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NEURAL GAIN OF HUMAN-ANIMAL INTERACTION IN COGNITION



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NEURAL GAIN OF HUMAN-ANIMAL INTERACTION IN COGNITION

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Assinatura

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*“Elegí un trabajo que te haga saltar de la cama con alegría
y tené una familia por la cual quieras siempre regresar a casa”*

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E finalmente cá estou eu a escrever os agradecimentos. Aos meus pais por me ensinarem e demonstrarem todos os dias como ser paciente, constante e perseverante, enquanto são o melhor exemplo de amabilidade, apoio e resiliência. À minha mãe, por todas as horas que, desde sempre, passou a estudar comigo. Por me ensinar a pensar de forma crítica, a ver os problemas desde todas as perspetivas possíveis e, mais importante, por me ensinar a resolvê-los com calma e ponderação, mas com a sua garra tão característica. Ao meu pai, pela sua leveza e juventude eterna. Pelas piadas, gargalhadas e humor. Por essa preocupação paterna, tão cheia de amor. Por todas as horas de esforço que, ainda hoje, continua a fazer por esta família e as que a partir dela se originaram. Ao meu irmão que sempre foi e será, no silêncio tão seu, o meu fã número um. À minha irmã que desde sempre deu sentido, valor e, mesmo antes de eu perceber, vocação à minha vida. *"The very things that hold you down are going to lift you up"*. À restante família e amigos que sempre me acompanharam com palavras alentadoras, sempre nessa primeira fila. Ao Marco, meu companheiro em todos os sentidos que a palavra poderá ter. És a minha calma, quem faz o meu sangue condensar novamente depois de eu o ter evaporado. És o meu passado, presente e futuro. Aos meus cães, que me acompanharam em cada segundo de inspiração e escrita desta dissertação. À Sueca, por continuar a fazer-se sentir mesmo sem cá estar. Ao Gomas, por me obrigar de vez em quando a sair da cadeira. À Macarena, por dançar ao som do meu típico cantar desesperado. À Luna, pela sua doce companhia, por esse apoiar de cabeça na minha perna. À Julieta, por se empoleirar e confirmar se tudo continua bem. À Aris, por manter os meus pés sempre quentes, até mesmo no calor algarvio. Por último, mas não menos importante, à Indie. Esta cadela extraordinária que me acompanhou de forma tão incansável durante todo o estudo, com cada participante do grupo experimental. Desde a sua chegada até à limpeza do último elétrodo. Indie, obrigada pela tua estranha combinação de inocência e seriedade. Fica também o meu agradecimento aos participantes, especialmente aos do grupo de controlo que não puderam beneficiar da companhia da Indie. Finalmente, aos meus orientadores João e Mena. Desde o princípio me fizeram sentir como se isto fosse o início da minha carreira de investigadora e não o fim da minha vida de aluna. Esse sentimento fez toda a diferença. Por último e em especial, mais um agradecimento para o João, por ver nos meus olhos a vontade de investigar sobre este assunto e por abraçar o tema sem medo e com tanta força e carinho quanto eu. Nem nos meus sonhos e delírios mais ousados me imaginei um dia poder vir a escrever esta tese. Sou uma pessoa com muita sorte.

Resumo em Português

A história humana está maravilhosamente entrelaçada com a dos animais. Ao longo de milhões de anos, até aos dias atuais, humanos e animais estabeleceram uma forte ligação. Atualmente, os cães são o animal de estimação mais comum nas casas, vivendo como membros da família para muitos. A proximidade e as experiências partilhadas rapidamente trouxeram novos temas com valor antropológico e científico, nos quais se incluem questões como o vínculo humano-animal e as interações humano-animal (IHA). Na última década, diferentes estudos focaram-se nos benefícios da IHA no bem-estar humano e a literatura comumente descreve-os a nível social, cognitivo, emocional e fisiológico. A inclusão de tais benefícios na melhoria da qualidade de vida e/ou independência de pessoas com patologias neurológicas tem ganho especial relevância, nomeadamente através das intervenções assistidas por animais. Os poucos estudos comportamentais e de neuroimagem que procuram investigar o impacto das IHA na cognição têm demonstrado resultados esparsos e pouco conclusivos. Contudo, potenciais marcadores da IHA têm sido estudados através de outros métodos, como através da análise de alterações químicas na saliva (por exemplo, hormonas e neurotransmissores). Estes estudos apontam para o papel central da atividade do eixo hipotálamo-hipófise-adrenal (HPA) no benefício obtido pelas IHA. Por outro lado, alguns estudos têm demonstrado também a influência do eixo HPA na cognição, mais especificamente, na sua influência sobre as funções executivas como o controlo inibitório. No presente estudo procuramos explorar a influência da IHA na cognição, tendo por base o facto desta interação ter impacto no eixo HPA, e este, por sua vez, influenciar o desempenho cognitivo. Assim sendo, neste estudo com recurso ao EEG, foi utilizada uma tarefa de controlo inibitório (go-nogo) para investigar as possíveis diferenças da IHA a nível comportamental e de ativação neuronal. Dois grupos de participantes realizaram a tarefa com a presença de um cão amigável (grupo experimental, N = 15) ou sem o mesmo (grupo controlo, N = 13). Para a tarefa go-nogo foi estabelecida uma relação de 80/20% e um intervalo entre trials fixo de 500 ms, com uma exibição máxima de 1000 ms (ou até a resposta) do estímulo. Este design permite avaliar melhor o sinal neuronal do controlo inibitório, incluindo a resposta cerebral antecipatória relacionada com as projeções dos gânglios da base-tálamo-corticais. Foram realizados três blocos de 250 trials, precedidos por estados de repouso (com os olhos fechados) e um estado de repouso final. Os múltiplos blocos permitiram investigar possíveis mudanças ao longo do tempo em ambos os grupos. Os estados de repouso permitiram registar uma medida de EEG independente da tarefa. O tempo de reação e a precisão durante as condições go e nogo constituíram as medidas comportamentais. Por fim, os ERPs obtidos da tarefa go-nogo (CNV, N2 e P3) e a potência de oscilação cerebral (Alfa e Beta) obtidos nos estados de repouso e no período de *baseline* constituíram as medidas neuronais. Foi estabelecido como hipótese que os participantes que interagem com o cão, enquanto participam na tarefa go-nogo, obteriam resultados comportamentais aprimorados (ou seja, tempos de reação mais curtos e maior precisão) e alteração nas respostas neuronais que podem estar ligadas ao controlo inibitório.

Os resultados comportamentais parecem sugerir um leve aumento do desempenho do grupo experimental em relação ao grupo de controlo durante a tarefa, embora pareça não ser específico para o controlo inibitório uma vez que os principais resultados se relacionem com a condição go. Contudo, a análise das médias dos resultados comportamentais globais e por bloco não diferem de forma significativa entre os grupos. Um olhar mais atento sobre essas variáveis entre os blocos mostra uma melhoria significativa no tempo de reação (go) apenas no grupo experimental. Ao contrário, a precisão na condição nogo piorou de forma significativa em ambos os grupos. Para além disso, foi encontrada uma interação significativa com efeito moderado entre o grupo e o bloco na acuidade durante a condição go, onde se observou um aumento de desempenho no grupo experimental e o efeito invertido no grupo de controlo. Relativamente aos dados neuronais, foram encontradas diferenças significativas nos componentes do ERP. O potencial P3 apresentou menor amplitude para o grupo experimental (em relação ao grupo de controlo) em ambas as condições. Por outro lado, não foram encontradas diferenças no componente N2. Os dados neuronais mostram maiores diferenças entre os grupos no componente CNV. Diferenças significativas foram encontradas neste componente, onde se verifica uma maior negatividade e inclinação no grupo experimental. Além disso, o componente CNV foi gradualmente perdido pelo grupo de controlo ao longo dos blocos, enquanto o grupo experimental mostrou a progressão inversa, com aumento da negatividade do CNV. Estes resultados parecem ser não específicos para a tarefa de controlo inibitório, uma vez que a interação surge em ambas condições e começa durante o período de preparação para os estímulos (quando o participante ainda desconhece se é um estímulo go ou nogo). Quanto às oscilações cerebrais, não foram encontradas diferenças nas ondas Beta durante o estado de repouso. Contrariamente, níveis significativamente mais altos de ondas Alfa surgem no grupo de controlo durante os três estados de repouso. Não se encontraram diferenças nas oscilações durante o período de *baseline*.

Embora os resultados comportamentais não tenham diferido de forma global, os dados do EEG parecem indicar que o grupo experimental e o de controlo realizaram a tarefa de maneira diferente. O efeito da IHA na cognição parece assim não estar relacionado com o controlo inibitório em si, mas talvez com outras variáveis com implicação mais global na cognição. Por outras palavras, parece influenciar fatores como a capacidade de se manter atento e/ou motivado ou reduzir a fadiga cognitiva, podendo influenciar a forma como a tarefa é realizada, com impacto em alguns resultados comportamentais. Esta investigação pode contribuir com uma nova visão na influência da IHA para a cognição, pois sugere que, embora ambos os grupos alcancem resultados semelhantes a nível comportamental, o processamento é diferente, pois há evidência de um processo neuronal diferente na presença do cão. Isto reforça a relevância do presente estudo e abre novos horizontes para compreender os possíveis benefícios da IHA na cognição.

