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Trauma Meets Trust

The Role of Service and Companion Dogs in Supporting Police Officers with PTSD

Charlotte L. Witjes-Roelofs

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Trauma Meets Trust

The Role of Service and Companion Dogs in Supporting Police Officers with PTSD

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Charlotte Lina Roelofs
geboren op 1 maart 1996
te Amsterdam

Promotoren:

Prof. dr. E.S. Becker
Prof. dr. A.S. Smit (Universiteit voor Humanistiek)
Dr. M.L.A. Jongsma

Manuscriptcommissie:

Prof. dr. R.H.J. Scholte
Prof. dr. S. van der Steen (Rijksuniversiteit Groningen)
Prof. dr. G.E. Smid (Universiteit voor Humanistiek)

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Chapter 1

General Introduction

A Dutch police officer had been serving for over two decades, witnessing some of the most distressing aspects of society during his shifts. He never thought much about the toll those experiences were taking on him. It was only years later, when his condition deteriorated, that a medical consultation revealed an unexpected diagnosis: Post-Traumatic Stress Disorder. This diagnosis, which he had previously associated only with military veterans, seemed incongruous with his self-perception as a resilient police officer. Despite him undergoing various interventions over the years, these treatments provided only limited relief, and symptoms persisted. The nightmares, anxiety, and constant tension remained. Ultimately, he withdrew to his attic, isolating himself from the outside world as every stimulus was overwhelming.

Three years later, Max, a black Labrador, was assigned to him through a program providing service dogs to officers experiencing PTSD. Initially, he was uncertain about the potential benefits. Could a dog truly provide assistance when other interventions had failed? However, Max's calm behavior and gentle presence gradually began to alleviate his distress. Max did not judge or inquire; he simply offered steady companionship through both the highs and lows. Over time, Max facilitated the reconnection with the world. Reflecting on this experience, the police officer remarked, "He gave me my life back," with emotion in his voice.

Post-traumatic stress disorder is a prevalent disorder among police officers, who frequently encounter potentially traumatic events as part of their daily duties. Since 2013 PTSD is acknowledged as an occupational disease by the Dutch police organization. The prevalence of PTSD among Dutch police officers is unknown. Of the whole Dutch population, about 7% experiences PTSD at some point in their life (de Vries & Olff, 2009). For police officers, this number is expected to be higher (Wagner et al., 2020). For instance, studies in the UK estimate that 21-27% of police officers who have encountered a potentially traumatic event develop PTSD (Brewin et al., 2020; Stevelink et al., 2020).

Post-traumatic stress disorder

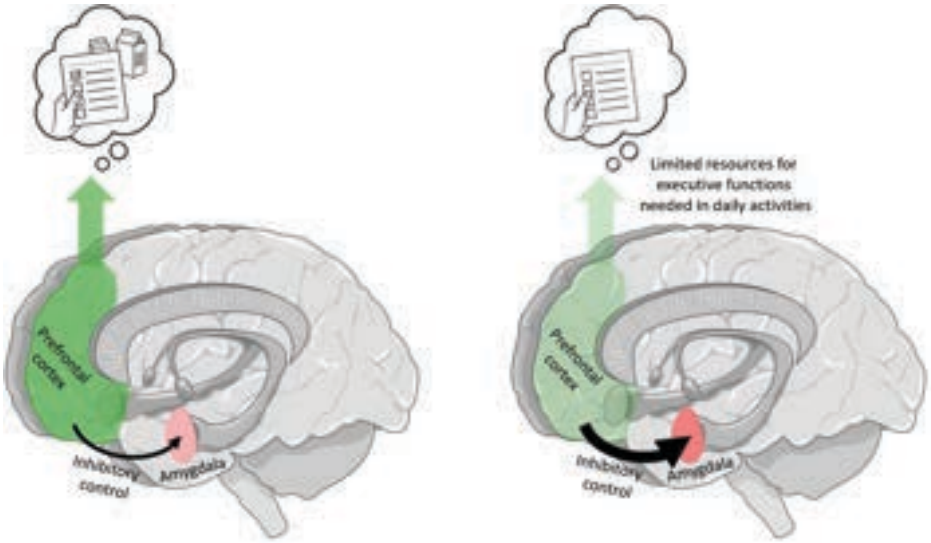
While some police officers who are diagnosed with PTSD are able to recover with minimal long-term effects, others may experience severe psychological distress that interferes with their daily functioning (Jellestad et al., 2021). The symptoms of PTSD can significantly impact the daily functioning and well-being of police officers, both professionally and personally. In the DSM-V PTSD classifies as a trauma- and stressor-related disorder and is characterized by four primary symptom clusters: intrusive symptoms, avoidance, negative alterations in cognition and mood, and alterations in arousal and reactivity (American

Psychiatric Association, 2013). Intrusive symptoms include recurrent, involuntary memories of the traumatic event, flashbacks, and distressing dreams (American Psychiatric Association, 2013). Avoidance behaviors may involve efforts to avoid reminders of the trauma, such as specific locations, conversations, or emotions linked to the event (American Psychiatric Association, 2013). Negative cognitive and mood changes may be expressed as feelings of detachment, persistent negative beliefs, or an inability to experience positive emotions (American Psychiatric Association, 2013). Finally, heightened arousal and reactivity can include symptoms like irritability, reckless behavior, hypervigilance, heightened startle response, and sleep disturbances (American Psychiatric Association, 2013). Additionally, as individuals with PTSD often struggle to focus on relevant information, regulate intrusive thoughts, and maintain cognitive flexibility, research also shows underlying difficulties in working memory and attention (Aupperle et al., 2012; Vasterling et al., 1998).

Model of PTSD: the prefrontal-amygdala circuit

A neurocircuitry model of PTSD (Rauch et al., 2006) highlights how dysregulated interactions among the amygdala and the prefrontal cortex can drain the resources needed for executive functioning. In PTSD, the fear system remains chronically overactive (Luethi et al., 2009) and the hyperactivity of the amygdala demands enhanced suppression by the prefrontal cortex in order to regulate stress-induced responses (McKlveen et al., 2015), as shown in Figure 1. In PTSD, the hyperactivation of the amygdala results in increased demands on executive functions capacity of the prefrontal cortex (Selemon et al., 2019). When the prefrontal cortex needs to allocate its resources to regulate excessive responses to external stimuli, less resources remain available. The prefrontal cortex is critical for rational, contextual interpretation of threats and several executive functions crucial for daily activities (Salzman & Fusi, 2010). The disturbance in the regulation of fear and stress responses by the prefrontal–amygdala circuit may therefore underlie not only the core symptoms of PTSD but also the cognitive difficulties frequently reported in individuals with PTSD, such as working memory and executive attention. EEG provides a fitting method to investigate these processes, as its millisecond-level temporal resolution allows for precise tracking of attentional allocation and working-memory updating in real time, offering a window into how disrupted fear circuitry shapes executive functioning in PTSD.

Figure 1 Schematic representation of the prefrontal cortex and the amygdala in the brain



Note. Left: A typical brain with the prefrontal cortex marked in green and the amygdala in pink. The amygdala receives inhibitory control from the prefrontal cortex. Apart from inhibitory control, cognitive resources from the prefrontal cortex are needed in daily activities that rely on for example working memory and attention. Right: In PTSD, the hyperactivation of the amygdala results in increased demands of inhibitory control. Less resources of the prefrontal cortex remain to engage in daily activities. Figures adapted from a brain illustration by Servier medical art, licensed under CC BY 4.0.

Working memory

Working memory is a limited-capacity cognitive system responsible for temporarily storing and manipulating information necessary for complex cognitive tasks, such as learning, language understanding, and reasoning (Diamond, 2013). Working memory can be divided into several dimensions, such as working memory capacity and working memory updating. The working memory updating ability is essential to the effective operation of working memory and higher-order advanced cognitive functions, such as reasoning and navigation. Research indicates that individuals with PTSD experience difficulties in working memory, particularly in capacity and updating abilities (Qian, 2023). PTSD patients demonstrate reduced accuracy on working memory tasks, suggesting limitations in executive control resources (Honzel et al., 2014). The reduced working memory capacity and updating in PTSD makes it difficult for patients to remember new information and forget irrelevant materials. Neuroimaging evidence suggests that these working memory related difficulties are associated with the prefrontal cortex, a brain region critical for executive functioning and working memory (Mansouri et al., 2015).

One commonly used task to study working memory is the 1-back task, in which participants indicate whether the current stimulus (letters or digits) matches the previous one in a sequence (Jaeggi et al., 2010). In a study where individuals with PTSD completed a 1-back task assessing working memory for emotional and non-emotional stimuli, results showed significantly lower working memory performance in PTSD patients compared to controls, for both neutral and emotional stimuli (Nejati et al., 2018). Neurophysiological evidence further supports these findings, with delayed N2 latencies and reduced P3 amplitudes observed during the 1-back task in individuals with PTSD, reflecting difficulties in executive functioning and attentional processing (Veltmeyer et al., 2005). These difficulties have profound implications for daily life. Individuals with PTSD often struggle to maintain and manipulate information, leading to challenges in concentration, decision-making, and problem-solving, all of which hinder daily task management. Consequently, these cognitive challenges contribute to a significant reduction in quality of life (Silverberg et al., 2017).

Executive attention

As working memory in PTSD is diminished, attention is likely to be affected as well. Executive attention, also known as attentional control, refers to an individual's capacity to choose what they pay attention to and what they ignore (Wood & Worthington, 2017). This function is crucial as it allows individuals to prioritize relevant information while disregarding distractions. In the context of emotional processing, executive attention plays a role in determining which emotional stimuli capture attention and which are ignored. The amygdala is a key brain region involved in processing emotions, particularly fear and threat detection (Kredlow et al., 2022). When a person encounters an emotional face (such as an angry expression), the amygdala rapidly evaluates the emotional salience of the stimulus. The amygdala's response is typically automatic and fast, allowing for an immediate reaction to potential threats (Öhman, 2002). This immediate reaction is crucial for survival, as it helps prioritize emotionally significant information that might require action or further attention. In individuals with PTSD, the amygdala tends to show heightened reactivity, particularly in response to threatening or negative emotional stimuli (Liberzon & Martis, 2006). This heightened reactivity can lead to an exaggerated attention bias toward negative emotions (like fear or anger), as the brain over-prioritizes these stimuli, even in situations where they may not represent a true threat (Veerapa et al., 2022).

The prefrontal cortex plays a critical role in filtering stimuli based on relevance and priority (Kredlow et al., 2022). Specifically, when we encounter an emotional face, the prefrontal cortex can modulate the amygdala's response

by either enhancing or suppressing the emotional processing of the face, depending on the context. In PTSD, these prefrontal areas may show altered activity, potentially resulting in biased attention allocation, particularly toward threatening or emotionally charged cues (Fani et al., 2012). This mechanism is thought to contribute to the heightened vigilance and hyperarousal symptoms often observed in individuals with PTSD (Shin et al., 2006). The dysregulation in the emotional attention processes is also known as attentional bias, a concept that has been extensively studied as a key factor in the dysregulation of attentional processing (Schoorl et al., 2014). Emotion-related attentional bias can be measured by using a dot probe task (Bradley et al., 1998). In this task, a fixation cross precedes a brief (250 to 1000 ms) simultaneous presentation of two types of stimuli (e.g. one neutral, one with a specific emotion). Following an interstimulus interval, a probe (e.g. a dot) is presented in the spatial location of one of these stimuli. The participant is asked to respond to the probe as quickly as possible by indicating its location. When the participant attends to the emotional stimulus, they will be faster in reacting to trials in which the probe replaces the emotional stimulus (congruent trial) and slower in trials in which the probes replaces the neutral stimulus (incongruent trial), and vice versa. In the present dissertation, the dot probe task with angry and neutral faces has been used as paradigm in Chapter 4 and 6 to study threat-related attentional bias in PTSD. Threat-related attention bias on the dot probe task has been studied extensively in PTSD, but has yielded rather mixed results, with some studies indicating attention bias toward threat, some showing attention bias away from threat and others finding no attention bias at all (reviews: Bomyea et al., 2012; Cisler & Koster, 2010; Vyas et al., 2020). Nevertheless, both vigilance toward threat and avoidance can contribute to the persistence of core PTSD symptoms such as intrusive memories, avoidance, and alterations in arousal and reactivity such as exaggerated startle responses. These attentional processes can severely interfere with daily functioning.

The cognitive difficulties in individuals with PTSD can be studied using behavioral tasks alongside electroencephalography (EEG), a non-invasive method that records electrical activity from the scalp to assess neural activity during cognitive processing (Biasiucci et al., 2019). Behavioral tasks such as the n-back task can measure deficits in attention, working memory, and cognitive flexibility by requiring participants to respond selectively to stimuli while inhibiting automatic responses (Jaeggi et al., 2010). EEG can complement these tasks by capturing event-related potentials (ERPs), which are time-locked electrical responses to specific stimuli and reflect distinct stages of cognitive processing (see Wordlist). These ERPs include components such as the P3, which reflects information processing and attention (Han et al., 2018), and the N2, associated

with inhibitory processing and conflict monitoring (Shu et al., 2014; Enriquez-Geppert et al., 2010). By analyzing ERPs evoked by various stimuli and in different conditions, researchers can identify variations in different stages of cognitive processing in PTSD, providing insights into how brain activity relates to attentional and working memory deficits.

Interventions

There are several therapies and pharmacological interventions that have been shown to be effective to treat PTSD. Trauma-focused psychotherapies, such as Eye Movement Desensitization and Reprocessing (EMDR) and Cognitive Behavioral Therapy (CBT), are the most recommended treatments for PTSD (Bisson et al., 2013). These therapies focus on helping individuals process traumatic memories and reduce the distress associated with them. In addition to psychotherapy, pharmacological treatments like selective serotonin reuptake inhibitors (SSRIs) may be prescribed to manage symptoms such as anxiety and depression. However, there are currently no medications specifically designed to treat PTSD. Despite these treatment options, only about one-quarter of individuals with PTSD are entirely symptom-free after finishing therapy (Larsen, 2019a). The remaining 75% continue to experience residual symptoms, either at clinical levels (25%) or at subthreshold levels (50%). The most persistent symptoms include hyperarousal, detachment, insomnia, and distress related to trauma triggers (Larsen et al., 2019b).

There are several reasons why therapy may not be effective in addressing PTSD among police officers. One barrier may be the culture of toughness and resilience within law enforcement, where seeking help can be stigmatized as a sign of weakness. This stigma often discourages officers from starting with therapy or being open about their struggles. Furthermore, concerns about the potential career impact of disclosing mental health issues, such as fears of being sidelined from duties or being placed on administrative leave, further discourage officers from starting with treatment. Even for those who start therapy, the lengthy process required for PTSD treatment can be challenging to sustain, leading to high dropout rates. An additional challenge is the cumulative nature of trauma in policing, where repeated exposure to traumatic events can result in cumulative PTSD that is harder to treat, as therapy addresses only one trauma at a time.

Stress buffering

An approach that could be useful in improving daily life for individuals living with persistent PTSD symptoms, is the phenomenon of stress buffering (Kikusui et al., 2016). Stress buffering (also: social buffering) is the reduction of psychological and physiological stress responses by the presence of an individual (Hornstein & Eisenberger, 2017). Stress buffering contributes to reducing amygdala activity in healthy individuals (Mulej Bratec et al., 2020). One promising form of stress buffering is to provide the presence of an animal, particularly a dog, which have been shown to provide both physiological and emotional relief. Research has shown that dogs can act as a buffer against stress (Polheber & Matchock, 2014). A meta-analysis reveals that the presence of a dog during psychotherapy can lower physiological and subjective stress levels (Ein et al., 2018). In the context of traumatic stress, studies have shown that dogs can significantly reduce acute distress (Hunt & Chizkov, 2014) and alleviate subjective feelings of stress and anxiety both during and after an experimental traumatic stress situation (Lass-Hennemann et al., 2014; Lass-Hennemann et al., 2018). Notably, in the above-mentioned studies, the dog was unfamiliar to the participants. Several studies have highlighted the general health benefits of pet ownership, including reductions in distress and anxiety (Friedmann & Sonn, 2009). For veterans with PTSD, owning a dog has been linked to feeling calmer and less worried about personal and family safety (Stern et al., 2013).

Apart from the benefits of owning a pet dog, there are also specialized PTSD service dogs that are exhaustively trained to respond precisely to specific disabilities of the owner and are typically allowed entry into public facilities (Krause-Parello et al., 2016). Another study on veterans found that PTSD service dogs ultimately facilitate socialization, provide companionship, and reduce trauma-related symptoms while promoting independence (Yarborough et al., 2018). The dogs achieve this, for example, by acting as a calming influence and alerting the owner to signs of developing stress or panic. Both companion dogs and PTSD service dogs may act as stress-buffer (Richerson et al., 2023). Each type of dog offers benefits and challenges depending on the specific needs and circumstances of the individual. When conducting research on service dogs, it is therefore essential to adequately control for the general benefits of pet ownership.

Existing research on PTSD and the use of service dogs has predominantly focused on veterans in the United States, with limited attention given to other high-risk groups, such as police officers. While veterans represent a critical population for PTSD research, police officers experience unique occupational stressors, such as exposure to frequent trauma and a heightened risk of violence, which may lead to distinct manifestations of PTSD as trauma type may influence symptom profiles (Naifeh et al., 2008). Furthermore, despite the increasing interest in animal-assisted

therapies, there is a notable lack of experimental evidence on the effectiveness of service dogs in alleviating PTSD symptoms, particularly in terms of cognitive impairments such as working memory deficits and attentional biases. Much of the existing literature is qualitative in nature, providing valuable insights but lacking the methodological rigor of controlled experimental studies. This gap in experimental evidence calls for more research that employs experimental designs, controlled for pet ownership, to directly assess the impact of service dogs on executive functioning and well-being of police officers with PTSD. This dissertation aims to address this need by exploring how a (service) dog may enhance well-being and executive functioning in police officers with PTSD.

Stress buffering may work by lowering the stress response when in the presence of another individual (Mulej Bratec et al., 2020). In Chapter 3, a conceptual model of executive functions and stress-buffering is proposed. In PTSD, the prefrontal cortex devotes a lot of its capacity to inhibitory control on the amygdala. Therefore, limited capacity is left for the executive functions of the prefrontal cortex. Based on the conceptual model, we hypothesized that in the presence of a stress-buffer, an individual with PTSD would show better executive functioning than without a stress-buffer.

Research approach

Measuring the effect of the presence of a service dog requires a multidimensional approach that assesses both objective and subjective outcomes. The majority of research on service dogs for PTSD so far consists of survey studies on veterans (Kloep et al., 2017; O'Haire & Rodriguez, 2018; Rodriguez et al., 2020). These studies used symptom checklists and other self-report questionnaires to capture changes in psychological symptoms and well-being. However, self-report surveys are subject to social desirability bias, where respondents may provide answers they believe are more socially acceptable rather than fully accurate. Additionally, surveys often rely on the participant's memory, which can be influenced by external factors, leading to inaccuracies. When focusing on subjective outcomes, the objective measurable changes in behavior or physiology might be overlooked. To capture the full scope of the effects of (service) dogs on their owners with PTSD, we integrated behavioral, physiological, and qualitative measures to attempt to provide a comprehensive understanding of the (service) dog's impact.

In our mixed-methods approach, we used a variety of methods to assess the impact of service dogs on police officers with PTSD. Functional assessments focused on executive functioning, such as working memory, attention, and emotional processing. Brain activity was measured by the electroencephalogram

(EEG) to gain insights into neural responses and potential changes in cognitive processing. Additionally, we used several commonly used questionnaires to measure well-being, state anxiety, and life satisfaction. Qualitative semi-structured interviews were also conducted, offering rich, nuanced insights into participants' personal experiences. These in-depth interviews have captured aspects of the service dog's impact on the police officer with PTSD that may not have been evident through quantitative measures alone. They allowed for a deeper understanding of how the service dog influences daily life and well-being. When conducting research on service dogs, it is essential to control for the general benefits of pet ownership, which can have positive effects in itself (Friedmann & Sonn, 2009; Stern et al., 2013). Including three groups (police officers with PTSD owning a service dog, police officers with PTSD owning a companion dog, and police officers without PTSD owning a companion dog) allowed us to disentangle the effects of dog presence from those specific to trained service dogs in Chapter 2, 3 and 4. This design enabled us to isolate service-dog specific contributions beyond the general benefits of living with a dog, while also distinguishing PTSD-related characteristics from those associated with typical occupational stress. By integrating psychophysiological, behavioral, and qualitative measures, the three groups provided a rigorous evaluation of both the general impact of dog presence and the exploratory added value of specialized service-dog training.

Aims of the dissertation

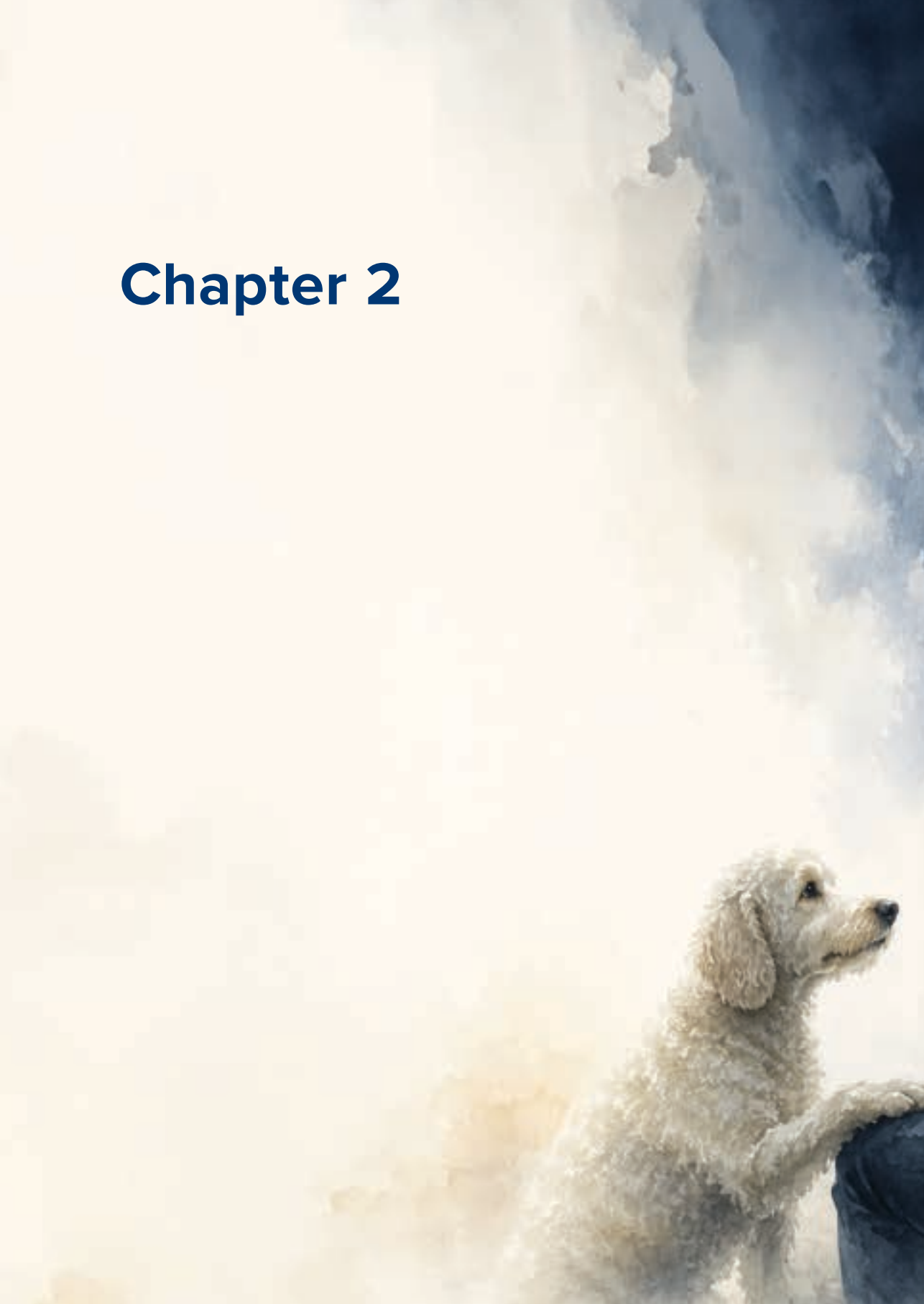
The overarching aim of this dissertation is to advance understanding of how the presence of a dog, whether a trained service dog or a companion dog, may support well-being and cognitive functioning in police officers with PTSD. To address this aim, the dissertation comprises a series of studies that examine both service-dog specific effects and the broader impact of dog companionship, using both qualitative and quantitative approaches.

First, we investigated how police officers with chronic PTSD perceive the support provided by service dogs compared to companion dogs (Chapter 2). This qualitative work aims to clarify the distinct and overlapping forms of assistance offered by each type of dog. Next, we examine whether the presence of a dog influences working memory performance in police officers with PTSD (Chapter 3), followed by an investigation into how dog presence affects emotional processing, specifically attention bias to emotional facial expressions (Chapter 4). Together, these chapters explore the potential mechanisms through which dogs may support individuals with PTSD.

A further aim of this dissertation is to investigate whether the supportive role of companion dogs can be enhanced through targeted training, and to examine the broader stress-buffering potential of dog presence beyond the PTSD context. Chapter 5 focuses on evaluating the feasibility and potential benefits of the Companion Dog Support Partnership (CDSP) training program for police officers with PTSD and their companion dogs. This chapter aims to determine whether a brief, structured training can strengthen supportive dog behaviors and improve police officers' well-being. Chapter 6 extends this evaluation to cognitive outcomes, examining whether the CDSP training influences working memory performance and attentional bias to emotional faces. This chapter aims to clarify whether training-related changes, or the presence of the dog itself, affect executive functioning in officers with PTSD.

To isolate the general effects of dog presence beyond the PTSD context, Chapter 7 investigates whether the mere presence of a dog can buffer acute stress responses in healthy participants. This chapter aims to assess self-reported stress measures, cardiovascular measures, and neurophysiological indicators of stress during exposure to aversive stimuli, thereby evaluating the broader generalizability of dog-related stress reduction. Together, these chapters contribute to the overarching goal of the dissertation to understand how trained service dogs, companion dogs, and a targeted training intervention may support cognitive functioning and well-being in Dutch police officers with PTSD, and to assess the broader potential of dog presence to reduce stress in humans.

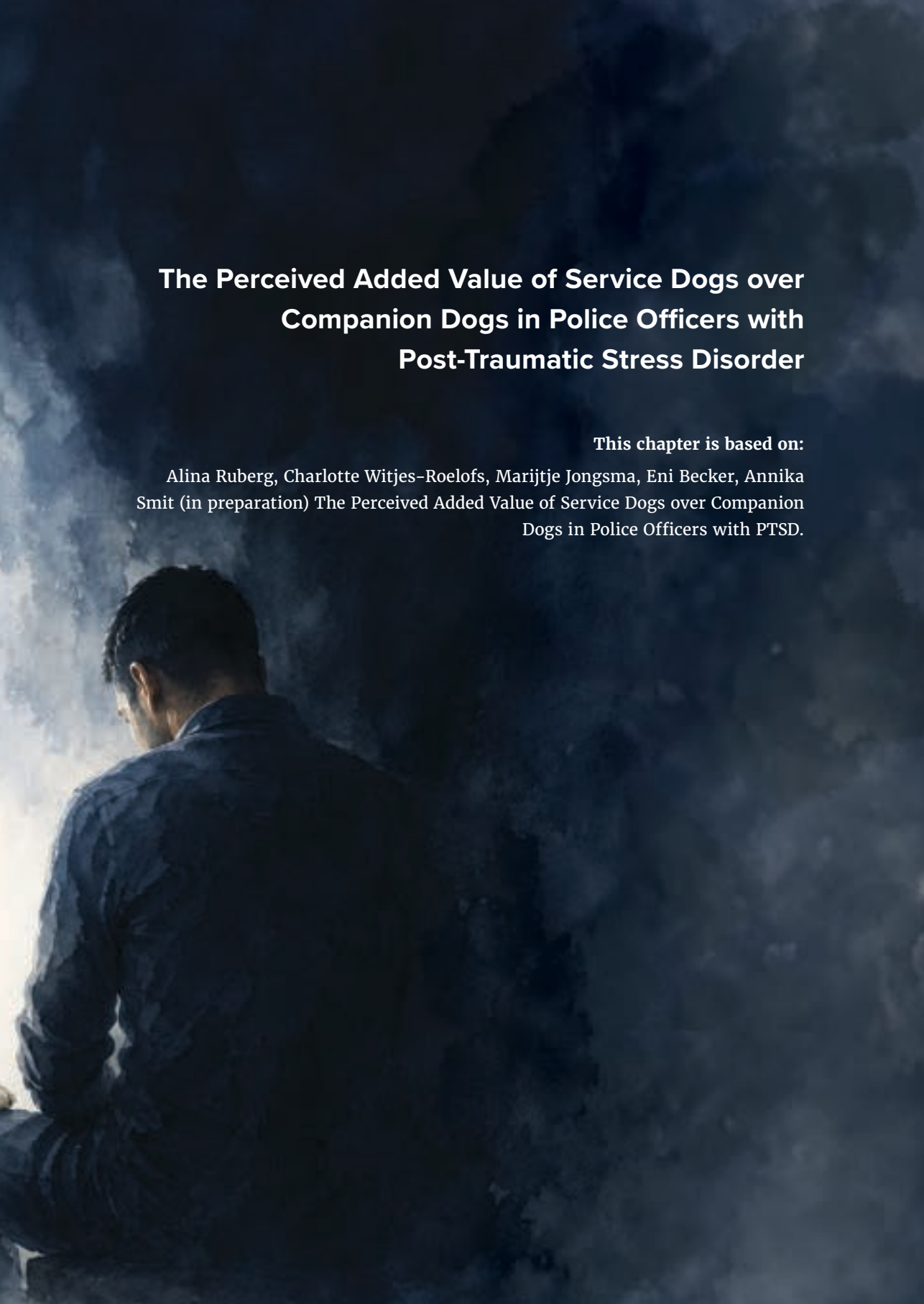
Chapter 2



The Perceived Added Value of Service Dogs over Companion Dogs in Police Officers with Post-Traumatic Stress Disorder

This chapter is based on:

Alina Ruberg, Charlotte Witjes-Roelofs, Marijtje Jongsma, Eni Becker, Annika Smit (in preparation) The Perceived Added Value of Service Dogs over Companion Dogs in Police Officers with PTSD.



Abstract

Post-traumatic stress disorder (PTSD) is prevalent among police officers and remission rates are relatively low. This study explored how Dutch police officers with PTSD perceive the impact of service dogs (n = 13) compared to companion dogs (n = 13) on their wellbeing, by employing interviews and comparing the results with a control group with a companion dog but without PTSD (n = 12). While both types of dogs provide emotional comfort and companionship, service dog owners report more reliable and targeted support through trained behaviors tailored to PTSD symptoms, such as interrupting nightmares, creating personal space, and signaling emotional distress. Some companion dogs were reported to display behaviors similar to those of trained service dogs, though in a less consistent and reliable manner. Companion dogs may serve as a meaningful alternative for individuals unable to access a service dog.

Introduction

Police officers face a significantly elevated risk of developing post-traumatic stress disorder (PTSD) due to frequent exposure to traumatic situations. This to an extent that PTSD has been classified as an occupational disease within the Dutch police force since 2013 (Politie Nederland). For those affected, PTSD profoundly diminishes quality of life (Balayan, 2014). PTSD symptoms typically include re-experiencing trauma (e.g., flashbacks, nightmares), avoidance, emotional numbness, hyperarousal, and cognitive difficulties (American Psychological Association, 2013). Although several evidence-based PTSD treatments are available, the majority (~75% at follow-up) of patients continue to experience residual symptoms such as insomnia, hyperarousal, and distress related to trauma triggers, and dropout rates are high (~16%) (Larsen et al., 2019a; Larsen et al., 2019b; Lewis et al., 2020). These challenges highlight the need for complementary interventions that can support daily functioning and wellbeing.

One such complementary intervention is the use of PTSD service dogs. These dogs are trained to perform specific tasks to alleviate PTSD symptoms by offering both psychological and functional support (Jensen et al, 2021; Yarborough et al, 2018). Research among military veterans has shown that service dogs are associated with reduced PTSD symptom severity and better daily psychosocial functioning (Jensen et al., 2021; Leighton et al., 2024). For example, Leighton et al. (2024), found that veterans with service dogs reported improved affect, fewer panic attacks, and enhanced social interactions. Qualitative studies confirm these findings, with partners of veterans noting reduced anxiety and increased confidence in public settings (McCall et al., 2020). Veterans have further reported improved sleep quality, enhanced emotion regulation, and reductions in suicidal ideation and substance use due to service dogownership (McLaughlin & Hamilton, 2019). The service dogs were described as enhancing a sense of safety and helping bring the owner back to the present moment during episodes of hyperarousal.

Multiple qualitative studies have investigated how service dogs may achieve a reduction of PTSD symptoms. Veterans have reported that owning a service dog leads to improved quality (and duration) of sleep by waking them up from nightmares (McCall et al., 2020; McLaughlin & Hamilton, 2019; Scotland-Coogan, 2019; Williamson et al., 2021; Yarborough et al., 2018). Service dogs of veterans can further divert their owners attention from intrusive (trauma-related) thoughts and bring them back to the present moment through behaviours such as nudging their owner, but also by barking or jumping (McCall et al., 2020; Williamson et al., 2021; Yarborough et al., 2018). Dogs further offer tactile interruption or deep pressure to interrupt acute negative feelings such as anxiety (McLaughlin & Hamilton, 2019; Scotland-Coogan, 2019; Williamson et al., 2021). Veterans further reported that

the dog gives prompts that help them recognize their own emotional distress (McCall et al., 2020). Lastly, the presence of a service dog provided veterans with a sense of safety and security (McLaughlin & Hamilton, 2019; Scotland-Coogan, 2019) and reduced hypervigilance, for example by creating physical space for their owner and by being alert to the surroundings (Yarborough et al., 2018). While these findings demonstrate the value of service dogs for individuals with PTSD, most studies do not distinguish between the effects of trained service dogs and those of untrained companion dogs, which may also provide emotional comfort, structure, and social support.

Although companion dogs are not formally trained as PTSD service dogs, research suggests that companion dogs can positively impact human wellbeing. Companion dogs have been associated with improved mood, reduced stress, increased feelings of safety, and decreased loneliness (Barker et al., 2016; Jarolmen & Patel, 2018; Machová et al., 2020; Stern et al., 2013). Veterans with PTSD who own companion dogs have further reported less depression and anxiety along with stronger feelings of calmness (Stern et al., 2013). These findings suggest that both trained and untrained dogs may enhance wellbeing, though potentially through different mechanisms.

However, few studies have directly compared the effects of service and companion dogs. For instance, a study by Richerson, et al. (2023), compared service dogs with emotional support dogs (dogs providing comfort with no special training) and showed that veterans with a service dog experienced a significantly greater reduction in PTSD symptoms than veterans with an emotional support dog (Richerson et al., 2023). Yet, little is known about the underlying aspects that may account for this difference in symptom reduction. Given these gaps, it remains unclear how the benefits of service and companion dogs differ, particularly among non-veteran populations. However, to justify the substantial costs associated with providing trained service dogs for PTSD, it is essential to demonstrate the qualitative differences of service dogs compared to companion dogs, particularly regarding wellbeing.

The present study aimed to explore how (former) police officers in the Netherlands with PTSD perceive the impact of living with either a service dog or a companion dog on their wellbeing and quality of life. We hypothesized that while both types of dogs can offer comfort, structure, and emotional support, service dogs are trained to perform specific tasks that directly address PTSD symptoms, such as interrupting nightmares, providing a sense of safety in public spaces, and assisting with emotion regulation. Given the study's objective to explore perceived differences in how service and companion dogs influence wellbeing, a qualitative approach was considered most appropriate. By examining the self-reported

experiences of officers living with either a service dog or a companion dog, this study investigates what specific characteristics of each dog type contribute to the potential differences in wellbeing and daily functioning. These insights may help clarify the specific added value of service dogs and guide future support interventions for police officers dealing with persistent PTSD.

Methods

All participants in this study were (former) police officers in the Netherlands. The participants were recruited through internal communication within the Dutch police organization. To be included in the PTSD group, participants needed to have a work-related PTSD diagnosis, have finished at least one type of treatment, have owned a service or companion dog for at least six months, and are (or have been) employed within the police force. Exclusion criteria for the PTSD group was a remission of the PTSD symptoms concluded from the interview data, neurological or psychiatric conditions other than PTSD, and/or the presence of a severe somatic condition. In order to be eligible for the control group, inclusion criteria were being employed within the police force, owning a companion dog for at least six months, and having no current or past diagnosis of PTSD. There was no restriction on the breed of the dog. In the group with PTSD and a companion dog, seven participants were excluded due to remission of PTSD concluded from the interview data, which resulted in a group of 13 participants. In the group with PTSD and a service dog, 13 participants were included. The control group with a companion dog existed of 12 participants. For descriptives per group, see Table 1. All participants (N=38, 26 female, 24 male) completed three standardized questionnaires:

- *Satisfaction With Life Scale (SWLS, Dutch version; Arrindell et al., 1999).* This questionnaire contains 5 items concerning satisfaction with life. The SWLS has shown good reliability and validity (Pavot et al., 1991).
- *Short version of the World Health Organization Quality of Life assessment (WHOQoL-BREF, Dutch version; De Vries & Van Heck, 1997).* This questionnaire contains 26 items concerning the affective components of wellbeing. These are divided into 4 sub-categories (physical health, psychological health, social relations and surroundings). The questionnaire has good reliability and validity (De Vries & Van Heck, 1997).
- *Short version of the State-Trait Anxiety Index (STAI-6; De Vries & Van Heck, 2013; Van Der Bij et al., 2003).* This questionnaire consists of 6 items measuring the transient state of arousal subjectively experienced as anxiety and has good reliability and validity (Tluczek et al., 2009).

