in 23 adult French patients with PTSD and confirmed that these patients showed increased fear conditioning and delayed extinction compared to controls without PTSD. Fear processing (both acquisition and extinction) in these patients was restored to normal after successful EMDR therapy. EMDR intervention in 41 mice was translated by applying electrical bilateral alternating stimulation of the eyelid during extinction learning, which does not necessarily promote eye movement, but does provide bilateral sensory stimulation. The bilateral sensory stimulation in mice ($N = 16$) facilitated extinction learning, led to low fear responses compared to control animals ($N = 25$) and may lead to general reduced anxiety levels as demonstrated by lower freezing levels. The results in mice demonstrated that bilateral sensory stimulation leads to long term fear reduction during fear recovery (conditioned fear response) following extinction. This indicates that for the field

of Clinical Ethology there is a need for future validation of EMDR in clinical situations in dogs with fear and anxiety spontaneously induced after a traumatic experience.

For future clinical studies on the effects of EMDR in dogs, reliable and valid parameters are needed to evaluate the effects of the intervention. Human PTSD patients have a low parasympathetic tone compared to controls, and a prolonged psychophysiological arousal during 'script-driven trauma imagery' (Sack et al., 2004). Both after and during treatment EMDR consistently results a decrease in heart rate (HR), decrease in skin conductance, decrease in respiratory frequency, increase in blood pressure, increase in skin temperature, and changes in HRV parameters indicating increased parasympathetic activity as well as reduced arousal (Wilson et al., 1996, Sack et al., 2007; Elofsson et al., 2008; Sondergaard & Eloffson, 2008). Even after just one EMDR session, heart rate and skin conductance during trauma recall decreased significantly as compared to a relaxing state (Aubert-Khalfa et al., 2008). Skin conductance is an adequate measure of arousal, as it reflects rapid fluctuations in endocrine sweat gland activity in response to the release of acetylcholine by the sympathetic nervous system. Proving that animals experience PTSD-like symptoms in the same way as humans is difficult if not impossible, however psychophysiological changes accompanying high sympathetic nervous activity indicate at least analogy, if not homology (Ohl et al., 2008). Behavioural and psychophysiological symptoms in animal models of PTSD are analogous to human PTSD (Foa et al., 1992; rats: Cohen et al., 2012; laboratory rodents: Goswami et al., 2013). It is possible to reliably measure heart rate and heart rate variability in dogs that were stationary on the veterinary treatment table (Jonckheer-Sheehy et al., 2012). Skin conductance in dogs metacarpal pads also reflects changes in the sympathetic nervous system (Ishibashi et al., 2013). Furthermore, the surface temperature from the dog's nose is a robust measure of psychological arousal (Part et al., 2014) and is easy applicable using an infrared thermometer. In conclusion, both heart rate and heart rate variability, skin conductance and nose temperature can be reliably and non-invasively measured in dogs. Future validation studies on the effects of EMDR should include psychophysiological parameters comparable to those in humans to assess if EMDR can be an effective intervention for dogs with fear and anxiety disorders.

5. Conclusion

A non-invasive intervention like EMDR might have value in the treatment of dogs with fear and anxiety disorders after a traumatic event for the field of Clinical Ethology. Future research should focus on the development and application of nonverbal EMDR protocols for dogs. Effect monitoring should include well designed control groups and incorporate behavioural and psychophysiological parameters to validate the effectiveness of the EMDR as a useful intervention tool.

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