Palavras-chave: interação humano-animal; eletroencefalograma; controlo inibitório; eixo HPA; cão

Abstract

Human history is wonderfully intertwined with animals. The closeness and shared experiences quickly brought to the surface new topics with anthropologic and scientific value, in which matters such as human-animal interactions (HAI) are included. Different studies focused on the benefits of HAI in humans. The few behavioural and neuroimaging studies that investigate the impact of HAI on cognition have demonstrated inconclusive results. However, potential HAI markers were observed using other methods, such as chemical changes in saliva. These studies point to the central role of the activity of the hypothalamic-pituitary-adrenal (HPA) axis in the benefit obtained by HAI. Additionally, some studies have demonstrated the influence of the HPA axis on executive functions such as inhibitory control. Therefore, we sought to explore the influence of the HAI on cognition, since this interaction has an impact on the HPA axis, which influences cognitive performance. In the present study, we employ a go-nogo task to investigate potential differences in behavioural and EEG responses of inhibitory control due to HAI using two groups who performed the task in the presence of a friendly dog (experimental group, N = 15) or without it (control group, N = 13). Although the behavioural results did not differ globally, the EEG data showed interesting differences. The main differences were found in the CNV component, where its negativity, in addition to being more pronounced, is maintained throughout the blocks only in the experimental group. The results suggest that the effect of HAI on cognition may not be related to inhibitory control per se. Instead, HAI in our task may have influenced the ability to remain attentive and/or motivated throughout the experimental session. A new insight is provided attending to the fact that, although both groups reached similar behavioural results, their EEG responses differed significantly. This underlines the relevance of the present study since it opens new horizons to understand the possible benefits of HAI in cognition.

Keywords: human-animal interaction; electroencephalogram; inhibitory control; HPA axis; dog

Acronym list

AAI – Animal assisted intervention

CG – Control group

CMS – Common mode sense active electrode

DRL – Driven right leg passive electrode

EEG – Electroencephalogram

EG – Experimental group

ERP – Event-related potential

GDPR – General data protection regulation

HAI – Human-animal interaction

HPA – Hypothalamic-pituitary-adrenal

ICA – Independent component analysis

ISI – Interstimulus interval

NIRS – Near infrared spectroscopy

PAS – Pet Attitude Scale

ROI – Region of interest

STICSA – State-trace inventory for cognitive and somatic anxiety

TOI – Time of interest

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1. Introduction

Human history is wonderfully intertwined with animals. Over millions of years, until the present day, humans and animals have established a strong link. For some animals, this link led to a domestication process, encompassing an incredible evolutionary development (Larson & Fuller, 2014; Zeder, 2012). One of the greatest examples is the domestication of wolves into dogs, with altered social and communication abilities toward humans, along with their physical characteristics. This relationship was based on a synergy where Man offered food, protection, health, hygiene, shelter, and a social context to dogs, while dogs contributed back to some of these aspects, including hunting, shepherding, protection from predators, alarm, and in establishing social and emotional interactions with humans (Carter & Porges, 2016; Friedsmann, 2019; Gee, Rodriguez, Fine & Trammell, 2021; Hoy-Gerlach, Delgado, Sloane & Arkow, 2019, 2019; Pierotti, Fogg & Anderson, 2018; Wynne, Dorey & Udell, 2011). Nowadays, dogs are the most common animal in households, living as a pet and, more importantly, as family members for many (Growth from Knowledge, 2016; Gee, Rodriguez, Fine & Trammell, 2021). The closeness and shared experiences quickly brought to the surface new topics with anthropologic and scientific value, in which matters such as the human-animal bond and human-animal interactions (HAI) are included. Self-experiences and reports with some lack of scientific support brought awareness to the potential of HAI in human well-being, including physical and mental benefits (Gee, Rodriguez, Fine & Trammell, 2021). Furthermore, the inclusion of the benefits of HAI in the improvement of quality of life and/or independence of people with neurological pathologies has gained special relevance, namely through animal-assisted interventions (AAI) (McCune et al., 2020; Muñoz Lasa et al., 2015; Yacilla, 2021). AAI aims to promote the physical, social, emotional and/or cognitive well-being of people, through interaction and/or bonding with an animal (Jegatheesan et al., 2018; Winkle et al., 2020). Despite the fact HAI and AAI are widely used in some clinical settings, they are still poorly studied, and a comprehensive neurobiological mechanism is still missing (Hoy-Gerlach, Delgado, Sloane & Arkow, 2019; Friedsmann, 2019; Wynne, Dorey & Udell, 2011).

In the last decade, different studies focused on the benefits of HAI in human well-being (Charry-Sánchez et al., 2018; Muñoz Lasa et al., 2011, 2015, see table 1.1). Some of the described social benefits of HAI are the increase in social competence, interaction, communication, and the reduction in social isolation (Ávila-Álvarez et al., 2020; Brooks et al., 2018; Jones et al., 2019); at the cognitive level, studies report an increase in attention spans and a reduction of disturbing behaviours, agitation, and apathy (Busch et al., 2016); at the emotional level, a reduction of depressive, anxious, and stress symptoms (Brooks et al., 2018; Charry-Sánchez et al., 2018; Jones et al., 2019); and at the physiological level, a global calming effect with a reduction in cortisol levels and an increase in psychomotor activation (Ávila-Álvarez et al., 2020; Feng et al., 2021). Overall, a global increase in individual performance stands out, with improvements in the achievement of goals, motivation and adherence to treatment and working sessions, as well as an overall positive impact in symptomatology severity and improvement in quality of life (Fine, 2015). However, despite the positive outcomes commonly reported by AAI

professionals, studies on the potential impact of HAI and AAI on cognitive functions are often contradictory. For example, even though self-reported and observational measures point to a positive impact of HAI on attention, concentration, memory, or learning (Hediger and Turner, 2014; Brelsford et al., 2017; Busch et al., 2016; Gee et al., 2010, 2017), a more recent study failed to provide behavioural evidence that HAI could boost long-term memory, working memory, or attentional control (Thayer and Stevens, 2021).

Intrigued by some of the previous behavioural evidence on the positive influence of pets (mainly friendly dogs) on cognition, several researchers sought to combine HAI protocols with neuroimaging techniques to study the brain involvement in HAI (Balconi and Vanutelli, 2016; Hediger and Turner, 2014). Balconi and Vanutelli (2016) made use of functional near infrared spectroscopy (fNIRS) and electroencephalography (EEG) in combination with an audio-visual task to investigate the brain response to interpersonal inter-species contexts with different emotional valence. Hediger and Turner (2014) studied possible neural effects of HAI by comparing fNIRS responses in several attention tasks when a dog, in comparison to a robotic dog, was present. Despite their different research strategies, namely, to perceive HAI stimuli or perform a cognitive task in the presence of an animal, both these studies converge in the saliency of the prefrontal cortex. Beyond neuroimaging studies, potential HAI markers can be studied using chemical changes in the saliva related to HAI (e.g., hormones and neurotransmitters). A significant increase in β -endorphin, oxytocin, prolactin, phenylacetic acid, and dopamine were observed both in humans and dogs during HAI events, and a significant reduction in cortisol, epinephrine, and norepinephrine in humans (Odendaal, 2000; Odendaal et al., 2003; Pendry & Vandagriff, 2020). These findings pointed to the central role of the hypothalamus-pituitary-adrenal glands (HPA) axis activity in HAI (Pendry & Vandagriff, 2020; Serpell et al., 2017; Yorke & Yorke, 2010). Both the hypothalamus and pituitary gland are subcortical structures that form part of the limbic system, while adrenal glands, responsible for hormone production (e.g., cortisol), are located above the kidneys. The HPA axis is a neuroendocrine system regulating our brain response to stress, mood, and emotions (Gazzaniga, 2014; Kolb & Whishaw, 2013).

Few studies investigated the relation between the HPA axis and cognition, specifically, the influence of the HPA axis on executive functions (EF) (e.g., Bulter et al., 2017; Perry et al., 2019). EF are the pillars of human cognition. They enable us to plan, focus attention, remember instructions, maintain self-control, or juggle multiple tasks successfully (Carlson, Zelazo & Faja, 2013). The connection between the HPA axis and EF holds potential to find a link between HAI and cognition. However, whether HAI directly impacts EF remains unclear (Ling, Kelly & Diamonds, 2016). Interestingly, a recent investigation with at-risk college students found that EF could be enhanced through programs focused on interacting with animals (Pendry et al., 2021). Inhibitory control is one of the main EF, and involves the connectivity between subcortical nuclei, namely the basal ganglia, and the frontal lobe via the thalamus - a circuit known as the basal ganglia-thalamo-cortical circuit (Carlson, Zelazo & Faja, 2013). While the direct pathway of the basal ganglia-thalamic-cortical circuit serves an excitatory purpose, both indirect and hyperdirect pathways play an important role in inhibition (Beste et al., 2010; Carlson,

Zelazo & Faja, 2013). Considering the evidence linking the HPA axis and HAI and provided the fact that both basal ganglia and HPA axis are involved in emotion processing and susceptible to mood (Marchand, 2010; Pierce & Péron, 2020), we hypothesized that the neural correlates of inhibitory control may be also modulated by HAI. Despite accumulating, although indirect, evidence suggesting that HAI may trigger neural responses that alter frontal lobe circuits, potentially involving inhibitory control via basal ganglia-thalamic-cortical projections, no study has insofar studied the impact of HAI in inhibitory control. Importantly, no study has investigated differences in brain response related to HAI during inhibitory control tasks. This relation may help uncovering the influence of HAI in cognition, and bring into light a mechanistic explanation for why and how the presence of a friendly pet (e.g. a dog) can affect behaviour. In a recent HAI study, Thayer & Stevens (2021, unpublished) found unchanged behavioural results in all EF tested. However, the authors did not test inhibitory control (Thayer & Stevens, 2021, unpublished).