Table 1 Descriptives and Mean Questionnaire Scores

Group	PTSD with service dog	PTSD with companion dog	Control
N	**13**	**13**	**12**
Mean age (SD)	51 (10.6)	46.8 (11.4)	49.5 (9.45)
Female/Male	3 (23.1%)	5 (38,5%)	10 (83.3%)
Satisfaction of Life (SD)	17.55 (4.59)	20.03 (5.00)	28.47 (2.69)
State Anxiety (SD)	16.62 (2.6)	14.69 (3.84)	8.33 (2.15)
WHO quality of life scale			
Physical Health (SD)	9.85 (1.86)	11.85 (2.91)	17.25 (1.91)
Psychological Health (SD)	11.69 (2.06)	12.62 (2.63)	16.58 (1.38)
Social Relationships (SD)	13.85 (2.79)	13.92 (3.40)	18 (1.65)
Environment (SD)	14.62 (2.02)	15.54 (2.07)	18.67 (1.56)

Procedure

The study has been reviewed independently by the Ethics Committee Social Sciences (ECSS) of the Radboud University and there is no formal objection to this study (ECSW-2020-012). This study was part of a larger project examining executive functions in police officers with and without PTSD in the presence and absence of their dog (Smit et al., 2022), however, those objectives fall outside the scope of the present qualitative analysis. Data were collected between July 2020 and March 2021. COVID-19 safety measures were in place.

The service dogs were trained by the Royal Dutch Guide Dog Foundation (KNGF) according to the specific PTSD-related needs of their future owners. The training includes teaching specific tasks such as waking the owner from nightmares or guarding personal space by keeping others at a distance. All participants provided written informed consent. Participants completed three well-being questionnaires. Semi-structured interviews were guided by previously determined questions, were audio recorded and lasted around 30 minutes.

Interview data analysis

Transcribed interviews were analyzed and coded within Atlas.ti (https://atlasti.com), using thematic analysis as described in Braun and Clarke (2006), as well as descriptive coding. Thematic analysis was employed to identify key patterns across participants' experiences and allowing comparison between groups. Descriptive coding describes the summary of a part of one's qualitative data in a word or short phrase (Saldaña, 2021). The second, third and fourth author familiarized themselves with the data to established their overarching impressions of the data and identify common themes. During this process, the research team came

together on multiple occasions to discuss potential codes and overarching themes. Based on the emerging themes an initial codebook was designed and applied to the first few interviews. The research team met multiple times during this process to refine the initial codebook. Once a definitive version of the codebook was established all interviews were coded again. Finally, each interview was reviewed by a different author than it was coded by. Any cases of uncertainty were discussed until consensus was reached.

Results

Six main themes emerged: motivation to go outside, comforting presence, mental support, social contact, sleep, and challenges. For example quotes, see Appendix.

Motivation to go outside

Participants across all groups described that owning a dog brings structure to the day and motivates to go outside. Service dog owners specifically emphasized this structure during periods of isolation and mentioned that their dog helps them get out of bed in the morning (See Appendix, Quote 1). The service dog owners described their dog as staying constantly vigilant and that their dog's awareness allowed them to be less alert themselves, reducing stress in crowded or unfamiliar spaces. Service dog owners highlighted the reassurance that their dog would act if something went wrong, which leads them to be able to walk outside with more ease. Beyond meeting the dog's basic needs, the feelings of trust and safety provided by both companion and service dogs encouraged participants with PTSD to leave the house (See Appendix, Quote 2–4). While participants with PTSD and a companion dog described that their dog keeps an eye on them, it was not reported that this lead to a reduction of stress.

Among service dog owners a sense of safety was described due to their dog's ability to create personal space by keeping others at a distance (See Appendix, Quote 5). Some stated this enabled them to reengage with society or experience more freedom. Service dog owners emphasized their dog's ability to "block" others by physically positioning themselves to create a buffer. Both participant groups with a companion dog (with and without PTSD) mentioned similar behaviour, but they described it as their dog walking or lying between them and others. Participants with PTSD and a companion dog also reported feeling safer because of this positioning, which made it easier to go outside.

Comforting presence

Participants of all groups describe their dogs presence as inherently calming, with additional relaxation from touching or cuddling (See Appendix, Quote 6). They also characterized their dogs as a friend and companion that is always on their side, alleviating feelings of loneliness. Service dog owners note that already the physical presence of the dog is meaningful and calming for them (See Appendix, Quote 7, 13). Service dog owners further described that their dog is always by their side and follows them around. While this constant presence is generally experienced as positive, it has been noted that this can also be overwhelming (See Appendix, Quote 8). Dogs help reduce sadness and provide comfort to participants with PTSD (both with a companion or a service dog), often by being physically close (See Appendix, Quote 10). Participants with PTSD further appreciated the unconditional loyalty of their dog (service and companion dogs). Participants with PTSD experience the dog (service or companion) as a "therapist on four legs" to whom you can talk (without it talking back) and which can give (self)confidence and feelings of support (See Appendix, Quote 12). Further, some companion dog owners with PTSD mention that their dog helps them put things into perspective. Some of the participants with PTSD and a companion dog express the desire to bring their dog to work specifically for the sense of relaxation and security. Participants with PTSD and a companion dog noted that they love their dog, or in any case that the dog gives them a warm feeling. Control group participants often viewed their dog as a full-fledged family member. Participants of the control group did not report active consolation but appreciated their dog's continuous presence at home (See Appendix, Quote 9).

Mental Support

Participants of all groups report that the dog can help in reducing stress levels and can sense their emotional state. Only participants with a service dog note that the dog occasionally removes them from situations in which they are not feeling well (See Appendix, Quote 14). Participants with a service dog note that the dog seems to know when their emotions are running high even before they are aware of it themselves (See Appendix, Quote 18). They report multiple ways in which the service dog reacts to their emotions. Service dogs pull the attention of their owner towards them for example by walking up to them with toys (See Appendix, Quote 20). Other actions of the service dogs in this context are walking up to their owner and/or lying next to them. Further the service dogs look for body contact with their owner for example by laying their head on their owners lap (See Appendix, Quote 16). Lastly, participants with a service dog report behaviour known as "mirroring" where the dog takes over their owners behaviour and thus "mirrors" their actions (See

Appendix, Quote 17). Participants with PTSD and a companion dog report similar behaviour like mirroring. While these participants report that the companion dog senses their emotional state, the reactions of the dog differ per participant in this group. Reported reactions were that the companion dogs look at their owners when they are emotional, look for physical contact, ask to be pet or stand in front of their owner. Most participants of this group thus note that the companion dog makes some kind of contact with them when the participant is sad. However, it is also reported that the companion dog leaves the room if their owner is in distress. Participants with a companion dog (both with PTSD and without) specifically note that walking the dog can aid in reducing stress levels (See Appendix, Quote 15). Some participants of the control group note the dogs senses emotional states. The control group further reports that the dog gives them an extra lick or cuddle, but also that the dog walks away when their owner is stressed.

Next to signalling emotional states, participants with PTSD report that the dog can also help them deal with these emotions by providing distraction (See Appendix, Quote 19). Service dogs distract their owners by getting up, barking, wanting to be pet or bringing toys to their owner. Companion dogs provide distraction for participants with PTSD by being present or walking up to their owners. Participants of the control group did not report similar behaviour. While the dogs respond to and aid in dealing with negative emotions, participants of all groups also report that their dog positively influences their emotions, for example by being funny or making them laugh. Participants with PTSD and a companion dog noted feeling happy when their dog greets them excitedly.

Social Contact

Participants of all groups report that their dogs facilitate social interaction, specifically because the dog serves as a conversation starter. Participants with a service dog highlight the importance of this for a reduction of social isolation and further note that they talk more or more at ease over their PTSD with others. Participants with PTSD and a companion dog report that the dog often serves as a conversation starter, which has even lead to new friendships. However, some in the control group experience negative social effects, such as difficulties with people who dislike dogs (See Appendix, Quote 21). Specifically service dogs attract significant attention as they wear a vest with ‘do not pet’ and come in unusual places for dogs like in the supermarket or the hospital. Owners value that the presence of the dog diverts attention away from themselves and toward the dog (see Appendix, Quote 22). While service dog owners mainly appreciate positive reactions, attention can also become overwhelming. Specifically excessive staring and frequent questions, particularly about the service dog vest can be

experienced as negative (See Appendix, Quote 23). As the companion dog does not wear a specific vest, this topic was not discussed in the other two groups. Many participants with PTSD, whether with a service or companion dog, find their dog a useful excuse to exit situations (See Appendix, Quote 24).

Sleep

Service dogs can actively assist by waking their owners during nightmares, using nudging, licking, or jumping on the bed (See Appendix, Quote 25) and for some, already the knowledge that the service dog will wake participants from nightmares can improve sleep (See Appendix, Quote 26). None of the participants with a companion dog reported that that their dog wakes them from nightmares. Participants with PTSD report that their dogs (service or companion dog) already have a positive effect on their nights by adding calmness through being present when they are falling asleep or waking up (See Appendix, Quote 27, 28). At this time service and companion dogs display various comforting behaviours, such as lying close or on the bed. The control group does not note behaviour of their dogs at night. Some of the control group and the companion dog group do not allow the dog upstairs and/or in the bedroom.

Challenges

Participants of all groups report it as challenging that they always have to take the dog into account, for example when booking vacations or that they have to find someone to watch over the dog when they are away for longer. Participants of the control group add high vet costs, time needed for the dog and training as well as attention-seeking behaviour of the dog as challenging. Participants of the control group further mention practical difficulties such as barking and increased need for cleaning as challenges. Participants across all groups fear the eventual loss of their dog (See Appendix, Quote 29). Participants of all groups reported that they find it difficult that their dog is not allowed into all spaces.

Service dog owners face unique difficulties, including adjusting during the initial training period. Participants with a service dog note sharing of attention between the dog and family members and feeling guilty about the dog taking the place of their partner as challenging. Further, participants struggle with the dog's limited working capacity (See Appendix, Quote 30, 31). Additionally, service dogs retire after a set number of years, which many participants find difficult to accept (See Appendix, Quote 32). Despite the challenges, participants with a service dog report that their dog has given them their life back (See Appendix, Quote 33). In some cases, the dog takes over tasks from a partner, allowing the partner to regain their own life as well.

Discussion

This study compared the perceived impact of service dogs versus companion dogs on the wellbeing of Dutch police officers with PTSD. Qualitative findings revealed meaningful differences, as companion dogs were reported to provide emotional comfort and companionship, service dog owners reported specific skills of their dog that offered reliable support.

Service dogs and companion dogs both contributed emotional comfort, structure, and motivation to go outside, consistent with broader findings on dog ownership and well-being (Barker et al., 2016; Jarolmen & Patel, 2018; Machová et al., 2020; Stern et al., 2013). In addition, service dogs uniquely offered reliable, trained behaviors, such as blocking, interrupting nightmares, signaling distress, and removing owners from stressful situations, that enhanced feelings of safety, control, and public re-engagement, aligning with prior evidence on their benefits for PTSD (Jensen et al., 2021; Leighton et al., 2024; McCall et al., 2020; McLaughlin & Hamilton, 2019; Scotland-Coogan, 2019; Williamson et al., 2021; Yarborough et al., 2018). In contrast, companion dogs provided meaningful but less consistent support, with behaviors that varied widely, from behaviors similar to service dogs (nudging or barking) to leaving the room. While both dogs engage in behaviors like blocking, companion dogs cannot be expected to do so reliably or on command. Similarly, while companion dogs were reported to comfort their owner at night, they did not actively interrupt nightmares. Lastly, companion dogs cannot provide aid in areas where dogs are not allowed, which may limit their role in public environment re-engagement. The trained behaviors of service dogs provided a form of externalized self-regulation and these behaviors were described by the participants as predictable and reliable, which is essential for individuals with PTSD. The knowledge that the dog will always intervene before symptoms fully escalate, may function as a safety cue that reduces anticipatory anxiety. This idea aligns with theories of trauma recovery that emphasize the importance of restoring agency and predictability when living with residual symptoms of PTSD (Bajpai et al., 2025).

At the same time, service dogs come with their own unique challenges. Such challenges are the initial adjustment during training, the dogs need for rest, and the eventual retirement of the dog. Further, service dogs wear an identifying vest which can attract significant attention in public. While this can be perceived as positive as it shifts attention away from the owner, it can also be overwhelming due to frequent questions and staring. These ambivalences underscore that support is not one-dimensional, as even highly beneficial interventions can introduce new stressors. Service dog programs may benefit from preparing owners for the social and emotional complexities of working in public with a service dog. In contrast, companion dogs offered a form of support that was less structured but did not

attract the same level of public attention. For some participants, this lower visibility may align better with their identity as police officers, a group that often values autonomy and discretion. The specific occupational culture of policing, marked by exposure to trauma, stigma around help-seeking, and strong norms of emotional control, may shape how officers perceive their dog's support. This population remains underrepresented in the literature, and their needs and preferences may differ from those of military veterans, who dominate existing research.

Across groups, participants described their dogs as central figures in their lives, offering comfort, routine and motivation to re-engage with daily life. These experiences resonate with broader literature on human-animal interaction, which conceptualizes animals as co-regulators of emotion and as attachment figures that provide non-judgmental presence and comfort (Stamataki & Tragantzopoulou, 2025). From a trauma-related perspective, these aspects are connected to key therapeutic processes, such as grounding, affect regulation, and restoration of a sense of safety (Maercker et al., 2022). The presence of their dog seemed to support the participant in managing distress to such an extent that they were able to return to environments they had previously experienced as threatening. In this perspective, the dog-owner relationship can be understood as a form of embodied therapeutic aid, where trust is built not through language but through consistent behaviour and an attuned connection.

Additionally, the findings challenge the view that companion dogs simply are an inferior version of service dogs. Companion dogs displaying behaviors resembling trained tasks (nudging, comforting during distress, or positioning themselves protectively) was often reported, suggesting that the boundary between the two categories may be more fluid than initially assumed. Rather than a dichotomy, the data point toward a continuum of support, where training enhances reliability but does not create entirely new forms of behavior. This view raises conceptual and practical questions, such as whether a targeted, short-term training program could expand the usefulness of their companion dog for individuals who do not qualify for a service dog. These insights have practical implications. If companion dogs can provide meaningful emotional support and occasionally perform behaviours similar to service dogs, they may represent a more accessible option for individuals facing long waiting lists or strict eligibility criteria. Short-term training programs could enhance the consistency of key behaviours, offering an in-between solution that is less resource-intensive than full service dog training. For healthcare providers and insurers, this raises questions about how to broaden access to dog-assisted support while maintaining quality and safety standards. For police organizations, it highlights the importance of recognizing diverse pathways to recovery and the potential value of integrating dog support into occupational health strategies.

This study has several limitations. First, service dogs are typically assigned to individuals with more severe PTSD, which is why initial symptom severity may have varied between groups. Additionally, service dog owners may have been more familiar with terms like “blocking”, making them better equipped to describe their dogs’ behaviour in detail than companion dog owners. Second, the study relied on self-report and retrospective accounts, which are susceptible to bias. Future research could incorporate third-party perspectives (e.g., partners or clinicians) to validate findings.

In conclusion, service dogs provide consistent, specific support for (former) police officers with PTSD. While companion dogs lack formal training, they offer emotional comfort and companionship. For individuals who are ineligible for or unable to access a service dog, companion dogs may still serve as a meaningful alternative, as some companion dogs exhibit behaviours similar to service dogs.

Appendix

Quotes

Motivation to go outside

1. “I'm always up early, and then I think: ugh, I don't feel like facing the day. But then he jumps on top of me, because that's how he thinks he should greet me, and then there's tail wagging, and I get a lick and also a toy.” (P39, service dog)
2. “I’m doing things again—and before, I didn’t do any of that. Since I’ve had her, I go outside again and do things.” (P4, service dog)
3. “I have to go outside with him. That was quite confronting, I must say. I had no reason to be outside. For about three or four years, I barely went outside at all.” (P41, service dog)
4. “When he’s there, there’s more calm, then I think: okay, nothing’s going to happen.” (P1, service dog)
5. “She basically blocks anyone who tries to come too close to me. She just steps in front, like that. (…) If someone comes from the right, she moves to the right; if someone comes from the left, she moves to the left.” (P3, service dog)

Comforting presence

6. “Then I already feel better just cuddling with her for a moment… then I think, well, she doesn’t have a care in the world [laughs]. You know, that helps for a bit.” (P25, control group)
7. “It’s really just her presence and her calmness and serenity that help me stay calm as well.” (P5, service dog) .
8. “There are also moments when I think: okay, not right now, please. That happens too. Especially in the beginning—when you go to the toilet and want to close the door, and then he’s right there in between.” (P1, service dog)
9. “When I sit, she lies next to me. Wherever I am, that’s where she lies (P31, control group)
10. “Because when I was sad—or still am—I just go to her for a moment. And she gives me, in that moment, a sense of calm.” (P13, companion dog).
11. “That dog doesn’t judge you. […] Even my wife gets fed up with me sometimes. But [dog] doesn’t. [Dog] is never fed up with me, [dog] always comes back, even if you’re angry at him and push him away. He just comes back.” (P40, service dog)
12. “You can tell him your story […] he’ll never say, ‘Oh, I’ve heard that already, you’ve told me that 27 times.’” (P45, service dog)
13. “Finding relaxation—just the fact that he’s constantly around me—has really brought my tension down. That gives you your energy back. Because that constant tension completely drains you. The severe fatigue people with PTSD feel comes from being tense all day long.” (42, service dog)

Mental Support

14. "If I don't realize myself that I'm crossing a boundary, he intervenes. [...] He gives a little nudge, and then I have to leave—and if I don't listen, he'll tighten the leash and start walking backwards, because I need to get out of there." (P45, service dog)
15. "You just clear your head while walking [...] it helps you put things into perspective and also simply let go of your worries for a while." (P36, control group)
16. "Well, I often only notice it when she reacts. Then she comes over to me and puts her paw, so to speak, over my legs." (P2, service dog)
17. "When he becomes restless, he mirrors my behavior. He starts getting restless too, and that's when I can see that I need to take a break." (P40, service dog)
18. "They pick up on your mood. And then, well, they come sit next to you, just quietly being there. Then suddenly, they're not incredibly annoying anymore." (P35, control group).
19. "When I feel sad, she notices it immediately and takes just enough of the edge off. That's really nice. It pulls me out of my bubble." (P17, companion dog).
20. "Sometimes he barks too. He really doesn't like it when I'm in that kind of state. Then he really barks, it's his way of insisting... He really wants my attention, and there's no avoiding it then." (P42, service dog) .

Social Contact

21. "There are plenty of people who don't like dogs, or who find them scary or dirty (...). I'm responsible for that dog, [...] so I'm more relaxed when she's not with me, I don't have to keep an eye on her then." (P36, control group)
22. "Before the dog, I was often that weird [person] who sometimes left their groceries behind. [...] And with the dog, you're that [person] with the nice dog. And that's it. [...] So for me, less tension as well." (P39, service dog)
23. "In the beginning, there were a lot of people who stared at you. Yeah, they'd really look at you, and at the dog, and at me. [...] '[Ma'am/Sir], may I ask what kind of dog that is?' Well, in the beginning I'd politely answer, but now I just go about my business. I say, 'yeah, a guide dog.' And that's it—I don't owe anyone an explanation." (P3, service dog)
24. "It's also no shame to say, [dog] needs to pee, instead of saying I can't handle this. [...] And everyone accepts that. But if I say I'm not feeling well, then everyone wonders what's going on—it all feels much heavier." (P40, service dog)

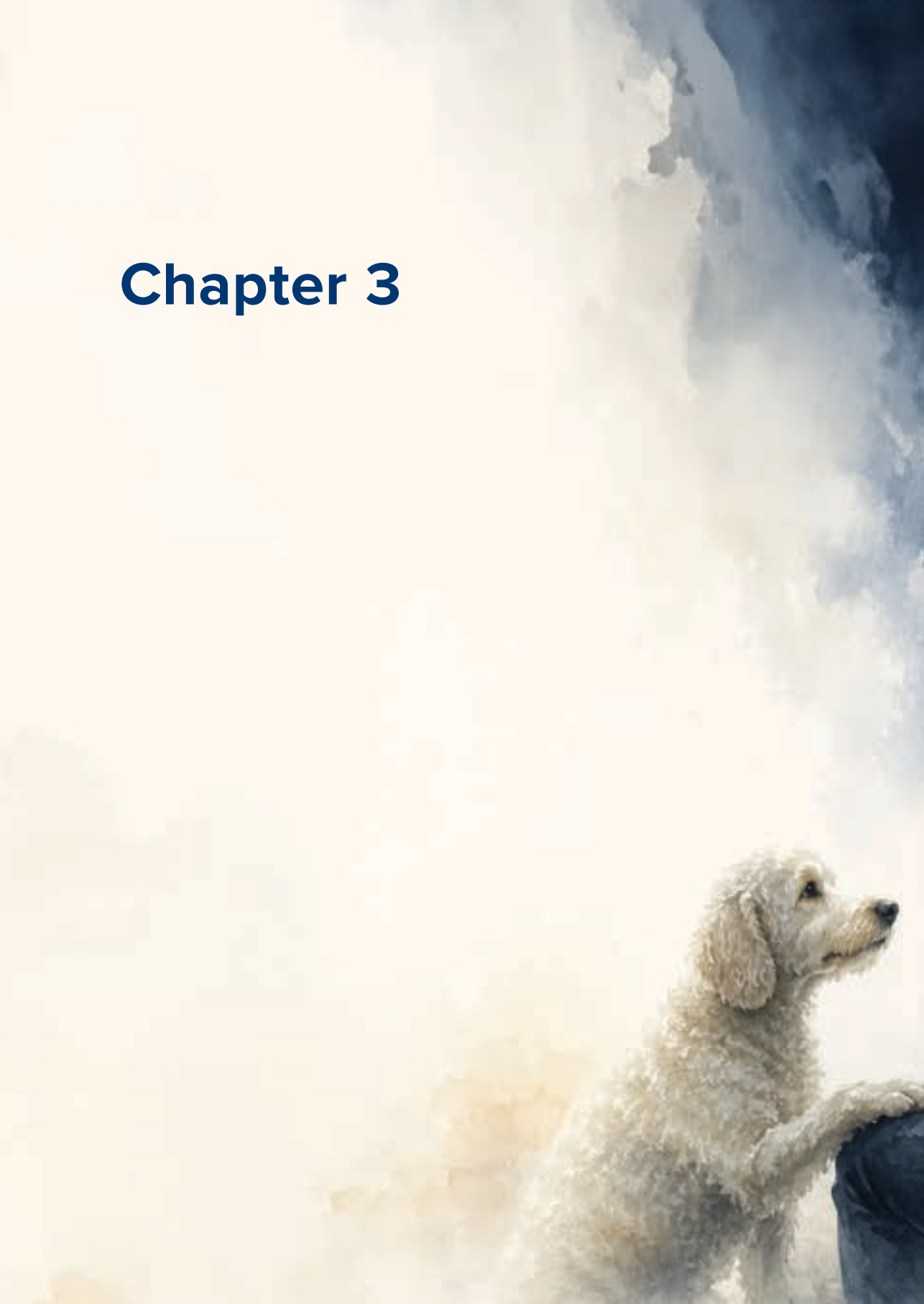
Sleep

25. “He really wakes me up, he’ll start nudging me with his snout, like ‘wake up, come on.’ If that doesn’t work, even harder. And if that still doesn’t help, then he goes around and wakes up my wife.” (P45, service dog)
26. “Since I got him, I’ve hardly had any nightmares. That immediately decreased, and for me, it was the knowledge that he would wake me up, that alone already calmed me down, or something like that.” (P37, service dog)
27. “That I sleep better. Without a dog, I’m really very anxious about going to sleep because I often fall back into re-experiencing things. And with a dog… I had it with my first dog too, within a week, I was sleeping fairly normally again.” (P39, service dog)
28. “When I wake up in the morning after bad dreams, and I’m in that emotional haze, he pulls me out of it. It turned out that he really helps me snap out of it.”(P40, service dog) .

Challenges

29. “That I’m genuinely scared for when he dies. He’s seven now. He’s getting older. Because if in two or three years he’s no longer around… yeah, then what? […] And that really causes a lot of stress too.” (P37, service dog)
30. “He can really manage about 8 hours of activity, and then, if I’ve had really bad nights, I really shouldn’t do too much with him during the day either, yeah, then you have to go to the store (…). So yeah, then it’s for tomorrow, and the day after that he’s done too. He really needs time to recover then.” (P1, service dog)
31. “When I notice that I’ve slept badly for three or four nights, I take temazepam once. (…) Then he’s also really tired at some point (…). Of course, he can’t keep working endlessly, so to speak.” (P1, service dog)
32. “I’m already dreading the moment that we… yeah, that she might have to retire. I’m already struggling with that thought. (…) They’re saying that around eight years of age, they start considering retirement… So that means next year already. (…) Well, they’ll have a hard time getting her out of the house. She’s really not going anywhere. No, absolutely not.” (P4, service dog)”
33. “A service dog doesn’t make you better, but he teaches you how to cope with it. Look, I’ll never get better. I know that. But because of him, I have a normal life again. Maybe not quite the life I had before, but a big part of it back.” (P44, service dog)

Chapter 3



Exploring the Effects of Service Dogs: Enhanced Working Memory in Police Officers with Post-Traumatic Stress Disorder

This chapter is based on:

Witjes-Roelofs, C. L., Jongsma, M. L. A., Becker, E. S., & Smit, A. S. (2025). Exploring the Effects of Service Dogs: Enhanced Working Memory in Police Officers With Post-Traumatic Stress Disorder. *Anthrozoös*, 1–17. https://doi.org/10.1080/08927936.2025.2557661

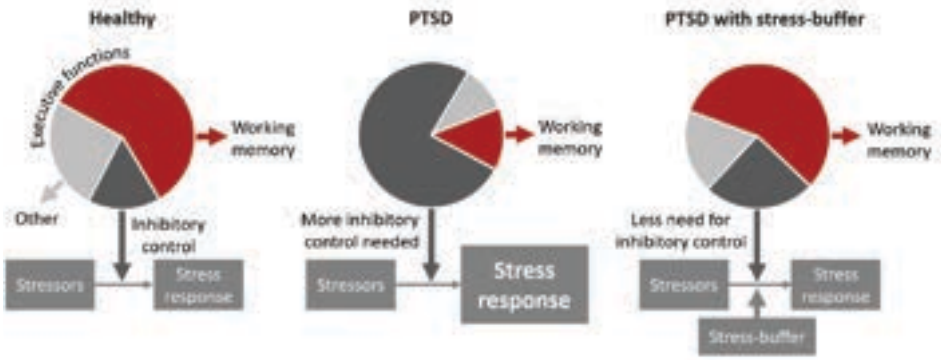
Abstract

Post-traumatic stress disorder (PTSD) has been associated with decreased executive functioning due to an imbalance in the frontal-amygdala circuit. Researchers theorized that an overactive amygdala increases the demand for regulating stress-related responses, thus depleting the prefrontal cortex of the limited resources needed for executive functions such as working memory. We hypothesized that working memory performance in people with PTSD could be partially restored by presence of their dog, potentially working as stress-buffer. This study investigated the effect of the presence of a dog on working memory performance in police officers (n = 49) either with PTSD (n = 25) or without PTSD (n = 24), using behavioral and electrophysiological measures. Working memory performance was assessed on a 1-back task, both in the presence and absence of the participants' companion or service dog. We measured event-related potentials (ERPs) with a focus on the N2 and P3 components. The results showed that police officers with PTSD exhibited improved working memory performance in the presence of their dog, as evidenced by enhanced task performance and a larger N2 component amplitude to target stimuli compared with when the dog was absent. In contrast, the police officers without PTSD showed in the absence of the dog a better task performance and a larger N2. The findings suggest that the presence of a dog enhances working memory performance in police officers with PTSD.

Introduction

In individuals with post-traumatic stress disorder (PTSD), inhibitory control primarily serves to suppress recurrent, involuntary, and intrusive memories of the traumatic event to reduce the impact of stressors and triggers (Hayes et al., 2012). The symptom of re-experiencing therefore places great strain on executive functioning, reducing the allocation of resources to everyday executive functions such as working memory (Bomyea et al., 2012). Inhibitory control and working memory are two core executive functions that are closely related and support one another (Diamond, 2013). Inhibitory control refers to the cognitive process that enables an individual to regulate attention, behavior, thoughts, and emotions by suppressing impulses or distractors. Working memory involves holding information in mind and mentally working with it. Working memory and inhibition depend on the same limited-capacity system of executive functions (Figure 1), and increasing the demand on either of them affects the ability to do the other (Diamond, 2013).

Figure 1 Conceptual model of executive functions and stress-buffering



Note. The circle diagram depicts the limited capacity system of executive functions. In healthy individuals, exposure to stressors leads to normal physical and psychological stress responses. These stress responses can be managed with minimal inhibitory control, leaving sufficient resources for other executive functions, including working memory processes. As a result, performance on working memory tasks is effective in standard situations. In individuals with PTSD, exposure to stressors results in excessive stress responses. Controlling these heightened responses requires substantial inhibitory control, depleting the executive function resources to be allocated to other executive functions, including working memory, leading to diminished performance on a working memory task. The presence of a stress buffer may mitigate the psychological and physiological stress response. When a stress buffer is present, the stress response may be reduced, less inhibitory control is needed, and more resources remain available for working memory. Thus, the performance on the working memory task may be partially restored. The figure is a combination of an executive functions model (Diamond, 2013) and a stress buffering model (Masson et al., 2019).

Increased demands on inhibitory control capacity could result from the hyperactivation of the amygdala in individuals with PTSD (Selemon et al., 2019). In this context, the negative relationship between executive functions and re-experiencing symptoms can be explained by an imbalance of the fronto-amygdala circuit. PTSD causes increased amygdala activity (Luethi et al., 2009), resulting in an increased responsiveness to potentially threatening stimuli. Consequently, the hyperactive amygdala demands enhanced inhibitory control in order to regulate stress-induced responses (McKlveen et al., 2015). When the prefrontal cortex (PFC) needs to allocate its resources to regulate excessive responses to external stimuli, less resources remain available (Figure 1). Adequate resources are essential for executive functions, enabling the successful performance of tasks that require working memory and other executive functions crucial for daily activities (Salzman & Fusi, 2010). Persistent stress in PTSD limits the capacity of the frontal cortex for executive functions, including working memory (Westphal et al., 2021).

Considering that persistent stress is associated with decreased executive functioning in individuals with PTSD (Woon et al., 2017), interventions that attenuate stress responses may help restore these executive functions. Research has shown that dogs may have stress-reducing effects (Polheber & Matchock, 2014). A meta-analysis reveals that the presence of a dog during psychotherapy can lower physiological and subjective stress levels (Ein et al., 2018). In the context of traumatic stress, studies have shown that dogs can significantly reduce acute distress (Hunt & Chizkov, 2014) and alleviate subjective feelings of stress and anxiety both during and after an experimental traumatic stress situation (Lass-Hennemann et al., 2014, 2018). Most research on dogs for PTSD so far has been done on veterans (Krause-Parello et al., 2016; Stern et al., 2013; Yarborough et al., 2018).

The presence of dogs may have a positive effect on working memory functioning in people with PTSD. One potential mechanism for a positive effect of a dog could be stress-buffering (Kikusui et al., 2006). Stress-buffering is the reduction of psychological and physiological stress responses through various factors (Hornstein & Eisenberger, 2017). One form of stress-buffering is social buffering, where the presence of a supportive individual helps alleviate stress. Stress buffering contributes to reducing amygdala activity (Mulej Bratec et al., 2020). The reduction in amygdala activity allows the PFC to allocate resources to executive functions instead of regulating excessive responses to external stimuli. Therefore, people with PTSD may perform better on, for example, a working memory task in the presence of a stress buffer compared with the absence of a stress buffer. If dogs act as stress buffers, their presence may reduce the need for inhibitory control, leaving more resources for other executive functions (Figure 1).

Working memory tasks have been widely used to test executive functions in people with PTSD (Honzel et al., 2014). Research has shown that PTSD patients perform poorly on neutral working memory tasks in terms of both response speed and accuracy (Quinones et al., 2020). This study aimed to investigate the effect of the presence compared with the absence of a dog on performance on a neutral 1-back working memory task as an indicator of executive functioning in police officers with PTSD. We hypothesized that the presence of a dog restores working memory performance compared with situations without a dog in police officers with PTSD. To test our hypotheses, we examined both overt responses (such as reaction times and errors) and covert responses using neurophysiological measurement techniques (Van Houtert et al., 2018). Such research could offer an evidence-based rationale for using dogs to enhance various outcomes, including improvements in executive functions, which are essential for performing daily activities.

To determine changes in covert behavior related to working memory performance following stress buffering, we also examined event-related potentials (ERPs) extracted from the electroencephalogram (EEG) recordings during the working memory task (Veltmeyer et al., 2009). ERPs are the average brain responses time-locked to a specific event and are characterized by positive and negative components labeled with a letter indicating polarity followed by a number indicating the order in which they appear. Among the ERP components, N2 and P3 component amplitudes have been reliably associated with WM function (Peng et al., 2020; Stroux et al., 2016). The N2 component is a negative wave reaching maximum amplitude between 200 ms and 350 ms post-stimulus and is assumed to be an indicator of inhibition, feedback processes, and conflict monitoring (Miller et al., 2021). The P3 is a positive component reaching maximum amplitude between 300 ms and 500 ms post-stimulus and has been associated with attention control and memory updating (Patel & Azzam, 2005).

This study examines the impact of dog presence on working memory performance among police officers with (n = 25) and without PTSD (n = 24). We hypothesized that the presence of their dog enhances working memory performance in police officers with PTSD compared with the absence of their dog. An improved working memory performance would be reflected in higher scores on the 1-back task and increased amplitudes in both the ERP N2 component and the P3 component.

In addition to our primary hypothesis, we also explore the potential differences between a specifically trained PTSD service dog and an untrained companion dog in the effect on restoring working memory in police officers with PTSD. The stress-buffering effect of a dog may depend on whether the dog has been specifically trained as a service dog to help reduce PTSD symptoms and stress responses (Van Houtert et al., 2018). This exploratory analysis may provide insights into the potential benefits of companion versus service dogs for police officers with PTSD.

Methods

Participants

The participants were recruited through internal communication within the Dutch police organization. In total, 57 police officers participated in the study. All participants provided written informed consent. The study has been reviewed independently by the Ethics Committee Social Sciences (ECSS) of the Radboud University and there is no formal objection to this study (ECSW-2020-012). To be included in the PTSD group, participants needed to have a work-related PTSD diagnosis provided by a mental health professional of the police organization, have finished at least one type of treatment, own a service or companion dog for at least six months, and be (or have been) employed within the police force. Two of the participants with a service dog were not employed anymore within the police force; all the other participants were still employed. In the group with PTSD, 16% have worked in the police force for less than 15 years, 48% have worked for 15 to 30 years, and 12% have worked for more than 35 years within the police force. Of 6 participants, we did not have the employment duration data (24%). Two-thirds of the group with PTSD who had a companion dog used medication, and 54% of the group with PTSD with a service dog used medication. An overview of the used medication in the group with PTSD is provided in the supplementary material (Table S9). To determine if the PTSD diagnosis was still current, interview responses were evaluated after data collection to decide if they should be included based on the presence of symptoms. Based on the symptoms mentioned during the interview, seven participants were excluded due to (almost full) remission of PTSD. Additionally, the EEG data of one participant could not be collected and was therefore excluded from the analysis. For the control group, inclusion criteria were being (or have been) employed within the police force, owning a companion dog for at least six months, and having no current or past diagnosis of PTSD. The police officers with PTSD (n = 25; 17 males, 8 females; mean age = 48.4 years old, SD = 11.0) had either a trained dog (PTSD service dog, n = 12; 9 males, 3 females) or a companion dog (n = 13; 8 males, 5 females), while the police officers without PTSD (n = 24; 6 males, 18 females; mean age = 49.0 years old, SD = 10.7) all had a companion dog.

The companion dogs were all kinds of breeds and did not receive training aimed at PTSD symptoms. The service dogs were all labradors bred and trained by the KNGF, the Royal Dutch Guide Dog Foundation. The KNGF trains guide dogs for visually impaired people and, amongst others, for people with PTSD. The service dogs are trained to the user's specific needs, e.g. waking up its owner in the early stages of a nightmare, ensuring sufficient personal space by preventing other people to come close and acting as a reassuring and ever present buddy.

Power analysis

An a priori power analysis was conducted using G*Power (Faul et al., 2007) to determine the required sample size for a repeated-measures ANOVA with a within-subjects factor (dog presence: present vs. absent) and a between-subjects factor (group: PTSD vs. control). The analysis was based on a moderate effect size (Cohen's $f = 0.25$), an alpha level of 0.05, and a power of 0.80. The results indicated that a total sample of 34 participants was needed to detect a significant interaction effect.

A separate power analysis was conducted for the N2 and P3 component amplitudes using a repeated-measures ANOVA with three within-subject factors (dog presence, trial type, electrode site) and one between-subjects factor (group). A small-to-moderate effect size (Cohen's $f = 0.25$) was assumed, with an alpha level of 0.05 and power of 0.80, which is common in ERP experiments (Butt et al., 2019). The analysis suggested that a total of 16 participants would be required to detect significant effects reliably.

Given the available sample size ($n = 12$ for the service dog group and $n = 13$ for the companion dog group), a post-hoc sensitivity analysis was conducted to determine the minimum detectable effect size. Assuming an alpha level of 0.05 and a power of 0.80, the analysis indicated that the smallest detectable effect size for a repeated-measures ANOVA was $f = 0.29$. Thus, while our study is sufficiently powered to detect medium to large effects, smaller effects may not be reliably detected.

Procedure

This study was part of a larger project aiming to investigate the added value of the service dog (Smit et al., 2022). A qualitative study was conducted in parallel with this project, though its objectives fall outside the scope of the present analysis. This current study used an experimental design to compare working memory performance between police officers with and without PTSD and compare the effect on working memory performance of a dog's presence to its absence. To achieve this, data were collected in two subsequent sessions on the same day, one with the dog present and one with the dog absent, in both the control and experimental groups. Each condition lasted approximately 20 minutes. Due to ethical reasons, the conditions were not counterbalanced since the absence of a service dog has a significant impact on the group with PTSD, and beginning the experiment without the dog would have been excessively stressful for this group. The complete experiment, including EEG preparation, lasted approximately one hour. At the start of the task, instructions were provided both verbally by the researcher and presented on-screen as text. Participants were given the option to take breaks between experiments and sessions, though few chose to do so. During the task in the dog present condition, the dog was close to the participant,

either laying down loose or on a leash, to create the most natural setting (Gee et al., 2015). When participants performed tasks without the dog, the dog was cared for in a separate room by either an accompanying relative or a second researcher.