To investigate inhibitory control via basal ganglia-thalamic-cortical projections and potential differences in brain response, the EEG becomes a valuable tool. Several EEG studies have used temporally predictable cues to investigate basal ganglia-thalamo-cortical projections, included in inhibitory control, using an event-related-potential (ERP) known as contingent negative variation (CNV) (Brunia, 2003; McCallum, 1988; Luck, 2014; Tecce, 1979). Basal ganglia-thalamo-cortical projections are rhythm-dependent and thus modulated by exogenous cues that help anticipating the onset of a given stimuli related to perceptual and action tasks (Rektor et al., 2003). Typically, the CNV shows a slow negative slope prior the stimulus that is being anticipated, reflecting task preparation (Brunia, 2003; McCallum, 1988; Luck, 2014; Tecce, 1979). Other ERP components related to inhibitory control tasks are the N2 and the P3 (Beste et al., 2010; Wessel, 2018). The N2 component is a negative peak that occurs 200 ms after stimulus onset and is usually associated with conflict processing before a correct response is given (Donkers & van Boxtel, 2004; Groom & Cragg, 2015; Smith, Johnstone & Barry, 2008). The P3 component is a positive peak occurring between 250 and 500 ms after stimulus onset and reflects cognitive resource allocation in a later stage of information processing. Furthermore, the P3 component has long been purported to index response inhibition through motor inhibition (Beste et al., 2010; Michel, Bolte & Liepelt, 2018; Smith, Johnstone & Barry, 2008; Wessel, 2018).

Conclusively, our literature review led to identify inhibitory control as a cognitive function that might be connected to HAI, attending on its influence over activation/cessation of the HPA axis and how this neuroendocrine system interferes with cognition. In this EEG study, we employ a go-nogo task to investigate potential differences in the neural correlates of inhibitory control due to HAI using two groups of participants, who performed the task with (experimental group) or without the presence of a friendly dog (control group). A ratio of 80-20% of go-nogo trials, a fixed inter-trial-interval (ITI) of 500 ms, and 1000 ms of maximum stimulus duration was used (Wessel, 2018). Three blocks of 250 trials were administered per subject, each preceded by a resting-state (eyes-closed) block. The three blocks allow to investigate possible changes over time across the groups. The resting-state blocks allow to investigate EEG-HAI effects independent on task. Sociodemographic data were also collected to

assess/guarantee group homogeneity. Overall, reaction times and accuracies during the go-nogo task constitute the behavioural measures. ERPs obtained from the go-nogo task (CNV, N2 and P3) and the power of brain oscillation (*Alpha* and *Beta*) obtained from the task baseline (pre-stimulus) period and resting-state blocks constitute the EEG measurements. We expect that participants who interact with a dog while taking part in the go-nogo task show enhanced behavioural (i.e., shorter reaction times and/or higher accuracy) and altered EEG responses that can be linked to inhibitory control.

1.1. Extended literature review on HAI

Aiming to better understand HAI and its practical application, a thorough review of literature was conducted. Even though several topics are relevant to the basic understanding of the field and its connection to neuropsychology or cognitive neuroscience, this information may make less clear how literature review led to the purpose of this study. In order not to lose this information that contextualizes HAI, this section of extended literature review was created to keep the introduction of the study clearer.

Since the beginning of the growth of this area of study, several theories were proposed to explain the interest in proximity between humans and animals. Bowlby's theory of attachment (Bretherton, 1992) explains the need for humans to protect and to be protected. Keeping proximity helps to better cope with the world and may explain the reason for the relationship established with animals (Sable, 1995). HAI can also be explored via the social support theory (Beetz & Bales, 2016). This theory suggests that humans seek social support as a coping mechanism to help maintain physical and mental health. Furthermore, another theory entitled the Biophilia hypothesis (Fine & Beck, 2019; Frumkin, 2008) highlights the human desire and the need to connect and interact with other living organisms. Lastly, the biopsychosocial model (Engel, 1980; Gee et al., 2021) aims to understand human condition through biological, psychological, and social aspects and can be used to explore the influence of HAI and its outcomes. These theories and models help us understand the reason behind the establishment of deep connections and the consequent benefits of interacting with animals. Nonetheless, all of them lack to explore the in-between events. For example, does HAI alter neurobiology in a way that promotes cognitive changes?

Attending to the various unanswered questions, throughout the last decade different studies focused on the benefits of HAI for human (Charry-Sánchez et al., 2018; Muñoz Lasa et al., 2011, 2015, see table 1.1) and several models have been presented. Although the body of research keeps growing, the specific characteristics of HAI, like high variability in HAI and AAI (e.g., intensity and frequency, individual or group setting, length, species, location, type, and specificity of the evaluated group) tend to add difficulties to draw firm conclusions.

Table 1.1.

Summary of results of investigations in HAI and AAI in populations with neuropsychological pathology

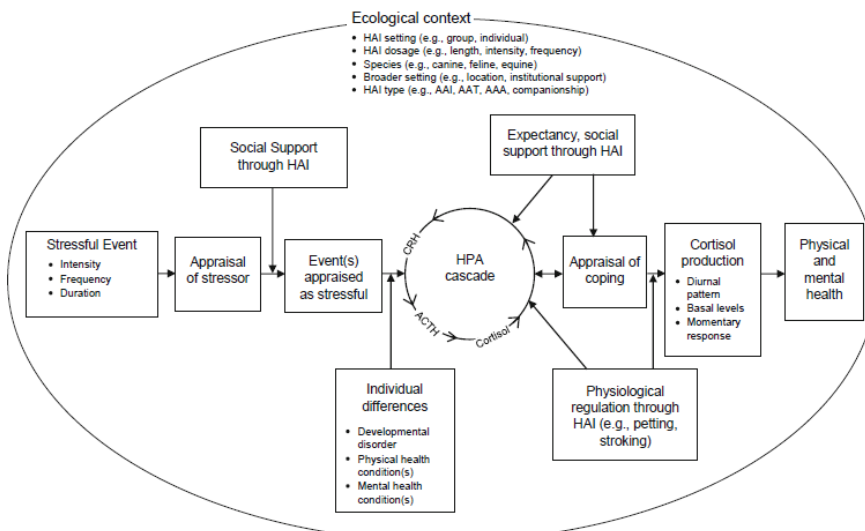
References	Population	Main results
Busch et al., 2016	Attention deficit and hyperactivity disorder (ADHD)	↓ symptom severity ↓ agitation reduction ↑ attention spans ↑ achievement of goals ↑ motivational, cognitive, and academic performance ↑ socialization, overall calming effect
Ávila-Álvarez et al., 2020; O’Haire, 2013, 2017; Viau et al., 2010	Autism spectrum disorder	↑ social interactions and communication ↓ cortisol ↓ problem behaviours ↓ symptom severity ↓ stress
Muñoz Lasa et al., 2011, 2015	Multiple sclerosis, spinal cord injury, stroke, cerebral palsy	↓ spasticity ↑ balance ↑ limb control
Charry-sánchez et al., 2018; Park et al., 2020; Peluso et al., 2018; Yakimicki et al., 2019; Zafra-Tanaka et al., 2019	Dementia	↓ depressive, aggressive, and anxious symptoms ↓ agitation and apathy ↑ physical activity and food intake ↑ relationship skills and social interaction ↑ quality of life
Brooks et al., 2018; Charry-Sánchez et al., 2018; Jones et al., 2019	Mental health	(adults) ↓ worry ↓ isolation and feelings of loneliness ↑ comfort ↑ symptom distraction ↑ physical activity ↑ social interaction behaviours (adolescents) ↓ symptomatology ↓ disruptive behaviours ↑ treatment adherence and socialization
Calvo et al., 2016; Charry-Sánchez et al., 2018; Hawkins et al., 2019; Peluso et al., 2018; Sahebalzamani et al., 2020; Stefanini et al., 2015	Schizophrenia and psychiatric disorders	↓ negative symptoms ↓ social isolation ↓ positive symptoms (less frequent) ↓ cortisol ↑ adherence to work sessions (adolescents) ↑ overall functioning ↓ necessary care ↑ school attendance
Contalbrigo et al., 2017	Substance abuse	↑ social skills ↓ desire ↓ anxiety symptoms ↓ depression
Arnskötter et al., 2021; Boitier et al., 2020; Hediger et al., 2019	Minimal state of consciousness	↑ behavioural responses ↑ eye movement ↑ active movements by tactile stimulation ↑ activation and consciousness ↑ neurovascular reaction of the frontal cortex ↑ activation of attention processes and emotional processes ↑ rating scales of vegetative states
Calcaterra et al., 2015; Feng et al., 2021; Fine, 2015	Pain/neuropathy	↓ Pain

These difficulties are specially highlighted when one tries to understand the neurobiological mechanisms and consequent benefits underlying HAI and AAI (Busch et al., 2016; Muñoz Lasa et al., 2015; Pendry and Vandagriff, 2020). Furthermore, the scientific evidence supporting AAI is inconsistent, despite the positive outcomes commonly reported by professionals operating in the clinical and therapeutic settings, suggesting a lack of scientific robustness and the need to develop new studies.