Measures

1-back task

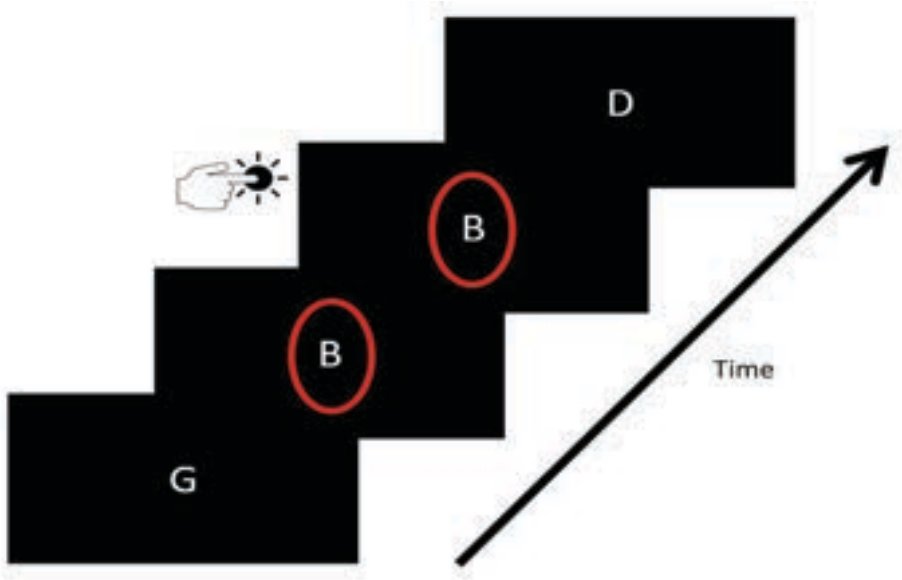
The 1-back task was created using Presentation software (Version 17.0, Neurobehavioral Systems, Inc., Berkeley, CA, www.neurobs.com) and was displayed on a 21.5-inch LCD computer monitor with a refresh rate of 60 Hz. During the task, participants were required to press a key when the stimulus of the current trial matched the stimulus they saw one step back (1-back, Figure 2). The task used nine different single digits in version A (1, 2, 3, 4, 5, 6, 7, 8, 9) and nine different single letters in version B (A, B, C, D, E, F, G, H, K) as stimuli. Each participant completed both versions, A and B, in a counterbalanced order. The stimuli were presented in white against a black background in a 20-point font size for 500 ms, followed by 2000 ms of black screen. Each trial lasted 2500 ms.

Each version of the 1-back task consisted of 96 trials: 32 target trials, where participants had to press the button, and 64 background stimuli, where no button press was required. The task lasted approximately 5 minutes, including task instruction. About 15 minutes of other tasks were in between the two N-back tasks. The sequences of targets and background stimuli were pseudo-randomly generated. We calculated the balanced integration score (BIS) as suggested by Liesefeld and Janczyk (2019) to evaluate the speed and accuracy of performance. The BIS is commonly used to decrease intra-individual variability concerning speed-accuracy trade-offs. The BIS was computed by first standardizing reaction times and proportions correct to bring them to the same scale and then subtracting one standardized score from the other. The mean and standard deviation were calculated over all subjects and all conditions.

EEG recording and preprocessing

The EEG setup utilized the BrainProducts ActiCap 32-channel active EEG system, positioned according to the 10-20 system standard electrode placements. In the current study, we used four scalp electrodes (Fz, Cz, Pz, Oz), two electrodes for recording the electrooculogram located below and lateral of the outer canthus of the left eye, and a reference and ground electrode on the left and right mastoid, respectively. The limited number of electrodes was due to the COVID-19 pandemic, as we needed to minimize close contact time with participants. The electrode-scalp impedance was reduced to less than 20 kΩ for all electrodes. EEG data were recorded at a 500 Hz sampling rate using an amplifier with an input impedance of 10 MΩ.

Figure 2 1-back task



Note. In the 1-back task, participants were instructed to press a response button if the presented letter was the same as the previous letter (one back). The stimuli were presented for 500 ms, followed by 2000 ms of black screen.

Offline data analysis was conducted using Brain Vision Analyzer (BrainVision Analyzer, Version 2.2.0, Brain Products GmbH, Gilching, Germany). The data were digitally filtered with 0.5 Hz high pass and 30 Hz low pass filters. ERP segments were set from 250 ms before stimulus onset until 750 ms after stimulus onset. Following segmentation, a DC detrend, and a Gratton & Coles ocular correction without raw average subtraction were applied.

We excluded segments containing incorrect responses (false hits, misses), segments with an amplitude exceeding ±100 µV, and segments with activity below 0.5 µV for 100 ms or more from further analyses. The average percentage of included segments was 97.9% (SD 2.5), with a minimum of 24 segments (out of 32) of the target stimuli per participant. Lastly, a 100 ms baseline correction was applied. We obtained ERPs by averaging segments separately for background and target stimuli.

Fixed time windows were defined for the ERP N2 and P3 components based on the combined data from both groups in an across-condition grand average, following the recommended approach in the literature (Kappenman & Luck, 2016). We calculated the average amplitude of the ERP N2 component within a fixed latency window of 200-300 ms. Similarly, the average amplitude of the ERP P3 component was determined within the fixed latency window of 380-480 ms.

Statistical analyses

The statistical analysis was performed using IBM SPSS Statistics (Version 27). To examine differences in task performance, we conducted a GLM analysis on the corrected reaction time (BIS) with a within-subjects factor of condition (dog present vs. dog absent), a between-subjects factor of group (PTSD vs. control group), and gender (male vs. female) as covariate. On the N2 and P3 component amplitudes, two Generalized Linear Model (GLM) analyses were performed with group (PTSD vs. control) as the between-subject variable, condition (dog present vs. dog absent), trial type (background vs. target), and electrode (Fz, Cz, Pz, Oz) as the within-subject variables, and gender (male vs. female) as covariate. When the assumption of sphericity was violated, we used the Greenhouse-Geisser correction. Significant interactions were followed up using t-tests.

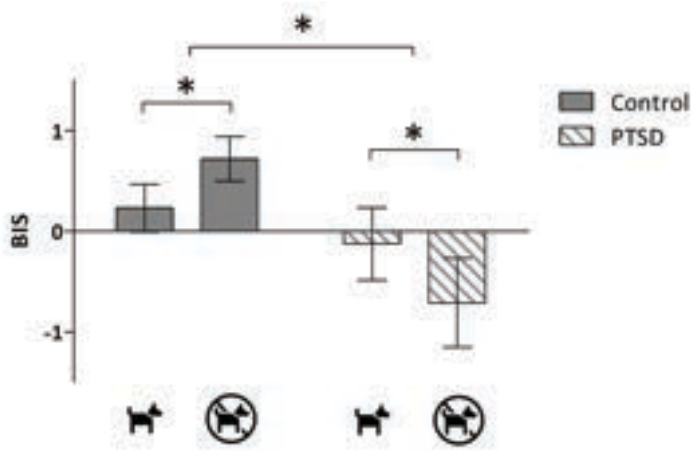
To examine potential differences in working memory performance among police officers with PTSD based on the level of training their dog had received, the PTSD group was further analyzed by exploring the effects of the presence of a trained service dog (n = 12) versus a companion dog (n = 13). We conducted a repeated-measures GLM on the corrected reaction time to examine whether there were any performance differences between the two subgroups on the working memory task and whether the presence of a dog affected performance. Additionally, for the N2 and P3 component amplitudes to the background and target stimuli, we used four GLM analyses with electrode (Fz, Cz, Pz, Oz) and condition (dog present vs. dog absent) as within-subject variables, group (service dog vs. companion dog) as a between-subject variable, and gender (male vs. female) as covariate.

Results

Performance on the working memory task

The percentage of correct trials and reaction times are provided in the supplementary material (Table S1). Analysis of the score on the working memory task (BIS) revealed a significant interaction effect of condition x group, $F_{(1,46)} = 10.52$, $p = 0.002$, $\eta^2 = 0.19$. Pairwise comparisons per group showed that the control group scored higher (faster and/or made fewer errors) when the dog was absent compared with when the dog was present, $t_{(23)} = -3.20$, $p = 0.004$, $d = -0.65$. The group with PTSD scored significantly lower (slower and/or made more errors) when they completed the task without their dog compared with when their dog was present, $t_{(24)} = 2.18$, $p = 0.039$, $d = 0.44$ (Figure 3). There was no main effect of group, $F_{(1,46)} = 0.88$, $p = 0.354$, $\eta^2 = 0.02$, and no main effect of condition was found, $F_{(1,46)} = 0.26$, $p = 0.613$, $\eta^2 = 0.01$. A main effect of gender was found, $F_{(1,46)} = 5.01$, $p = 0.030$, $\eta^2 = 0.10$, and no interaction effects with gender, indicating that females scored significantly better than the males.

Figure 3 Balanced Integration Scores (BIS) on the 1-back task

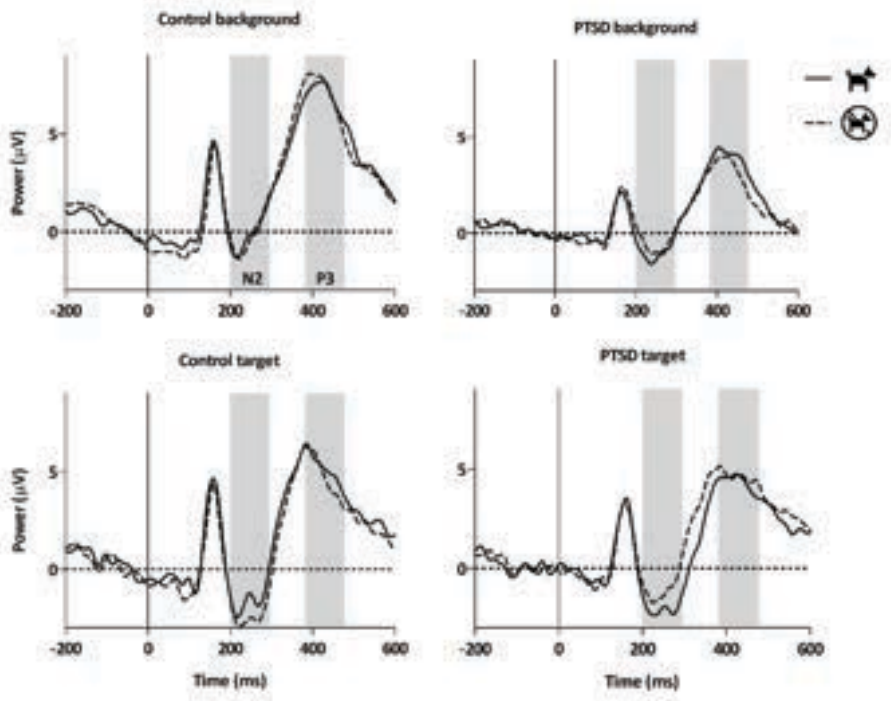


Note. Balanced Integration Scores (BIS) corrected for gender with SEM for each group in the two conditions (with dog and without dog).

The ERP N2 component amplitude

Figure 4 shows the grand averages of the ERPs, illustrating the average response of participants to the stimuli presented. See supplementary material for full statistical results (Table S2). The primary GLM revealed interaction effects with stimulus type (target, background). Consequently we conducted separate GLM analyses for both stimulus types. In these analyses, we included electrode (four levels: Fz, Cz, Pz, Oz) and condition (two levels: dog present, dog absent) as within subject variables, group (two levels: PTSD, control) as between subjects variable, and gender (two levels: male, female) as covariate. On the target stimuli we found an interaction effect of condition x group, $F_{(1,46)} = 5.63$, $p = 0.022$, $\eta^2 = 0.11$, and an interaction effect of condition x electrode x group, $F_{(3,130)} = 4.57$, $p = 0.005$, $\eta^2 = 0.09$. Pairwise comparisons within the control group revealed a larger (more negative) N2 amplitude when the dog was absent compared with when the dog was present, $t_{(23)} = -2.76$, $p = 0.011$ (Fz). Additionally, for the group with PTSD, pairwise comparisons showed that the amplitude of the N2 was larger (more negative) when the dog was present compared with when it was absent on Fz, $t_{(24)} = 2.60$, $p = 0.016$, and on Cz, $t_{(24)} = 2.88$, $p = 0.008$.

Figure 4 Event Related Potentials 1-back task



Note. Grand averages on electrode Cz for the background stimuli (top panels) and the target stimuli (bottom panels) for the control group (left) and the PTSD group (right). Solid line: dog present, dashed line: dog absent. The N2 ERP component is indicated by the first grey area (200–300 ms), while the second grey area indicates the P3 ERP component (380–480 ms).

On the target stimuli we did not find any main effects, apart from a significant main effect of electrode, $F_{(2,97)} = 16.85$, $p < 0.001$, $\eta^2 = 0.27$. With respect to the background stimuli, except for a main electrode effect with a maximum amplitude on electrode Fz, $F_{(2,94)} = 16.05$, $p < 0.001$, $\eta^2 = 0.26$, no significant differences in the N2 amplitudes were observed. In summary, the results indicate a more pronounced (more negative) N2 amplitude to target stimuli in the PTSD group when the dog was present, and in the control group when the dog was absent. A complete overview of the statistical analyses of the N2 is provided in the supplementary material (Table S3).

The ERP P3 component amplitude

The results of the primary GLM on the P3 component amplitudes (see supplementary material Table S4) revealed significant interaction effects with stimulus, which prompted us to conduct separate analyses elicited by target and background stimuli. For this purpose, we employed two GLM analyses, using electrode (Fz, Cz, Pz, Oz)

and condition (dog present vs. dog absent) as within-subject variables, group (PTSD vs. control) as between subjects variable, and gender (male vs. female) as covariate. For the target stimuli no significant effects were found except a main effect of electrode, $F_{(2,100)} = 11.88$, $p < 0.001$, $\eta^2 = 0.21$. With respect to the background stimuli, a significant interaction effect of electrode x condition was observed, $F_{(2,100)} = 3.87$, $p = 0.021$, $\eta^2 = 0.08$. However, a paired T-test with dog absence versus dog presence per electrode did not yield any significant effect ($p > .1$). No main or interaction effects of gender were found, $F_{(1,46)} = 0.28$, $p = 0.100$, $\eta^2 = 0.01$. A main effect of electrode with a maximum amplitude over electrode Pz was observed, $F_{(1,46)} = 13.60$, $p < 0.001$, $\eta^2 = 0.23$. We found a significant main effect of group for P3 amplitude to the background stimuli, $F_{1(1,46)} = 5.15$, $p = 0.028$, $\eta^2 = 0.10$, with a lower P3 amplitude in the group with PTSD than in the control group. Overall, these findings demonstrate that individuals with PTSD exhibit a lower P3 amplitude to background stimuli compared with the control group. A complete overview of the statistical analyses of the P3 is provided in the supplementary material (Table S5).

Comparing the presence of a companion dog to the presence of a service dog

For exploratory purposes, we further analyzed the data from the PTSD group by comparing police officers with a companion dog ($n = 13$) to those with a trained service dog ($n = 12$). The percentage of correct trials and reaction times per group (Table S6) and an overview of the statistical analyses (Table S7 and S8) is provided in the supplementary material. Our analyses of the score on the working memory task (BIS) revealed no interaction effects, and no main effect of group (companion dog versus service dog), $F_{(1,22)} = 2.92$, $p = 0.102$, $\eta^2 = 0.12$. We did find a main effect of gender, $F_{(1,22)} = 4.46$, $p = 0.046$, $\eta^2 = 0.17$, indicating that females scored significantly better than males. With respect to the ERP N2 component, we found interaction effects with stimulus type, therefore background and target stimuli were analyzed separately. On the target stimuli, we found a main effect of electrode and no other effects. On the background stimuli, interaction effects of condition x gender, condition x electrode and condition x electrode x gender were found, with only in females a larger (more negative) N2 amplitude when the dog was present compared with when the dog was not present, $p < 0.033$ on all electrodes. In males no significant effect was found, $p > 0.1$. Additionally, we found a main effect of electrode, a main effect of condition, $F_{(1,22)} = 17.10$, $p < 0.001$, $\eta^2 = 0.44$, and a main effect of gender, $F_{(1,22)} = 5.02$, $p = 0.035$, $\eta^2 = 0.19$.

With respect to the ERP P3 component, an interaction effect with stimulus type was found, therefore one GLM for target stimuli and one GLM for background stimuli were performed. For target stimuli, no group differences were observed.

There was an interaction effect of condition x gender, with a higher P3 when the dog was present in females, however, post hoc tests revealed no significant differences. On the background stimuli, interaction effects of condition x group, $F_{(1,22)} = 9.31$, $p = 0.006$, $\eta^2 = 0.30$, and electrode x condition x group were found, $F_{(2,45)} = 3.37$, $p = 0.042$, $\eta^2 = 0.13$. A GLM for each group with electrodes separate showed that the P3 amplitude was significantly higher (on Fz, Cz, and Pz) when the dog was present compared with when the dog was absent, but only in the group with the service dog, $F_{(1,11)} = 15.68$, $p = 0.002$, $\eta^2 = 0.59$ (electrode Cz), and not in the group with the companion dog, $F_{(1,12)} = 2.87$, $p = 0.116$, $\eta^2 = 0.19$ (electrode Cz). Overall, these results show a higher P3 amplitude to background stimuli in the group with the service dog compared with the group with the companion dog, when the dog was present.

Discussion

The study investigated the impact of the presence of a service or companion dog on the working memory performance of police officers with PTSD compared with a control group of police officers without PTSD, using behavioral and electrophysiological measures. Our findings indicate that police officers with PTSD perform better on a working memory task in the presence of their service or companion dog.

We hypothesized that the presence of a dog enhanced working memory performance in police officers with PTSD compared with the absence a dog. The results support this hypothesis, as the improvement in working memory performance in the presence of a dog was only found in the PTSD group and not in the control group. The improvement in working memory performance in the PTSD group aligns with our conceptual model presented in the Introduction (Figure 1), suggesting that the presence of a dog enhances executive functioning, potentially due to stress-buffering effects. This result was supported by the physiological data showing a larger N2 component amplitude in response to target stimuli when the dog was present in the group with PTSD. The N2 component reflects inhibition and feedback processes (Miller et al., 2021), and its larger amplitude when the dog was present suggests enhanced capacity devoted to these functions. In the absence of the dog, the lack of a stress-buffer could cause attention to shift from the task to the surroundings, leading to a depletion of frontal resources essential for executive functioning (Schweizer & Dalgleish, 2011).

The control group (police officers without PTSD) performed significantly better in the absence of their dog compared with the presence of their dog, as indicated by higher scores on the working memory task and a larger N2 component amplitude when the dog was absent. One explanation for this outcome is the

effect of repeated testing, or learning effects, as the order of the conditions of dog presence were not counterbalanced. The control group likely experienced lower stress levels than the PTSD group, enabling the control group to benefit more from repeated exposure to the task, resulting in improved performance without the dog. Another possible explanation may be that the presence of the dog may have diverted attention in the control group, consuming executive function resources needed for task engagement and leading to poorer performance. This explanation is supported by the finding of a larger N2 amplitude in the control group when the dog was absent, suggesting increased attentional engagement to the task (Folstein & Van Petten, 2008).

In addition to our main findings, our results revealed a significant gender effect on working memory performance, with females outperforming males. However, this effect must be interpreted with caution due to the unequal gender distribution between groups, which may have influenced the results. The PTSD group was predominantly male (17 males, 8 females), whereas the control group was predominantly female (6 males, 18 females). This imbalance is noteworthy because the observed gender differences in working memory may have been amplified by the group composition rather than reflecting a true biological difference. A meta-analysis by Wang et al. (2019) found no significant gender differences in N-back working memory performance, suggesting that our findings may have been driven by factors other than inherent cognitive differences between males and females. The overrepresentation of females in the control group could have contributed to their superior performance, as previous research indicates that individuals with PTSD generally exhibit impaired working memory (Nejati et al., 2018). Thus, the gender effect observed in our study may partly result from the interaction between PTSD diagnosis and gender distribution rather than an gender-based advantage in working memory. However, our exploratory analysis also indicated that females with PTSD performed significantly better than males, though this finding was based on a small sample and no conclusions should be drawn from this. Future studies should aim for more balanced group compositions to clarify the relationship between gender, PTSD, and working memory.

Supporting the arguments for a group difference based on PTSD diagnosis, we observed a lower ERP P3 component amplitude in individuals with PTSD compared with the control group. This finding is in alignment with the literature showing lower P3 amplitudes to neutral stimuli in PTSD (Johnson et al., 2013). A lower P3 amplitude may indicate difficulties in updating working memory, which is supported by previous findings of abnormal working memory functioning in individuals with PTSD (Javanbakht et al., 2011; Johnson et al., 2013; Moores et al., 2008; Shaw et al., 2009). The group effect was observed with background

stimuli and not with target stimuli. This result can be explained by the theory that the P3 component is associated with memory updating (Patel & Azzam, 2005), which is primarily triggered by background stimuli rather than target stimuli during the 1-back task.

We also explored whether the presence of a trained service dog would yield greater stress-buffering effects than that of an untrained companion dog. Although police officers with PTSD exhibited similar working memory performance with both types of dogs, we noted an interaction effect regarding the ERP P3 component amplitude, despite a small sample size. The P3 amplitude in response to background stimuli was higher in the service dog group, which may reflect enhanced resource allocation toward working memory (Javanbakht et al., 2011). This result has two possible explanations. First, the service dog may reduce the owner's stress response by simply being present, freeing up cognitive resources for the task. Alternatively, companion dogs may have been more distracting than the trained service dogs.

Several limitations of our study require consideration. First, conditions could not be counterbalanced due to ethical reasons. The absence of especially a service dog has great impact on the owner in the group with PTSD, and it would have been too stressful to start with the dog absent condition. As a consequence, the results should be interpreted with caution and more research is needed to draw firm conclusions. While fatigue may occur more easily in individuals with PTSD, additional analyses of reaction times revealed no evidence of fatigue-induced slowdowns during tasks. Second, we did not conduct a clinical assessment of PTSD symptoms at the study's onset, relying instead on current diagnoses for inclusion, which may have led to variability in symptom severity within the experimental group. Third, a gender imbalance existed between the experimental (17 males, 8 females) and control groups (6 males, 18 females). Fourth, we could not control for medication use, which may influence cognitive control and working memory in police officers with PTSD (Bymaster et al., 2002), leaving the potential for unaccounted effects on task performance and ERP components. An overview of medication use in the PTSD group is provided in the supplementary material. Finally, despite significant ERP findings, the effect sizes were small, emphasizing the need for replication of these results.

Understanding the connection between stress, executive functions, and PTSD symptoms is important for uncovering the cognitive mechanisms underlying PTSD. We based our hypotheses on the theory that reduced executive functioning results from hyperactivation of the amygdala coupled with increased demands on the prefrontal cortex (Selemon et al., 2019). In contrast, other studies suggest that individuals with poorer executive functions are more vulnerable to psychopathology

after extreme stress due to their diminished capacity to regulate intrusive cognitions (Bomyea et al., 2012). Future research should further explore the relationship between PTSD symptoms, stress levels, and frontal resource depletion. Additionally, investigating how service dogs influence stress levels directly could provide valuable insights into their therapeutic potential for individuals with PTSD. Survey studies consistently report that service dogs have stress-reducing abilities beneficial for veterans with PTSD (Kloep et al., 2017; O'Haire & Rodriguez, 2018; Rodriguez et al., 2020). Our research was not able to determine if dog presence and changes in working memory performance are directly associated with stress levels, so future work should focus on this using physiological measurements to gain a better understanding of this topic.

In conclusion, our findings suggest that the presence of a dog enhances working memory performance in individuals with PTSD. The potential stress-buffering effects of the dog's presence may underlie these benefits, making this study an important step in uncovering the mechanisms through which service dogs can reduce PTSD symptoms. The daily presence of a dog may help regulate stress responses and mitigate executive function impairments. The findings support the integration of dogs into therapeutic options for police officers with PTSD. Law enforcement agencies might consider expanding programs that provide service dogs to officers suffering from severe PTSD, helping those who have not benefited from traditional treatments or continue to experience persistent symptoms.

Chapter 4

Exploring Attentional Bias in Posttraumatic Stress Disorder: Insights from Police Officers with Service Dogs

This chapter is based on:

Charlotte L. Witjes-Roelofs, Marijtje L.A. Jongsma, Eni S. Becker, Annika S. Smit (submitted) Exploring Attentional Bias in Posttraumatic Stress Disorder: Insights from Police Officers with Service Dogs

Abstract

PTSD is characterized by hypervigilance and attentional bias to threat, which can severely interfere with daily functioning. Stress exacerbates this bias by increasing amygdala activity and depleting prefrontal resources, reducing attentional control. The presence of a dog may help regulate attention by reducing stress. This study investigates attentional bias to emotional faces in police officers with PTSD and examines whether the presence of their service or companion dog diminishes this bias by mitigating stress-related cognitive depletion. Police officers with and without PTSD completed the dot-probe task with angry and happy faces in the presence and absence of their dog. Reaction times and event-related potentials (ERP) were analyzed to assess attentional bias. Officers with PTSD showed a greater trial level bias score but no consistent bias direction. The P3 amplitude indicated no differentiation between happy and angry faces in the PTSD group, unlike the control group. The VPP amplitude was higher in the PTSD group when the dog was absent, suggesting increased early-stage attention to faces in without the dog. Officers with PTSD showed also slower reaction times when their dog was absent. The findings suggest that PTSD is associated with a reduced ability to selectively allocate attention based on emotional content and increased reaction time variability rather than a consistent directional bias toward or away from emotional stimuli. The presence of a dog appeared to regulate early-stage attentional processing and reaction speed.

Introduction

Post-Traumatic Stress Disorder (PTSD) is a mental health condition that can develop following exposure to a traumatic event. One of the primary symptom clusters is hypervigilance, characterized by a persistent search for potential threats in the environment and difficulty disengaging from perceived dangers (American Psychiatric Association, 2013). Hypervigilance dysregulates attentional processing, which contributes to the maintenance of PTSD symptoms and severely interferes with daily functioning (Kimble et al., 2014). This dysregulation in the emotional attention process is also known as attentional bias, a concept that has been extensively studied as a key factor in the dysregulation of attentional processing (Schoorl et al., 2014). Emotion-related attentional bias can be measured by using a dot probe task (Bradley et al., 1998). In this task, a fixation cross precedes a brief (250 to 1000 ms) simultaneous presentation of two types of stimuli (e.g. one neutral, one with a specific emotion). Following an interstimulus interval, a probe (e.g. a dot) is presented in the spatial location of one of these stimuli. The participant is asked to respond to the probe as quickly as possible by indicating its location. When the participant attends to the emotional stimulus, they will be faster in reacting to trials in which the probe replaces the emotional stimulus (congruent trial) and slower in trials in which the probes replaces the neutral stimulus (incongruent trial), and vice versa.

Threat-related attention bias on the dot probe task has been studied extensively in PTSD, but has yielded rather mixed results, with some studies indicating attention bias toward threat, some showing attention bias away from threat and others finding no attention bias at all (reviews: Bomyea et al., 2012; Cisler & Koster, 2010; Vyas et al., 2020). Quantifying this attention bias has been done by aggregating mean differences of responding between trial types, which assumes that attention bias may be conceptualized as a static trait-like phenomenon, such that a person may express either attention bias towards or away from salient stimuli (MacLeod et al., 1986). In contrast to a static trait-like phenomenon, attentional bias to threat in PTSD may be better understood as a dynamic process with alternating periods of attention towards and away from threat over time (Iacoviello et al., 2014; Zvielli et al., 2014, 2015). Based on this perspective, the trial-level bias score (TLBS) was developed to quantify the attentional bias on a trial-by-trial basis (Zvielli et al., 2015). The TLBS is the difference between each congruent and incongruent trial and the closest opposing trial type, and demonstrates significantly higher levels of reliability than traditional bias scores (Naim et al., 2015; Price et al., 2015). A positive score indicates greater attention to threatening stimuli, while a negative score suggests avoidance of threat. A score closer to zero indicates healthier functioning or more regulated attention.

The majority of research on attention bias linked to PTSD has focused on reaction times of response tasks. However, the responses capture only a snapshot of attention. Information processing exists of multiple stages including early perceptual processing, initial orienting, sustained attention, and response selection (Cosman et al., 2016). Participant responses are downstream from these information processing stages, making it challenging to disentangle these processes. Therefore, neuroimaging methods such as electroencephalogram (EEG) can be used to investigate whether the different attentional processing observed in PTSD (Buckley et al., 2000) is driven by the early or late stages of covert information processing (Portella et al., 2012). Information about differences in stimulus processing can be obtained by extracting the Event-Related Potential (ERP) from the ongoing EEG time-locked to stimulus presentation. Furthermore, these ERPs' distinctive peaks and troughs have been linked to different cognitive processes. For example, the occipital N170 ERP component has been linked to emotional facial expressions, eliciting a larger amplitude to angry and happy faces compared with neutral faces (Hinojosa et al., 2015), and PTSD patients show greater N170 amplitudes for faces compared with healthy controls (Schneider et al., 2019). The Vertex Positive Potential (VPP) is the fronto-central equivalent of the N170 component. Using the VPP could help distinguish early automatic threat processing in PTSD (Klimova et al., 2013) from later, more controlled stages of attention, which can for example be measured by the P3 amplitude. The P3 is increased in healthy participants in response to anger-related stimuli, which has been linked to the P3's relationship with target evaluation and response selection (Eldar & Bar-Haim, 2010). The P3 has been related to attentional processing with higher amplitude for the more emotional content of attended stimuli (Polich, 2007; Torrence & Troup, 2017).

Attention bias to threat contributes to maintenance of PTSD symptoms, as constant scanning for threats may increase hypervigilance (Schäfer et al., 2016). In individuals with PTSD, heightened stress may amplify the attention bias due to increased amygdala activity, which in turn depletes cognitive resources from the prefrontal cortex (Nicholson et al., 2017). This depletion reduces the ability to modulate attentional focus away from threats, resulting in a rigid and prolonged focus on threat-related cues (Schönenberg & Abdelrahman, 2013). To mitigate this pattern, interventions that reduce stress, such as a stress buffer, may help improve attentional control and decrease hypervigilance (Liu et al., 2020). Stress buffering is defined as reducing stress- and fear-induced responses by the presence of a familiar individual (also: social buffering). Stress buffering contributes to the downregulation of aversive emotion-induced brain activity in the amygdala (Mulej Bratec et al., 2020). Research has shown that dogs can act as a buffer against stress. A meta-analysis reveals that the presence of an (unfamiliar) dog during

psychotherapy can lower physiological and subjective stress levels (Ein et al., 2018). In the context of traumatic stress, studies have shown that dogs can reduce acute distress (Hunt & Chizkov, 2014) and alleviate subjective feelings of stress and anxiety both during and after watching a 'traumatic' film clip (Lass-Hennemann et al., 2014, 2018). Other studies highlight the health benefits of pet ownership, such as reductions in distress and anxiety, decreases in loneliness and depression, and increases in exercise (Friedmann & Son, 2009). For individuals with PTSD, owning a dog has been linked to feeling calmer, less lonely, less depressed, and less worried about personal and family safety (Stern et al., 2013). These dogs were not specifically trained for this purpose. However, there are also PTSD service dogs that are trained to respond precisely to the specific disabilities of their owners and are typically allowed entry into public facilities (Krause-Parello et al., 2016). PTSD service dogs ultimately facilitate socialization, provide companionship, and reduce trauma-related symptoms while promoting independence (Yarborough et al., 2018). They achieve this by acting as a calming influence during stressful situations and by alerting their handlers to signs of developing stress or panic (Yarborough et al., 2018). So, for people with PTSD, both companion dogs and service dogs may have stress-buffering effects (Richerson et al., 2023). An eye-tracking study in veterans with PTSD showed that the presence of a service dog as stress buffer reduced visual attention toward angry faces (Woodward et al., 2017). This result suggests that the presence of the dog reduces attentional bias toward threat.

The objective of the current study was to investigate attentional bias to angry and happy faces in police officers with and without PTSD and the effect of the presence of their dog on this attentional bias. We hypothesized that police officers with PTSD would demonstrate an attentional bias towards angry faces compared with the police officers without PTSD, i.e. they are more likely to detect or respond faster to the probe when it appears where the angry face was (congruent trial). This would be demonstrated by a higher TLBS towards angry stimuli and higher amplitudes on an early ERP component, the VPP, that is associated with face processing. This would reflect heightened sensitivity to potential threats in the environment. It was expected that the presence of the stress buffer (the dog) would lead to less hypervigilance to potential threats in the environment in police officers with PTSD, as demonstrated by a lower TLBS towards emotional faces and a lower VPP amplitude when the dog is present compared with when the dog is absent. Additionally, we hypothesized that individuals with PTSD will show a greater P3 amplitude in response to angry faces compared with happy faces, reflecting increased attentional engagement and emotional evaluation of threat stimuli.

Methods

Participants

The participants were recruited through internal communication within the Dutch police organization. In total, 57 (former) police officers participated in the study. All participants provided written informed consent. The study has been reviewed independently by the Ethics Committee Social Sciences (ECSS) of the Radboud University and there is no formal objection to this study (ECSW-2020-012). To be included in the PTSD group, participants needed to have a (self-reported) work-related PTSD diagnosis, have finished at least one type of treatment, have owned a service or companion dog for at least six months, and are (or have been) employed within the police force. Interview data were collected for a separate, qualitative component of the study. Although not designed as a diagnostic assessment, the responses of the interviews were reviewed post hoc to determine whether participants still exhibited PTSD symptoms, solely for the purpose of inclusion in the analysis. Based on the symptoms mentioned during the interview, seven participants were excluded due to (almost full) remission of PTSD. EEG data of one participant could not be collected, and data from this participant was therefore excluded from analysis. Reaction time data were screened for outliers, and one participant was excluded because their responses (mean > 1.5 s) were consistently and substantially slower than the group average. For the control group, inclusion criteria were: being employed within the police force, owning a companion dog for at least six months, and having no current or past diagnosis of PTSD. The police officers with PTSD (16 males, 8 females; mean age = 48.4 years old, SD = 11.0) had either a trained dog (PTSD service dog, n = 12) or a companion dog (n = 12), while the police officers without PTSD (6 males, 18 females; mean age = 49.0 years old, SD = 10.7) all had a companion dog. The total sample size included in the final analysis is 48 participants.

Power analysis

A sensitivity analysis was conducted using G*Power (Faul et al., 2007) to determine the smallest effect we were be able to find with a repeated measures design with 48 participants, a probability level of .05 and a desired power of 0.80, which is common in ERP experiments (Clayson & Larson, 2013; Butt et al., 2019). The design included 2 groups (PTSD vs. control) and eight within-subjects measurements (Congruency [2] × Emotion [2] × Condition [2]). The results indicated that with the given sample size and power, the smallest within-subjects and interaction effects that we are able to find is f = 0.14 (small to medium). For the between-subjects factor (group: PTSD vs. control) the minimum detectable effect size is f = 0.31 (medium to large). Gender was included as a covariate in the main analysis

but was not incorporated into the sensitivity analysis. The inclusion of gender as a covariate could increase statistical power by reducing error variance and improving precision, potentially allowing for the detection of smaller effects.

Procedure

This study was conducted as part of a broader project exploring the added value of service dogs (Smit et al., 2022). Within this project a qualitative study was carried out and working memory performance was investigated, though its goals lie beyond the scope of the current analysis. The present research employed an experimental design to examine attentional bias toward emotional facial expressions in police officers with and without PTSD, and to assess the impact of a service dog's presence on this bias. Data were collected during two consecutive sessions on the same day: one with the dog present and one without the dog, in both the control and experimental groups. Each session lasted approximately 20 minutes. Due to ethical reasons, the conditions were not counterbalanced since the absence of a service dog has a significant impact on the group with PTSD, and beginning the experiment without the dog would have been excessively stressful for this group. Starting the study without the dog would likely have been more stressful for officers because they lack immediate emotional support, face unfamiliar conditions without their usual coping mechanism, and have not yet built trust in the study setting. The complete experiment, including EEG preparation, lasted approximately one hour. Participants were given the option to take breaks between experiments and sessions, though few chose to do so. When participants performed the task without the dog, the dog was cared for in a separate room by an accompanying relative or a second researcher.

Dot probe with emotional faces

The dot-probe task was programmed using Presentation software (Version 17.0, Neurobehavioral Systems, Inc., Berkeley, CA, www.neurobs.com) and displayed on a 60 Hz 21.5" LCD computer monitor. Stimuli consisted of one of the picture pairs: 6 neutral–neutral (filler trials), 32 angry–neutral, and 32 happy–neutral. Each actor from the Chicago Face Database (Ma et al., 2015) was presented twice within a single task version. A new set of actors was selected for the second version of the task. Each trial started with a white fixation cue (+) in the center of a black screen for a random amount of time between 1000 and 2000 ms. Two faces were presented simultaneously on the horizontal axis for 500 ms. The target dot appeared immediately after the faces disappeared. The objective of the dot probe task was to select the key corresponding to the location on the screen (left or right) where the dot probe appeared as quickly as possible. The time

between dot presentation and key press was recorded in milliseconds. The task included congruent trials (dot at the same side as the emotional face), incongruent trials (dot at the same side of the neutral face), and filler trials (two neutral faces). The task consisted of 70 trials in total, 32 congruent, 32 incongruent and 6 neutral-neutral trials. Incorrect responses were excluded from the analysis. Apart from comparing the RTs to incongruent and congruent trails separately for angry and happy faces, trial level bias scores (TLBS; Swick and Ashley, 2017) were computed by matching each congruent and incongruent trial to its closest opposing trial type for both angry and happy faces. The incongruent-congruent difference was calculated for each pair. The mean was calculated on the individual differences in the degree to which the TLBS was above 0 ms, or towards emotional stimuli, and the mean was calculated on the individual differences in the degree to which the TLBS was below 0 ms, or away from target stimuli, for each emotion.

EEG recording and preprocessing

The EEG setup utilized the BrainProducts ActiCap 32-channel active EEG system, positioned according to the 10-20 system standard electrode placements. In the current study, we used four scalp electrodes (Fz, Cz, Pz, Oz), two electrodes for recording the electrooculogram located below and lateral of the outer canthus of the left eye, and a reference and ground electrode on the left and right mastoid, respectively. The decision to use a limited number of electrodes was driven by the need to minimize close contact with participants during the COVID-19 pandemic. The electrode-scalp impedance was reduced to less than 20 kΩ for all electrodes. EEG data were recorded at a 500 Hz sampling rate using an amplifier with an input impedance of 10 MΩ.

Offline data analysis was conducted using Brain Vision Analyzer (BrainVision Analyzer, Version 2.2.0, Brain Products GmbH, Gilching, Germany). The data were digitally filtered with 0.5 Hz high pass and 40 Hz low pass filters, and a DC Detrend was applied. ERP segments for face stimuli were set from 250 ms before face stimulus onset until 750 ms after face stimulus onset. Following segmentation, a Gratton & Coles ocular correction without raw average subtraction was applied. We excluded segments containing incorrect responses, segments with an amplitude exceeding ±100 µV, and segments with activity below 0.5 µV for 100 ms or more from further analyses. The average percentage of included segments was 98.9%. Lastly, a 100 ms baseline correction was applied. We obtained ERPs by averaging segments separately for angry-neutral pairs and happy-neutral pairs. Based on previous literature, we analyzed the vertex positive potential (VPP) and P3 ERP components for the face stimuli (Torrence & Troup, 2017). The time windows of these components were determined by visually inspecting the grand average of all data together. Each component's mean amplitudes in those time windows were calculated for each individual.

Statistical analysis

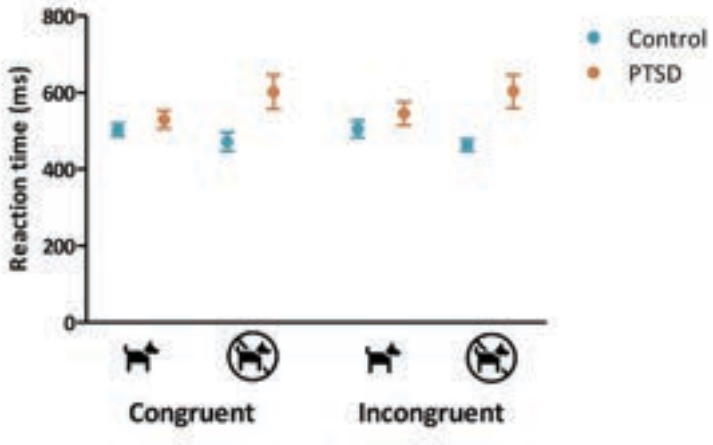
The statistical analysis was performed using IBM SPSS Statistics (Version 27). To examine differences in reaction time, we conducted a repeated measures Generalized Linear Model (GLM) analysis on the reaction time of the correct trials with within-subjects factors of congruency (congruent/incongruent), emotion (angry/happy) and condition (dog present/absent), between-subjects factor group (PTSD/control), and gender (male/female) as covariate. The Trial-Level Bias Score (TLBS) was also calculated, and analyzed using a repeated measures GLM with within-subjects factors direction (towards/away), condition (dog present/absent) and emotion (angry/happy), as between-subjects factor group (PTSD/control), and gender (male/female) as covariate. For the ERP components following the face stimuli, a repeated measures GLM was used with a group (PTSD/control) as the between-subject variable, and condition (dog present/absent), emotion (happy/angry) and electrode (Fz/Cz/Pz/Oz) as within-subject variables. Significant interactions of all GLMs were followed up using t-tests.

Results

Performance on the dot-probe task

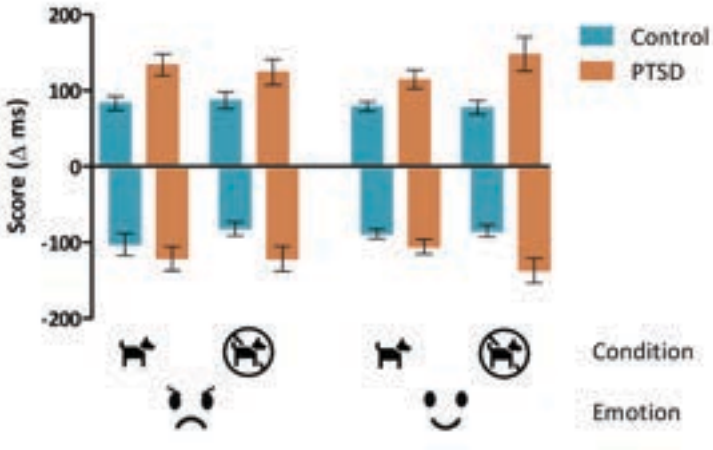
The repeated measures Generalized Linear Model (GLM) analysis on the reaction time showed no main effect of congruency, meaning the average reaction time did not differ significantly between incongruent and congruent stimuli, $F(1, 45) = 0.00$, $p = .993$, $\eta 2 = .00$. No main effect was found of emotion, $F(1, 45) = 0.95$, $p = .336$, $\eta^2 = .02$, and there was no main effect of group, $F(1, 45) = 3.39$, $p = .072$, $\eta^2 = .07$. We found an interaction effect of condition x group, $F(1, 45) = 7.78$, $p = .008$, $\eta^2 = .15$ (Figure 1). The control group was significantly faster when the dog was absent compared with when the dog was present, $F(1, 23) = 15.85$, $p < .001$, $\eta^2 = .41$. The group with PTSD was significantly slower when the dog was absent compared with when the dog was present $F(1, 23) = 4.76$, $p = .040$, $\eta^2 = .17$. Additionally, we found a interaction effect of emotion x gender, $F(1, 45) = 4.81$, $p = .034$, $\eta^2 = .10$. Although post hoc paired comparisons were non-significant, the means showed a trend of a slower reaction times in females for the angry faces (M = 505.09, SE = 19.16) than the happy faces (M = 499.89, SE = 17.60), and slower reaction times in males for the happy faces (M = 567.83, SE = 37.67) compared with the angry faces (M = 555.47, SE = 36.78).

Figure 1 Reaction time to angry-neutral trials



Note. Mean reaction times with SEM to angry-neutral trials during the conditions dog present and dog absent.

Figure 2 Mean TLBS with SEM



Note. Mean Trial Level Bias Score (TLBS) for control and PTSD groups. The TLBS is the difference between each congruent and incongruent trial and the closest opposing trial type. Positive values in the graph indicate attention towards emotional stimuli, and negative values in the graph indicate attention away from (i.e. avoidance of) emotional stimuli. On the x-axis the experimental conditions are shown, with the dog present and dog absent conditions and the facial icons indicating the presented stimuli, i.e. angry faces and happy faces.

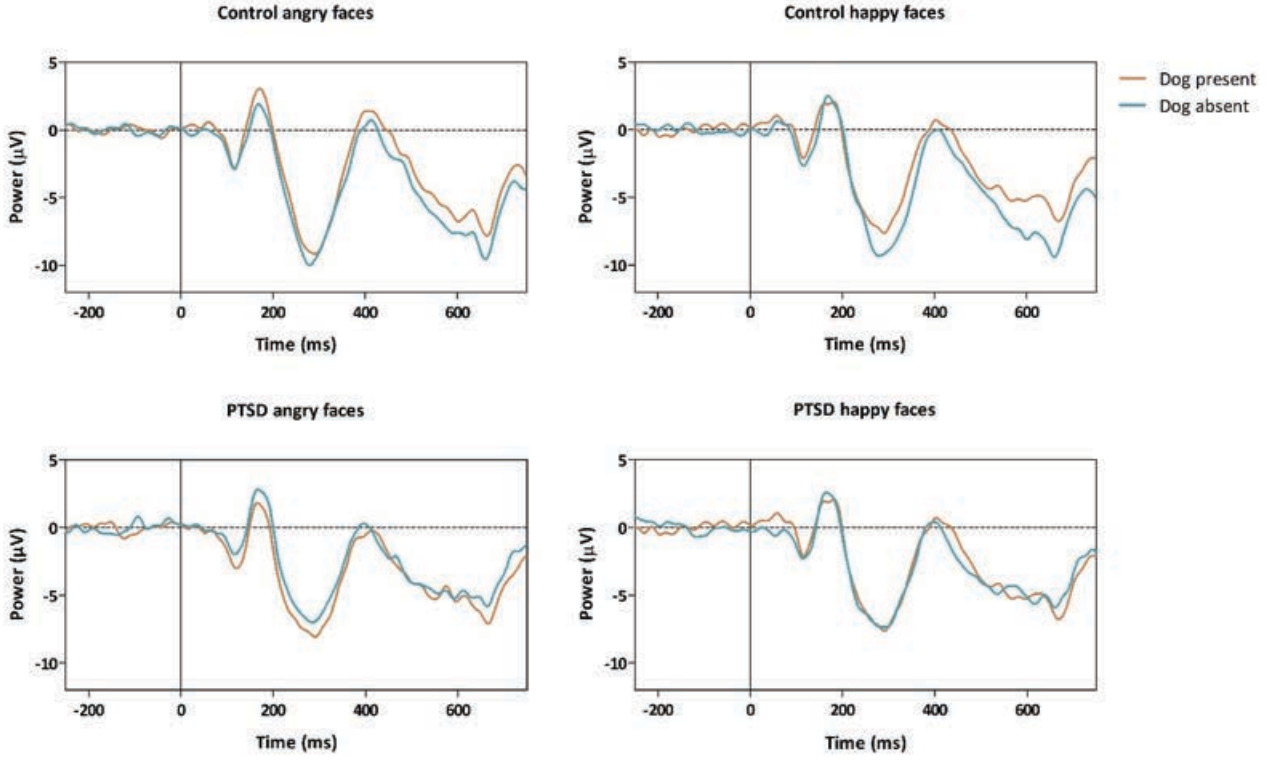
The GLM on the TLBS showed a main group effect, $F(1, 45) = 4.99$, $p = .031$, $\eta^2 = .10$ (Figure 2). No main effects of gender, emotion or condition were found. The interaction effect of direction x group was equal to the significance level, $F(1, 45) = 4.07$, $p = .050$, $\eta^2 = .08$, and a post-hoc paired t-test showed no significant effects. The mean values show a general higher TLBS in the group with PTSD compared with the control group, and the group with PTSD showed a trend of a higher TLBS towards emotional faces ($M = 130.19$, $SE = 13.73$) compared with away from emotional faces ($M = 120.06$, $SE = 10.89$), whereas the control group showed the opposite trend (away from emotional faces, $M = 88.45$, $SE = 5.88$; towards emotional faces, $M = 81.89$, $SE = 7.57$). No other interaction effects were found. In sum, the group with PTSD showed a higher TLBS compared with the control group.

Amplitude of ERP components following the face stimuli

Since the analysis of the VPP/N170 component (160–180 ms) showed interaction effects with electrode, separate GLMs were performed for each electrode. No main effect of emotion, group, or gender was found. On electrode Fz (and Cz) an interaction effect of condition x group was found, $F(1, 45) = 15.02$, $p < .001$, $\eta^2 = .25$, where the group with PTSD showed a significantly higher VPP amplitude on Fz when the dog was absent compared with when the dog was present, $F(1,23) = 12.74$, $p = .002$, $\eta^2 = .36$ (Figure 3). In the control group this was the other way around, the VPP amplitude was significantly higher when the dog was present compared with when the dog was absent, $F(1,23) = 5.59$, $p = .027$, $\eta^2 = .19$. No other effects were found.

On the P3 amplitude (380–480 ms) there were interaction effects with electrode, therefore a GLM for each electrode separately was done. On Fz, a main effect of condition was found, $F(1, 45) = 12.08$, $p = .001$, $\eta^2 = .21$, and an interaction effect of condition x gender, $F(1, 45) = 4.13$, $p = .048$, $\eta^2 = .08$. Post hoc analysis showed only in females a lower P3 when the dog is absent compared with when the dog is present, $F(1, 25) = 9.68$, $p = .005$, $\eta^2 = .28$. An interaction effect of emotion x group was found on Cz (and Pz), $F(1, 45) = 6.96$, $p = .011$, $\eta^2 = .13$. Post hoc GLM per group showed only in the control group a higher P3 on Pz to angry faces than happy faces, $F(1, 22) = 5.28$, $p = .031$, $\eta^2 = .19$. In the group with PTSD no difference between happy and angry was found, $F(1, 22) = 1.26$, $p = .273$, $\eta^2 = .05$.

Figure 3 Grand average ERPs at Cz in response to face stimuli



Note. Grand averages of the event related potentials (ERPs) time-locked to stimulus onset (0 ms) measured on electrode Cz for the two groups in the different conditions.

Discussion

The current study aimed to examine attentional bias towards threat in police officers with and without PTSD and explore the potential influence of dog presence on this bias. As expected, police officers with PTSD showed a significantly higher TLBS compared with police officers without PTSD, i.e. more attention both towards and away from angry faces. The presence of a dog did not appear to influence attentional bias. However, participants with PTSD showed slower reaction times when the dog was absent than when it was present, whereas control participants showed the opposite pattern, responding faster in the absence of the dog. Consistent with this behavioral finding, early neural processing also differed by condition, as the PTSD group exhibited a higher VPP amplitude in the dog-absent condition , suggesting heightened initial attentional engagement with face stimuli when the dog was not present. At later stages of face stimuli processing, the P3 ERP findings suggest altered emotional processing in the PTSD group relative to controls. Whereas the control group showed the expected increase in P3 amplitude to angry compared with happy faces, the PTSD group did not differentiate between emotional expressions, showing no P3 differences across angry or happy faces. Together, the findings indicate that police officers with PTSD show heightened and dysregulated attentional processing of emotional stimuli, with dog presence modulating early neural responses and reaction speed but not altering overall attentional bias.

When comparing police officers with PTSD to police officers without PTSD, no significant difference in reaction time was observed between the congruent and incongruent trials. This finding aligns with the literature, which suggests that attentional bias may fluctuate throughout the task rather than being reliably captured by subtracting mean reaction times of incongruent trials from congruent trials (Carlson & Fang, 2020). Our analysis of the TLBS revealed a significantly higher TLBS in the group with PTSD compared with the control group, suggesting overall differences in attentional engagement with emotional stimuli. Although post-hoc tests of a significant direction x group interaction were not significant, there was an indication that the group with PTSD showed a greater bias toward emotional faces, where controls demonstrated higher TLBS away from emotional faces. This inconclusive pattern mirrors the mixed results in existing research on the direction of attention bias in PTSD (Bomyea et al., 2012; Cisler & Koster, 2010; Vyas et al., 2020). Despite these uncertainties, our results confirm that attentional processing in PTSD differs from that of controls, consistent with prior research indicating that PTSD is associated with altered attention-related brain function (Ely et al., 2023).

The ERP results indicated potential differences in emotional processing between the groups. The control group exhibited a higher P3 for angry faces than happy faces, while no such difference was found in the group with PTSD. The hypothesis that there

is a sensitivity to potential threats in PTSD suggested that the PTSD group would demonstrate greater ERP activity to angry faces relative to the controls. In contrast to this prediction, no significant difference was found in ERP amplitude between the control and the PTSD group in response to angry faces. Further, the ERP response of the PTSD group did not differentiate between angry and neutral expressions. This result is in line with a previous ERP study in PTSD (Felmingham et al., 2003), where they found a difference in ERP amplitude to angry and neutral faces in the control group and did not find this difference in the PTSD group. The P3 component has been associated with attentional processing (Polich, 2007), and emotionally salient stimuli typically increase its amplitude (Luo et al., 2010). The absence of differentiation between happy and angry faces in the PTSD group may indicate a broader cognitive disruption in emotion processing, affecting their ability to selectively allocate attention based on emotional content. This could reflect a diminished capacity to prioritize emotionally relevant stimuli, regardless of valence.

It is important to interpret our findings with caution, as increased TLBS in PTSD may also reflect greater reaction time variability independent of the emotional stimuli, as reaction time variability was strongly correlated with TLBS in previous studies (Carlson & Fang, 2020; Swick and Ashley, 2017, Kruijt et al., 2016). The higher TLBS in the group with PTSD may therefore reflect inconsistencies in response speed across different trials, regardless of the specific stimuli presented. These fluctuations in reaction time can be influenced by various factors unrelated to attentional processing, such as fatigue or emotional state. Since patient groups often show longer and more variable RTs than controls, group comparisons of TLBS data need to be interpreted carefully, as these differences may stem from general response variability rather than threat-related attentional bias. However, an increase in trial-to-trial variability in reaction time is also considered a marker of executive dysfunction (West et al., 2002; Ode et al., 2011). Reaction time variability has been correlated with PTSD symptom severity in tasks using neutral stimuli (Swick et al., 2013). Thus, while increased TLBS in the dot probe task may be attributed to reaction time variability, it could also reflect broader executive functioning difficulties in PTSD.

If dog presence would have an effect on attentional processing by functioning as a stress buffer, we would expect an effect of condition on the TLBS in the group with PTSD. We did not find such an effect of dog presence on the TLBS, but only an effect on general reaction time, with a slower RT in the PTSD group when the dog was absent compared with present. An effect of dog presence seems also to be represented in the ERP data, as the VPP amplitude was higher in the PTSD group when the dog was absent compared with present. The VPP is linked to early-stage face processing and attentional allocation (Luo et al., 2010),

suggesting that heightened initial attention to face stimuli occurred in the absence of the dog. While a higher VPP indicates enhanced early-stage processing, it does not necessarily lead to more efficient behavioral responses. The slower reaction times when the dog was absent could be due to increased cognitive load, stress, or difficulty disengaging from the emotional stimuli, which may have caused delays in decision-making or response execution. The presence of the dog may have reduced stress and facilitated a more regulated attentional state, reducing hypervigilance and preventing excessive engagement with emotional faces. This idea aligns with research suggesting that service dogs can help individuals with PTSD modulate their stress response (Nieforth et al., 2023). Despite differences in early attentional engagement (VPP) and reaction times, no difference was found on TLBS across conditions. This indicates that the dog's presence did not systematically shift attentional focus toward or away from emotional stimuli, but rather influenced how attention was allocated at an early stage and how quickly participants could respond. The dog's presence may have facilitated a more regulated attentional state, preventing hyper-alertness searching for emotional faces but not necessarily altering the attention patterns once the emotion was detected. Interestingly, the control group was faster when the dog was absent, possibly due to a test-retest effect, whereby repeated task exposure improves performance. Overall, these findings suggest that while the dog's presence influenced early attentional processes and reaction times, it did not lead to a measurable change in attentional bias towards or away from emotional stimuli.

Due to COVID-19 restrictions, we were measured four midline electrodes to minimize close contact time with participants. Attentional bias components are typically measured either laterally or on the midline (Torrence & Troup, 2017). Given these constraints, we focused on analyzing the components that are known to be represented on the midline electrodes – specifically the VPP (face) and the P3 (face). However, other components, such as P1 (face and probe), N170 (face), N2pc (face), N1 (probe), are typically measured laterally (Torrence & Troup, 2017). Since our setup did not include electrodes positioned laterally, we were not able to analyze these components.

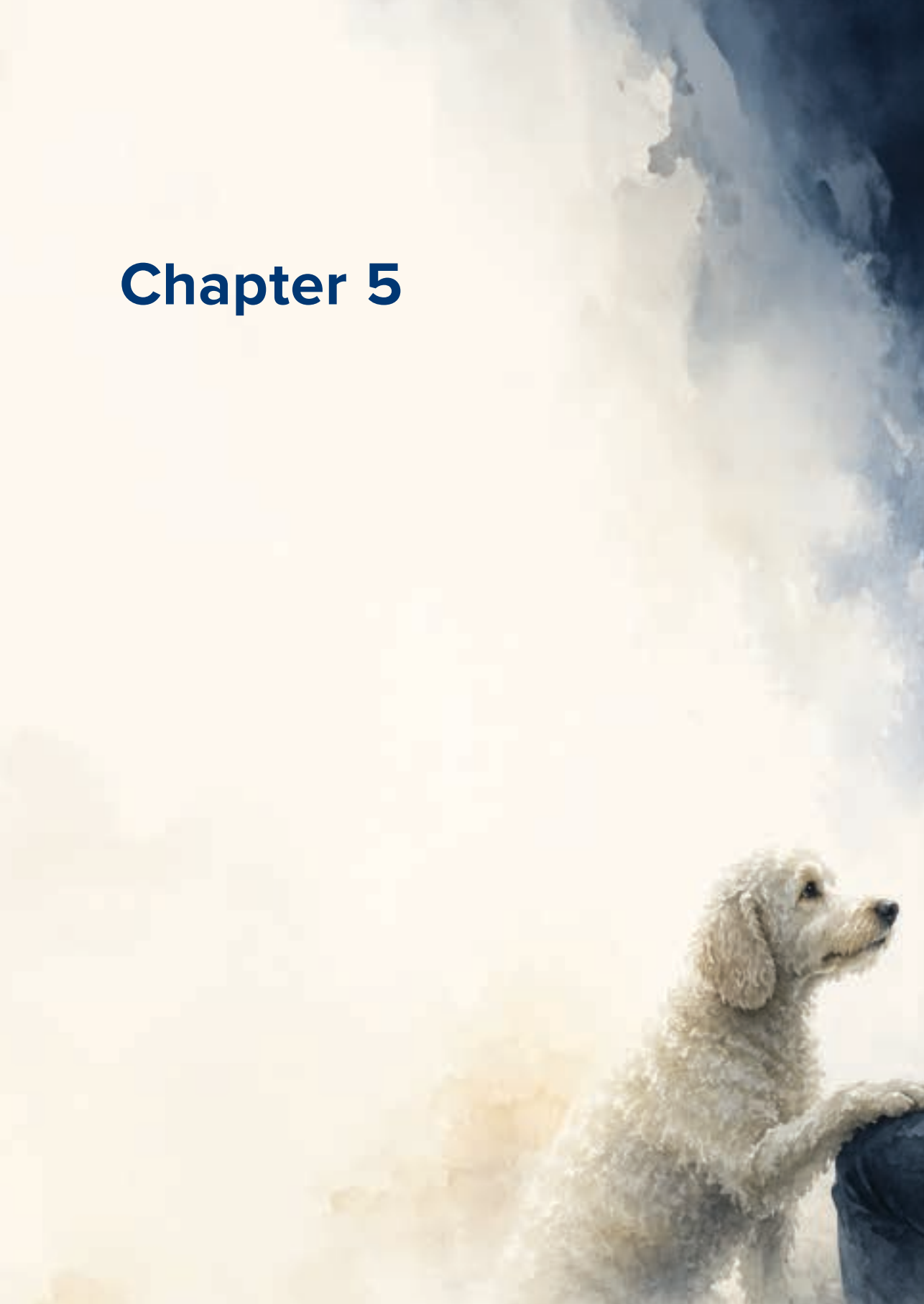
In addition to these technical constraints, the study design introduced limitations related to the non-counterbalanced order of conditions. Both groups completed the dog-present and dog-absent blocks in a fixed sequence, which raises the possibility of test–retest or order effects influencing the results. Factors such as habituation, learning, or fatigue may have contributed to changes in reaction times, independent of the experimental condition. Without counterbalancing, it is difficult to disentangle condition effects from time-related influences, and this should be considered when interpreting the observed patterns.

Future research should consider alternative methodologies to assess attentional bias in PTSD. The dot probe task in its traditional form has been criticized for its low reliability and individual variability in measuring attentional bias to threat (Schoorl et al., 2014). Some studies suggest that RT data from the dot probe task do not provide an internally reliable measure of attentional bias (Schmukle et al., 2005; Kappenman et al., 2014; Rodebaugh et al., 2016). Future studies may benefit from using an adapted dot probe task, such as the dual probe task (Grafton et al., 2021), or incorporating eye-tracking technology to provide more precise measurements of attentional engagement. Combining multiple assessment methods could enhance reliability and provide a more comprehensive understanding of attentional biases in PTSD.

The results of this study highlight the complexities of attentional processing in police officers with PTSD, giving insight into how emotional stimuli are processed. Police officers with PTSD exhibited a heightened TLBS, suggesting a tendency to engage more with emotional stimuli. However, ERP data indicated a lack of differentiation between happy and angry faces in the PTSD group, which suggests the PTSD group may have difficulty discriminating threat and non-threatening stimuli and which may affect their ability to selectively allocate attention based on the emotional content of the stimuli, as typically seen in individuals without PTSD. The increased TLBS could than be explained by a higher reaction time variability, independent of stimulus type. Supporting this theory, the presence of a dog influenced reaction times and early-stage attentional processing but did not appear to alter the PTSD group's attentional bias toward or away from emotional faces.

4

Chapter 5



Enhancing Companion Dog Support for Post-Traumatic Stress Disorder: The Role of Targeted Training

This chapter is based on:

Charlotte L. Witjes-Roelofs, Sarah Willekes, Marijtje L.A. Jongsma, Eni S. Becker, Annika S. Smit (submitted) Enhancing Companion Dog Support for Post-Traumatic Stress Disorder: The Role of Targeted Training

Abstract

This study examined the feasibility and perceived impact of a Companion Dog Support Partnership (CDSP) training program for police officers diagnosed with PTSD and their own companion dogs. While existing literature highlights the therapeutic benefits of trained service dogs, evidence regarding the role of companion dogs in PTSD support remains limited. We explored qualitatively how targeted training could enhance the supportive role of companion dogs. Following the CDSP training, participants reported improvements not only in their dogs' behavior, such as increased protective responses and tension-reducing abilities, but also in their own emotion regulation, self-awareness, and engagement in daily activities. The CDSP training fostered a deeper understanding of the dog's supportive potential and encouraged behavioral activation through joint activities. Questionnaire results revealed significant post-training improvements in life satisfaction and physical health, and reduced state anxiety. Even among participants that experienced limited direct benefits of the training, the training was positively evaluated, often due to peer contact and the compassionate nature of the sessions. These findings suggest that the CDSP training may enhance the supportive value of companion dogs, offering a promising and accessible form of support for individuals with PTSD.

Introduction

Posttraumatic Stress Disorder (PTSD) is a mental health condition that can develop after exposure to one or more traumatic events. Professional first responders, such as police officers, firefighters, and ambulance personnel, are at an elevated risk of experiencing such traumatic events (Skogstad et al., 2013), leading to a higher prevalence of PTSD within these populations (Syed et al., 2020). Standard treatments for PTSD include cognitive behavioral therapy, pharmacological interventions, and EMDR (eye movement desensitization and reprocessing) (Mavranezouli et al., 2020). While these treatments have been effective for many, a substantial number of individuals with PTSD struggle with initiating or completing therapy, or continue to experience symptoms despite treatment (Lewis et al., 2020).

For those who do not benefit from conventional treatments, a supplemental intervention could be the use of service dogs (Jensen et al., 2021). Service dogs are trained to assist individuals with PTSD by providing emotional support and practical help during moments of stress (Rodriguez et al., 2020). Research indicates that dogs in general have positive impact on reducing stress and improving overall well-being (Ein et al., 2018). In the context of traumatic stress, studies have shown that dogs can significantly reduce acute distress (Hunt & Chizkov, 2014) and alleviate subjective feelings of stress and anxiety both during and after an experimental traumatic stress situation (Lass-Hennemann et al., 2014; Lass-Hennemann et al., 2018). Notably, in these studies, the dog was an unfamiliar, friendly dog. Furthermore, studies highlight the health benefits of pet ownership, such as reductions in distress and anxiety, decreases in loneliness and depression, and increases in exercise (Friedmann & Son, 2009). For individuals with PTSD, owning a dog has been linked to feeling calmer, less lonely, less depressed, and less worried about personal and family safety (Stern et al., 2013). These dogs were not specifically trained for this purpose. However, there are also PTSD service dogs that are trained to respond precisely to specific disabilities of their owners and are typically allowed entry into public facilities (Krause-Parello et al., 2016). PTSD service dogs ultimately facilitate socialization, provide companionship, and reduce trauma-related symptoms while promoting independence (Yarborough et al., 2018). They achieve this by acting as calming influence and alerting their owners to signs of developing stress or panic (Rodriguez et al., 2020). People with PTSD may benefit from both companion dogs or service dogs (Richerson et al., 2023). Both types of dogs may offer benefits and challenges, mainly dependent on the specific needs and circumstances of the individual.

The high costs and intensive training requirements of service dogs limit their accessibility, highlighting the need for viable alternatives. To address this challenge, a training was developed for individuals with PTSD and their own companion dogs to train them together with their dogs to enable the dog to assist with PTSD-related needs. This approach enhances the individual's sense of agency by actively involving them in tailoring the training of their own dog to their specific needs. Companion dogs, when involved in specialized training with their owners, may offer meaningful support in managing stress and emotions through specific skills, such as creating physical barriers ('blocking') or interrupting nightmares. This approach may be of interest to those for whom an untrained dog is insufficient but a fully trained service dog is either too intensive or inaccessible. The training program emphasizes improving the officers' understanding of their dogs' body language and behavior, as well as equipping them with skills to train their dogs in tasks specifically related to PTSD support. Studies have found that involving the owners with PTSD in the service dog training programs can lead to significant decreases in posttraumatic symptoms (Bergen-Cico et al., 2018; Kloep et al., 2017; Scotland-Coogan et al., 2020; Whitworth et al., 2019). Most of these programs involve intense training of service dogs by participants, close communication with dog trainers, increased physical activity, and veteran peer-support involvement. Each of these variables, along with the participant's relationship with their dog, may play a role in the improved functioning and decreased trauma symptoms described by participants.

This study evaluated the feasibility and perceived impact of the 6-week Companion Dog Support (CDSP) training program for Dutch police officers with PTSD and their own companion dogs by comparing the role of the dog in their daily life a week before the training with 6 months after the CDSP training. The CDSP training consisted of six days of training, once a week, in groups of eight dog owners with PTSD and their companion dogs, led by a PTSD service dog trainer. The primary objective was to evaluate the feasibility of implementing the CDSP training in terms of participant engagement and perceived value. The interview data provided in-depth insights into participants' subjective experiences with the CDSP training and their relationship with their dogs. A secondary aim was to explore potential changes in participant's well-being by comparing questionnaire responses obtained one week before the training and and six months after the CDSP training. We hypothesized that post-training well-being scores would show improvement compared to pre-training, indicating potential benefits of the CDSP training.

Methods

Participants

The participants were recruited through internal communication within the Dutch police organization. In total, 43 (former) police officers signed up for participation in the CDSP training and the study (for participant characteristics see Results section). All participants provided written informed consent. The study has been reviewed independently by the Ethics Committee Social Sciences (ECSS) of the Radboud University and there is no formal objection to this study (ECSW-2020-012). To be included in the PTSD group, participants needed to have a work-related PTSD diagnosis, have finished at least one type of treatment, own a companion dog for at least six months, and be or have been employed within the police force.

Training

The Companion Dog Support (CDSP) training program is a short-term intervention designed to enhance the supportive role of companion dogs for individuals diagnosed with PTSD. The CDSP training was taught by the KNGF (The Royal Dutch Guide Dog Foundation: KNGF Geleidehonden), which trains guide dogs for visually impaired people, assistance dogs for people with other handicaps such as young children with a disability or autism, and service dogs for veterans, policemen and firefighters with PTSD. The service dogs are usually trained to the user's specific needs e.g. waking up its owner in the early stages of a nightmare, ensuring sufficient personal space by preventing other people to come too close and acting as a reassuring and ever present buddy. The CDSP training program consists of six weekly group sessions, each lasting approximately 3 hours (including lunch), facilitated by a certified PTSD service dog trainer from the KNGF, in groups of eight dog owners with PTSD and their companion dogs. Sessions include practical exercises, psychoeducation, and guided interactions between participants and their dogs. The CDSP program aims to explore the feasibility and potential benefits of using partially trained companion dogs as a more accessible alternative to fully trained assistance dogs.

The training was open to dogs of all breeds, with dogs screened in advance to ensure they were sociable with other dogs and had the appropriate temperament to learn the necessary skills. The primary goals of the CDSP training, as outlined by the organizing body, were to provide insight into understanding the body language of the participants' dogs, and to teach how to train the dogs in PTSD-related skills to better assist their owners in managing stress and emotions. Another key objective was to help owners gain a deeper understanding of their dogs' behavior, enhancing their ability to communicate and work together effectively. Specific skills that were focused on included waking the owner from nightmares, responding to the owner's mood, and blocking i.e. positioning themselves to create space between the owner and others.

Procedure

The study has been preregistered (Part B: doi.org/10.17605/OSF.IO/DA3M8) and is part of a larger project investigating cognitive effects (Part A in the preregistration). The central question guiding the interviews was: 'What is the impact of a dog on the quality of life of (former) police officers with PTSD, and what role does the CDSP training play in this?' To explore how participants experience life with a companion dog and the influence of the CDSP training they received, semi-structured interviews were conducted. Each participant was interviewed twice: once before the CDSP training and once about six months after the training. Interviews lasted 20–60 minutes and were conducted in-person, apart from two post-training interviews that were conducted via telephone (1) or video call (1). All interviews were audio-recorded with participants' consent and transcribed. This study takes a qualitative approach, focusing on participants' experiences, emotions, and perspectives. Researchers play an active role in data collection and analysis, shaping findings through observation and reflection. However, ensuring alignment with participants' authentic experiences remained a priority throughout the analysis.

The dataset consisted of interviews with 29 (former) police officers diagnosed with PTSD who participated in the CDSP training program (58 interviews in total). The findings are drawn from a comprehensive analysis of these interviews, capturing a collective narrative while acknowledging that not every participant may relate to every aspect of the results. Two researchers (author CWR and SW) conducted thematic analysis (Braun & Clarke, 2006). Author CWR was familiar with the data as she conducted the interviews herself. Author SW was blank concerning the data, so she started blank with open coding. Independently, these two researchers openly coded three pre- and post-interviews, and discrepancies were resolved through discussion. Next, author SW openly coded all of the interviews that were left. The found codes were merged into themes by SW. Together with authors AS and CWR, the themes were discussed, defined, and (re) named. Once SW and CWR agreed on the codebook, all the interviews that were left were coded with the codebook by SW. Next, all the coded interviews were reviewed by author CWR and discrepancies were discussed.

Measures

On the first measurement day demographic information was collected and on both the pre- and post-measurement day participants were asked to fill out three short questionnaires that focus on the quality of life and well-being: the satisfaction with life scale (SWLS, Dutch version; Arrindell et al., 1999), a short version of the World Health Organization quality of life assessment (WHOQOL-BREF, Dutch version; Trompenaars et al., 2005) and a short version of the State-Trait Anxiety

Inventory (STAI-6, Dutch "Zelf Beoordelings Vragenlijst, ZBV"; van der Bij et al., 2003). The SWLS consists of 5 items and focuses on life functions, and WHOQOL-BREF consists of 14 items and focuses on affective aspects of well-being divided into 4 subdomains (physical health, psychological, social relationships, environment). The STAI-6 consisted of 6 items and measured the transient state of arousal subjectively experienced as anxiety (Tluczek et al., 2009).

Statistical analyses

The statistical analysis was performed using IBM SPSS Statistics (Version 27). For the questionnaire data a paired samples T-test was performed.

Results

Participant characteristics

The CDSP training had 45 participants filling almost all 48 available spots. 42 participants completed the training. Of those, 28 participated both in the pre- and post-measurement. One participant of the CDSP training declined in advance to complete the measurements, and one participant was enrolled in the training just after the premeasurements took place. Drop-out reasons included unavailability to attend posttest (n=6), dissatisfaction with the training not meeting their expectations (n=1), health conditions that prevented them from completing the posttest (n=4), not owning the dog anymore at the time of the posttest (n=3), or another reason (n=2). The drop-out group pre-test did not differ statistically from the included group pre-test on any of the demographics or questionnaire data (see supplemental Table S2). An overview of the breeds of the dogs is included in the supplementary materials. Participants included in the study were 15 men and 13 women, mean age = 51.0 years old, SD = 8.7. 21 out of 28 were still employed within the police organization. Of these 28 participants that were included in the analysis, the majority did not use PTSD-symptom related medication, though 10 participants did use PTSD-symptom related medication such as sleep medication, antidepressants, anxiolytics, or antipsychotics.

Interview data

The thematic framework (Figure 1) presents the findings from the interview data. In the supplements, the different themes, subthemes, variations and sub-variations within the thematic framework are explained. At the core of the framework is the evolving role of the dog in the life of an owner with PTSD, which is positioned at the top of the overview. From this central concept, the

framework outlines four key themes that describe the role of the dog. Each theme progressively adds depth and complexity, which is why the process is described as a development. The overview begins with the general significance of dogs, independent of PTSD (Theme 1), followed by the specific role of the individual dog in the life of an owner with PTSD (Theme 2). From there, the necessary criteria for the dog's role are explored (Theme 3). Finally, the perceived impact of the intervention is described from the participants' perspective (Theme 4). Each theme includes subthemes, variations, and sub-variations, which provide further insight into the overarching themes. For full description of all themes, see Supplementary materials. It is important to note that all results described in this section arose from participant perceptions rather than experimental validation.

According to the participants, companion dogs can support individuals with PTSD in multiple ways. The dog's behaviors, such as their dedication to the owner, protective responses, and sensitivity to the owner's rising tension, were perceived to contribute to improvements in emotional well-being, cognitive relief, and behavioral activation. Secondly, participants indicated that the dog's protective behavior contributes meaningfully to their sense of safety. Thirdly, it was a common experience among participants that the dog has an important role in reducing tension. The first step in the tension reduction process is the dog sensing the mood or state of the participant. According to the participants, the dog can recognize certain emotions and behaviors. The second step in reducing tension is that the dog makes the owner aware. The dog mirrors the owner, signaling that something is wrong. According to the participants, this can occur, for example, when the dog starts barking or jumps on the owner. The owner's awareness (about their situation and the dog's reaction) may come later, or does sometimes not occur at all. The third step in reducing tension is that the dog either takes action itself or encourages the owner to do something. The purpose of this action is to reduce tension and pull the owner back to the present moment. For example, the dog may lie next to the owner or lick the owner, which helps the owner calm down. Alternatively, the owner may be encouraged to play or go for a walk with the dog, thereby alleviating the tension.

The third theme (Assistance Criteria) outlines the essential conditions for dogs to effectively support the owner with PTSD, emphasizing that successful assistance depends on factors related to the owner, the dog, and the environment. Owners must understand their dog's signals, acknowledge their own need for help, and possess the ability to train and trust their dog's capabilities. Dogs, in turn, must exhibit traits such as focus, obedience, protective instincts, and the ability to detect and respond to their owner's tension, traits that are influenced by breed and age. A strong owner-dog bond is crucial for maximizing support. Additionally,

situational factors like accessibility and the owner's comfort in bringing the dog into various environments can either enable or hinder the dog's ability to assist, highlighting the importance of accessible and accepting environments to enable optimal support.