One of the most consolidated effects is HAI influence over activation/cessation of the HPA axis and, subsequently, how this neuroendocrine system interferes with emotion, cognition, and behaviour. Pendry and Vandagriff (2020) proposed a model (Figure 1.1.) that, while highlighting HAI's impact on the HPA axis, frames itself within social support and stress-coping concepts, where both individual differences and the ecological context are contemplated.

Figure 1.1.

Proposed HAI-HPA transactional model by Pendry and Vandagriff (2020)



Note: HPA - Hypothalamic-pituitary-adrenal; CRH - Corticotropin releasing hormone; ACTH - Adrenocorticotropin hormone

More specifically, Pendry and Vandagriff (2020) suggest that HAI might play a role in the activation and cessation of the HPA cascade through perceptions of the social support provided by the animal, acting in the cognitive appraisal of the perceived stressor. Moreover, appraisal and reappraisal may help in the evaluation of stressor factors as less overwhelming, together with the capacity to adjust expectancy as a coping mechanism. Physiological responses related to the interaction with animals co-occur, producing oxytocin, which downregulates cortisol and attenuates the HPA cascade by interrupting the production of Corticotropin releasing hormone and Adrenocorticotropin hormone. At the same time, interacting with animals has a psychological impact that suppresses HPA activation (also by the mentioned process of appraisal/reappraisal and expectancy). The role of specific dyadic interaction behaviours in both animals and humans is considered, as well as the development, treatment, and other variables in specific populations often targeted in AAIs. Individual differences are likely to influence the extent to which HAI

influences HPA activity, as well as the ecological context (i.e. individual or group setting, length, intensity and frequency, specie, location) in which it occurs.

It seems that interacting with animals (e.g., friendly dog) causes changes in brain hormones and neurotransmitters that affect its functioning and, consequently, the emotional state, cognition, and behaviour. Even so, there is currently a lack of scientific evidence to fully support this hypothesis. Importantly, some authors point to the need to integrate functional neuroimaging, including functional magnetic resonance image (fMRI), EEG, fNIRS, and salivary bioscience to understand the neurobiological mechanisms subserving the therapeutic applications and benefits of HAI (Kazdin, 2017; McCune et al., 2014; Pendry, & Vandagriff, 2020; Serpell et al., 2017). It is in this sense that the present investigation seeks to contribute to the scientific literature of the subject.

2. Methodology

2.1. Participants

The sample consisted of 28 individuals residing in Portugal, divided in two groups: the Control Group (CG) and the Experimental Group (EG). Psychiatric disorder, neurological disorder and/or history of neurosurgery were exclusion criteria. One participant was excluded from the CG for having a diagnosis of a psychiatric disorder and another participant from the EG was excluded due to a technical failure in EEG acquisition. Three participants in the CG did not attend the appointment for data collection. The CG consisted of a total of 13 individuals (11 female, 84.62%), aged between 18 and 46 years old (Mean \pm Standard Deviation (SD) = 24,31 \pm 8,86) and 13 to 17 years of school education (Mean \pm SD = 14,23 \pm 1,739). The EG had 15 individuals (13 female, 80%), aged between 18 and 50 years old (Mean \pm SD = 25,27 \pm 8,38) and 13 to 17 years of school education (Mean \pm SD = 14,00 \pm 1,512). Table 2.1. presents the data referring to the sociodemographic variables of both groups, where significant differences between groups were only found in the owning pets variable ($X^2 = 5,791, p = 0,016$).

2.2. Instruments

2.2.1. Sociodemographic and clinical information questionnaire

The sociodemographic and clinical information questionnaire (Appendix A) was designed as a tool for characterizing groups in terms of age, sex, nationality, place of birth, years of education, and occupation, as well as for collecting other information on factors related to human-animal interaction, relevant to the present investigation. The clinical information was used to determine the eligibility of the participants attending to the pre-defined exclusion criteria.

2.2.2. The Pet Attitude Scale (PAS)

The PAS (Templer, Salter, Dickey, Baldwin & Veleber, 1981; Temper & Arikawa, 2011) aims to measure the human-animal bond and its results are related to attitudes and treatment towards animals. The scale consists of 18 items, whose answers are given using a Likert scale from 1 (strongly disagree) to 7 (strongly agree).

For the process of adapting the scale to European Portuguese, the importance of achieving a good equivalence, both linguistically and culturally, was considered (Werner & Campbell, 1970). Initially, two translations were carried out by two bilingual speakers, and both translations were compared and discussed to obtain a consensus version. Then, this version was translated into the original language by an independent third bilingual speaker, aiming to compare the retroversion to the original version. Small adjustments were made to obtain semantic equivalence. This second version of the consensus was then applied to 15 adults, not participating in the present investigation, to carry out the content equivalence. After these steps, one can then consider the PAS scale translated into European Portuguese (Appendix B).

Table 2.1.*Sociodemographic characterization of the two groups*

	CG (N = 13)	EG (N = 15)	p
Sex	Fem. (N = 11; 84,62%) Male (N = 2; 15,38%)	Fem. (N = 12; 80%) Male (N = 3; 20%)	$X^2 = 0,101$ $p = 0,750$
Age (mean age in years \pm SD)	24,31 \pm 8,864	25,27 \pm 8,379	$U = 114,50$ $p = 0,440$
Education level (mean years \pm SD)	14,23 \pm 1,739	14,00 \pm 1,512	$U = 94,00$ $p = 0,892$
Owns pets	Yes (N = 7; 53,85%) No (N = 6; 46,15%)	Yes (N = 14; 93,33%) No (N = 1; 6,66%)	$X^2 = 5,791$ $p = 0,016^*$
Human-animal interaction	Daily (N = 3; 23,08%) Weekly (N = 1; 7,69%) Monthly (N = 2; 15,38%) Annual (N = 1; 7,69%) Doesn't have (N = 6; 46,15%)	Daily (N = 8; 25,33%) Weekly (N = 0; 0%) Monthly (N = 4; 26,67%) Annual (N = 2; 13,33%) Doesn't have (N = 1; 6,67%)	$U = 55,00$ $p = 0,052$
PAS (total score, mean \pm SD)	110,62 \pm 7,698	114,87 \pm 5,643	$U = 63,00$ $p = 0,118$
Anxiety – Somatic state (STICSA-1) (total score, mean \pm SD)	13,62 \pm 3,176	12,07 \pm 2,764	$U = 129,00$ $p = 0,156$
Anxiety – Cognitive state (STICSA-1) (total score, mean \pm SD)	15,31 \pm 4,328	14,33 \pm 4,806	$U = 106,50$ $p = 0,683$
Anxiety – Somatic trace (STICSA-2) (total score, mean \pm SD)	17,92 \pm 5,024	17,73 \pm 4,317	$U = 96,00$ $p = 0,964$
Anxiety – Cognitive trace (STICSA-2) (total score, mean \pm SD)	19,77 \pm 5,718	21,87 \pm 7,434	$U = 78,50$ $p = 0,387$

Note: U - Mann-Whitney test; X^2 - chi-square independence test; PAS – Pet Attitude Scale

2.2.3. State-Trace Inventory for Cognitive and Somatic Anxiety (STICSA)

The STICSA (Ree, French, MacLeod, & Locke, 2008) is a self-response instrument that assesses anxiety in the cognitive and somatic dimensions and allows to distinguish trace anxiety from state anxiety. For the present investigation, the adaptation of Mendes (2018) for the Portuguese context was used (Appendix C).

As proposed by Mendes (2018), item 11 was excluded in all measures. In state anxiety, items 3, 4, 5, 9, 10, 13, 16, 17 and 19 were considered in the calculation of the cognitive dimension, while items 1, 2, 6, 7, 8, 12, 14, 15 and 18 for the somatic dimension, excluding items 20 and 21. As for trace anxiety, the items that constitute the cognitive and somatic dimension are identical to those of state anxiety, with items 20 and 21 being added to the calculation of the somatic dimension.

2.2.4. Go-nogo task

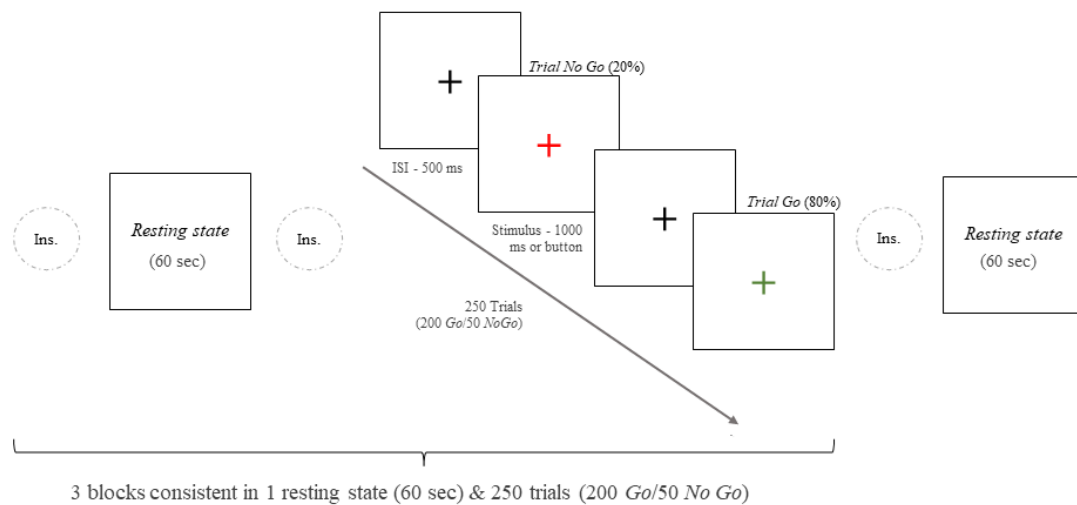
For the inhibitory control task, a go-nogo design was drawn and respective practice version, with a ratio of 80% for the go condition and 20% for the nogo condition (Wessel, 2017). The practice version consisted of a resting state moment (10 seconds) and 150 trials. On the other hand, the task consisted of 3 blocks, each composed by a resting state period and the inhibitory control task, ending with an additional resting state period (Figure 2.1.).