Participants perceived several improvements following the CDSP training, including increased owner knowledge, enhanced dog effectiveness, and a strengthened owner-dog bond. Owners reported gaining deeper insight into their dog's role and their own behavior:

> *"But also everything I've learned: I took it all with me. I was genuinely disappointed that it ended, because I actually wanted to learn even more. But overall, it was really: I learned so incredibly much, about myself, but especially about the dog." (Participant 45, post-interview)*

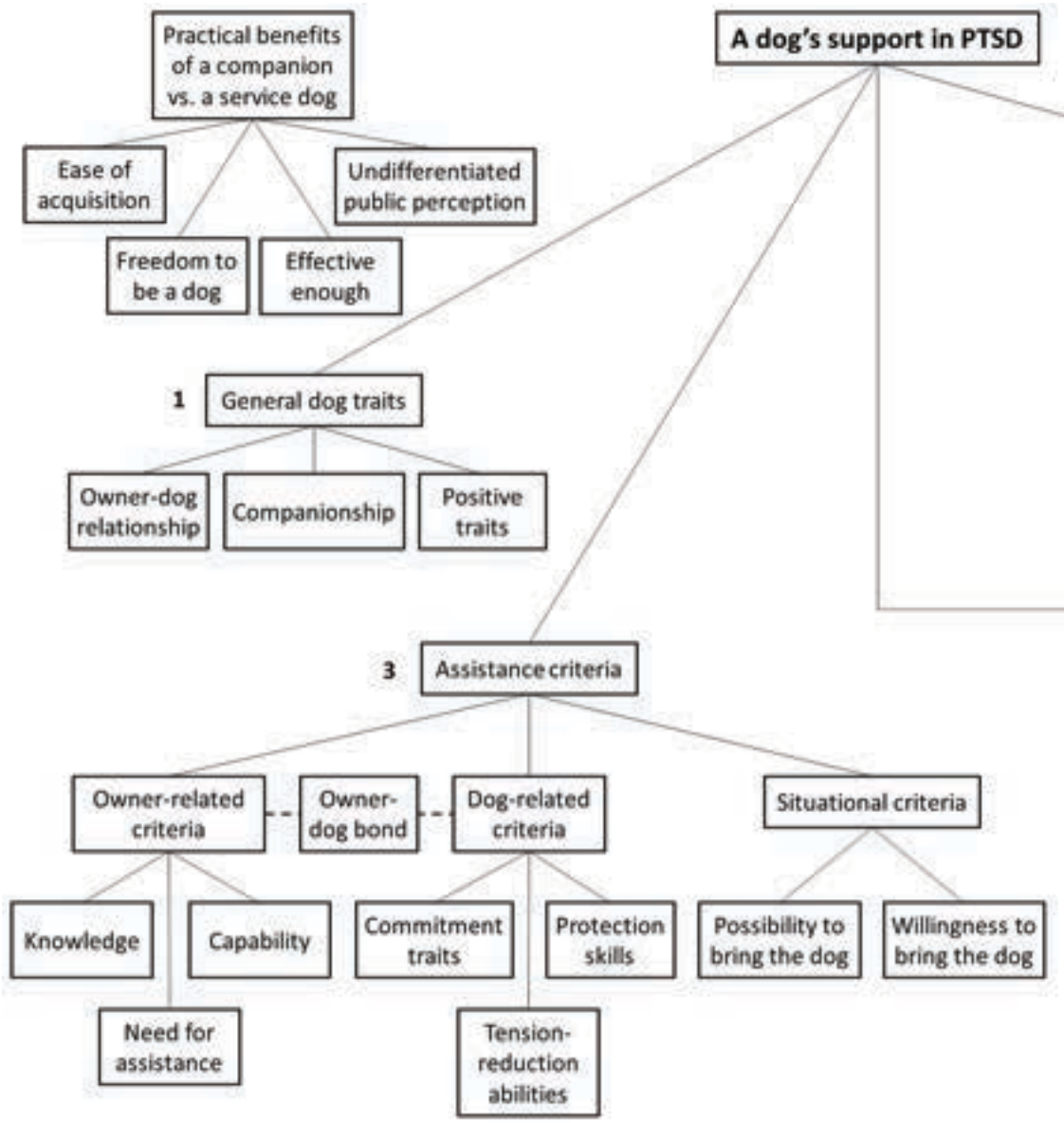
The participants also learned to better interpret their dog's signals:

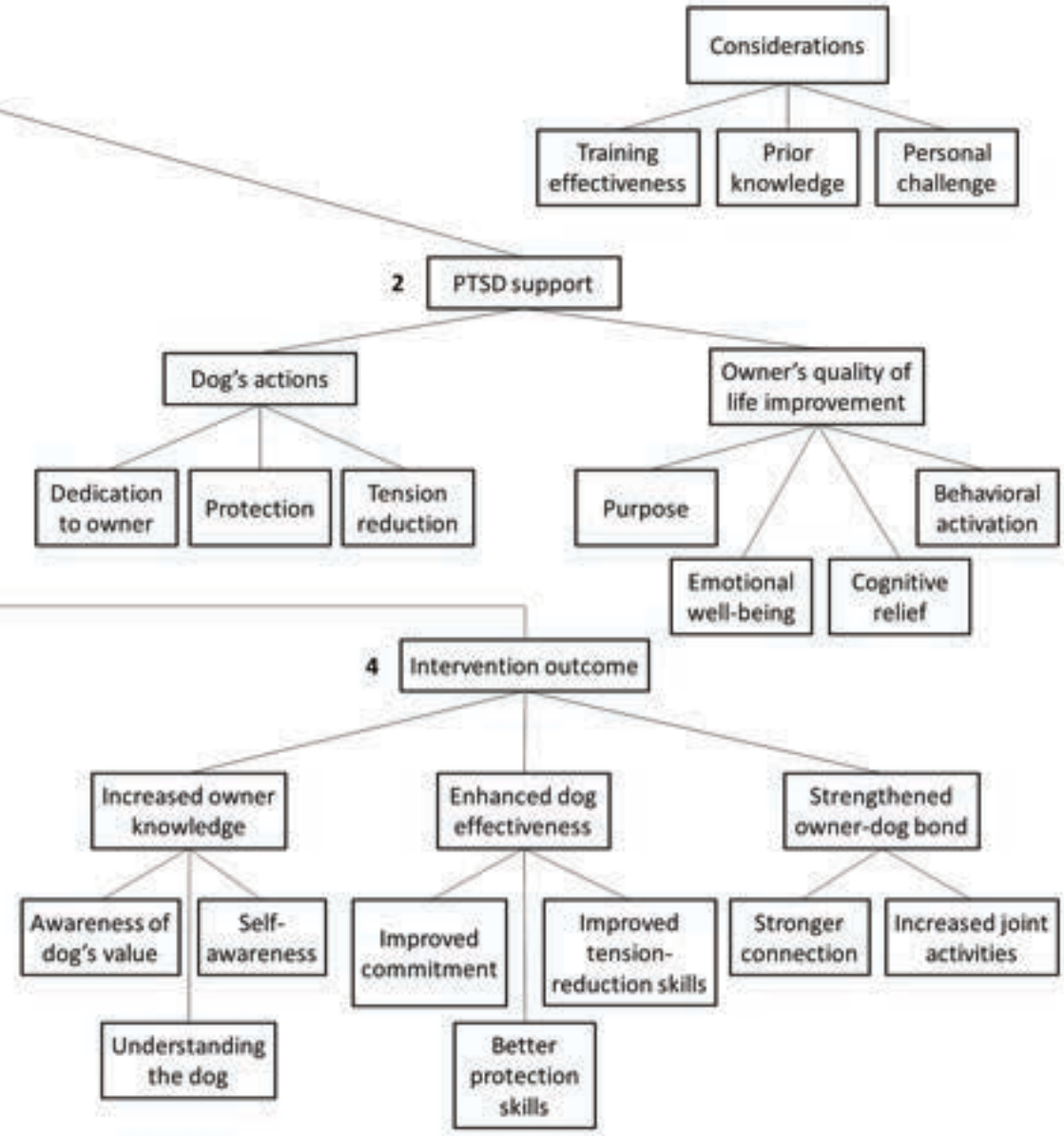
> *"Above all, I've learned to better recognize the dog's signals, which is actually the most important thing. You see, the dog is just doing its thing. The key is how I pick up on those signals. And that, to me, was the main goal of the entire training." (Participant 50, post-interview)*

Dogs were perceived as more focused and protective, acquiring skills like 'blocking':

> *"He has learned to position himself between me and others, and sometimes he does that on his own. I've also taught him to stand behind me. I do need to give him a command for that, but he understands it and then stands behind me. I especially feel discomfort when people approach from behind, and then I know he's still standing between us, it makes things feel more relaxed." (Participant 21, post-interview)*

Figure 1 Thematic framework




Considerations
Training effectiveness
Prior knowledge
Personal challenge
2
PTSD support
Dog's actions
Owner's quality of life improvement
Dedication to owner
Protection
Tension reduction
Purpose
Behavioral activation
Emotional well-being
Cognitive relief
4
Intervention outcome
Increased owner knowledge
Enhanced dog effectiveness
Strengthened owner-dog bond
Awareness of dog's value
Self-awareness
Improved commitment
Improved tension-reduction skills
Stronger connection
Increased joint activities
Understanding the dog
Better protection skills

Finally, the bond between owner and dog grew stronger through shared experiences and increased joint activities. While participants reported dog ownership already encouraged behavioral activation through regular walks, the CDSP training appeared to further enhance this effect by promoting more joint activities. Participants reported that, due to the skills acquired by both themselves and their dogs, they now engage in more shared activities. This increase was attributed to not only to enhanced capabilities but also to a greater willingness to involve the dog, either out of a desire to include the dog or a heightened need for support of the dog:

> *"I take her with me more often now, precisely because of the training. If it's at all possible, I bring her along, and that has made me more relaxed. I do notice that." (Participant 6, post-interview)*

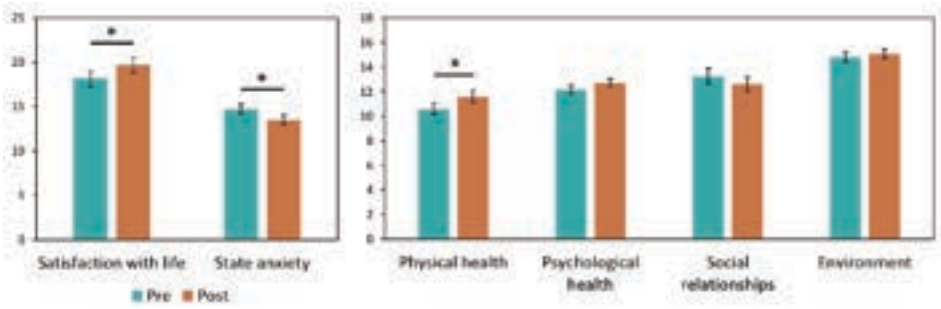
The perceived effectiveness of the CDSP training appeared to depend on individual factors, such as prior knowledge, the suitability of the dog, alignment with personal needs, and practical applicability of the training content. Even among participants who reported limited direct benefits, due to for example pre-existing knowledge or an unsuitable dog, the training was still evaluated positively. This positive evaluation was often attributed to the peer contact and the compassionate nature of the training sessions, which may have provided a sense of being supported and understood. However, some found the group setting occasionally stressful. The training itself was often described as exhausting, with many needing time to recover afterward. Despite this, the facilities were viewed as high-quality overall, and trainers were consistently praised for their support and empathy.

> *"It was extremely tough, yes. I was exhausted. Tired. I came home and immediately went to sleep. I slept for a few hours and then... well, I felt broken the whole day and the next day too. It's very intense. But still worth it." (Participant 16, post-interview)*

Questionnaires

The results on the SWLS showed a significant increase in satisfaction with life from pretest to posttest, $F(1, 24) = 5.97$, $p = .022$, $\eta^2 = .20$ (Figure 2). State anxiety decreased from pretest to posttest, $F(1, 24) = 4.81$, $p = .038$, $\eta^2 = .17$. On the WHO quality of life questionnaire only a difference on the domain physical health was found, which increased from pretest to posttest, $F(1, 22) = 4.36$, $p = .049$, $\eta^2 = .17$. On the domains psychological health, social relationships, and environment, no differences were found from pretest to posttest, $p > .15$ (Figure 2).

Figure 2 Questionnaire results before and after training



Note: Mean scores with SEM on the Satisfaction with Life scale, State Anxiety Index, and four domains of the Quality of Life scale.

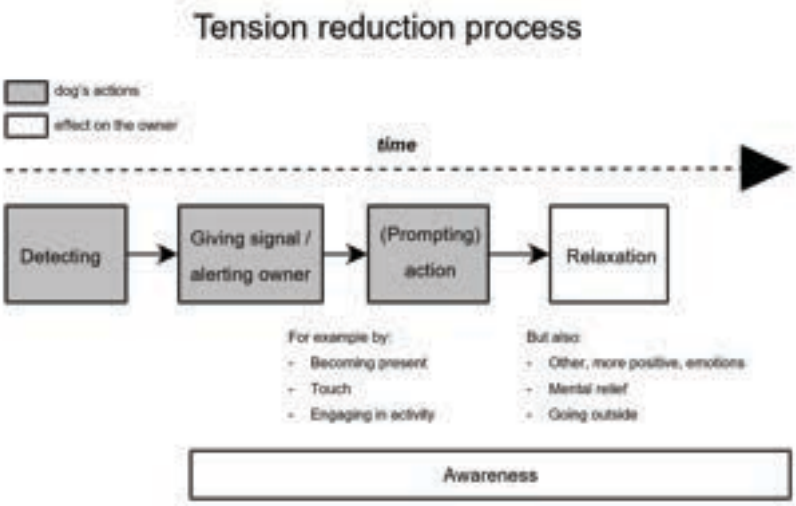
Discussion

This study evaluated the feasibility and perceived impact of the CDSP training program for police officers with PTSD. Overall, the training was positively received. Participants reported not only improvements in their dog's behavior but also enhanced self-awareness and greater ability to actively engage with their dog for support. Even prior to the CDSP training, participants indicated that their dog already provided meaningful PTSD support through their mere presence. The training appeared to strengthen their bond, equipping both owner and dog with the skills needed to collaborate more effectively. Questionnaire results underscore the potential of companion dogs to improve well-being, with post-training improvements observed in life satisfaction, physical health, and reductions in state anxiety. These results suggest that even a short training intervention can amplify the value of companion dogs for individuals affected by PTSD, contributing to reduced distress and overall well-being, in line with previous literature (Beetz et al., 2012).

Participants reported that, following the CDSP training, their dogs exhibited enhanced protective behaviors. This perceived change may have played a role in the reduction in state anxiety among participants, as evidenced by reductions in self-reported anxiety levels on the questionnaire. However, this decrease could also be partially attributed to increased familiarity with the experiment setting, rather than the CDSP training alone.

One notable pattern was the common experience among participants of the important role of the dog in reducing tension. This pattern could be described as a conceptual model of tension reduction (Figure 3). The reduction of tension is perceived as a process involving a sequence of actions carried out by the dog. Participants described that the dogs help alleviate tension through firstly detecting (rising) tension, then making their owner aware, and finally prompting action with the goal that the tension decreases.

Figure 3 Conceptual model of tension reduction



Note: Schematic visualization of the pattern revealed by the consistent narratives in the interview data. We have visualized this as a conceptual model, intended as a preliminary interpretation and not as an empirically tested mechanism. Dogs help alleviate tension through firstly detecting (rising) tension, then making their owner aware, and finally prompting action with the goal that the tension decreases.

While this conceptual model of tension reduction was not directly experimentally investigated in this study, consistent narratives in the qualitative interview data suggest its relevance. The first step of the process, where the dog senses the owner's state aligns with existing literature indicating that dogs are capable of detecting physiological stress through their highly sensitive olfactory system (Wilson et al., 2022), and are also able to recognize emotional information from humans through visual and auditory cues (Albuquerque et al., 2016). The training facilitated progress by teaching dogs specific skills how to respond and secondly increasing owners' awareness of their dogs' behavior. Although the effectiveness of the process varied across owner-dog pairs, a growing mutual understanding enabled dogs to assist more effectively in reducing tension during moments of stress. While a previous study has demonstrated the benefits of service dogs for individuals with PTSD describing the trained behaviors 'interrupt and alert to anxiety or distress' and 'calm/comfort to anxiety' as most important (Rodriguez et al., 2020), our conceptual model offers a preliminary framework for understanding the processes underlying this attunement between owner and dog. Additionally, the conceptual model may serve as a framework for future research exploring how companion animals contribute to stress regulation in individuals with PTSD.

Another important improvement that may be linked to the CDSP training was increased engagement in outdoor activities. While participants reported dog ownership already encouraged behavioral activation through regular walks, a finding supported by previous research (Adams et al., 2025; Wu et al., 2017), the CDSP training appeared to further enhance this effect by promoting more joint activities. Participants reported that, due to the skills acquired by both themselves and their dogs, they now engage in more shared activities. This increase was attributed to both enhanced capabilities and a greater willingness to involve the dog, either out of a desire to include the dog or a heightened need for support of the dog. These changes were supported by questionnaire data, which showed a significant improvement in physical health following the CDSP training.

Participants reported that benefits of the CDSP training extended beyond improvements in their dog's behavior to meaningful developments in themselves as dog owners. These included increased self-awareness, a deeper understanding of their dog's supportive potential, and greater insight into how to utilize this support in daily life. Taken together, the reported improvements may have contributed to the observed increase in life satisfaction, as reflected in the questionnaire results.

This study has several limitations that warrant consideration. First, the lack of a control group limits our ability to determine whether the experiences and observed effects were specifically due to the CDSP training or could have resulted from other factors, such as repeated testing. Including a control group that participate with their dogs in an alternative intervention without the targeted training component could help isolate and clarify the specific effects attributable to the CDSP training. Secondly, when interpreting the results, it is important to note that the experiences of participants for whom no post-intervention data were available were excluded from the analysis. This exclusion presents a limitation related to the selective composition of the final sample, which may predominantly reflect the experiences of particularly motivated dog owners. Thirdly, it must be emphasized that the qualitative results are primarily derived from the participants' own perspectives. As such, the findings reflect the self-reported experiences of (former) police officers with PTSD regarding the influence of their companion dog and the CDSP training program. A particularly noteworthy finding is that participants reported their dogs demonstrated more skills after the CDSP training, such as improved recognition of their owner's stress signals. This effect may partly be explained by an increased awareness on the part of the owners themselves. It is plausible that the dogs already exhibited these behaviors prior to the CDSP training, but that the participants became more capable of recognizing and interpreting them as a result of the intervention. This supports the notion that the intervention not only influenced the behavior of the dogs but also enhanced participants' understanding of their dog's capabilities and significance.

While existing literature strongly supports the benefits of trained service dogs for individuals with PTSD (Jensen et al., 2021; O'Haire et al., 2018), there is comparatively little evidence regarding the efficacy of general companion dogs in this context. Studies comparing service dogs to emotional support or companion dogs suggest that the specialized training and task performance of service dogs contribute to more pronounced outcomes (Richerson et al., 2023; Van Houtert et al., 2018). Our findings contribute to this area by demonstrating that even non-service dogs, when involved in targeted training such as the CDSP program, can offer meaningful support to individuals with PTSD. Participants in our study reported improvements in emotion regulation, behavioral activation, and life satisfaction, suggesting that the bond between owner and dog, when strengthened through training, may yield mental health benefits. These results align with broader research on the human-animal bond and its role in psychological resilience (Amiot et al., 2025; Ratschen et al., 2020), while also extending the conversation to include the potential of companion dogs as a more accessible form of support. Importantly, our study highlights that the effectiveness of such training depends on individual factors, including the suitability of the dog and the owner's readiness to engage with the process. This nuance underscores the need for further research to delineate which elements of training and dog-owner dynamics are most critical for achieving positive outcomes with companion dogs.

In conclusion, the reported positive experiences highlight the potential of companion animals as an accessible alternative for police officers coping with PTSD-related stress. With additional training, companion dogs could be a valuable component in PTSD support systems, offering help to individuals who may not have benefitted from conventional treatments and are not eligible for a certified service dog.

Supplementary materials

Theme 1: general dog traits

The first theme, general dog traits, encompasses characteristics typically associated with dogs. Participants described dogs as inherently possessing positive qualities that distinguish them from other beings. While these traits are not directly linked to PTSD assistance, they may form the foundation for it. The dog's intrinsic qualities could explain its ability to provide PTSD-related support (Theme 2). Theme 1 includes three subthemes:

Owner-dog relationship: Participants described the bond between owner and dog as special, strong, and unconditional, often likening the dog to a close friend.

Companionship: Participants valued the comforting companionship dogs provide in their daily lives. Unlike humans, dogs are more consistently present at home and are not bound by external obligations such as work. This constant presence contributes to a sense of warmth and sociability.

Positive traits: Participants did not describe negative traits, instead they highlighted dog's affectionate, cheerful, playful, and social nature.

Theme 2: PTSD support

The second theme examines how dogs enhance the lives of owners with PTSD. The benefits are divided into two interrelated subthemes: 'dog's actions' and 'owner's quality of life improvement'. The dog's various actions contribute to different improvements in the owner's life as described by participants. Important to note here is that the findings reflect the participant's perspective. The dog's actions and the reported improvements in the owner's quality of life are based on the participant's perception. It is therefore possible that the dog behaves differently in practice than how the participant experiences it, and that the perceived improvement is primarily subjective.

Dog's actions

Dogs perform various supportive actions, both passive and active, that can be perceived as supportive within the context of living with PTSD. The first action is categorized as 'dedication to owner', which entails that the mere presence of a dog and daily interactions can be beneficial. This includes being present, physical contact such as petting, hugging or licking, and engaging in activities such as walking or playing. Secondly, participants indicated that the dog's protective behavior contributes meaningfully to their sense of safety. Dogs provide this sense of safety through their (constant) attentiveness to their owner, following their owner, warning their owner (for example by barking when someone enters), and

creating distance between them and other people. Thirdly, the dog has an important role in reducing tension, which was a common experience among participants. The reduction of tension is perceived as a process involving a sequence of actions carried out by the dog. Dogs help alleviate tension through firstly sensing the mood or state of the participant. According to the participants, the dog can recognize certain emotions and behaviors. The second step in reducing tension is that the dog makes the owner aware. The dog mirrors the owner, signaling that something is wrong. According to the participants, this can occur, for example, when the dog starts barking or jumps on the owner. The owner's awareness (about their situation and the dog's reaction) may come later, or does sometimes not occur at all. The third step in reducing tension is that the dog either takes action itself or encourages the owner to do something. The purpose of this action is to reduce tension and pull the owner back to the present moment. For example, the dog may lie next to the owner or lick the owner, which helps the owner calm down. Alternatively, the owner may be encouraged to play or go for a walk with the dog, thereby alleviating the tension.

Owner's quality of life improvement

Dogs improve owners' lives in several ways. First, the dog provides a sense of purpose and meaning in the participant's life. Owning a dog provides a reason to live. Second, the presence of the dog leads to a greater sense of emotional well-being for the participant. Dogs provide uplifted mood, calmness, mental support, sense of safety, and trust or more courage in facing certain situations. They described self-confidence because of the dog and a greater willingness to visit certain places. Third, the participants experience cognitive relief as a result of the dog's presence in several ways, which lead to improved quality of life. The dog's actions helped regulate emotions, with participants reporting that they felt more able to express and manage their feelings. Additionally, the dog provided positive distraction, helping shift attention away from negative thoughts. Participants also noted a reduction in hypervigilance; they felt the dog took over part of their need to remain constantly alert, allowing them to relax more. Finally, the presence of the dog was associated with improved concentration, as participants felt better able to focus when their dog was nearby. Fourth, the dog encourages activity, as the participant is obliged to go outside, which can be difficult for the participant. For example, the participant has to walk the dog, which leads to the participant going outside more often. This is experienced as positive. Dogs necessitate outings which promotes routine, physical exercise, and social interaction during walks.

Theme 3: assistance criteria

The theme assistance criteria identifies necessary conditions for dogs to effectively assist their owners. The criteria are derived from the support conditions explicitly mentioned by participants, as well as from aspects that, according to the participants, are not yet functioning optimally (based on the assumption that improving these aspects would enhance PTSD–related support). These criteria can be linked to elements within Theme 2 'PTSD support': in order to provide or receive specific PTSD support, certain conditions must be met. The criteria appeared across different dimensions, reflected in the subthemes: related to the owner, the dog, and the situation.

Owner-related criteria

This subtheme describes what is required from the owner in order to enable the dog to provide assistance. Firstly, it is essential that the owner has certain knowledge and understands and the behavioral signals of the dog. The dog may try to communicate something (for example, indicating tension), but if the owner does not notice or understand these signals, the support provided by the dog is limited. Additionally, the owner must be aware of their own role in interacting with the dog. For example, participants mention struggling with anger outbursts, which causes them to push the dog away. By recognizing this behavior (and taking steps to address it), they can give the dog the chance to provide support (see Supplements Quote 1). Secondly, owners must recognize their need for assistance of the dog to be able to provide help. If an owner does not believe they need assistance, they may not be open to receiving it, preventing the dog from offering support. Of course, it is also possible that the owner does not require help in a given situation. Thirdly, participants indicated that, in order for the dog to provide effective assistance, the owner must possess two types of capabilities. The owner must be able to recognize the dog's potential to provide support or the potential of the dog to learn how to do so. Participants indicate that they sometimes lack this belief, which makes it more difficult to allow the dog to assist. Additionally, the owner should be able to provide the proper training to the dog, both for teaching a puppy basic skills but also for training in PTSD assistance skills. Participants acknowledged that raising a dog is demanding, especially given their PTSD.

Dog-related criteria

This subtheme outlines the characteristics and skills required from the dog in order to provide effective assistance. Before discussing the dog's traits and skills, it is important to consider unchangeable factors that may influence them. Participants noted that breed and age influence trainability and suitability.

In practice, these factors may be relevant when deciding which type of dog to acquire, or may retrospectively help explain why training efforts may not always have been successful.

According to the participants, the dog must possess various commitment traits that ensure it is truly present for the owner. Ideally, the dog should consistently be available to support the owner, even in the presence of distracting or disruptive factors. To support a dog should avoid being disruptive, maintain focus at owner, and obey commands. These traits may be more difficult to develop or train in younger dogs or certain breeds. Secondly, the dog must be capable to protect the owner. This requires specific skills, which can be trained, but it is also important to recognize that this depends on factors such as breed and age. For example, smaller dogs may have more difficulty providing protection. The third variation within the assistance criteria related to the dog concerns 'tension-reduction abilities'. Participants indicate the dog must possess specific abilities to help reduce the owner's tension, which is considered a prerequisite for effectively navigating the stress reduction process (as described under Theme 2: PTSD support, Dog's actions). To be able to reduce tension, the dog should recognize the tension, be able to indicate to the owner that there is tension, and respond appropriately (Figure 3). With indicating the tension, the dog should make the owner aware of the tension by signaling it in a specific way. However, the owner also plays a role in this process, as they need to recognize and understand these signals.

Within the overview (Figure 1), there is a variation that is linked to both the subtheme 'owner-related criteria' and 'dog-related criteria'. This variation, referred to as 'owner-dog bond', highlights that a strong bond between the owner and the dog is essential to optimize support. Participants indicated that when this bond is well-established, the dog is able to provide more effective assistance.

Situational criteria

The subtheme 'situational criteria' describes what is required from the situation (environment, location) in order to enable the dog to provide assistance. Some environments restrict dogs, limiting their role. There are also situations where it is not possible to bring the dog, for example a high building without an elevator. In situations where the dog is not allowed or where it is not possible to bring the dog, the dog can not provide support. As a result, the participant are sometimes forced to avoid certain situations. Additionally, owners must feel comfortable bringing their dog into specific settings, for example a loud environment or their bedroom. Participants considered certain situations unsuitable for bringing the dog, which prevents the dog from providing support.

Theme 4: intervention outcome

This theme reflects post-training improvements as perceived by participants. While subjective, these insights highlight key perceived intervention effects.

Increased owner knowledge

Participants indicated that the intervention enhanced their knowledge across various domains (see Supplements Quote 2). Firstly, participants reported that the intervention increased their awareness of the value their dog (already) provides. They developed greater insight into their dog's role in their well-being and potential as service animal. They learned more about the capabilities of their current dog, as well as a better understanding of the potential benefits a trained service dog could offer in the future. A second aspect of increased owner knowledge is enhanced self-awareness. Participants indicated that the intervention led to greater insight into their own behaviors, particularly in their interactions with their dog. A third aspect is improved understanding of the dog. Participants noted that the CDSP training enabled them to better interpret their dog's signals and behaviors. This improved ability to 'read' their dog allows them to recognize when the dog is attempting to communicate, which can facilitate the provision of support (see Supplements Quote 3). Through the CDSP training, owners also gained a better understanding of how to teach their dog new skills. Participants reported that they received practical tools for independently training their dog in the future, which may further enhance the dog's ability to provide support.

Enhanced dog effectiveness

The participants reported that their dog contributes more effectively to their daily lives. It is important to note that it could be the participants think the dog's skills are improved but that the skills remained the same and they simply paid more attention to it. According to the participants, the commitment-related qualities of the dog improved as a result of spending significant time together during the CDSP training and learning to work as a team. Owners reported that the dogs became less disruptive, more focused on the owner, and more obedient. Additionally, participants indicated that the dog acquired skills that enable it to better protect the owner. One important skill learned is 'blocking', in which the dog positions itself between the owner and other to create a physical barrier (see Supplements Quote 4). The third aspect of increased dog effectiveness concerns the perceived improvement of stress reduction skills. These skills were previously described under the subthemes 'Dog's actions' (Theme 2: PTSD support) and 'Dog-related criteria' (Theme 3: assistance criteria). Firstly, after the CDSP training the owners report that their dog is better able to detect signs of tension in them.

There is no clear distinction made between improvement in recognizing tension and indicating tension (as is made in Figure 3), as participants generally reported that the dog's signaling abilities have improved. Secondly, owners noted that after the CDSP training, the dog is better able to perform the appropriate actions to reduce their tension.

Strengthened owner-dog bond

Participants felt that participating in the CDSP training with their dog strengthened their bond. They attributed this to spending more time together and learning how to work as a team. Additionally, participants indicated that, as a result of the skills learned by both owner and dog, they now engage in more joint activities. This is partly because increased knowledge and skills have made more activities possible, but also because the owner is more willing to involve the dog, either by wanting to bring the dog along or due to an increased need for support (see Supplements Quote 5).

Independent theme 1: practical benefits of a companion dog vs. service dog

This theme highlights that owning a companion dog may have advantages over a trained service dog as described by the participants.

Ease of acquisition

Obtaining a companion dog is generally easier than acquiring a trained service dog. Participants noted that eligibility for a service dog typically requires severe PTSD symptoms, the trained service dogs are expensive for the police organization, and there are long waiting lists.

Freedom to be a dog

Participants indicated that they highly value a dog's freedom. For example, they believe it is important that a dog can play freely and be social. Trained service dogs are largely at the service of their owner, which is not always preferred by participants. A companion dog generally has more freedom, which is seen as a positive aspect.

Effective enough

Participants reported that a companion dog already provides sufficient support, making a trained service dog not needed in their view. The theme of 'PTSD support' further illustrates that participants experience substantial benefits from having a companion dog.

Undifferentiated public perception

Participants indicated that owning a companion dog does not outwardly signal their PTSD to others. In contrast, a trained service dog typically wears a special vest, making it apparent to the public that the owner may have a condition. Several participants expressed a preferences for a companion dog for this reason, as they do not wish their mental health status to be visible to others. However, the opposite perspective was also present among some participants. For these individuals, the approachable image of a companion dog can be uncomfortable, as it may invite unwanted social interactions. In such cases, a service dog's vest can serve as a useful signal to keep others at a distance. Thus, participants described both advantages and disadvantages to having a certified dog with a vest.

Independent theme 2: considerations for future participants

The interviews revealed several factors that could play a role in the decision to participate in the CDSP training. These considerations are based on the experiences and conclusions drawn after completing the CDSP training and may provide valuable guidance for prospective participants when deciding whether to enroll in the future. It is important to note that these findings reflect what the participant themselves perceive as effective. No empirical evaluation was conducted to determine whether enhancing these aspects would improve training outcomes.

Training effectiveness

The effectiveness of the CDSP training depended on the suitability of the dog, as participants retrospectively recognized that certain dogs may not be capable of performing specific tasks. For example, older dogs may be unable to jump onto a bed to wake their owner, and smaller dogs may not be able to create sufficient distance between their owner and others. A second determinant of training effectiveness is the extent to which the training alighns with the participant's needs. The CDSP training comprises various components and exercises, not all of which may be relevant for every individual. More information on the content of the CDSP training in advance could be beneficial to make an informed decision about participation. A third factor is the applicability of the training components in daily life. While certain exercises may be successfully performed during training sessions, participants reported difficulties implementing them at home for various reasons. Finally, participants perceived the CDSP training as relatively short and expressed a desire for more or longer sessions to maximize its benefits. Extending the CDSP training may enhance its effectiveness and applicability in daily life according to the participants.

Prior knowledge

Some participants reported that they were already familiar with certain components of the CDSP training or had already taught these skills to their dog, rendering parts of the training redundant for them. It is therefore important to consider the prior knowledge of (prospective) participants when deciding whether to enroll in the CDSP training.

Personal challenge

Firstly, the presence of peers (other participants and their dogs) was generally valued for the understanding, support, and assistance it provided. However, some participants also found the group setting to be a source of restlessness or tension. Secondly, the CDSP training was generally described as exhausting (varying degrees from person to person), and participants often required one or more days to recover after a training session (see Supplements Quote 6). Finally, the quality of facilities were perceived as high, with some exceptions, and the trainers were regarded as highly supportive and understanding.

Table S1 Breeds of the companion dogs

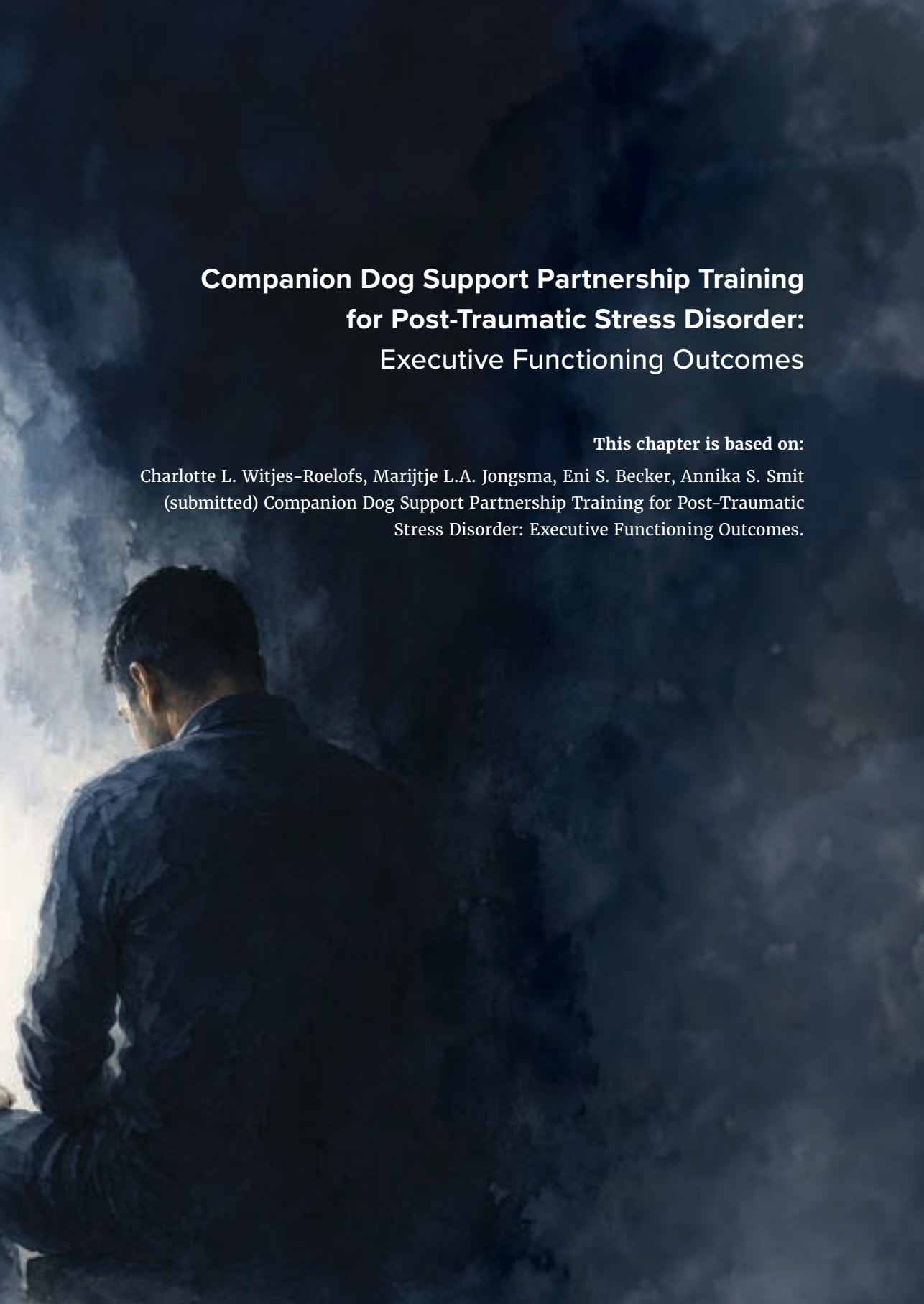
Groups of breeds	**Count**
Sheepdogs and Cattledogs	11
Pinchers, Schnauzers, Molossoid and Swiss Mountain dogs	2
Pointing dogs	3
Retrievers, Flushing Dogs, Water dogs	3
Companion and toy dogs	4
Labrador retriever crossbreed	4
Crossbreed other than labrador retriever	2

Table S2 Demographics included group and drop-out group

	Included (n = 28)	**Drop-out (n = 17)**	**Difference (p-value)**
Male/female	15/13	9/8	0.883
Age	51.0 (8.7)	49.2 (10.3)	0.558
Satisfaction with life scale	18.3 (5.0)	18.2 (5.7)	0.715
State anxiety	14.6 (3.2)	15.9 (4.2)	0.195
Quality of life			
Physical health	10.6 (2.5)	10.3 (2.5)	0.694
Psychological health	12.2 (1.8)	12.1 (2.5)	0.986
Social relationships	12.9 (3.6)	14.9 (3.2)	0.120
Environment	14.9 (3.2)	14.4 (2.4)	0.684

Note. Mean (SD)

Chapter 6



Companion Dog Support Partnership Training for Post-Traumatic Stress Disorder: Executive Functioning Outcomes

This chapter is based on:

Charlotte L. Witjes-Roelofs, Marijtje L.A. Jongsma, Eni S. Becker, Annika S. Smit (submitted) Companion Dog Support Partnership Training for Post-Traumatic Stress Disorder: Executive Functioning Outcomes.

Abstract

This study examined whether the Companion Dog Support Partnership (CDSP) training for police officers with PTSD and their companion dogs could enhance PTSD-related support and normalize executive functioning. Twenty-five officers completed behavioral and EEG assessments before and six months after the CDSP training, under conditions with and without their dog present. While no changes were observed in attentional bias, participants consistently exhibited an attentional bias toward angry faces. Notably, working memory performance improved in the presence of the dog, as evidenced by better scores and increased P3 ERP component amplitudes during a 1-back task, suggesting a stress-buffering effect of dog presence. The absence of significant training effects may be attributed to the limited sample size. The findings support the potential of companion dogs to enhance working memory performance in individuals with PTSD. Future research with larger samples is warranted to validate this effect and explore the role of companion dogs as an accessible form of support for PTSD.

Introduction

First responders such as police officers are at increased risk of developing post-traumatic stress disorder (PTSD) due to repeated exposure to traumatic events (Skogstad et al., 2013; Syed et al., 2020). PTSD is linked to difficulties in both executive and affective functioning. Research shows that working memory is an important domain of impairment in individuals with PTSD (Honzel et al., 2014). Multiple PTSD symptoms can be linked to changes in attentional processing, including attentional bias towards threat and hypervigilance (Scott et al., 2015). In individuals with PTSD, the suppression of intrusive memories demands substantial inhibitory control, thereby depleting cognitive resources available for other executive functions, such as working memory (Bomyea et al., 2012). Hyperactivity of the amygdala in PTSD (Luethi et al., 2009) requires more regulation from the prefrontal cortex, which limits cognitive resources (Salzman & Fusi, 2010). In sum, chronic stress in PTSD reduces prefrontal cortex resources available for executive functions such as working memory and attention.

Persistent stress is associated with decreased executive functioning in individuals with PTSD (Woon et al., 2017). Interventions that reduce stress responses may help restore executive functions. The presence of a dog can buffer stress and lower amygdala activity following stressful events. This buffering may free up prefrontal resources, helping to restore executive functioning. In our previous study, service dog presence was linked to improved working memory in police officers with PTSD (Witjes-Roelofs et al., 2025). Service dogs have also shown promise in reducing PTSD symptoms and improving well-being (Rodriguez et al., 2020; Yarborough et al., 2018). However, their availability is limited due to high costs and intensive training (Krause-Parello et al., 2016). By exploring a form between a companion dog and a fully trained service dog, this study aims to provide a more accessible animal-assisted intervention for individuals with persistent PTSD. The current study investigates whether companion dogs, after short training, can offer similar cognitive benefits as service dogs for police officers with PTSD. The companion dogs that officers already owned were trained to provide PTSD-related support. Involving the owner in the process aimed to enhance agency (Bergen-Cico et al., 2018; Kloep et al., 2017; Whitworth et al., 2019).

To explore whether companion dogs, following brief training, can provide cognitive support comparable to that of certified service dogs (Witjes-Roelofs et al., 2025), it is essential to identify sensitive measures of cognitive functioning that capture the psychological challenges associated with PTSD. Given the impact of PTSD on executive functioning skills such as making decisions, controlling impulses and emotions, and focusing attention (Flaks et al., 2014; Ouhmad et al., 2024), attentional bias and working memory may be particularly relevant

measures. These skills not only reflect core executive functioning problems in PTSD (Ouhmad et al., 2024) but may also offer insight into potential effects of canine-assisted interventions.

Attentional bias is the tendency to preferentially attend to certain types of stimuli over others. Individuals with PTSD often exhibit heightened sensitivity to perceived threats, even in safe environments (Kredlow et al., 2022). The chronic stress in PTSD leads to deficits in executive functioning, among others, a dysregulation of attention, e.g., a bias toward threatening stimuli, such as angry faces. Such a bias contributes to the maintenance of PTSD symptoms by reinforcing hypervigilance (Bar-Haim et al., 2010). Facial expressions are ecologically valid and emotionally salient stimuli for probing attentional bias (Leyman et al., 2011). Threat-related expressions are processed rapidly and automatically, which makes them suitable for assessing threat-related attentional biases in PTSD. Threat-related attentional bias can be measured using a dot-probe task (Bradley et al., 1998). In this task, a fixation cross precedes a brief (250 - 1000 ms) simultaneous presentation of two types of stimuli (e.g., one neutral face picture and one angry face picture). Following an interstimulus interval, a probe (e.g., a dot) is presented in the spatial location of one of these stimuli. The participants are asked to respond to the probe as quickly as possible by indicating its location. When the participants attend to the image of an angry face, they exhibit faster reaction times in trials where the probe replaces the angry face (congruent trial), and slower reaction times when the probe replaces the neutral face (incongruent trial), and vice versa. By presenting pairs of angry and neutral faces followed by a probe, the task captures shifts in attention toward or away from threat-related stimuli. Reaction times to the probe function as an indirect measure of attentional allocation, enabling inferences regarding whether attention was directed toward or diverted away from the emotional stimulus. In this study, we investigate whether the presence of a dog reduces attentional bias to angry faces in individuals with PTSD, and whether a brief training intervention for the owner and dog amplifies this effect. Research suggests that the calming presence of dogs is associated with reductions in physiological stress (Meixner & Kotrschal, 2022), which may attenuate amygdala hyperactivity. This buffering effect may free up prefrontal resources, enhancing top-down attentional control and reducing automatic vigilance toward threat-related cues. As a result, individuals may exhibit less attentional bias toward angry faces. This effect may be amplified following the training intervention. Post-training, the dog may have a more pronounced stress reducing effect, potentially resulting in a greater attenuation of attentional bias toward angry facial expressions.

In addition to attentional bias, PTSD is associated with deficits in working memory (Bomyea et al., 2012; Honzel et al., 2014). Working memory is the ability to temporarily hold and manipulate information. Assessing working memory in PTSD provides insights into the cognitive mechanisms underlying the disorder. The n-back task offers a measure of working memory, requiring continuous monitoring, updating, and comparison of stimuli, functions that rely heavily on prefrontal cortical resources (León-Domínguez et al., 2015). Prior research has shown that individuals with PTSD exhibit reduced accuracy and increased reaction times on n-back tasks, reflecting diminished working memory performance (Weber et al., 2005). The 1-back task is a validated paradigm for probing working memory in both healthy and clinical populations (Hepdarcan & Can, 2025; Nikolin et al., 2021). It requires participants to continuously monitor a stream of stimuli and identify repetitions based on a one-item delay, engaging both maintenance and updating processes. Compared to higher-load versions (e.g., 2-back or 3-back), the 1-back task offers a manageable cognitive challenge that remains sensitive to subtle impairments, making it especially suitable for individuals with PTSD who may be overwhelmed by more demanding tasks. Moreover, its simplicity and use of neutral stimuli (letters or numbers) reduce confounding factors, allowing for a more precise evaluation of working memory capacity without emotional interference. Its inclusion in the present study allows for a complementary assessment of cognitive functioning alongside attentional bias, providing a more comprehensive picture of how PTSD may affect executive functioning.

In this study, we investigate whether the presence of a dog improves executive functioning in police officers with PTSD, and whether a brief training intervention for the owner and dog amplifies this effect. We hypothesized that police officers with PTSD show a better performance on the working memory task and less attentional bias to angry faces with their companion dog present than absent. Furthermore, we expected that this effect would be more pronounced following CDSP training, reflecting post-training improvements in working memory performance and reduced attentional bias toward angry faces in the presence of the dog.

To determine changes in covert behavior related to working memory performance and attentional bias following the training, we examined event-related potentials (ERPs) extracted from electroencephalogram (EEG) recordings during the working memory task and the dot-probe task with angry faces (Veltmeyer et al., 2009). ERPs are the averaged brain responses time-locked to a specific event and are characterized by positive and negative peaks labeled with a letter indicating the polarity, followed by a number indicating the order in which they appear. Among the ERP components, the N2 and P3 component

amplitudes have been reliably associated with WM function (Peng et al., 2020; Stroux et al., 2016). Enhanced working memory performance would be reflected in higher scores on the 1-back task and increased amplitudes in both the N2 and P3 ERP components. The N2 component is a negative wave reaching maximum amplitude between 200 ms and 350 ms post-stimulus and is assumed to be an indicator of inhibition, feedback processing, and conflict monitoring (Miller et al., 2021). The P3 is a positive component reaching a maximum amplitude between 300 ms and 500 ms post-stimulus and has been associated with attention allocation and memory updating (Patel & Azzam, 2005). The P3 has also been related to attentional processing, with larger amplitudes observed in response to emotionally salient content of attended stimuli (Polich, 2007; Torrence & Troup, 2018). Additionally, the occipital N170 ERP component has been linked to emotional facial expressions, eliciting a larger amplitude to angry and happy faces compared with neutral faces (Hinojosa et al., 2015). In addition, it has been reported that PTSD patients show enhanced N170 amplitudes in response to angry faces, relative to healthy controls (Schneider et al., 2019).

We hypothesized that police officers with PTSD would demonstrate reduced attentional bias towards angry faces in the presence of their companion dog compared with its absence, as reflected by a smaller difference in reaction times between incongruent and congruent trials and a smaller N170 amplitude in response to angry face pairs. It was expected that the presence of the dog after CDSP training would lead to a further reduction in attentional bias to angry faces, as demonstrated by a smaller difference in reaction time between congruent and incongruent trials, and a smaller N170 amplitude when the dog is present compared with when the dog is absent after training. Additionally, we hypothesized that individuals with PTSD would show larger N2 and P3 amplitudes in response to angry-neutral face pairs compared with neutral-neutral face pairs, reflecting increased attentional engagement and emotional evaluation of threat stimuli. Furthermore, we hypothesized that police officers with PTSD would demonstrate improved working memory performance in the presence of their companion dog, as reflected in better scores (faster RTs and higher accuracy) on the 1-back task and increased amplitudes of the N2 and the P3 ERP components in response to target stimuli. This effect was expected to be enhanced following CDSP training.

Methods

Participants

The participants were recruited through internal communication within the Dutch police organization. All participants provided written informed consent. The study has been reviewed independently by the Ethics Committee Social Sciences (ECSS) of the Radboud University and there is no formal objection to this study (ECSW-2020-012). To be included in the PTSD group, participants needed to have a work-related PTSD diagnosis, have finished at least one type of treatment, own a companion dog for at least six months, and be or have been employed within the police force.

The CDSP training had 45 participants filling almost all 48 available spots. 42 participants completed the training. Of those, 25 completed the full pre- and post-measurement. One participant of the CDSP training declined in advance to complete the measurements, and one participant was enrolled in the training just after the premeasurements took place. Drop-out reasons included unavailability to attend posttest (n=6), technical difficulties during posttest (n=2), dissatisfaction with the training not meeting their expectations (n=1), health conditions that prevented them from completing the posttest (n=4), not owning the dog anymore at the time of the posttest (n=3), or another reason (n=2). The drop-out group pre-test did not differ statistically from the included group pre-test on any of the demographics or behavioral data (see Table 1). Participants included in the study were 13 men and 12 women, mean age = 50.6 years old, SD = 8.2. 19 out of 25 were still employed within the police organization. Of the 25 participants that were included in the analysis, the majority did not use PTSD-symptom related medication, though 10 participants did use PTSD-symptom related medication such as sleep medication, antidepressants, anxiolytics, or antipsychotics.

Table 1 Demographics included group and drop-out group

	Included (n = 25)	Drop-out (n = 20)	Difference (p-value)
Male/female	13/12	11/9	.846
Age	50.6 (8.2)	50.0 (10.7)	.832
Dog present			
IES	567.0 (170.8)	581.2 (229.5)	.814
RT congruent trials	573.4 (177.5)	575.0 (210.1)	.978
RT incongruent trials	606.0 (225.1)	591.8 (223.5)	.835
RT neutral trials	608.49 (188.2)	618.6 (314.3)	.895
Dog absent			
IES	591.4 (236.2)	624.6 (242.8)	.650
RT congruent trials	514.93 (162.7)	646.3 (279.7)	.110
RT incongruent trials	538.20 (193.0)	638.30 (274.0)	.320
RT neutral trials	509.73 (170.8)	629.16 (260.2)	.152

Note. Mean (SD)

Training

The Companion Dog Support Partnership (CDSP) training program is a short-term intervention designed to enhance the supportive role of companion dogs for individuals diagnosed with PTSD. The CDSP training was taught by the KNGF (The Royal Dutch Guide Dog Foundation: KNGF Geleidehonden), which trains e.g. guide dogs for visually impaired people, and service dogs for veterans and policeofficers with PTSD. The service dogs are usually trained to the user's specific needs: e.g. waking up its owner in the early stages of a nightmare, ensuring sufficient personal space by preventing other people to come to close, and acting as a accompanying buddy.

The CDSP training program consists of six weekly group sessions, each lasting approximately 3 hours (including lunch), facilitated by a certified PTSD service dog trainer from the KNGF, in groups of eight dog owners with PTSD and their companion dogs. Sessions include practical exercises, psychoeducation, and guided interactions between participants and their dogs. The CDSP program aims to explore the feasibility and potential benefits of using partially trained companion dogs as a more accessible alternative to fully trained assistance dogs.

The training was open to dogs of all breeds, with dogs screened in advance to ensure they were sociable with other dogs and had the appropriate temperament to learn the necessary skills. Given the brief duration of the CDSP training, its primary focus was on teaching owners how to train their dogs in essential

service dog skills. The primary goals of the CDSP training, as outlined by the organizing body, were to provide insight into understanding the body language of the participants' dogs, and to teach how to train the dogs in PTSD-related skills to better assist their owners in managing stress and emotions. Another key objective was to help owners gain a deeper understanding of their dogs' behavior, enhancing their ability to communicate and work together effectively. Specific skills that were focused on included waking the owner from nightmares, responding to the owner's mood, and blocking i.e. positioning themselves to create space between the owner and others.

Procedure

The study has been preregistered (Part A: doi.org/10.17605/OSF.IO/DA3M8) and is part of a larger project using also a qualitative approach. The complete experiment, including EEG preparation, lasted approximately one hour. The experiment consisted of two conditions, one with the dog present and one with the dog absent. The recording of each condition lasted approximately 20 minutes. Conditions were not counterbalanced to be able to compare results to the previous study with the same research design (Smit et al., 2022; Witjes-Roelofs et al., 2025). At the start of both EEG tasks, instructions were provided both verbally by the researcher and presented on-screen as text. Both tasks were programmed using Presentation software (Version 17.0, Neurobehavioral Systems, Inc., Berkeley, CA, www.neurobs.com) and displayed on a 14-inch laptop screen. Participants were given the option to take breaks between experiments and sessions, though few chose to do so. When participants performed the tasks without the dog, the dog was cared for in a separate room by either an accompanying relative or a second researcher.

Measures

Working memory task

During the 1-back task, participants pressed a key when the stimulus of the current trial matched the stimulus one step back (1-back). Stimuli included nine digits (1–9) or nine letters (A-H, K), displayed in white (20 pt) on a black background. The stimuli were presented sequentially for 500 ms followed by 2000 ms of black screen. The participants completed one digit and one letter task (counterbalanced). The task consisted of 96 trials; 32 targets and 64 background stimuli, with pseudo-randomized sequences, lasting ~5 minutes. Data analysis included calculation of the Inverse Efficiency Score (IES) (Bruyer & Brysbaert, 2011) by dividing the reaction time by the proportion of correct responses. In addition, the Event-Related Potentials (ERPs) for both target and background stimuli were extracted from the EEG.

Attentional bias task

Stimuli of the dot-probe task consisted of 16 neutral–neutral and 36 angry–neutral picture pairs and were obtained from the RADIATE database (Conley et al., 2018). Each trial started with a white fixation cue (+) in the centre of a black screen for a random amount of time between 1000 and 2000 ms. Two faces were presented simultaneously on the horizontal axis for 500 ms. The target dot appeared immediately after the faces disappeared. The objective of the dot-probe task was to select the key corresponding to the location on the screen (left or right) where the dot-probe appeared as quickly as possible. The time between when the dot presentation and key press was recorded in milliseconds. The task included congruent trials (dot at the same side as the angry face), incongruent trials (dot at the side of the neutral face), and baseline trials (two neutral faces). Incorrect responses were excluded from the analysis.

EEG recording and preprocessing

The EEG setup utilized the BrainProducts ActiCap 32-channel active EEG system, positioned according to the 10-20 system standard electrode placements. In the current study, we used 32 electrodes for recording, including the electro-oculogram located below and lateral of the outer canthus of the left eye, and a reference on the left mastoid and a ground electrode on AFz. The electrode-scalp impedance was reduced to less than 20 kΩ for all electrodes. EEG data were recorded at a 500 Hz sampling rate using an amplifier with an input impedance of 10 MΩ. Offline data analysis was conducted using Brain Vision Analyzer (BrainVision Analyzer, Version 2.2.0, Brain Products GmbH, Gilching, Germany). The data were digitally filtered with 0.5 Hz high pass and 30 Hz low pass filters. ERP segments were set from 250 ms before stimulus onset until 750 ms after stimulus onset. Following segmentation, a DC detrend, and a Gratton & Coles ocular correction without raw average subtraction were applied. We excluded segments containing incorrect responses (false hits, misses), segments with an amplitude exceeding ±100 µV, and segments with activity below 0.5 µV for 100 ms or more from further analyses. Lastly, a 100 ms baseline correction was applied. We obtained ERPs by averaging segments separately for each type of stimuli. Fixed time windows were defined for the ERP components based on the combined data from both groups in an across-condition grand average, following the recommended approach in the literature (Kappenman & Luck, 2016).

For the working memory task, we calculated the average amplitude of the ERP N2 component within a fixed latency window of 200-300 ms on electrodes Fz, Cz, Pz, and Oz. Similarly, the average amplitude of the ERP P3 component was determined within the fixed latency window of 380-480 ms on electrodes Fz, Cz,

Pz, and Oz. For ERPs to the faces of the attentional bias task, we analyzed the N170 (electrode P7, P8) in the window of 150–170 ms, and the N2 (240–290 ms) and P3 (330–430 ms) component on electrodes Fz, Cz, Pz, and Oz.

Statistical analyses

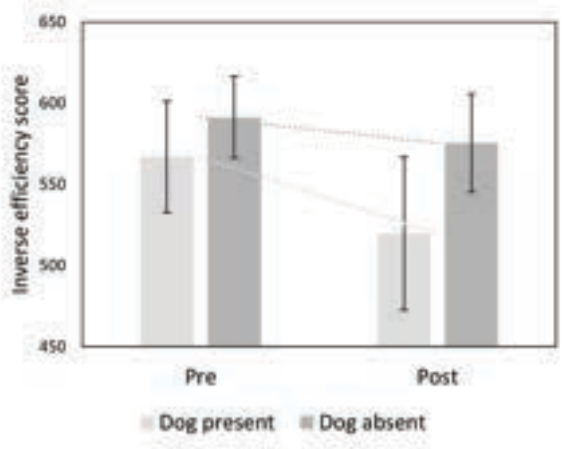
The statistical analysis was performed using IBM SPSS Statistics (Version 27). To examine differences in working memory task performance, we conducted a repeated measures Generalized Linear Model (GLM) analysis on the inverse efficiency score (IES) with within-subjects factors of training (pre vs. post) and condition (presence or absence of dog). On the N2 and P3 component amplitudes two GLM analyses were performed with training (pre vs. post), condition (dog present vs. absent), trial type (background vs. target), and electrode (Fz, Cz, Pz, Oz) as the within-subject variables. To analyze attentional bias, a GLM was performed on the average reaction times per stimulus category (congruent vs. incongruent) with within-subjects factors of training (pre vs. post) and condition (presence vs. absence of dog). The analysis on the N170 amplitude of the ERPs to the faces was done on the average amplitude of electrode P7 and P8. This N170 amplitude, the N2 amplitude and the P3 amplitudes to the presentation of the face were analyzed with GLM's including training (pre vs. post), condition (dog present vs. absent), emotion of the presented stimulus pair (neutral-neutral vs. angry-neutral), and electrode (Fz, Cz, Pz, Oz) as the within-subject variables. When the assumption of sphericity was violated, we used the Greenhouse-Geisser correction. Significant interactions were followed up using t-tests.

Results

Performance on the working memory task

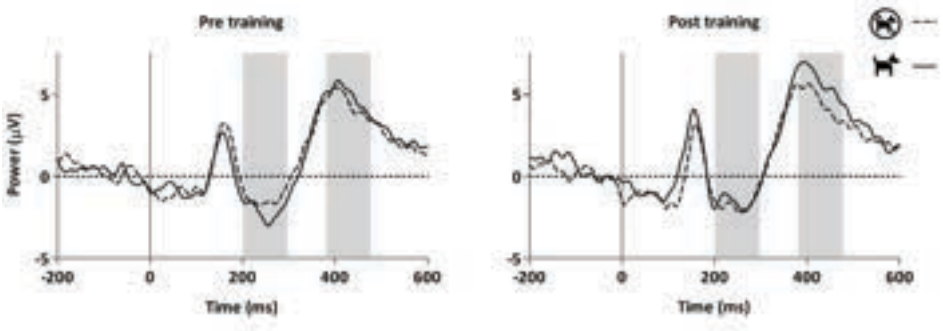
Analysis of the inverse efficiency score on the 1-back task showed no interaction effect $F(1, 24) = 0.90$, $p = .35$, $\eta 2 = .04$ and no main effect of training, $F(1, 24) = 1.27$, $p = .27$, $\eta 2 = 0.05$. However, we found a main effect of dog presence, $F(1, 24) = 9.12$, $p = .006$, $\eta 2 = .28$, with better performance (lower IES) in the dog present condition (Figure 1).

Figure 1 Inverse efficiency score on the 1-back task



Note. Inverse efficiency score (IES) with SEM before and after the training in the two conditions (dog present and dog absent). Lower IES represents better performance.

Figure 2 Event related potentials of 1-back task



Note. Grand average ERPs on electrode Cz for the target stimuli, shown for pre-training (left) and post-training (right). The solid line represents the dog present condition, while the dashed line represents the dog absent condition. The first shaded region (200-300 ms) indicates the N2 ERP component, and the second shaded region (380-480 ms) marks the P3 ERP component.

ERP component amplitudes on 1-back task

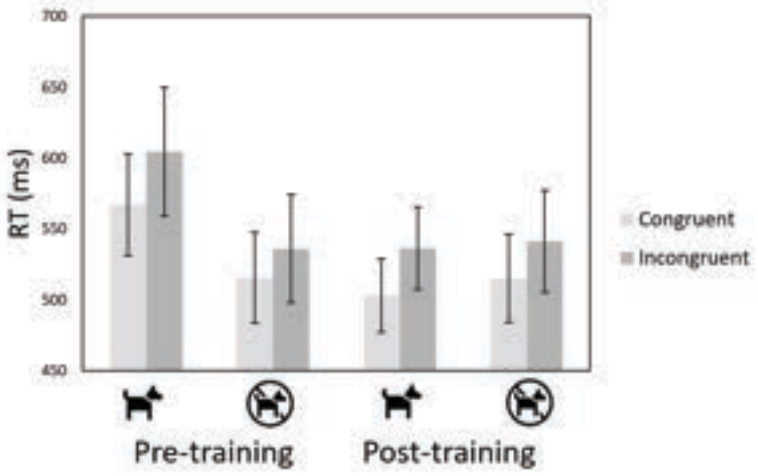
The GLM analysis of the mean amplitude of the N2 component (200-300 ms) showed a significant interaction between electrode and stimulus, $F(2, 23) = 23.09$, $p < .001$, $\eta 2 = .49$, as well as a significant effect of stimulus, $F(1, 24) = 33.67$, $p < .001$, $\eta^2 = .58$ (Figure 2). The N2 amplitude was larger (more negative) for target stimuli than for background stimuli at electrode Fz, Cz, and Pz. No other significant interactions were observed ($p > .20$). Additionally, there were no significant main effects of condition, $F(1, 24) = 0.25$, $p = .620$, $\eta^2 = .01$, or training, $F(1, 24) = 0.22$, $p = .646$, $\eta^2 = .01$.

The GLM on the ERP P3 component amplitude (380–480 ms) showed an interaction effect of electrode x stimulus, $F(2, 52) = 10.07$, $p < .001$, $\eta^2 = .30$, with a higher P3 amplitude to target than background stimuli on Fz, Pz, and Oz (Figure 2). The interaction of condition x training was not statistically significant, $F(1, 24) = 2.04$, $p = .17$, $\eta^2 = .08$. There were significant main effects of electrode, $F(2, 53) = 29.71$, $p < .001$, $\eta^2 = .55$, and stimulus, $F(1, 24) = 12.88$, $p = .001$, $\eta^2 = .35$. Additionally, a significant main effect of condition was found, $F(1, 24) = 12.99$, $p = .001$, $\eta 2 = .35$, with a higher P3 amplitude when the dog was present compared to when the dog was absent. No main effect of training was found, $F(1, 24) = 0.29$, $p = .598$, $\eta 2 = .01$.

Attentional bias on the dot-probe task

The GLM on the reaction times indicated a significant main effect of stimulus, $F(1, 23) = 11.97$, $p = .002$, $\eta^2 = .34$, with a slower reaction times to incongruent stimuli compared to congruent stimuli (Figure 3). There were no main effects of training, $F(1, 23)=1.21$, $p = .282$, $\eta^2 = .05$, or condition $F(1,23) = 1.83$, $p = .190$, $\eta^2 = .07$. The interaction of training x condition did not reach statistical significance $F(1, 23) = 3.90$, $p = .061$, $\eta^2 = .15$. The interactions training x stimulus, condition x stimulus, and training x condition x stimulus were also all not significant ($p > .44$).

Figure 3 Reaction times on dot-probe task

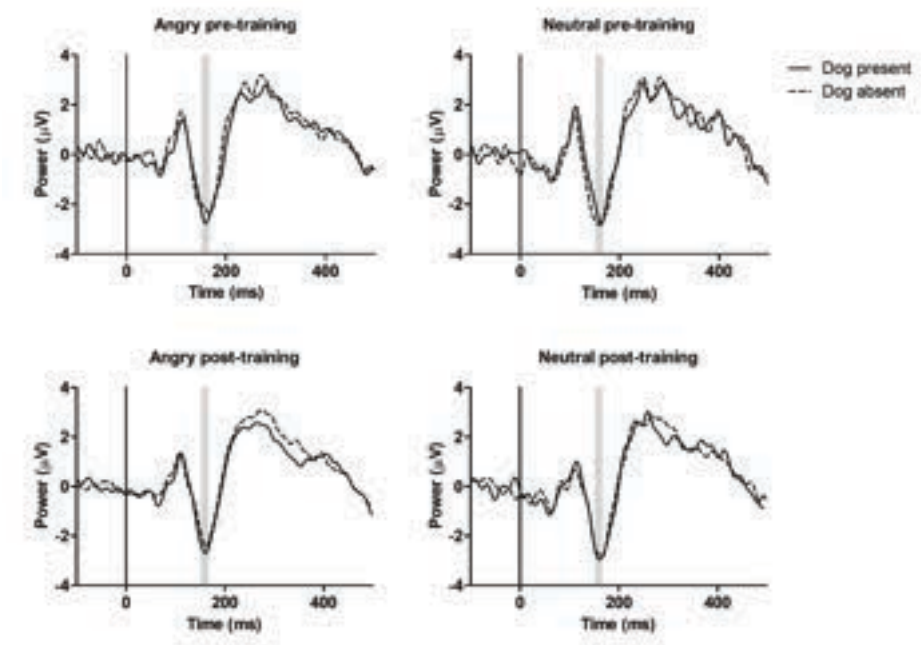


Note. Reaction times to the dot on congruent trials (where the dot appeared behind the angry face in an angry-neutral trail) on incongruent trials (where the dot appeared behind the neutral face in an angry-neutral trial). The conditions dog present and dog absent are depicted on the x-axis for both pre-training and post-training.

ERP component amplitudes to face pairs

The grand average ERP waveform is presented in Figure 4. The GLM on the mean amplitude of the N170 component (150–170 ms) in response to the face stimuli, calculated across electrode P7 and P8, revealed no significant effects. No significant interaction effects were found of condition x emotion, $F(1, 23) = 3.47$, $p = .075$, $\eta^2 = .13$, training x condition, $F(1, 23) = 1.79$, $p = .194$, $\eta^2 = .07$, training x emotion, $F(1, 23) = 0.28$, $p = .600$, $\eta^2 = .01$, and training x condition x emotion, $F(1, 23) = 0.00$, $p = .963$, $\eta^2 = .00$, and no significant main effects were found of training, condition, or emotion ($p > .27$).

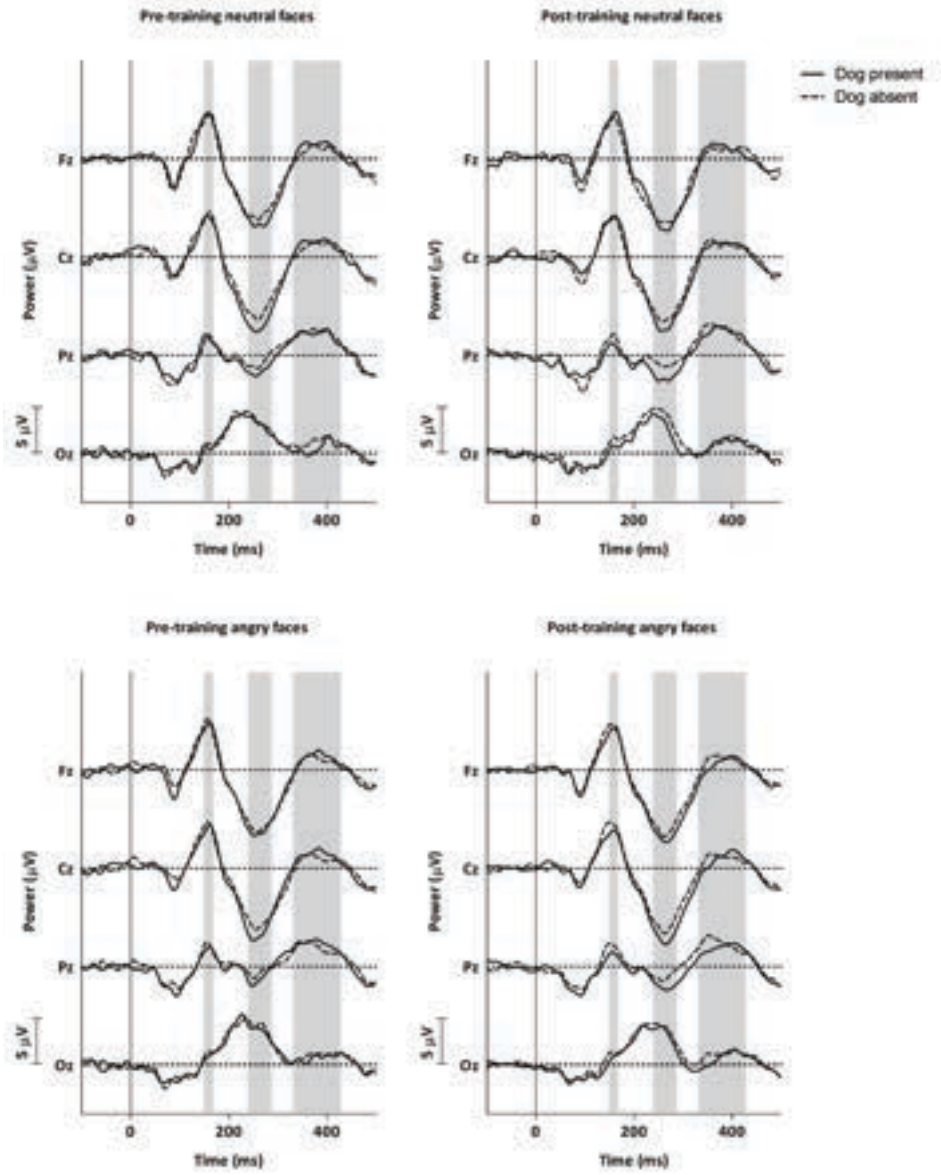
Figure 4 Average event related potential of electrode P7 and P8 together of the dot-probe task



Note. Grand average ERPs aligned with face-pair presentation at 0 ms are displayed for pre-training (left) and post-training (right) for the neutral-neutral (top) and angry-neutral (bottom) face-pairs. The first shaded region (150-170 ms) highlights the N170 ERP component.

The GLM analysis on the N2 amplitudes (240–290 ms) in response to the face stimuli revealed no significant interactions among all factors, including no interactions with electrode (all $p > .17$). No significant main effects were observed of training, condition or emotion (all $p > .54$). There was a significant main effect of electrode, $F(1,28) = 80.06$, $p < .001$, $\eta^2 = .78$. The grand average ERP waveforms are presented in Figure 5.

Figure 5 Event related potentials of the dot-probe task



Note. Grand average ERPs aligned with face-pair presentation at 0 ms are displayed for pre-training (left) and post-training (right) for the neutral-neutral (top) and angry-neutral (bottom) face-pairs. The first shaded region (150-170 ms) highlights the VPP ERP component, the second shaded region (240-290 ms) the N2 ERP component, and the third shaded region (330-430 ms) the P3 ERP component.

Since a primary GLM on the P3 amplitudes (330-340 ms) revealed interaction effects of training x electrode and condition x electrode, separate GLMs were conducted for each electrode site. In these GLMs, the interaction effects training x condition, condition x emotion, and training x condition x emotion were all not significant (all $p > .27$). A significant interaction effect of training x emotion was observed only on electrode Pz, $F(1,23) = 4.76$, $p = .040$, $\eta^2 = .17$, and not on other electrodes ($p > .16$). No main effects of training, condition or emotion were found for any electrode (all $p > .19$). Post-hoc pairwise comparisons shows only post-training a significantly higher P3 amplitude on Pz to the neutral faces ($M = 3.51$, $SE = .67$) than the angry faces ($M = 2.76$, $SE = .69$), $p = .019$. Pre-training shows no significant difference in P3 amplitude between neutral and angry faces, $p = .43$. The grand average ERP waveforms are presented in Figure 5.

Discussion

This study investigated whether providing the CDSP training to police officers with their companion dogs could enhance PTSD-related support by the dog and facilitate normalization of executive functioning. While no significant improvements were found in attentional bias, working memory was improved in the presence of the dog. The training itself did not yield statistically significant effects on working memory performance, although an effect may not have been detectable due to limited sample size. Overall, the findings offer support for the potential of companion dogs to improve working memory functioning in PTSD-affected individuals.

Working memory performance was improved in the presence of the dog, as indicated by improved IES and a heightened P3 amplitude on the 1-back task ($\eta^2 = .28$). This result suggests an improvement in working memory when the dog was present, even before training. In the presence of a dog the P3 amplitude was higher, both before and after the training, indicating more resources available for information processing when the dog was present, which may be a possible stress-reducing effect that aligns with existing literature on the soothing impact of companion animals (Wheeler & Faulkner, 2015). This effect may imply that following the stress reducing effects of a dog, less resources of the prefrontal cortex are needed to inhibit the stress response, and more capacity is left for working memory. This finding implies a potential stress-buffering effect of the dog already before the training. It is important to consider that these effects may also reflect a test-retest fatigue effect, as dog presence was not counterbalanced. The absence of a main effect of training and the non-significant interaction between condition and training suggest that while the presence of the dog had

a measurable impact, this effect did not differ significantly between trained and untrained conditions. However, the effect size for the interaction (η^2 = .08) was medium, indicating a possible trend that may not have reached significance due to limited statistical power.

The participants with PTSD exhibited attentional bias toward angry faces, as reflected in slower reaction times for incongruent trials, when the dot appeared behind the neutral face, compared with congruent trials, where the dot appeared behind the angry face. This result suggests that attention was more allocated toward angry rather than neutral facial expressions, a result which is supported by previous literature indicating hypervigilance in PTSD towards angry faces (Ashley & Swick, 2019; Cisler & Koster, 2010). The measured attentional bias, however, did not show significant changes across conditions or between pre- and post-training. While an attentional bias towards angry faces was observed, reaction times did not appear to be influenced by the presence of the dog, either before or after training. This suggests that while the dog may reduce general stress levels, it may not alter more specific attentional patterns associated with responses to threat.

One possibility is that the dot-probe task lacked sensitivity to detect subtle shifts in attentional bias. The dot-probe task has often been criticized for its low reliability (Chapman et al., 2019; Xu et al., 2024), which raises concerns about its robustness as a measure of attentional processes. Even when attentional bias is present, the task may fail to capture it consistently across sessions, making it difficult to detect changes. Alternatively, the dog's influence may be more generalized, affecting arousal regulation rather than specific attentional mechanisms. This interpretation is supported by the lack of significant effects in N2 ERP component, a component that has been related to conflict detection and response inhibition (Miller et al., 2021), and the N170 component, linked to early face perception (Hinojosa et al., 2015).

The P3 ERP component amplitude, typically associated with attention and stimulus evaluation (Patel & Azzam, 2005), revealed that post-training, participants showed significantly higher P3 amplitudes in response to neutral faces compared to angry faces, whereas no such difference was observed pre-training. This pattern may suggest that after the CDSP training more attentional resources were available for the neutral cues, as a higher P3 amplitude has been linked to enhanced attention for the stimulus (Johnson et al., 2013). This finding was not reflected in the behavioral data, i.e. faster reaction times when the dot appeared behind the neutral face post-training, which indicates that subtle changes in attentional engagement are not always immediately observable in behavioral output, highlighting the value of combining behavioral and electrophysiological measures.