The stimulus was a black coloured fixation cross displayed at the centre of the screen for 500 ms, randomly changing to green (go condition) or red (nogo condition) for a maximum duration of 1000 ms or until the participant's response. In accordance with the instructions given to the participants, they should click on the space button as quickly as possible, with their dominant hand, whenever the stimulus changed to green, and refrain from pressing the button when it changed to red. Each of the 3 block consisted of 250 trials (200 go trials and 50 nogo trials), making a total of 750 trials (600 go trials, 150 nogo trials) for each session. Each participant took part of one session in total. After the last block, a fourth resting state was performed, but was not yet included in the analysis. The resting state periods had a duration of 60 seconds and during this period the participants were asked to relax with their eyes closed until a verbal indication from the researcher.

Continuous EEG recordings were performed using the BioSemi ActiveTwo 64-channel Ag/AgCl electrode system (*BioSemi Amsterdam, Netherlands*). The signal amplification was performed by the BioSemi ActiveTwo amplifier, with a sampling rate of 264 Hz during the entire period of the experiment and recorded by the ActiveView600-Hires software (BioSemi).

Figure 2.1.

Inhibitory control task design – go-nogo



2.3. Procedures

The present investigation was submitted to the *Universidade do Algarve*'s Ethics Committee. The divulgation was conducted by e-mail, approaching psychology undergraduate and master's students at the *Universidade do Algarve*, where the purpose of the study was indicated, as well as the participants' exclusion criteria. The registered participants were then randomly assigned to the control or experimental groups. Both groups performed the same tasks and received the same instructions. The only difference in the groups was the fact that in the session of the experimental group a trained and experienced dog in AAI (female, 3 years old, Labrador Retriever) was present at all stages, including EEG preparation, instructions, and tasks. Since the dog is commonly used in the AAI context, it holds a liability insurance. During pilot testing for the study, the dog was introduced to the context where the experiment was going to take place. Several habituation and training sessions were carried out to ensure well-being conditions for the dog. Furthermore, rest and water intake times were respected, and equally across groups. The main investigator, who is also a professional trainer and the dog tutor, was always present.

In agreement with the standards of the Declaration of Helsinki and the Oviedo Convention, all participants signed the informed consent (Appendix D) and the data privacy requirements information document (Appendix E). Subsequently, the participants completed the sociodemographic questionnaire (Appendix A), previously submitted to the Data Protection Officer to obtain the Opinion on GDPR Compliance (Appendix F). At last, participants responded to the PAS (Appendix B). In this initial phase, small moments of social interaction were created between the main researcher and the participants, and in the case of the EG opportunities to interact with the dog were promoted (i.e., petting, giving food, clarifying some curiosities).

EEG recording preparation included placing electrodes on the participants' scalps using a 10/20 system cap (centred through the midpoint between the inion and nasion bones in the sagittal plane, and the midpoint between the ears in the coronal plane). Conductive gel was applied using a plastic syringe. The 64 electrodes were then placed in the predefined areas of the right and left hemisphere, together with the CMS and DRL electrodes that function as active reference and ground in the Biosemi EEG system.

After checking the quality of electrode connectivity (i.e., impedance and data monitor), participants were comfortably positioned in the chair (see Figure 2.2-A). For the EG, the dog was positioned on the left side of the participants using a platform that allowed greater proximity to the animal throughout the session (see Figure 2.2-B). Apart from the presence of the dog, all other aspects of the experiment were matched between the CG and the EG. Regarding the go-nogo experimental task, the participants did a short training of the task (150 trials) before beginning the recording. Regarding the resting-state periods, participants in the EG kept their left hand over the dog (Figure 2.2-B). After completing all cognitive tasks, participants responded to the STICSA questionnaire.

Figure 2.2.

Photographic record of the experimental setting



2.4. Data analysis

Statistical analysis of the collected data was performed using the *Statistical Package of the Social Sciences* (SPSS, version 28) together with *EEGLab* for all pre-processing stages and for the statistical analysis of the epoched EEG data (i.e., event-related-potentials, ERP), which used *MathLab* (version R2021b) and custom-made scripts. We also report Cohen's *d* of multiple measures.

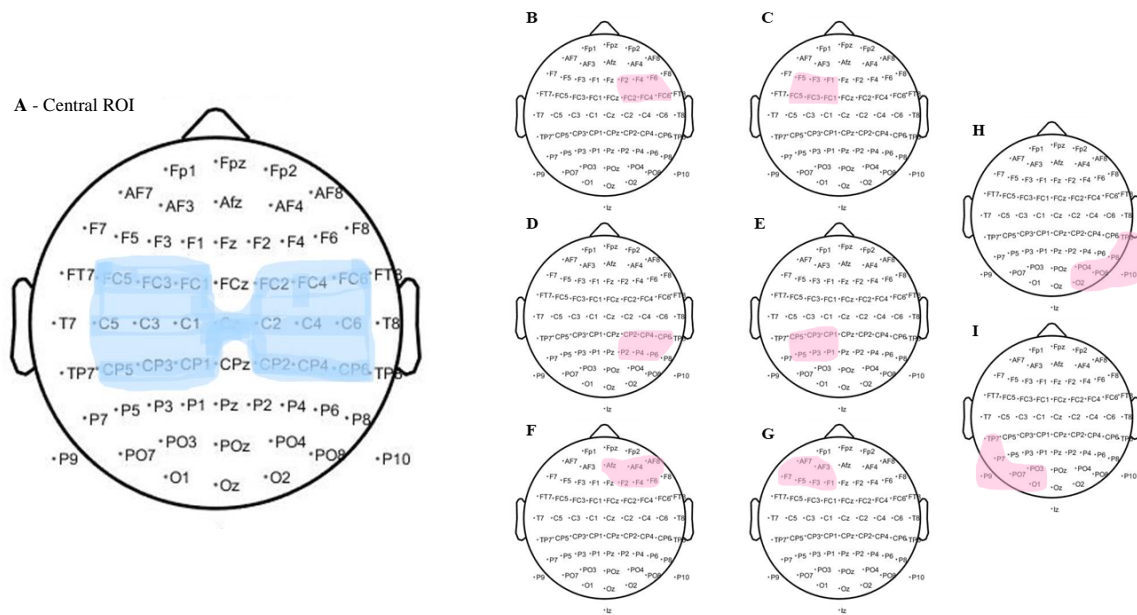
EEG data processing started with re-referencing the EEG channels to the Fz electrode, followed by band-pass filtering (0,5-40 Hz), epoch extraction of 1000 ms (-500 to 500 ms) in relation to the time-point at which the fixation-cross changed color from black to green (go condition) or from black to red (nogo condition) and baseline

correction using the pre-stimulus window of (-250 to 0 ms). Removal of signal artifacts was performed in two steps: (1) epoched, filtered and baseline corrected data were visually inspected and epochs with atypical artifacts rejected; (2) data were corrected for stereotypical artifacts related to eye movements, eye-blinks and/or noisy electrodes using independent component analysis (ICA, INFOMAX-runica algorithm as implemented in EEG Lab). Participant-specific independent components (ICs) were categorized as neural activity or non-neural artifacts by visual inspection of their scalp topography, spectral peak(s) at typical EEG frequencies, range of voltage, and consistency of their response time-course across all single trials using ERP images. ICs representing non-neural artifacts were removed. EEG data were then reconstructed from the remaining component activations representing brain activity and further baseline correction (-250 to 0 ms).

For the analysis of the resulting EEG data, 9 regions of interest (ROI) were considered (Figure 2.3): frontal, central, parietal, and posterior region (both left and right) and a wider central region. In addition, 4 times of interest (TOI) for central ROI were defined corresponding to the periods [-20 0] ms, [120 140] ms, [170 190] ms and [240 260] ms.