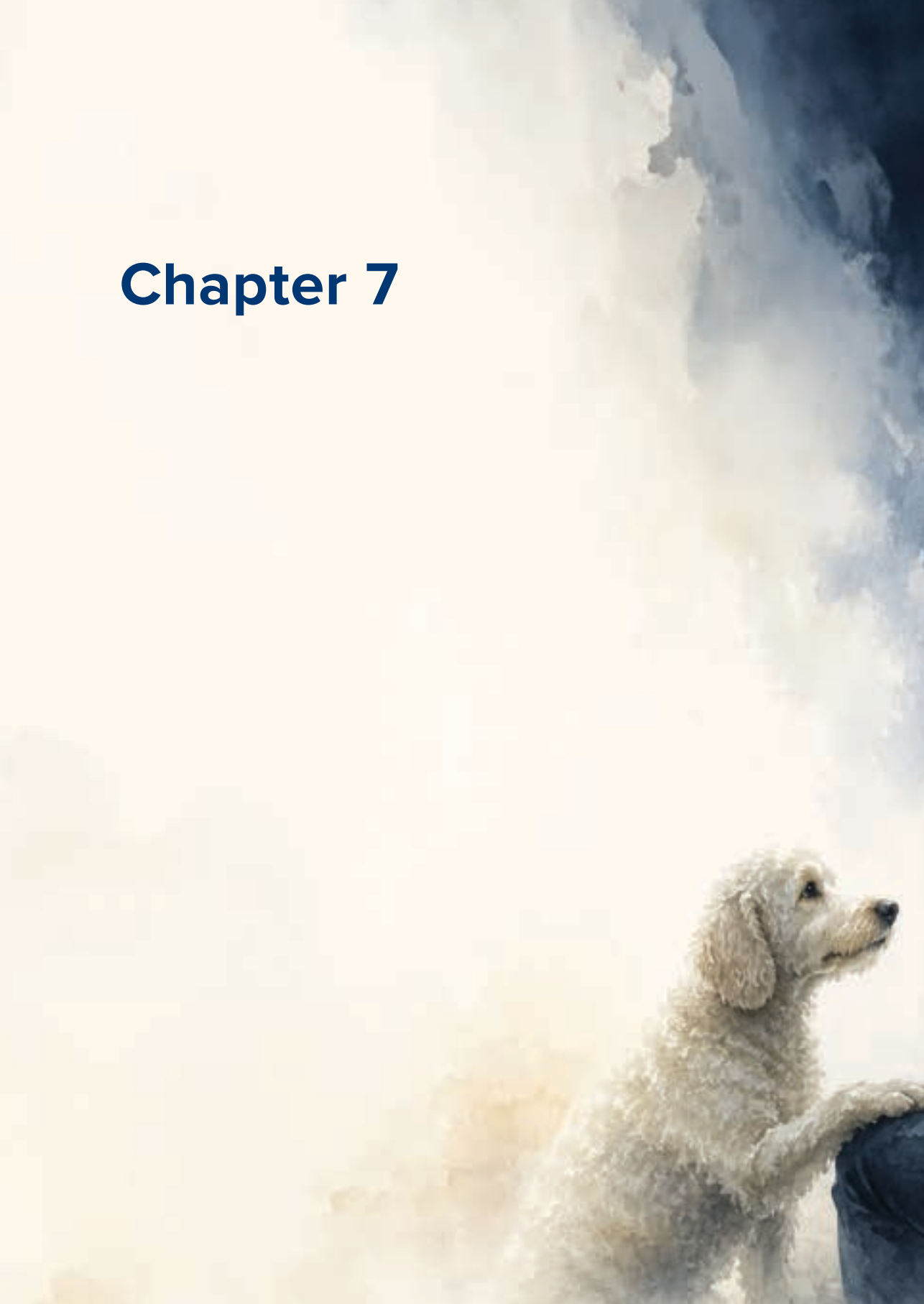
In the preregistration of this study, an a priori power analysis indicated that a total sample size of 34 participants was required to detect a medium effect size (f = 0.25) with a power of 0.80, based on a repeated measures design with one group and two measurements. However, in the behavioral and EEG data, the design included four measurements across two conditions (2x2 within-subjects design). Additionally, only 25 participants completed the post-measurement. This reduced sample size may have impacted the statistical power of the study, increasing the risk of type II errors, i.e. failing to detect a true effect. A post-hoc sensitivity analysis revealed that, with this reduced sample size of n = 25 and 4 measurements, the study was still sufficiently powered to detect medium effects, with a sensitivity of f = 0.24. Interaction effects typically require more statistical power to detect than main effects. With a sample size of 25 participants, the ability to detect an interaction effect may have been limited. While the post-hoc sensitivity analysis indicated sufficient power to detect medium-sized main effects (f = 0.24), the power to detect interaction effects of similar or smaller magnitude may have been lower, increasing the risk of Type II errors in this analysis, i.e. medium or small effects may have gone undetected, and null results should be interpreted with caution. Future research should aim to replicate these results with a larger sample to confirm the observed patterns.

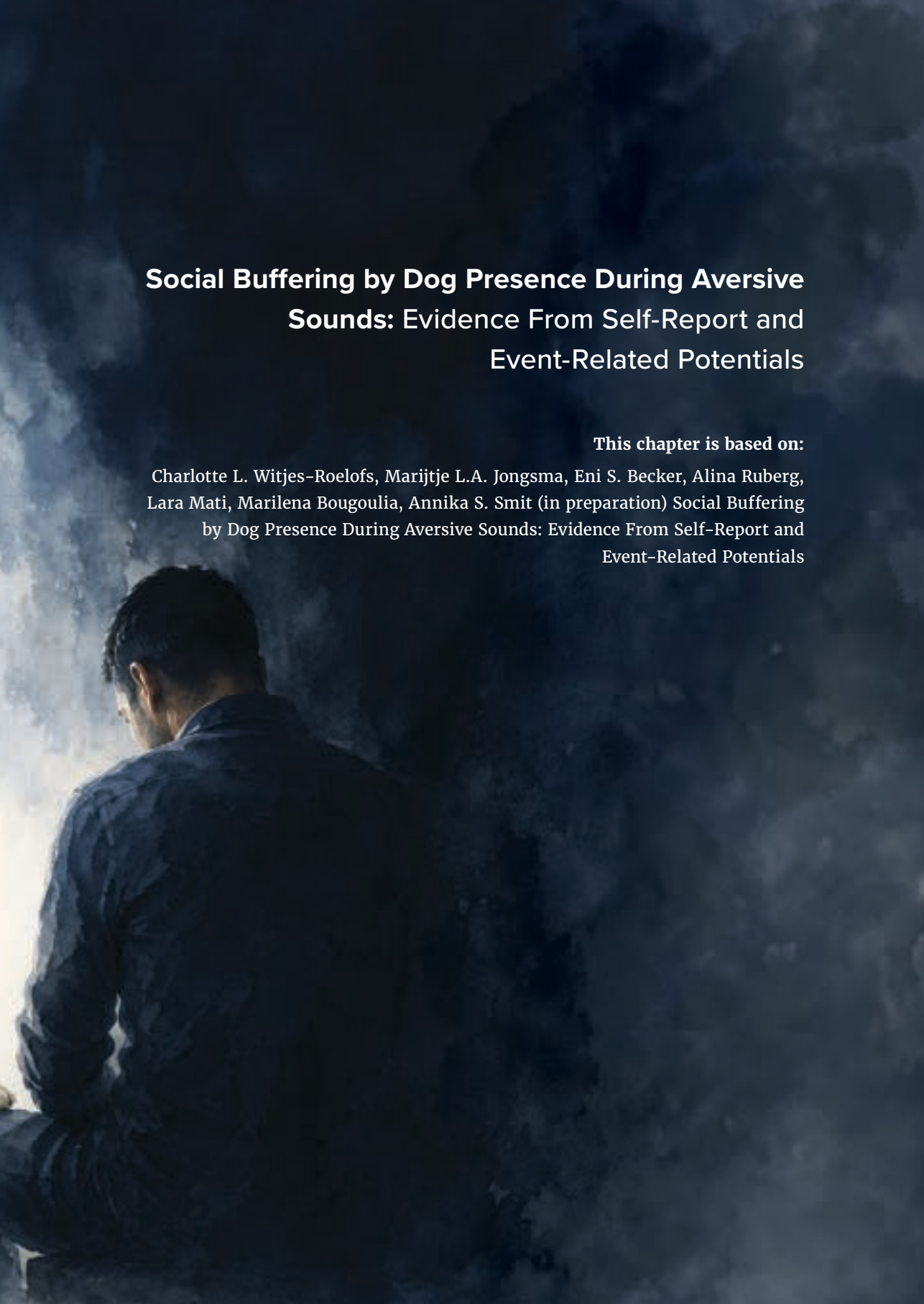
This study has several limitations that warrant consideration. First, the lack of a control group limits our ability to determine whether the observed effects and experiences were specifically due to the presence of the dog or could have resulted from other factors, such as repeated testing. Including a control group with a dog that participated in an activity not related specifically to PTSD could help clarify the specific contribution of the CDSP training. Secondly, the conditions were not counterbalanced, which may introduce order effects. For example, prior exposure could influence performance in ways unrelated to the presence of the dog. Counterbalancing conditions in future studies would provide more reliable insight into the dog's specific effects.

In conclusion, while our study did not find evidence that companion dogs significantly impact attentional bias toward threat-related stimuli, the dogs appeared to positively influence working memory in police officers with PTSD. These findings highlight the potential of companion dogs as an accessible alternative for police officers coping with PTSD-related stress. Future research should attempt to replicate the findings to potentially confirm the stress-buffering effect of companion dogs for individuals with PTSD. With additional research, companion dogs could be a valuable component in PTSD support systems, offering help to individuals who may not have benefitted from conventional treatments.

6

Chapter 7





Social Buffering by Dog Presence During Aversive Sounds: Evidence From Self-Report and Event-Related Potentials

This chapter is based on:

Charlotte L. Witjes-Roelofs, Marijtje L.A. Jongsma, Eni S. Becker, Alina Ruberg, Lara Mati, Marilena Bougoulia, Annika S. Smit (in preparation) Social Buffering by Dog Presence During Aversive Sounds: Evidence From Self-Report and Event-Related Potentials

Abstract

This study investigated whether the presence of a dog or a human buffers self-reported stress, neurophysiological, and cardiovascular responses to aversive sounds. Participants rated aversive sounds as more unpleasant than neutral sounds. For both sound types, ratings were less negative and state anxiety was diminished when a dog was present compared to the alone condition, indicating reduced self-reported stress. Event-related potentials revealed condition-specific modulations of early and later processing stages, with reduced N1 amplitude in presence of the dog compared to human presence, and reduced P2 in the presence of the dog compared to alone, suggesting dampened early attentional and evaluative reactivity. Both dog and human presence increased N2 amplitudes compared to alone, reflecting heightened later cognitive processing. No effect of companion type on heart rate and heart rate variability was found. The findings suggest that dogs may serve as social buffers during acute stress, reducing early attentional engagement and enhancing perceived support.

Introduction

Chronic exposure to stressors has been linked to adverse health outcomes, including anxiety and cardiovascular disease (McEwen, 2007). Everyday stressors, such as sudden or unpleasant sounds, can trigger heightened physiological arousal (Noteboom et al., 2001). When such stimuli are detected, the amygdala, a brain region involved in processing fear and threat, signals the hypothalamus to activate the sympathetic nervous system (LeDoux, 2002). Physiologically, acute stress triggers increased heart rate, decreases heart rate variability (Castaldo et al., 2015), and induces alterations in electroencephalographic activity, such as increased amplitudes of the early event-related potential (ERP) (Shackman et al., 2011). ERPs are time-locked neural responses that reflect the processing of sensory and cognitive events. Early ERP components are thought to index automatic attentional allocation and perceptual sensitivity (Correa et al., 2006). Under stress, these early components, such as the N1, often are amplified, suggesting that acute stress enhances the brain's initial reactivity to incoming stimuli before higher-order cognitive processing (Qi & Gao, 2020).

To reduce the impact of acute stressful experiences, the presence of a familiar individual may help, also known as the phenomenon of social buffering (Fuzzo et al., 2015). The presence of a friend or loved one during a stressful experience can diminish the perceived severity of the stressor (Adams et al., 2011; Coan et al., 2006). Social buffering moderates the impact of stress by influencing how stressors are perceived, reducing the intensity of physiological responses, and encouraging effective coping strategies (Hennessy et al., 2009). The presence of another individual can be perceived as safety cue (Qi et al., 2021). It has been suggested that the presence of a companion leads to a reduced activity in the amygdala and the thalamus, by mediation of the prefrontal and cingulate cortices (Mulej Bratec et al., 2020). Evidence also shows that social support reduces heart rate, lower cortisol levels, and enhances subjective well-being during stressful tasks (Hostinar et al., 2014). Perceived social support is positively associated with heart rate variability, a measure of parasympathetic modulation, during stress (Goodyke et al., 2021).

However, personality traits can influence how individuals perceive and benefit from social support. For example, the presence of a person may induce stress due to evaluation apprehension, which refers to the fear of being evaluated (Bordia et al., 2006). This effect is particularly pronounced for individuals with high social concern (Taylor et al., 2007). Notably, social concern manifests differently between genders, with females exhibiting more generalized social anxiety across various contexts (Asher & Aderka, 2018), while males primarily experience anxiety in mating-related situations (Xu et al., 2012). These factors emphasize the need to consider social concern and gender when evaluating social buffering effects.

Beyond human relationships, social support from a pet, such as a dog, may be effective to reduce stress (Polheber & Matchock, 2014). Dogs can provide unconditional companionship and comfort, contributing to lower stress levels and improved emotional well-being (Beetz et al., 2012). Animal Assisted Interventions have demonstrated consistent positive effects in reducing physiological stress and enhancing mood and stress perception (Hediger et al., 2021; Hunt & Chizkov, 2014; Souter & Miller, 2007). Studies have reported significant reductions in blood pressure during stressful exam periods (Delgado et al., 2018) and subjective improvements in mood resulting from interactions with dogs (Barker et al., 2016; Jarolmen & Patel, 2018). However, it is important to consider that the duration and specific conditions of the dog interaction may substantially influence the observed outcomes (Martos-Montes et al., 2020). Accordingly, the central question of the current study is whether the mere presence of a dog can reduce stress.

Several studies found a stress reducing effect of the mere presence of the participant's pet dog compared to their human friend on heart rate (Campo et al., 2013; Allen et al., 2002; Gandenberger et al., 2024) and cortisol (Gandenberger et al., 2024). Investigating the presence of unfamiliar dogs, Lass-Hennemann and colleagues (2014) reported reduced subjectively experienced anxiety in female students after exposure to a stress-inducing trauma film in the presence of an unfamiliar dog. This effect was not present in the alone nor in the friendly person condition. They did not find significant effects for physiological stress markers (ECG, blood pressure, cortisol) in either of the conditions. Another study using an unfamiliar dog did find a reduction of heart rate and cortisol in the presence of the dog, but they did not find a significant difference on self-reported state-trait anxiety (Polheber & Matchock, 2014). Overall, while the mere presence of familiar dogs appear to reduce stress, the findings on the presence of unfamiliar dogs are less consistent.

The current study examined social buffering effects by comparing an experimental condition with an unfamiliar dog present to two control conditions: being alone and being accompanied by an unfamiliar human. Specifically, we aim to investigate whether the presence of the dog, without any interaction, can reduce subjective and physiological stress responses to aversive sounds compared to the presence of an unfamiliar human or being alone. To do this, we employed a multimodal approach. Self-reported stress was assessed through sound ratings after each aversive and neutral sound stimulus, a post-condition state anxiety inventory, and perceived social support ratings after each condition. Physiological stress markers included electrocardiogram (ECG) recordings to assess heart rate and heart rate variability, as well as electroencephalogram (EEG) measurements to examine ERPs. These measures were selected to provide a comprehensive picture of both conscious stress experiences and underlying autonomic and neural responses.

In comparison to neutral sounds, humans show a clear reaction on aversive sounds: higher self-reported anxiety (Maïano et al;., 2011), heart rate deceleration (Oh et al., 2025), and ERP amplitude increases (Ringer et al., 2023). By introducing a social buffer we expect a reduction in these effects in comparison to neutral sounds. We hypothesize that the presence of a companion will attenuate stress responses relative to being alone, as reflected in less negative ratings of aversive sounds, reduced state anxiety, and higher perceived social support. Consistent with the non-evaluative nature of dogs, we predict a stronger social buffering effect of dog presence compared to human presence due to the absence of evaluation apprehension typically associated with the presence of humans (Qi et al., 2021). Physiologically, we expect heart rate deceleration, increased heart rate variability, and reduced ERP amplitudes to the warning stimuli preceding the aversive sounds, indicating a less aroused and more regulated state in the presence of a companion compared to being alone. This study may not only provide insight into the relative effectiveness of social buffering by human and dog but also explores individual differences in stress responses based on perceived stress, social concern, and baseline anxiety levels. By addressing these questions, the research contributes to our understanding of the broader implications of human-animal interactions in mitigating stress.

Methods

Participants

Regarding ethical approval, the research complied with the ethical frameworks of the "Light Track" as drawn up by the Ethics Committee for Social Sciences of the Radboud University. There was no formal objection to the study (ECSW-LT-2023-2-13-94439). Participants were recruited through the Radboud SONA Participation System and received participation points or 15 euros for taking part in the experiment. Only females were included to prevent confounding effects of gender, aligning with previous research indicating enhanced social buffering effects in females (Nolen-Hoeksema, 2012). Furthermore, only participants who reported having a personal relationship with a dog, such as dog owners or dog lovers, were included in the study. This criterion aimed to exclude individuals who might perceive the presence of the dog as unpleasant or unfamiliar. Initially, a total of 54 participants were recruited to participate in the study. However, four participants were ultimately excluded from the analysis. Two of them did not complete all the required experimental conditions, while the data from the other two did not meet the necessary quality standards for analysis. The final sample had an age range from 18 to 60 (M = 22.14, SD = 5.98).

Power analysis

A post-hoc sensitivity analysis was conducted using G*Power (Faul et al., 2007) to determine the smallest effect size detectable given our study design and sample size. A repeated measures Manova with a desired power of 0.90, a total sample size of 50, and 3 measurements, indicated that the study was sensitive to detect effects of approximately small-to-medium magnitude (f = 0.21).

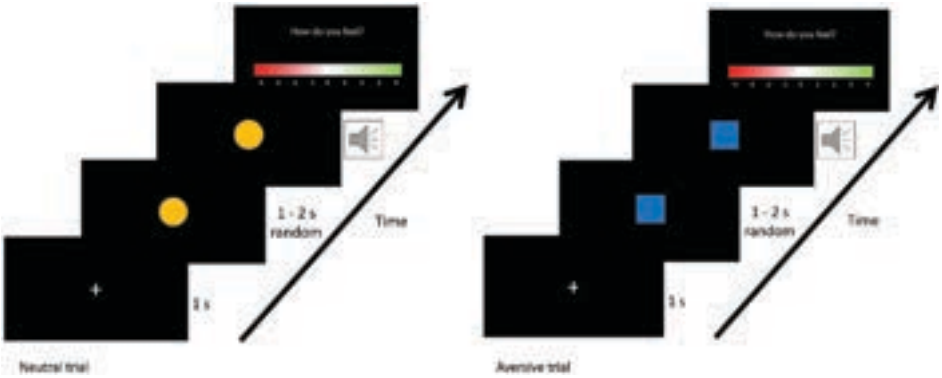
Procedure

After filling out a consent form, participants completed the questionnaires (see section Questionnaires) and an EEG was set up. During the experiment, participants were presented with 17 aversive (4 seconds of a random aversive sound out of 22 options) and 17 neutral sounds (4 seconds of pink noise) via headphones. Each participant experienced this within three conditions; alone, in the presence of an unfamiliar woman, or in the presence of an unfamiliar dog. All participants were exposed to the same dog, a 5-year-old Labradoodle. The human confederate was seated on a chair approximately 2 meters from the participant, facing the same direction as the participant. The dog was positioned on a small blanket on the floor, also at a distance of roughly 2 meters from the participant. All three conditions were administered on the same day and were counterbalanced across participants. Per condition (counterbalanced across participants), a unique symbol was assigned to the neutral sound and another to the aversive sounds (Figure 1), resulting in six distinct symbols, each with a different color. The sounds were played 1-2 seconds after the presentation of the respective symbol. After each stimulus, participants were further instructed to rate their feelings on a continuous VAS-like scale from -4 (very bad) to +4 (very good), with 0 as neutral. As a measure of state anxiety, the short version of the State Trait Anxiety Index Scale (STAIS-5; Zsido et al., 2020) was administered in each condition, after completing the task.

Questionnaires

Before starting the experiment, participants were presented with multiple questionnaires. Due to the moderating characteristics of social concern in previous research, the social concern subscale of the Anxiety Sensitivity Index-3 (ASI-3; Taylor et al., 2007) was administered in order to measure social concern. Further, the short version of the State Trait Anxiety Index Scale (STAIS-5; Zsido et al., 2020) was administered a total of four times, once before the experiment (baseline) and then after each condition, as a subjective measure of state anxiety throughout the experiment. Additionally, social support was assessed after each condition with the question 'How much support did you feel?'.

Figure 1 Visualization of the different trials



Event-related potentials

A BrainProducts ActiCap snap 32-channel EEG system was used in order to record brain activity at 500 Hz. The electrode-scalp impedance was reduced to less than 20 kΩ for all electrodes. EEG data were recorded at a 500 Hz sampling rate using an amplifier with an input impedance of 10 MΩ. The ground electrode was placed over the forehead and the reference electrode on the left mastoid bone. Furthermore, two electrodes were placed next to and below the right eye in order to obtain an Electrooculogram. Offline data analysis was conducted using Brain Vision Analyzer (Brain Products GmbH, 2019).

After re-referencing to linked mastoids, data were digitally filtered with a low cut-off of 0.5 Hz and a high cut-off of 30 Hz filter. ERP segments were set from 250 ms before stimulus onset until 750 ms after stimulus onset. Following segmentation a Gratton & Coles ocular correction without raw average subtraction and a 100 ms baseline correction were applied. We excluded segments with an amplitude exceeding ±100 µV, and segments with activity below 0.5 µV for 100 ms or more from further analyses. The difference wave was obtained by subtracting the individual average ERP response to the neutral sound from the individual average ERP response to the aversive sound within each condition. As ERP amplitudes were most pronounced over fronto-central regions, electrodes Fz, FCz, Cz were selected as region of interest (ROI) for analysis. Fixed time windows were selected around the peaks of the grand average of all conditions together, resulting in three components: N1 (120-170 ms), P2 (210-260 ms), N2 (290-360 ms). Mean amplitudes of the ROI within these windows were calculated for each condition and sound.

Heart rate and heart rate variability

The electrocardiogram (ECG) was recorded using a single electrode from the electrode set on the left wrist of the participant. The ECG was recorded and processed using BrainVision Recorder (Brain Products GmbH, 2020) and BrainVision Analyzer (Brain Products GmbH, 2019). For the ECG signal processing, initially, a high-pass filter at 1 Hz and a low-pass filter at 40 Hz were applied. Following this, R-peak markers were automatically placed onto the ECG signal by the EKG Markers option in the Solutions package from BrainVision Analyzer. To ensure these markers, a manual screening was performed to identify inaccurate R-peak detection and markers were adjusted where necessary. The heart rate was calculated by taking the mean R to R interval per condition and the heart rate variability was calculated by taking the root mean square of successive differences between R peaks (RMSSD) per condition.

Statistical analyses

This study employed a within-subjects design. The statistical analysis was performed using IBM SPSS Statistics (Version 27). To assess the relationship between social concern and state-trait anxiety across different conditions, Spearman's rank correlation coefficient (Spearman's rho) was used. We conducted a repeated measures Generalized Linear Model (GLM) with sound affect rating as dependent variable and condition (human, alone, dog) and sound (aversive, neutral) as independent variables. The same independent variables were used in the GLMs with ERP amplitude. Additionally, repeated measures GLMs were used with heart rate, heart rate variability, perceived support, and state anxiety as dependent variables and condition (alone, human, dog) as independent variable. When the assumption of sphericity was violated, we used the Greenhouse-Geisser correction. A significance threshold of $p < .05$ was used to determine statistical significance. Significant interactions were followed up using t-tests.

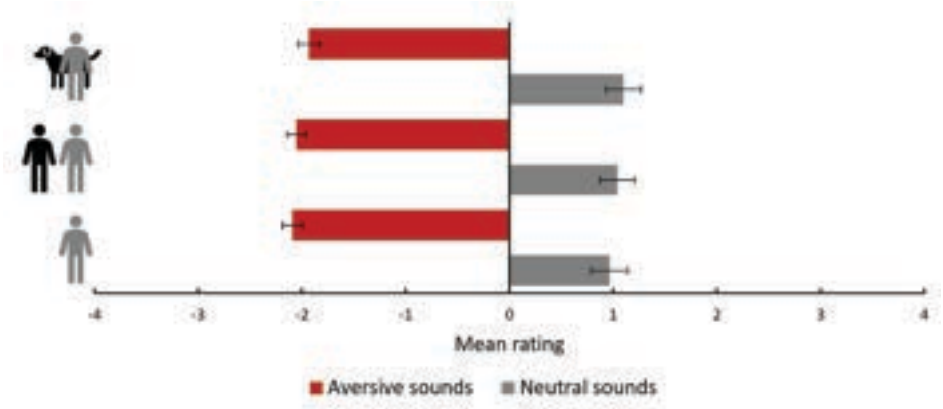
Results

Sound affect ratings

A repeated measures GLM indicated significantly lower sound affect ratings of aversive sounds than neutral sounds, $F(1, 49) = 216.60$, $p < .001$, $\eta^2 = .82$ (Figure 2). A significant main effect of condition was found, $F(2, 84) = 3.78$, $p = .033$, $\eta^2 = .07$. Pairwise comparisons with Bonferroni adjustments revealed a significant difference between alone and dog condition, p = .041, with a higher rating in the dog condition ($M = -0.42$, SE = 0.10) compared to the alone condition ($M = -0.56$, SE

= 0.10). No significant difference was found between alone and human condition, p = .536, and between human and dog condition, p = .433. There was no interaction effect of condition x sound, $F(2, 85) = 0.23$, p = .766, η^2 = .01.

Figure 2 Sound affect ratings



Note. Average subjective affect ratings with standard deviation to neutral and aversive sound stimuli in the absence of a companion, in the presence of an unfamiliar human, and in the presence of an unfamiliar dog.

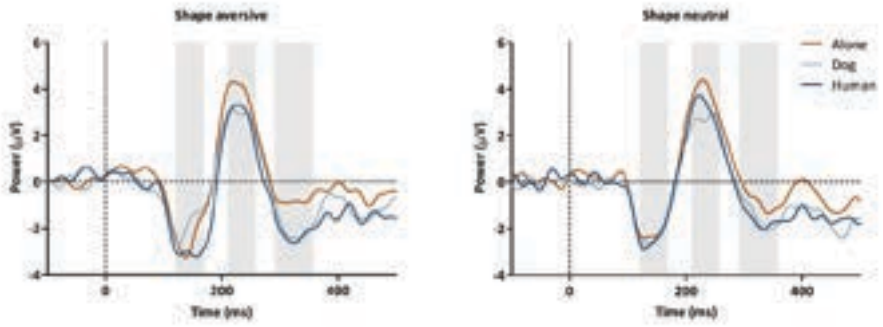
Event-related potentials

Analysis of the N1 component (120–170 ms, Figure 3) amplitudes in response to the shapes revealed no significant main effect of sound, $F(1,49) = 1.44$, p = .236, η^2 = .03. A significant main effect of condition was found, $F(2,98) = 3.71$, p = .028, η^2 = .07. Pairwise comparisons with Bonferroni adjustments revealed a more negative N1 amplitude in the human condition (M = –2.77, SE = .26) than the dog condition (M = –1.93, SE = .30), p = .014. No significant difference was found with the alone condition (M = –2.28, SE = .37), p > .38. There was no interaction effect of condition x sound, $F(2,98) = 1.86$, p = .161, η^2 = .04.

Analysis of the P2 component (210–260 ms, Figure 3) amplitudes in response to the shapes revealed no significant main effect of sound, $F(1,49) = 1.28$, p = .264, η^2 = .03. A significant main effect of condition was found, $F(2,98) = 5.16$, p = .007, η^2 = .10. Pairwise comparisons with Bonferroni adjustments revealed a higher P2 amplitude in the alone condition (M = 4.72, SE = .37) than the dog condition (M = 3.84, SE = .35), p = .014. No significant differences were found between the human (M = 3.93, SE = .40) and alone condition, p = .053, and between the human and dog condition, p = 1.00. There was no interaction effect of condition x sound, $F(2,98)$ = 0.47, p = .626, η^2 = .01.

Analysis of the N2 component (290–360 ms, Figure 3) amplitudes in response to the shapes revealed a significant main effect of sound, $F(1,49) = 5.61$, $p = .022$, $\eta^2 = .10$, with a more negative N2 amplitude to shapes preceding aversive sounds ($M = -1.41$, SE = 0.40) compared with shapes preceding neutral sounds ($M = -0.69$, SE = .41). A significant main effect of condition was found, $F(2,98) = 4.99$, $p = .009$, $\eta^2 = .09$. Pairwise comparisons with Bonferroni adjustments revealed a more negative N2 amplitude in the dog ($M = -1.34$, SE = .40) and human conditions ($M = -1.34$, SE = .42) compared with the alone condition ($M = -0.46$, SE = .43), $p = .031$ and $p = .043$, respectively. There was no interaction effect of condition x sound, $F(2,98) = 0.59$, $p = .554$, $\eta^2 = .01$.

Figure 3 *Grand average ERP in response to shapes*



Note. Grand average ERPs of each condition, depicting responses to shapes (presented at 0 ms) preceding aversive sounds (left) and shapes preceding neutral sounds (right), averaged over electrodes Fz, FCz, and Cz.

State anxiety and social concern

A repeated measures GLM was performed to determine if state anxiety differed between the alone ($M = 8.5$, SE = 0.4), human ($M = 8.1$, SE = 0.3), and dog ($M = 7.6$, SE = 0.4) conditions. There was a significant effect of condition, $F(2, 98) = 5.05$, $p = .008$, $\eta 2 = .09$. Post-hoc Bonferroni pairwise comparisons indicated a significant lower state anxiety in the dog condition compared to the alone condition, $p = .008$, whereas the other two pairwise comparisons did not reveal statistically significant differences between conditions, $p > .35$. Social concern was correlated with state anxiety at human condition, Spearman's $\rho = .29$, $p = .037$, and not with the other conditions (state anxiety baseline $p = .250$, alone condition $p = .057$, dog condition p = .593).

Perceived support

A significant main effect of condition was found, $F(2, 95) = 27.44$, $p < .001$, $\eta^2 = .36$. Post hoc pairwise comparison Bonferroni showed significant differences between each condition ($p < .003$). Participants perceived the least amount of social support while being alone ($M = 1.50$, SE = 0.13) and somewhat greater social support in the presence of a human ($M = 2.02$, SE = 0.12). They felt the greatest amount of support in the presence of a dog ($M = 2.54$, SE = 0.13).

Heart rate and heart rate variability

The GLMs showed no difference between conditions in mRR, $F(2, 96) = 0.93$, $p = .397$, $\eta 2 = .02$, and no difference between conditions in RMSSD, $F(2, 96) = 0.80$, $p = .45$, $\eta 2 = .02$.

Discussion

The current study examined the effects of social buffering, specifically the presence of a dog or a human, on self-reported stress and physiological stress responses and aversive sounds. Our findings suggest that the presence of a dog alleviated subjective stress, as evidenced by less negative sound ratings and lower state anxiety. The ERP components revealed condition-specific modulations of early and later processing stages, suggesting dog presence can buffer early attentional and evaluative reactivity while still engaging participants in later-stage cognitive processing. The presence of a dog or a human did not significantly alter cardiovascular measures heart rate and heart rate variability.

Participants rated aversive sound significantly more negative than neutral sounds, confirming that the stimulus manipulation was perceived as intended. Moreover, both types of sounds were rated less negative when a dog was present compared to the alone condition, suggesting that dogs may provide social buffering against both distressing and neutral auditory stimuli. This aligns with previous research demonstrating that animal companionship is perceived as stress-reducing (Beetz et al., 2012; Janssens et al., 2021).

Analysis of the ERP components revealed condition-specific modulations of early and later processing stages of the visual warning stimuli preceding the sounds. The smaller N1 amplitude when a dog was present relative to when the human was present indicates that dog presence may lower early attentional engagement to the stimulus (Correa et al., 2006). This result may indicate a possible buffering effect of the dog, whereby its presence dampened alertness to the stimulus. However, it is also possible that the dog diverted some attention away from the task, resulting in fewer early attentional resources being allocated

to the experimental stimulus. The P2 component is generally associated with early evaluative processes such as attention and judgment, even though its precise meaning remains uncertain (Zeng et al., 2021). The higher P2 amplitude in the alone condition suggests that participants engaged in enhanced evaluation of the stimulus when no dog was present. In contrast, the dog condition showed reduced P2 amplitudes, which may indicate that the dog's presence acted as a calming or attention-modulating influence, lowering arousal, reducing the perceived importance of the stimulus, or diverting cognitive resources. Overall, the pattern implies that being alone enhances early evaluative processing, whereas the presence of a dog dampens it. The N2 component, linked to cognitive control and response inhibition (Clayson & Larson, 2013; Hoyniak & Petersen, 2019), was more negative both when shapes predicted aversive sounds and when participants were accompanied by a dog or a human. This indicates increased cognitive and inhibitory control in response to cues predicting threat. Although both stimulus types and social presence influenced N2 amplitude, they did not interact, suggesting these effects operate independently. Overall, the ERP findings imply that the presence of a dog (and to some extent a human) modulates both early and later stages of stimulus processing, but in different ways. Dog presence appears to diminish early attentional and evaluative responses (reduced N1 and P2), consistent with a calming or attention-diverting effect that may lower the cognitive priority of the warning stimuli. Both dog and human presence enhance later inhibitory control processes (more negative N2), suggesting that social presence generally heightens cognitive control, independent of stimulus type. The absence of interactions between stimulus type and social condition indicates that social presence and threat prediction may influence cognitive processing through separate mechanisms. Overall, the pattern suggests that dogs can buffer early attentional and evaluative reactivity while still engaging participants in later-stage cognitive processing.

Participants reported significantly lower state anxiety when accompanied by a dog, supporting the psychological benefits of dog presence. Interestingly, while a human presence also increased perceived support compared to the alone condition, participants felt the greatest support in the presence of a dog. This may be because dogs provide nonjudgmental support, which has been noted in prior studies on animal-assisted therapy (Crossman et al., 2017). Further supporting this idea, we found that participants' social concern correlated with state anxiety when accompanied by a human. This suggests that the presence of another person may increase social evaluative concerns, whereas a dog's presence may be perceived as a source of comfort without social pressure.

No influence of presence of either a dog or a human was found on cardiovascular measures, as heart rate and heart rate variability did not differ between conditions. Although the presence of a dog seemed to be associated with reduced stress as indicated by the sound ratings, neurophysiological measures (ERPs) and perceived support, no significant effects were found on cardiovascular indicators such as heart rate. This pattern aligns with previous studies showing that dog presence can lower perceived stress and influence other measures such as the endocrine response, without affecting cardiovascular measures (Kerns et al., 2018, Lass-Henneman et al., 2014). One explanation is that cardiovascular measures may be less sensitive to subtle emotional modulation in experimental contexts. In contrast, neurophysiological measures as well as subjective stress measures may be more responsive to minor differences potentially caused by social buffering. However, some research did find a reduction in stress by mere presence of a dog as indicated by cardiovascular measures (Gandenberger et al., 2024; Campo et al., 2013). Notably, in these studies, participants were accompanied by their own companion dogs, whereas in our study the dog was unfamiliar. Familiarity with the dog may play a crucial role in the strength of the social buffering effect. An unfamiliar dog may not provide the same level of stress relief, potentially explaining why cardiovascular stress markers appeared to be unaffected by companion type in our study.

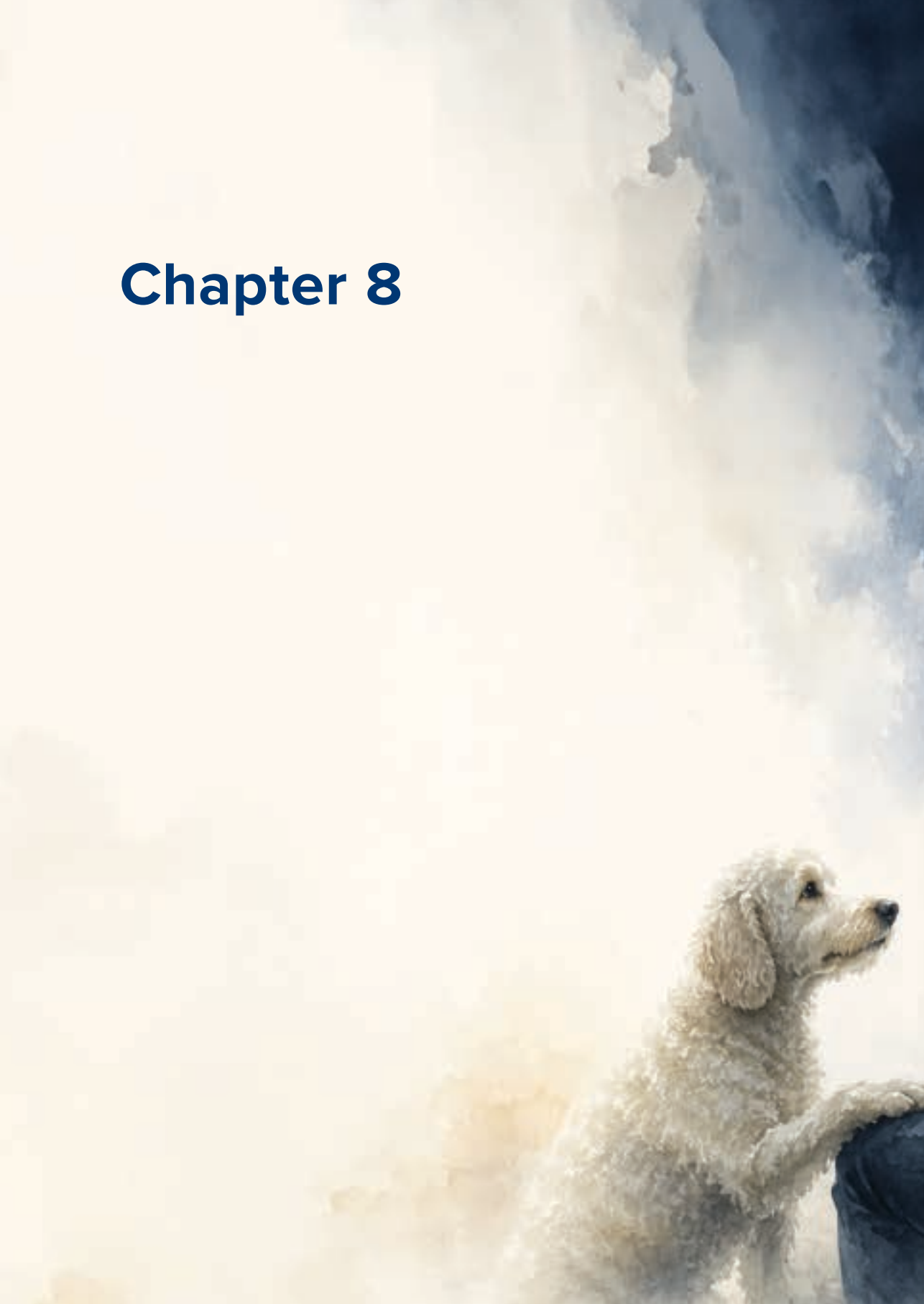
There are several methodological limitations that should be considered when interpreting these findings. First, heart rate data were collected via wrist electrodes, which may have been less reliable than chest-based measurements, potentially reducing sensitivity to detect subtle physiological changes. Second, the stimulus design included multiple different aversive sounds but only one type of neutral sound, which may not have provided an optimal comparison. A more balanced selection of stimuli could help ensure that differences in responses to trial type are due to the trial type rather than the nature of the auditory stimuli themselves.

In conclusion, these findings indicate that the presence of a dog can shape how individuals experience and process (the threat of) acute stressors. Overall, the results suggest that dogs may serve as an effective social buffer in the context of acute, experimentally induced stress, by dampening early attentional and evaluative reactivity and supporting more effective inhibitory control, highlighting a nonjudgmental form of support that dogs may provide in stressful contexts. Because the study examined reactions to brief, experimentally induced stress, the results primarily elucidate mechanisms underlying acute stress buffering, including reduced early attentional engagement, dampened evaluative processing, and increased perceived support. These processes may be relevant for understanding how service dogs assist individuals with chronic stress conditions,

including PTSD, where heightened vigilance and exaggerated threat processing are common. Although acute experimentally induced stress cannot fully capture the complexity of chronic stress or trauma-related symptoms, the observed modulation of early attentional and evaluative neural responses may offer preliminary insight into potential pathways through which PTSD service dogs may contribute to their beneficial impact. Specifically, the attenuation of early reactivity and the enhancement of perceived support may represent mechanisms that could help reduce hyperarousal and improve emotion regulation in daily life. Nonetheless, caution is warranted when generalizing from an unfamiliar dog in a controlled setting to long-term clinical contexts, and future research should examine how buffering processes operate in individuals with PTSD interacting with their own trained service dogs.

7

Chapter 8



General Discussion

The experience of the Dutch police officer described at the beginning of the General Introduction becomes more comprehensible in light of the findings discussed over the course of this dissertation. His struggle with hyperarousal, nightmares, and avoiding activities reflects patterns observed across officers with PTSD. The vigilance even in safe situations is reflected by the measured attentional instability (Chapter 4). His re-engagement with daily life after receiving his service dog Max illustrates the potential of service dogs to improve wellbeing (Chapter 2), by engaging several means simultaneously. Max's ability to offer targeted support because of trained behaviors such as waking his owner up resulted in for example reduced nightmares. His calm presence brought about less overwhelming stress responses because of a potential stress buffering effect. By mirroring the mood of his owner, Max seemed to support physiological self-regulation which prevented panic attacks from escalating. His non-judgmental companionship provided a sense of safety, trust, social connectedness, and a reduced sense of loneliness. Lastly, the daily routines associated with caring for Max facilitated behavioral activation. These interacting factors help explain how the police officer, who had retreated to his attic in overwhelming distress, was eventually able to re-engage with daily life. In this sense, his statement that "He gave me my life back" reflects not only a personal view but also the cumulative effect of the ways through which service dogs may support quality of life.

Summary of the main findings

This dissertation explored the role of dogs, both service and companion, in supporting police officers diagnosed with PTSD. Across six chapters that employed qualitative and quantitative approaches, the findings converge on the conclusion that both service and companion dogs can provide meaningful emotional, cognitive, and attentional support, and that a structured training program may enhance these effects in companion dogs. Together, the studies highlight both the unique contributions of service dogs and the promising potential of companion dogs as accessible alternatives.

Chapter 2 investigated how Dutch police officers with chronic PTSD perceive the impact of service dogs compared to companion dogs. Interviews revealed that while both types of dogs provide emotional comfort, service dogs deliver more reliable and targeted support through trained behaviors such as interrupting nightmares and signaling distress. Companion dogs occasionally displayed similar behaviors, though less consistently, suggesting they may serve as a meaningful alternative for individuals who do not have access to a service dog.

Chapter 3 shows that the dogs influence not only perceived wellbeing, but also core executive functions, suggesting a stress buffering effect of dogs. Police officers with PTSD showed improved working memory performance and enhanced N2 ERP amplitudes when their dog was present, whereas officers without PTSD performed better in the absence of their dog. These findings suggest that dogs may specifically restore executive functioning in individuals with PTSD.

Chapter 4 focused on attentional bias to emotional faces. Officers with PTSD demonstrated greater variability in attentional bias and impaired differentiation between emotional stimuli, as reflected in ERP measures. Reaction times were slower and early-stage attentional processing heightened when the dog was absent. The presence of the dog appeared to regulate attentional processing and improve reaction speed, suggesting their role extends beyond comfort to modulating fundamental cognitive processes like vigilance and selective attention.

Chapter 5 evaluated the feasibility and impact of the Companion Dog Support Partnership (CDSP) training program. Participants reported improvements in their dogs' supportive behaviors, as well as personal gains in emotion regulation, self-awareness, and daily functioning. Questionnaire data confirmed increases in life satisfaction and physical health, alongside reductions in state anxiety. These findings suggest that a short targeted training can help transform a dog's potential into practical support, enhancing the benefits of companion dogs and making this form of assistance more accessible than service dogs alone.

Chapter 6 extended the CDSP evaluation to cognitive outcomes. Behavioral and EEG assessments revealed no changes in attentional bias, but working memory performance improved in the presence of the dog, as indicated by better scores and increased P3 amplitudes. Although training effects were not statistically significant, likely due to sample size limitations, the results reinforce the stress-buffering role of companion dogs in executive functioning.

Chapter 7 showed that dog presence can buffer subjective acute stress responses to aversive sounds in healthy participants. Participants experienced aversive sounds as less unpleasant and reported lower state anxiety when a dog was present, and early neurophysiological responses (N1, P2) were reduced, indicating dampened early attentional engagement. Both dog and human presence increased N2 amplitudes, reflecting enhanced later cognitive processing. Cardiovascular measures did not differ across conditions. Overall, dogs appeared to reduce early stress reactivity and enhance perceived support during acute stress.

Interpretation of findings

Service vs. companion dogs

Service dogs provide a distinct comparative advantage over companion dogs for police officers with PTSD. While both types of dogs offer emotional comfort and companionship, service dogs deliver targeted, reliable, and symptom-specific support through trained behaviors such as interrupting nightmares, creating personal space, and signaling emotional distress (Chapter 2). These specialized skills directly address core PTSD symptoms and have been linked to reductions in PTSD symptom severity, improved social functioning and enhanced quality of life in veterans (O'Haire & Rodriguez, 2018; Leighton et al., 2024). Companion dogs, by contrast, may occasionally display similar supportive behaviors, but in a less predictable and less effective manner, consistent with broader human-animal interaction research showing that companion dogs primarily exert a positive effect through general social buffering (Polheber & Matchock, 2014). Thus, service dogs represent a structured intervention with demonstrable therapeutic precision, whereas companion dogs embody a more variable but accessible form of support.

The distinction between service and companion dogs establishes a continuum of PTSD support by dogs. At one end, service dogs are a specialized, high-cost, and high-impact intervention, and at the other end, companion dogs represent widely available but less structured support. Chapters 5 and 6 explored whether companion dogs, through their presence, natural behaviors, and targeted training programs, can bridge this gap by offering scalable, accessible, and empirically validated benefits. In this way, the initial comparison frames the dissertation's conclusion, demonstrating that while service dogs provide unique added value, companion dogs, especially when strengthened through a short training, can become viable alternatives for supporting police officers with PTSD.

Executive functioning

This dissertation demonstrated that dogs influence not only emotional well-being, but also executive functioning. Across chapters, the presence of a dog consistently improved working memory performance among officers with PTSD. This effect was present across service dogs and companion dogs, suggesting that the stress-buffering qualities of dog presence free cognitive resources necessary for executive functioning, aligning with our proposed conceptual model in Chapter 3 and the neurocircuitry model of PTSD (Rauch et al., 2006). Effects on attentional bias were more variable. While some officers showed reduced attentional bias towards threat (angry faces) in the presence of a dog, others did not exhibit significant changes. This variability aligns with the heterogeneity of attentional processes

in PTSD (Bardeen et al., 2020) and suggests that cognitive domains may differ in their sensitivity to stress reduction by the presence of a dog. Companion dogs also showed potential to enhance executive functioning, which aligns with the literature that shows that everyday interactions with companion animals can influence cognitive processes, even in the absence of specialized training (Gee et al., 2015; McDonough et al., 2022). Together, the findings underscore that dogs, regardless of training level, may serve as stress modulators allowing restored executive functioning, with service dogs offering precision and reliability, and companion dogs offering accessibility and scalability.

Enhancement by training

Chapters 5 and 6 demonstrated that targeted training can enable more effective use of the supportive potential of companion dogs. The Companion Dog Support Partnership (CDSP) training showed that even short-term, targeted training can stimulate behaviors that resemble those of service dogs, including protective positioning, tension-reducing actions, and engagement in joint activities that promote behavioral activation. Importantly, the benefits extended beyond dog behavior. Police officers reported improvements in emotion regulation, self-awareness, and satisfaction with life. These outcomes highlight the dual nature of the training program, as it enhances the dog's capacity to support the owner while simultaneously strengthening the owner's own regulatory skills. Such bidirectional effects are consistent with dyadic models of intervention, which conceptualize change through co-regulation, shared routines, and mutual responsiveness (Rodriguez et al., 2020; Rehn & Keeling, 2016). Even though cognitive effects of dog presence before the training compared to dog presence after the training were non-significant, the presence of the dog did improve working memory performance, strengthening the idea that emotional and cognitive benefits are connected (Phelps et al., 2006; Eysenck et al., 2007). Participants also valued the social dimensions of the program, such as peer contact and compassionate delivery, suggesting a positive contribution of the training environment itself (Charuvastra & Cloitre, 2008). Overall, targeted training may enable companion dogs to become supportive partners rather than passive sources of comfort. This makes dog-assisted support more accessible and scalable, reducing reliance on the limited supply of service dogs and expanding the range of officers who could benefit.

Stress and social buffering

Across studies, reductions in self-reported stress emerged as a consistent outcome of dog-assisted support. Dogs appear to function as stress buffers, attenuating physiological and emotional responses to stress. This buffering effect may help explain the cognitive improvements observed, as reducing stress and hyperarousal through dog presence may free prefrontal resources needed for working memory and executive attention, that would otherwise be consumed by regulating threat responses. This theory suggests emotional and cognitive benefits are not separate pathways but interconnected processes, which is in line with the literature (Phelps et al., 2006). The dog's presence seems to reduce stress, which in turn could enhances cognitive functioning, which then may support better daily functioning and well-being.

Dogs as indirect modulators in PTSD models

The findings can be understood through the conceptual model introduced in Chapter 3 (Figure 1), which positions dogs as indirect modulators of PTSD symptoms, consistent with stress-buffering models of social support (Masson et al., 2019). By reducing stress and hyperarousal, dogs may indirectly free cognitive resources in the prefrontal cortex, thereby enhancing executive functioning. This proposed mechanism aligns with the neurocircuitry model outlined in the General Introduction, which suggests that heightened stress and hyperarousal in PTSD compromise prefrontal control processes (Rauch et al., 2006). This mechanism might explain both the consistent improvements in working memory and the more variable effects on attentional bias, because these cognitive domains may differ in how strongly they depend on the prefrontal cortex. Working memory relies heavily on prefrontal cortex resources, whereas attentional bias is partly driven by automatic, subcortical processing, especially by the amygdala. The latter is less dependent on prefrontal control and could be more influenced by individual differences, such as vigilance and avoidance tendencies (Cisler & Koster, 2010). As a result, reducing stress may not shift attentional bias in one direction, but instead it produces greater variability between individuals, potentially accounting for the mixed and sometimes inconsistent effects reported in the existing literature on attentional bias (Bomyea et al., 2012; Cisler & Koster, 2010; Vyas et al., 2020).

The CDSP program enhanced emotion regulation, self-awareness, and daily functioning, aligning with social support models of PTSD (Lee, 2019) that emphasize the buffering role of supportive relationships. It also resonates with behavioral activation frameworks (Etherton & Farley, 2020), where engagement in structured, meaningful activities reduces avoidance and promotes recovery.

In conclusion, the results suggest that dog-assisted support for PTSD is not limited to a single symptom cluster. Instead, it addresses core mechanisms of PTSD including emotional, cognitive, and social domains. This broad impact highlights the unique value of dogs as supportive partners and underscores the potential of companion dogs, especially when supported through a short training, to serve as support for police officers with PTSD.

Strengths and limitations

A major strength of this dissertation lies in its focus on the unique and under-studied population of (Dutch) police officers with PTSD. The prevalence of PTSD among police officers is high, and first responders may experience trauma in ways that differ from civilian populations, as officers are repeatedly exposed to potentially traumatic situations and often face barriers to mental health care (Velazques & Hernandez, 2019). By centering on this group, the dissertation contributes evidence that is both scientifically valuable and practically relevant for a population with high unmet mental health needs. Another strength is the empirical work. Chapters 3 and 4 showed that dogs influence not only emotional wellbeing but also executive functioning, specifically working memory and emotional attention, which positions dogs as active modulators of cognitive mechanisms rather than passive companions. The use of behavioral tasks and EEG/ERP measures across Chapters 3, 4, and 6 provides neurophysiological evidence that dogs can restore working memory performance and may regulate attentional processing in individuals with PTSD. These findings move the existing evidence beyond anecdotal reports and self-perceived benefits toward measurable, physiological indications of dog-assisted support for PTSD.

Another strength is the practical contribution of the Companion Dog Support Partnership (CDSP) training. Chapters 5 and 6 demonstrate that a short, targeted training can substantially enhance the supportive value of ordinary companion dogs for police officers with PTSD. This training improved both dog behaviors, such as protective positioning and tension-reducing actions, and human outcomes, including emotion regulation and daily functioning. Given that service dogs are scarce, costly, and sometimes inaccessible, the finding that trained companion dogs may provide comparable benefits represents a step toward improving access to dog-assisted support for a much broader population of individuals with PTSD. Finally, the methodological diversity of the dissertation is a notable strength. By combining qualitative interviews, standardized questionnaires, behavioral experiments, and neurophysiological measures, the dissertation offers a comprehensive understanding of how dogs support police officers with PTSD. The variety of methods strengthens the validity of the conclusions and provides a richer, more nuanced picture of the mechanisms through which dog support operates.

Despite its contributions, this dissertation also has several limitations that should be considered. First, the sample sizes across studies were modest. Although this is a common challenge when working with specialized populations such as police officers with PTSD, limited sample sizes reduce statistical power, increase the risk of Type II errors, and restrict the generalizability of the findings. Second, the experimental conditions in the studies with police officers with PTSD could not be counterbalanced for ethical reasons. For participants with PTSD, particularly those with a service dog, the immediate absence of their dog at the start of the experiment would have had substantial emotional impact, making it too stressful to begin with a dog-absent condition. While this decision was necessary, it introduces the possibility of order effects and complicates causal interpretation. Relatedly, the possibility of placebo effects could not be fully ruled out (Linde et al., 2011), and the findings should therefore be interpreted with caution. Additional research using alternative designs, such as longitudinal studies, is needed to draw firmer conclusions. Placebo or expectancy effects in the CDSP training studies could also have played a role in the outcomes. Participants may have held strong beliefs about the benefits of dogs and the training, which could have influenced self-reported outcomes or even performance on certain tasks. Although the inclusion of neurophysiological measures helps mitigate this concern, future studies could incorporate more rigorous control conditions to better isolate the specific effects of the CDSP training. Third, variability in dog behavior and training represents another limitation. Companion dogs differ widely in temperament, prior experiences, and responsiveness to training. While the CDSP program aimed to standardize training, natural variation across dogs likely influenced outcomes. This variability is ecologically valid, as it reflects real-world conditions, but it complicates efforts to identify which specific training components or dog characteristics are most effective. Finally, PTSD severity was not assessed at the start of the studies. No clinical evaluation of symptom levels was conducted, and inclusion was based on participants' existing diagnoses. This approach may have introduced variability in symptom severity within the PTSD groups, potentially influencing cognitive performance en responsiveness to dog presence. Standardized clinical assessments should be included in the future to better characterize participant profiles and enable further interpretation of group differences. Together, these limitations highlight the need for continued research while underscoring the promising nature of the findings.

Practical implications

The findings of this dissertation carry several practical implications for clinical practice, policies, and society. Within clinical settings, the results suggest that service dogs may function as valuable adjuncts when no further treatment options are available, while trained companion dogs could offer a more accessible alternative for individuals who do not qualify for, or cannot access, a certified service dog. Although it is often assumed that introducing a dog before treatment is fully completed might undermine a person's natural recovery capacity, this belief lacks empirical support and warrants systematic investigation in future research. At the policy level, the outcomes highlight the need for clear guidelines on how dogs can be responsibly and effectively integrated into PTSD rehabilitation programs for police officers and other first responders, ensuring consistency, safety, and equitable access. Beyond clinical and policy domains, the broader societal impact includes increasing public awareness about the role of assistance dogs and promoting appropriate behavior around them, which can reduce stigma, prevent interference with their work, and foster a more supportive environment for the owners with PTSD.

Future directions

Future research should build on the findings by examining the longitudinal trajectory of dog-assisted support to determine whether the observed benefits persist over time and continue after the dog retires. Such research could clarify whether the improvements reflect temporary support effects or more durable therapeutic gains. Clarifying the underlying mechanisms is another essential step, particularly the question of whether stress reduction serves as the primary pathway through which executive functioning improves in individuals with PTSD, which will help refine theoretical models of dog-assisted support. Expanding the research to civilian populations will help determine whether the effects observed in first responders generalize across groups with different trauma histories. In addition, refining training protocols for companion dogs could enhance their supportive potential and make dog-assisted support more widely accessible.

As this dissertation shows, further integrating dogs into PTSD care opens promising avenues for innovation, compassion, and personalized support. Yet, it also challenges us to continue questioning assumptions, deepening the available evidence, and ensuring that these interventions are used responsibly and in an evidence-informed manner.

Appendices

Wordlist

References

Data management

Nederlandse samenvatting

Dankwoord

Wordlist

Amygdala

A subcortical brain structure involved in detecting and responding to emotionally salient stimuli, particularly threat. The amygdala initiates autonomic reactions to stressors and interacts with prefrontal and hippocampal regions to modulate vigilance, emotional reactivity, and stress-related learning (LeDoux, 2003).

Attentional bias

The tendency to pay more attention to certain types of stimuli, often based on emotional significance, while ignoring others (Becker & Rinck, 2004).

Companion dog

A dog kept for companionship rather than trained therapeutic or assistance tasks. Companion dogs may provide emotional comfort and social support through their presence and interaction (Stamataki & Tragantzopoulou, 2025).

Electroencephalography (EEG)

A non-invasive method to measure electrical brain activity, providing insights into brain functioning with high temporal resolution (Biasiucci et al., 2019).

Event-Related Potential (ERP)

A measured electrical brain response time-locked to a specific cognitive, motor, or sensory event (Hajcak et al., 2019). ERPs are derived by averaging electroencephalography (EEG) recordings and reflect neural activity during different stages of stimulus processing. Each ERP component is named based on the polarity (P or N) and the latency (in milliseconds, e.g. P300) or order (e.g. P3). The early components (within the first 100 to 200 ms after stimulus onset) reflect automatic, low-level sensory processing, dependent on for example stimulus characteristics. Late components (occur after 200 ms after stimulus onset) are related to higher order processing and reflect complex cognitive processes.

Executive attention

An individual's capacity to choose what they pay attention to and what they ignore (Diamond, 2013).

Executive functions

A range of top-down control processes essential for goal-directed behavior, used when going on automatic or relying on intuition would be inaccurate or impossible. These functions are typically associated with the prefrontal cortex and help individuals manage and regulate their thoughts, actions, and emotions. Executive functions include inhibitory control, working memory, and cognitive flexibility (Diamond, 2013).

N2

A negative ERP component reaching maximum amplitude between 200 and 350 ms post-stimulus and is assumed to be an indicator of inhibition, feedback processes, and conflict monitoring (Miller et al., 2021).

P3

A positive ERP component reaching maximum amplitude between 300 and 500 ms post-stimulus and is associated with attention control and memory updating (Patel & Azzam, 2005).

Post-traumatic stress disorder

A trauma- and stressor-related disorder that can develop following exposure to traumatic events, leading to persistent distress and various symptom clusters. PTSD is characterized by intrusive memories, avoidance, negative alterations in mood and cognition, and heightened arousal or reactivity (American Psychiatric Association, 2013).

Prefrontal cortex

A region of the frontal lobes involved in higher-order executive functions such as working memory, decision-making, and emotion regulation. It exerts top-down modulation over subcortical structures such as the amygdala during stress and threat processing (Kredlow et al., 2022).

Service dog

A dog individually trained to perform specific tasks that mitigate the effects of a person's disability. In the context of PTSD, these tasks may include interrupting dissociative or panic episodes, providing grounding during hyperarousal, alerting to escalating distress, facilitating safe social engagement, and supporting daily functioning (Rodriguez et al., 2020).

Social buffering

A type of stress buffering that highlights the importance of social support in reducing stress (Gilmour & Bard, 2022). Social support is for example talking to a friend, receiving emotional support, or simply being in the presence of supportive individuals. Dogs can provide emotional support, companionship, and comfort, which are all forms of social-buffering, also in the absence of active social interaction. However, there are also non-social mechanisms by which dogs may help reduce stress, for example, by providing a daily routine and physical activity.

Stress buffering

Mechanisms or factors that reduce the negative impact of stress on an individual. Exercise, meditation or personal resilience can all act as stress buffers (Gerber & Pühse, 2009).

Working memory

Working memory is a memory system with limited capacity that manipulates temporarily stored information for complex cognitive tasks (Diamond, 2013).

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Data management

The data in this dissertation were collected and stored in accordance with the data management policy of the Behavioural Science Institute and the General Data Protection Regulation (GDPR). Upon start of the project a Research Data Management Protocol was written and throughout the project data were processed following this protocol. Personal data were pseudonymized immediately after collection, and the key linking participant identities to their data was stored in an encrypted location and deleted after publication.
The study of Chapter 5 and 6 was pre-registered in OSF. The anonymized data of Chapter 3 can be retrieved upon request from the data repository of the Radboud University (https://doi.org/10.34973/m38q-cz87).

Nederlandse samenvatting

Politiemensen lopen een verhoogd risico op een post-traumatische stress stoornis (PTSS), een aandoening die grote gevolgen heeft voor het dagelijks functioneren. PTSS gaat gepaard met herbelevingen, vermijding, negatieve stemming, verhoogde waakzaamheid en problemen in executieve functies, die samenhangen met verstoringen in de balans tussen de prefrontale cortex en de amygdala. Bestaande behandelingen bieden niet altijd voldoende verlichting, de vaak cumulatieve aard van het trauma bemoeilijkt de behandeling en volhouden van de behandeling is vaak lastig voor deze groep mensen. Van degenen die wel in staat waren de behandeling af te ronden, houden er nog veel langdurige restklachten.

Voor hen die uitbehandeld zijn zou stressbuffering verlichting kunnen bieden. Stressbuffering verwijst naar het stress-verlagende effect van de aanwezigheid van een ander individu (mens of dier). Honden zouden deze stressbuffering kunnen bieden. Onderzoek gericht op veteranen suggereert dat zowel gezelschapshonden als speciaal getrainde PTSS assistentiehonden angst en spanning zouden kunnen verlagen en sociale verbondenheid vergroten, maar deze bestaande onderzoeken zijn veelal kwalitatief van aard en experimenteel bewijs over effecten op bijvoorbeeld executieve functies ontbreekt.

Dit proefschrift onderzoekt hoe de aanwezigheid van een hond, zowel een getrainde assistentiehond als een gezelschapshond, het welzijn en de executieve functies van politiemensen met PTSS kan ondersteunen. Aan de hand van verschillende kwalitatieve en kwantitatieve studies wordt zowel gekeken naar de specifieke effecten van assistentiehonden als naar de bredere impact van gezelschapshonden die niet speciaal zijn opgeleid om te ondersteunen bij PTSS.

In Hoofdstuk 2 werd onderzocht hoe Nederlandse politiemensen met PTSS de ondersteuning van assistentiehonden ervaren in vergelijking met gezelschapshonden. Hiervoor zijn interviews afgenomen bij drie groepen, een groep politiemensen met PTSS met een assistentiehond, een groep politiemensen met PTSS met een gezelschapshond, en een groep politiemensen zonder PTSS met een gezelschapshond, welke we onderling hebben vergeleken. De interviews laten zien dat beide typen honden emotionele steun bieden, maar dat assistentiehonden betrouwbaardere en doelgerichtere hulp leveren door getrainde gedragingen die specifiek zijn afgestemd op PTSS-symptomen, zoals het onderbreken van nachtmerries of het signaleren van oplopende stress. Gezelschapshonden vertonen soms vergelijkbaar gedrag, maar minder consequent en minder betrouwbaar. Gezelschapshonden kunnen daarmee mogelijk een waardevol alternatief zijn wanneer een assistentiehond niet beschikbaar is.

Hoofdstuk 3 laat zien dat honden niet alleen bijdragen aan het subjectieve welzijn, maar ook aan een verbetering in het executief functioneren. In de literatuur wordt PTSS in verband gebracht met verminderd executief functioneren, mogelijk veroorzaakt door een disbalans in het frontaal-amygdala-circuit. Een overactieve amygdala vergroot de behoefte aan regulatie van stress-gerelateerde reacties, waardoor de prefrontale cortex minder beschikbaar is voor executieve functies zoals het werkgeheugen. Daarom stelden we in Hoofdstuk 3 de hypothese dat de werkgeheugenprestaties van politiemensen met PTSS gedeeltelijk zouden kunnen herstellen in de aanwezigheid van hun hond, die mogelijk functioneert als stressbuffer. In dezelfde drie groepen als in Hoofdstuk 2 werd het effect van de aanwezigheid van hun hond op werkgeheugenprestaties onderzocht aan de hand van gedragsmatige en EEG maten. Het werkgeheugen werd gemeten met een 1-back taak, zowel in aanwezigheid als in afwezigheid van de gezelschaps- of assistentiehond van de deelnemer. Bij deze taak werden achtereenvolgens letters getoond op een beeldscherm, waarbij de deelnemers gevraagd was zo snel mogelijk op een knop te drukken als de getoonde letter hetzelfde was als de voorgaande letter. De uit het EEG verkregen Event-Related Potentials (ERPs) werden gemeten met een focus op de N2 en P3 ERP componenten. De resultaten laten zien dat politiemensen met PTSS betere werkgeheugenprestaties vertoonden in aanwezigheid van hun hond, wat bleek uit verbeterde taakprestaties en een grotere N2 ERP component vergeleken met wanneer de hond afwezig was. Bij agenten zonder PTSS werd juist in afwezigheid van de hond een betere taakprestatie en een grotere N2 ERP component gevonden. Deze resultaten suggereren dat de aanwezigheid van een hond het werkgeheugen van politiemensen met PTSS kan verbeteren, mogelijk door een stressbufferend effect.

Een ander aspect van het executief functioneren is aandachtsregulatie. PTSS wordt gekenmerkt door hypervigilantie en een aandachtsbias voor dreiging, wat het dagelijks functioneren aanzienlijk kan verstoren. In Hoofdstuk 4 werd de aandachtsbias voor emotionele gezichten bij politiemensen met PTSS onderzocht, en of de aanwezigheid van hun assistentiehond of gezelschapshond deze bias vermindert door stressgerelateerde uitputting van prefrontale cortex capaciteit te beperken. Politiemensen met en zonder PTSS voltooiden een dot-probe taak met afbeeldingen van emotionele en neutrale gezichten, zowel in aanwezigheid als in afwezigheid van hun hond. Bij deze taak kregen de deelnemers steeds kort twee afbeeldingen van gezichten te zien op een beeldscherm (bijvoorbeeld links een boos en rechts een neutraal gezicht), waarna op de locatie van één van de afbeeldingen een stip verschijnt. Snellere reactietijden op de stip die verschijnt op de plaats van een emotioneel geladen gezicht duidt op een aandachtsbias richting dat type stimulus. Reactietijden en ERPs werden geanalyseerd om aandachtsbias

te beoordelen. Politiemensen met PTSS lieten grotere variabiliteit in reactietijd zien maar geen consistente richting van een aandachtsbias. De P3 ERP amplitude liet in de groep met PTSS geen onderscheid zien tussen emotionele stimuli (blij en boos), in tegenstelling tot politiemensen zonder PTSS. Zonder hond waren reactietijden trager en vroege aandachtsprocessen sterker geactiveerd in de groep met PTSS. De aanwezigheid van de hond leek daarmee een effect te hebben op hypervigilantie bij de politiemensen met PTSS, wat suggereert dat honden niet alleen troost bieden, maar ook onderdelen van het executief functioneren zoals selectieve aandacht kunnen beïnvloeden. Ook suggereren de bevindingen dat PTSS gepaard gaat met een verminderd vermogen om aandacht selectief toe te wijzen op basis van emotionele inhoud, en met grotere variabiliteit in reactietijden, in plaats van met een consistente bias richting of weg van emotionele stimuli.

Hoofdstuk 5 onderzocht de haalbaarheid en effecten van de Companion Dog Support Partnership (CDSP) training, een kort trainingsprogramma voor politiemensen met PTSS en hun gezelschapshond. In dit kwalitatieve onderzoek verkenden we hoe een korte training de ondersteunende rol van gezelschapshonden kan versterken. Deelnemers rapporteerden zowel verbeteringen in het gedrag van hun hond, zoals meer beschermingsgedrag en het vermogen om spanning te verminderen, als persoonlijke vooruitgang in emotieregulatie, zelfbewustzijn en dagelijks functioneren. De training bevorderde het begrip van het ondersteunende potentieel van de hond en stimuleerde gedragsactivatie door het ondernemen van meer gezamenlijke activiteiten. Vragenlijsten lieten significante verbeteringen zien in tevredenheid met het leven en fysieke gezondheid, en een lagere toestandsangst na de training. Dit suggereert dat de CDSP-training het ondersteunend potentieel van gezelschapshonden kan versterken voor politiemensen met PTSS.

In Hoofdstuk 6 werd gekeken naar het effect van de CDSP-training op het executief functioneren. Vijfentwintig politiemensen voltooiden gedragsmatige en EEG-metingen vóór en zes maanden na de CDSP-training, zowel in aanwezigheid als in afwezigheid van hun hond. Hoewel er geen veranderingen werden gevonden in aandachtsbias, verbeterde het werkgeheugen in aanwezigheid van de hond, wat bleek uit betere scores op de 1-back taak en hogere amplitudes van de P3 ERP component. Trainingseffecten waren niet statistisch significant, waarschijnlijk door beperkte steekproefgrootte, maar de resultaten onderstrepen opnieuw de mogelijk stressbufferende rol van honden bij executieve functies.

Hoofdstuk 7 richtte zich op de bredere vraag of honden ook buiten de PTSS-context acute stressreacties kunnen dempen. We onderzochten of de aanwezigheid van een hond of een mens zelfgerapporteerde stress, neurofysiologische reacties en cardiovasculaire responsen op aversieve geluiden kan dempen. Voor zowel neutrale als aversieve geluiden werden de geluiden minder

negatief beoordeeld en was de toestandsangst lager wanneer een hond aanwezig was in vergelijking met wanneer ze alleen waren in de ruimte. ERPs lieten conditie-specifieke modulaties zien in zowel vroege als latere verwerkingsstadia. De N1 ERP amplitude was lager in aanwezigheid van de hond dan in aanwezigheid van een mens, en de P2 ERP amplitude was lager in aanwezigheid van de hond dan in de alleen conditie, wat duidt op een gedempte vroege reactiviteit. Zowel de aanwezigheid van een hond als van een mens leidde tot een toename van de N2 ERP amplitude ten opzichte van de alleen conditie, wat wijst op versterkte latere cognitieve verwerking. Cardiovasculaire reacties verschilden niet tussen condities. Deze bevindingen suggereren dat honden kunnen fungeren als sociale buffers tijdens acute stress, mogelijk door vroege (stress)reactiviteit te verminderen en een gevoel van steun te vergroten. De aanwezigheid van een mens leek eveneens sociale buffering te bieden, zichtbaar in de versterkte latere cognitieve verwerking.

Gezamenlijk tonen de studies aan dat honden, zowel getrainde assistentiehonden als gezelschapshonden, betekenisvolle ondersteuning kunnen bieden aan politiemensen met PTSS, ook op het gebied van executieve functies. Daarnaast laat deze dissertatie zien dat gerichte training het ondersteunend effect van gezelschapshonden kan versterken, en dat de aanwezigheid van een hond ook in bredere zin stress zou kunnen verminderen. Hiermee onderstreept de dissertatie de waarde van honden als toegankelijke en effectieve bron van ondersteuning voor mensen met PTSS en daarbuiten.

Curriculum Vitae

Charlotte Lina Witjes-Roelofs was born on 1 March 1996 in Amsterdam, the Netherlands. She completed a Bachelor's degree in Medical Biology in 2017 at the Radboud University. During this period she conducted her first scientific internship under the supervision of Dr. Marijtje Jongsma, investigating event-related potentials of sensory perception for individuals with cerebral palsy. This project was her initial introduction to electroencephalography (EEG) and laid the foundation for her later specialization in neurophysiology. Subsequently, she enrolled in the Research Master's programme in Medical Biology with a specialization in Neurobiology at Radboud University. Her first master's internship took place at the Sensorimotor Lab of the Donders Institute, where she examined saccade kinematics. She subsequently joined Brainclinics in Nijmegen for her second internship, where she received formal accreditation in clinical EEG acquisition with patients. Her work contributed to a peer-reviewed publication on the association between individual alpha frequency and clinical outcomes of rTMS treatment for depression, strengthening her profile at the intersection of clinical neuroscience and translational research. Following her master's degree, Charlotte worked as a research assistant at the Police Academy of the Netherlands, where she collected EEG data from police officers with post-traumatic stress disorder. This role introduced her to applied psychophysiology in professional contexts and inspired her doctoral research trajectory. Charlotte subsequently began her PhD at Radboud University, in close collaboration with the Police Academy. Her doctoral work focused on psychophysiological and stressbuffering mechanisms relevant to trauma in police professionals. Throughout her PhD she presented her research at multiple national and international scientific conferences, contributing to the dissemination of applied neurobiological insights within both academic and professional communities. She is currently employed as a researcher at the Police Academy, where she integrates scientific methodology with real-world applicability, bridging neuroscience and professional practice.

List of publications

Part of this thesis

Roelofs, C. L., Jongsma, M. L. A., Becker, E. S., & Smit, A. S. (2026). Exploring the Effects of Service Dogs: Enhanced Working Memory in Police Officers with Post-Traumatic Stress Disorder. *Anthrozoös*, *39*(3), 439–455. https://doi.org/10.1080/08927936.2025.2557661

Ruberg, A., **Witjes-Roelofs, C. L.**, Jongsma, M. L. A., Becker, E. S., & Smit, A. S., (submitted) The Perceived Added Value of Service Dogs over Companion Dogs in Police Officers with PTSD.

Witjes-Roelofs, C. L., Jongsma, M. L. A., Becker, E. S., & Smit, A. S., Alina Ruberg, Lara Mati, Marilena Bougoulia, Annika S. Smit (in preparation) Social Buffering by Dog Presence During Aversive Sounds: Evidence From Self-Report and Event-Related Potentials

Witjes-Roelofs, C. L., Jongsma, M. L. A., Becker, E. S., & Smit, A. S. (submitted). Companion Dog Support Partnership Training for Post-Traumatic Stress Disorder: Executive Functioning Outcomes.

Witjes-Roelofs, C. L., Jongsma, M. L. A., Becker, E. S., & Smit, A. S., (submitted) Exploring Attentional Bias in Posttraumatic Stress Disorder: Insights from Police Officers with Service Dogs

Witjes-Roelofs, C. L., Willekes, S., Jongsma, M. L. A., Becker, E. S., & Smit, A. S., (in preparation) Enhancing Companion Dog Support for Post-Traumatic Stress Disorder: The Role of Targeted Training

Other publications

Smit, A., **Roelofs, C.**, Rombouts, N., Slagmolen, N., Schreurs, W., & Jongsma, M. (2022). Meerwaarde van buddyhonden voor (oud-)politiemensen: Over leven met PTSS. *Boom Criminologie.*

Roelofs, C. L., Jongsma, M. L. A., Becker, E. S., & Smit, A. S. (2022). The effects of a novel dog-training program for companion dogs of police officers with PTSD. [pre-registration] *OSF.* https://doi.org/10.17605/OSF.IO/DA3M8

Roelofs, C. L., Krepel, N., Corlier, J., Carpenter, L. L., Fitzgerald, P. B., Daskalakis, Z. J., Tendolkar, I., Wilson, A., Downar, J., Bailey, N. W., Blumberger, D. M., Vila-Rodriguez, F., Leuchter, A. F., & Arns, M. (2021). Individual alpha frequency proximity associated with repetitive transcranial magnetic stimulation outcome: An independent replication study from the ICON-DB consortium. *Clinical Neurophysiology: Official Journal of the International Federation of Clinical Neurophysiology*, *132*(2), 643-649. https://doi.org/10.1016/j.clinph.2020.10.017

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