Figure 2.3

Diagram of the arrangement of the 64 EEG channels and area corresponding to the ROI



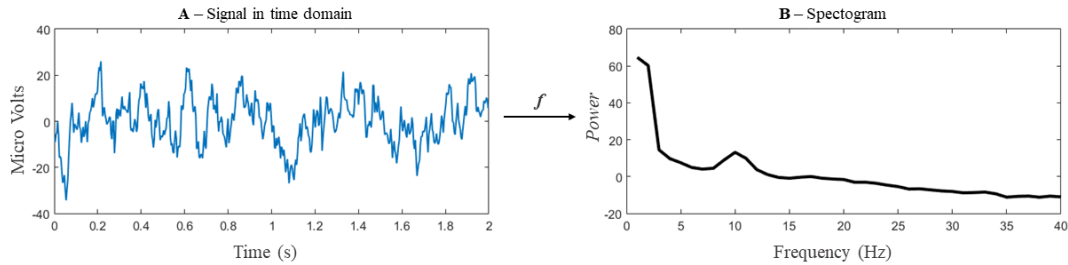
Note: A – Central ROI; B – Right Central ROI; C – Left Central ROI; D – Right Parietal ROI; E – Left Parietal ROI; F – Right Frontal ROI; G – Left Frontal ROI; H – Right Posterior ROI; I - Left Posterior ROI

To provide additional information about the responses associated with oscillatory activity during resting state and preparatory processes, oscillations *Alpha* (8-12 Hz) and *Beta* (12-38 Hz) were study. Signal analysis was performed using the resting state 60 second periods that preceded the blocks, as well as in the baseline period of the trials. *Fourier Transform* was used to decompose the signals from the time domain to the

frequency domain (Figure 2.4), allowing to obtain a spectrogram per participant, resting-state block, and baseline period of each trial.

Figure 2.4

Example of decomposed signal from time domain to frequency domain through Fourier Transform



Note: A – Signal in time domain; B – Spectrogram obtained through *Fourier* Transform (used to decompose the signals from the time domain to the frequency domain)

The statistical test used to validate between-group differences was the non-parametric Mann-Whitney U test, while within-group differences were validated using the non-parametric Wilcoxon Z test. Our choice for non-parametric tests was due to the inexistence of conditions to perform the parametric statistical analysis, given the insufficient size of the groups ($N < 30$). However, to study interactions between independent variables, analyses of variance (ANOVA) was chosen due to lack of non-parametric alternative solutions, to our knowledge. The magnitude of the effect of differences between groups was computed using the Cohen's d and Partial Eta Squared. According to Cohen (1988) the values of d can be interpreted as of reduced magnitude if greater than 0,20, moderate if greater than 0,50 and high if greater than 0,80, while Partial Eta Squared can be interpreted as of weak magnitude if greater than 0,01, moderate if greater than 0,06 and strong if greater than 0,14. Correlations were calculated using Spearman r .

3. Results

3.1. Behavioural analysis

The analysis of behavioural results indicates the non-existence of significant differences between groups means of reaction time and response accuracy in both go and nogo conditions. The results are shown in Table 3.1.

Table 3.1.

Behavioural results (reaction time and accuracy)

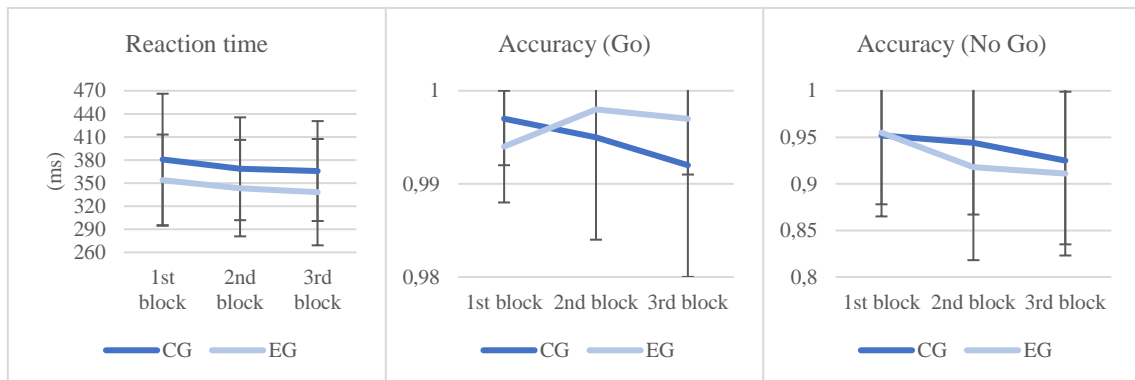
	CG (N = 13)	EG (N = 15)	U p	Cohen's d
Reaction time (go) (mean ± SD)	371,653 ± 68,440	345,198 ± 63,136	U = 123,00 p = 0,254	d = 0,40
Accuracy (go) (mean % ± SD)	0,994 ± 0,008	0,996 ± 0,004	U = 100,00 p = 0,928	d = 0,32
Accuracy (nogo) (mean % ± SD)	0,941 ± 0,081	0,928 ± 0,085	U = 118,00 p = 0,363	d = 0,16

Note: U - Mann-Whitney test

The analysis of the same behavioural results by block failed to show significant differences between groups, although it is possible to highlight that the EG was faster in their responses and both groups improve their reaction times over the blocks. The improvement in reaction times appears to negatively affect the accuracy of the CG in the go condition, but not in EG (Figure 3.1.). The obtained results are organized in Table 3.2.

Figure 3.1.

Behavioural results (reaction time and accuracy) throughout blocks



Furthermore, a comparison between the behavioural results from the first block to the third block was made (Table 3.3.) and results show an improvement in reaction time, only for the EG ($Z = 12,00$, $p = 0,006$). Neither group show significant differences on go condition accuracy, while both CG ($Z = 1,00$, $p = 0,004$) and EG ($Z = 6,500$, $p = 0,006$) show a significant decrease on nogo condition accuracy.

Interactions between the variables were also calculated using ANOVA tests due to the absence of a non-parametric alternative. We found a significant interaction between group and block in accuracy during the go condition ($F(1, 26) = 3,482, p = 0,038$), with a moderate to strong effect ($\eta^2 p = 0,118$). Specifically, the CG shows a tendency to worsen their accuracy throughout the blocks and the inverse effect is present on the EG. No interactions were found between group and block in reaction time ($F(1, 26) = 0,020, p = 0,946, \eta^2 p = 0,001$) or accuracy ($F(1, 26) = 1,424, p = 0,250, \eta^2 p = 0,052$) during the nogo condition.

Table 3.2.

Behavioural results (reaction time and accuracy) throughout blocks

	CG (N = 13)	EG (N = 15)	U p	Cohen's d
Reaction time, 1st block (go) (mean \pm SD)	380,744 \pm 85,424	353,871 \pm 59,235	$U = 110,00$ $p = 0,586$	$d = 0,37$
Reaction time, 2nd block (go) (mean \pm SD)	368,640 \pm 66,796	343,500 \pm 62,671	$U = 122,00$ $p = 0,274$	$d = 0,39$
Reaction time, 3rd block (go) (mean \pm SD)	365,681 \pm 64,917	338,221 \pm 69,095	$U = 126,00$ $p = 0,201$	$d = 0,41$
Accuracy, 1st block (go) (mean % \pm SD)	0,997 \pm 0,005	0,994 \pm 0,006	$U = 119,00$ $p = 0,339$	$d = 0,54$
Accuracy, 2nd block (go) (mean % \pm SD)	0,995 \pm 0,011	0,998 \pm 0,003	$U = 91,500$ $p = 0,786$	$d = 0,37$
Accuracy, 3rd block (go) (mean % \pm SD)	0,992 \pm 0,012	0,997 \pm 0,006	$U = 78,500$ $p = 0,387$	$d = 0,53$
Accuracy, 1st block (nogo) (mean % \pm SD)	0,952 \pm 0,087	0,955 \pm 0,077	$U = 119,50$ $p = 0,316$	$d = 0,04$
Accuracy, 2nd block (nogo) (mean % \pm SD)	0,944 \pm 0,077	0,918 \pm 0,100	$U = 117,00$ $p = 0,387$	$d = 0,29$
Accuracy, 3rd block (nogo) (mean % \pm SD)	0,925 \pm 0,090	0,911 \pm 0,088	$U = 111,50$ $p = 0,525$	$d = 0,16$

Note: U - Mann-Whitney test

Lastly, no significant difference has been found between groups on STICSA-1 on cognitive anxiety state ($U = 88,500, p = 0,683$), nor somatic anxiety state ($U = 66,000, p = 0,156$). Additionally, separate correlation analysis were conducted for each group. Only in CG somatic anxiety seem to be related with performance, since somatic anxiety state ($r = -0,796, p = 0,001$) and somatic anxiety trace ($r = -0,564, p = 0,045$) were negatively correlated with accuracy during go condition.

Table 3.3.

Comparison of behavioural results (reaction time and accuracy) from the 1st block to the 3rd block

	CG	EG
	Z, p	Z, p
Reaction time	Z = 34,00 p = 0,422	Z = 12,00 p = 0,006*
Accuracy (Go)	Z = 3,00 p = 0,114	Z = 33,00 p = 0,205
Accuracy (NoGo)	Z = 1,00 p = 0,004*	Z = 6,500 p = 0,006*

Note: Z – Wilcoxon test; * $p < 0,05$

3.2. EEG analysis

3.2.1. Task specific components

The analysis of the ERPs results of the go and nogo conditions makes it possible to identify the expected components for this type of task (Figure 3.2.). These are P1 (corresponding to sensory processing), N2 and P3 (specific components of the inhibitory control task). As it can be seen in graphs C and D of Figure 3.2., there are significant differences ($p < 0,05$) between conditions in N2 and P3 in both groups, at the level of central ROI. Similar results are found on the frontal and posterior regions when explored other ROI (Appendix G), highlighting a bilateral significant difference between conditions.

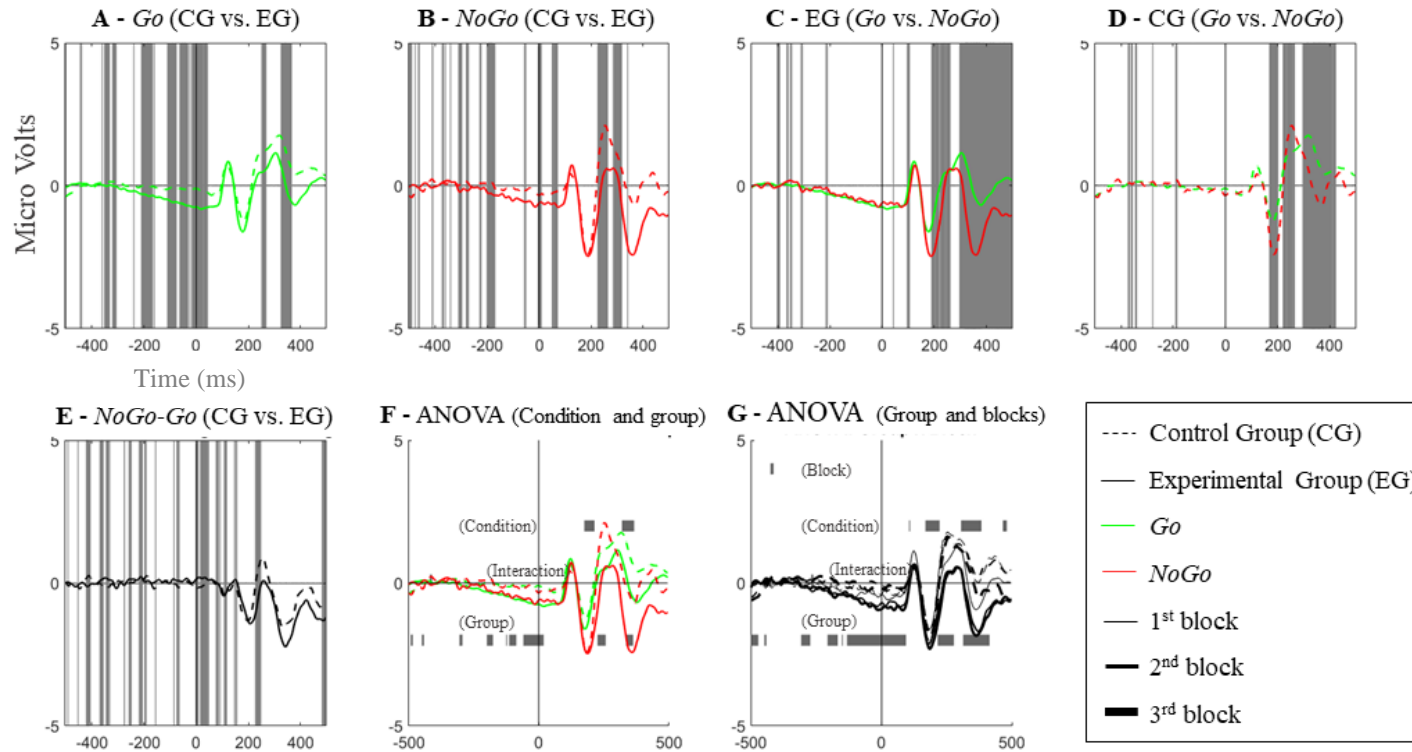
3.2.2. Differences between groups

A and B graphics (Figure 3.2.) show differences between groups on both conditions (go and nogo) on central ROI. More specifically, significant differences between groups are found on both conditions, especially during the previous moment and during the presentation of the stimulus, where the EG shows deepest inclination and negativity. Lower amplitudes of the EG with significant difference can also be described during P3.

Graphic G (Figure 3.2.) presents a significant group effect on the previous moment and during the presentation of the stimulus. The graphic representation allows to identify that, while the CG loses negativity throughout the blocks during that period (this means, ERP sign during baseline and stimulus presentation gets closer to zero throughout the block), the opposite happens to the EG, where an increase of the negativity throughout blocks is found. Significant differences also are observed during P3 and the period between 400-450 ms. Furthermore, interactions between condition and group, as well as group and blocks were calculated and presented on the x-axis of graphics F and G, respectively). (Figure 3.2.). No evidence of these interactions is shown.

Figure 3.2.

Central ROI ERPs



Note: Grand average of ERP signal from central ROI; Vertical and horizontal grey lines identify signal points where statistically significant results were found ($p < 0,05$); A - Go condition ERP from both control and experimental group; B - Nogo condition ERP from both control and experimental group; C - Go and nogo condition ERP from experimental group; D - Go and nogo condition ERP from control group; E - Difference signal (nogo minus go) from both control and experimental group; F - Go and nogo condition ERP from both groups. Condition and group interactions are presented on x-axis, while condition effect over x-axis and group effect under x-axis; G - Go and nogo condition ERP from both groups, per block. Line thickness represents blocks from 1st (thinner) to 3rd block (thickest). Group and blocks interactions are presented on x-axis, while block effect over x-axis, condition effect in between block effect and x-axis and group effect under x-axis.

Analysing the defined TOIs, significant differences were only found on the first selected period (-20-0 ms) of the go condition (Table 3.4.), with effects of moderate, almost elevated, level ($U = 143,00$, $p = 0,037$, $d = 0,78$). No significant results were found when analysed the interactions between the groups and the four TOI defined in this study, for both go ($F(1, 26) = 1,184$, $p = 0,317$, $\eta^2p = 0,044$) and nogo conditions ($F(1, 26) = 2,497$, $p = 0,092$, $\eta^2p = 0,088$).

Table 3.4.

TOIs results for central ROI

	CG (N = 13)	EG (N = 15)	U p	Cohen's d
TOI 1, -20-0 ms (Go) (mean ± SD)	-0,119 ± 0,969	-0,741 ± 0,590	$U = 143,00$ $p = 0,037^*$	$d = 0,78^{**}$
TOI 2, 120-140 ms (Go) (mean ± SD)	0,484 ± 1,481	0,627 ± 1,152	$U = 90,00$ $p = 0,751$	$d = 0,11$
TOI 3, 170-190 ms (Go) (mean ± SD)	-1,185 ± 1,384	-1,525 ± 1,264	$U = 114,00$ $p = 0,467$	$d = 0,26$
TOI 4, 240-260 ms (Go) (mean ± SD)	1,184 ± 1,906	0,475 ± 1,223	$U = 114,00$ $p = 0,467$	$d = 0,44$
TOI 1, -20-0 ms (NoGo) (mean ± SD)	-0,262 ± 0,790	-0,689 ± 0,790	$U = 129,00$ $p = 0,156$	$d = 0,54$
TOI 2, 120-140 ms (NoGo) (mean ± SD)	0,285 ± 1,444	0,567 ± 1,219	$U = 84,00$ $p = 0,555$	$d = 0,21$
TOI 3, 170-190 ms (NoGo) (mean ± SD)	-2,292 ± 1,775	-2,357 ± 1,610	$U = 104,00$ $p = 0,786$	$d = 0,04$
TOI 4, 240-260 ms (NoGo) (mean ± SD)	1,952 ± 2,462	1,856 ± 1,856	$U = 129,00$ $p = 0,156$	$d = 0,04$

Note: U - Mann-Whitney test

Attending to variations on *Alpha* and *Beta* waves during resting state and baseline periods (Table 3.5.), it is possible to observe significant differences between groups ($p < 0,05$) on the *Alpha* waves, with effects of moderate ($d < 0,5$) and elevated ($d < 0,8$) magnitude during all three resting state moments. Difference between *Alpha* values were also found during baseline, although non-significant.

When examined the interaction between group resting state, no significant results were found for *Alpha* ($F(1, 26) = 0,840$, $p = 0,291$, $\eta^2p = 0,046$), nor *Beta* ($F(1, 26) = 0,719$, $p = 0,492$, $\eta^2p = 0,027$).

Table 3.5.

Results of Alpha and Beta waves during resting state and baseline periods on the central ROI

	CG (N = 13)	EG (N = 15)	U p	Cohen's d
Resting State 1 (Alpha) (mean ± SD)	4,354 ± 3,441	1,824 ± 3,277	U = 145,00 p = 0,029*	d = 0,87*
Resting State 2 (Alpha) (mean ± SD)	4,133 ± 3,214	1,591 ± 2,726	U = 150,00 p = 0,015*	d = 0,85*
Resting State 3 (Alpha) (mean ± SD)	4,118 ± 3,195	2,183 ± 3,229	U = 142,00 p = 0,041*	d = 0,60*
Resting State 1 (Beta) (mean ± SD)	-6,144 ± 1,618	-6,271 ± 2,163	U = 105,00 p = 0,751	d = 0,07
Resting State 2 (Beta) (mean ± SD)	-5,689 ± 1,871	-5,904 ± 1,869	U = 108, 00 p = 0,650	d = 0,11
Resting State 3 (Beta) (mean ± SD)	-6,092 ± 1,531	-5,959 ± 2,009	U = 104,00 p = 0,786	d = 0,01
Baseline (Alpha) (mean ± SD)	0,954 ± 3,039	-0,716 ± 2,793	U = 130,00 p = 0,142	d = 0,08
Baseline (Beta) (mean ± SD)	-5,742 ± 1,881	-6,004 ± 1,917	U = 109,00 p = 0,618	d = 0,14

Note: U - Mann-Whitney test; * $p < 0,05$

4. Discussion

Attending to the lack of conclusive evidence in the scientific literature, this study sought to explore how HAI might alter neuronal functioning in a way that promotes cognitive enhancement. The literature review led to identify inhibitory control as a cognitive function that might be connected to HAI, attending on its influence over activation/cessation of the HPA axis and how this neuroendocrine system interferes with cognition. Therefore, both behavioural and neural (EEG recording) measures obtained from an inhibitory control task (go-nogo) were analysed.

Behavioural data seems to suggest a slight enhancement of EG over CG performance during the task, although appears to be nonspecific to inhibitory control since the main results appear during go condition. Means from global and per block behavioural results analysis did not significantly differ between groups. A closer look on these variables across blocks show a significant improvement in reaction time (go condition) only on the EG. Contrarily, accuracy in nogo trials significantly worsen in both groups. Moreover, a significant interaction with moderate effect was found between group and block in accuracy, in the go condition, where a tendency to improve was observed in the EG and the inverted effect in the CG.

Focusing now on neural measurements, significant differences were found on the ERP's components. P3 potential showed a lower amplitude for the EG on both conditions in comparison to the CG. On the other hand, no differences in N2 were found, neither an interaction between group and condition. Even so, neural data show larger differences between groups in the CNV component. Significant differences were found during CNV, both in TOI1 and ERP's, showing a higher negativity and inclination on the EG. Moreover, CNV component was gradually lost by the CG across blocks, while the EG show the inverse progression, with an enhance of CNV negativity. Complementary, significant group effects is shown during CNV. These results seem to be non-specific for inhibitory control, since this interaction appears on both go and nogo trials and start during the stimuli preparation period (i.e., regardless of the condition).

Looking closer into brain oscillations, no differences were found in *Beta* waves during resting state. On the other hand, statistically significant higher levels of *Alpha* waves were found in CG during all three resting states (moderate and high magnitude effects). Even though participants of both groups were indicated to relax with closed eyes during this period, possible interpretations of this differences must be done carefully. This is due to the order given to the EG to place the left hand on top of the dog, and the fact that participants could slightly pet her. *Alpha* and *Beta* waves were also analysed during baseline (i.e., before stimuli appearance) and no differences were found.

Although behavioural results did not differ in general, EEG recordings might indicate that experimental and control group performed the task differently. If HAI enhanced inhibitory control, we would expect to find statistical interactions between conditions and groups. These interactions were not found in the behavioural measures nor in ERP's. Even though, it is important to consider the ceiling effect, since the performed

task had a simple design. That is, a more complex design may allow to explore potential differences in behavioural measurements. In contrast to the hypothesis in this study, the effect of HAI in cognition seems to be more related to other variables than inhibitory control, maybe with more global implication in cognition. In other words, factors like attention, motivation, or cognitive fatigue might be intertwined with inhibitory control during the go-nogo task and influence both the way that the task is performed, as well as the behavioural results. For example, the lower P3 potential amplitude observed in the EG, might indicate same task performance with lower cognitive processing level (Michel, Bolte & Liepelt, 2018; Smith, Johnstone & Barry, 2008; Wessel, 2018). Also, CG decline quality of CNV throughout blocks, combined with significant increase of *Alpha* waves during resting states, can be related with cognitive fatigue or reduction on cognitive competence (Boksem, Meijman & Lorist, 2006; Lorist, 2008; Luck, 2014; van Boxtel & Brunia, 1994). The CNV component and its connection to the ability to monitor actions in an adequate manner (i.e., reaction time and accuracy) and the anticipatory brain response related to basal ganglia-thalamo-cortical projections, also has been related to motivation, which can counteract cognitive fatigue state (Boksem et al, 2006). Therefore, HAI may play a role in motivation during the task, especially on those where duration, repetition, or complexity (among other factors) can lead to fatigue. Despite this, these results allow to infer that the EG seems to have a more apt neural state for cognitive performance at the end of the task. Even so, the study design and measures do not allow to comprehend, for example, if that is so because HAI influences motivation, allowing fatigued participant to better cope with the cognitive demand, or if HAI allows participants to achieve the same results, using less cognitive resources.

In this line of thought, another possible theoretical framing to interpret these findings might be connected to the processing efficiency theory (Eysenck & Calvo, 1992; Eysenck et al., 2007). This theory states that anxiety negative effects are predicted to be significantly lower on effectiveness (quality of task performance) and greater on processing efficiency (relationship between the effectiveness of performance and the effort or resources spent on task performance) (Eysenck & Calvo, 1992; Eysenck et al., 2007). This being, if HAI positively regulates the negative impact of anxiety over cognition, the main results of these interactions might not be found in the behavioural results, but rather in the efficiency which those results are achieved. Therefore, our data seems to be in line with the proposed theory since it suggests that EG allocated lower effort/use of resources for equal effectiveness and show the ability to maintain efficiency over longer periods of time. This perspective might be especially interesting since it could open new opportunities for study and discussion with relevance to those cases where self-reported or observational measures differ from behavioural results.

Although this novel perspective is interesting, this study lacks information regarding the anxiety metrics to further support this line of thought (e.g., there were no differences between groups in the STICSA questionnaire and no physiological metrics were included). The only result regarding anxiety is that the CG show a negative correlation between both trace and state cognitive anxiety with accuracy (go condition). This could suggest that the presence of the dog counteracted the negative effects on

accuracy on the EG, but further investigations are necessary to reach possible conclusions. This information is particularly relevant since the experiment design failed to evaluate anxiety state at the beginning of the experiment, removing the possibility to better understand anxiety progression within groups and its relationship with the studied variables. This is one of its main limitations, both for the processing efficiency theory and HAI enhancement of inhibitory control. If HAI impacts anxiety response through HPA axis (Pendry & Vandagriff, 2020), and the neuroendocrine alterations are the responsible for inhibitory control improvement/decline (Egeland et al., 2005; Gomez et al., 2007; Oei et al., 2009; Schlosser et al., 2013; Scholz et al., 2009; Wolf et al., 2001), the absence of a clear anxiogenic influence and/or variation might not reveal possible benefits of HAI over inhibitory control.

Future investigations should take into consideration various factors that were highlighted throughout the present study. Focusing first on practical aspects, our investigation successfully integrated HAI into a cognitive task design with EEG recording. This achievement was mainly accomplished due to the inclusion of a trained dog that interacted freely with the participants during EEG preparation period and laid next to them during cognitive tasks. Other aspects can be considered. For example, if HAI main impact on cognition (i.e., inhibitory control) might appear related to anxiety modulation through HPA axis (see Pendry & Vandagriff, 2020), a more accurate anxiety assessment should carry out. At least initial and final anxiety state should be evaluated, which might be performed from both psychological and physiological approaches. Furthermore, our task design was simple, so future investigations might benefit of increasing the complexity and difficulty of the task. Another important topic for reflexion is related to the specific cognitive functions which future investigations might aim to study and how the evaluation is achieved. Although few investigations were design to study HAI possible influence over a wide range of cognitive functions (i.e., attention, memory, executive functions), most were focused on behavioural achievements, rather than the neural subliminal processes. The results of the present study might reinforce the need to evaluate factors as cognitive effort, cognitive fatigue, efficiency, or motivation, regardless of the specific cognitive function evaluated. This is relevant both for theoretical investigations, as well as for intervention evaluation. The majority body of literature describing the practical application and benefits of HAI in cognition are focused on clinical population (i.e., ADH, ADHD, or dementia). On the other hand, more theoretical approached such as experimental studies are typically conducted with non-clinical participants. If on experimental settings we only analyse behavioural results, this can create a discrepancy. This might happen because the non-clinical groups have higher resources than clinical populations to cope with cognitive demand to achieve goals or quality performance, regardless of interacting with an animal. So, if we only focus on achievements and discard the process by which such results are obtained, we might be losing an effect of HAI of higher importance for clinical populations. EEG recording and ERP's analyses became essential to provide this new insight since the main reflection of this investigation leans on the fact that, although both groups achieve basically the same results, the neural process towards the same goal seemed to be different.

5. Conclusion

The literature review led to identify inhibitory control as a cognitive function that might be connected to HAI. Even though this study failed to acquire data that confirm this hypothesis, the presented results provide a new insight that could be taken in account when considering investigating possible cognitive benefits of HAI. In this regard, although behavioural results did not differ in general, EEG recordings might indicate that experimental and control group performed the task differently, with slight enhancement towards the EG. The effect of HAI in cognition seems to be related to other variables with more global implication, such as cognitive fatigue or motivation, but further investigation should take place to provide clearer conclusions. Even so, EEG recording, and the ERP analysis revealed of great importance to this topic. Not only it is a neuroimaging technique that allows to study the neural process in which cognitive tasks are performed but is highly compatible with simultaneous proper HAI. Regardless of its limitations, the present study managed to input a novel topic of investigation, approaching HAI influence over inhibitory control. Also, the main findings seem to increase the relevance of including measures that are focused on the process, rather than only the cognitive achievements.

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APENDIX

Appendix A. Sociodemographic questionnaire

A INFLUÊNCIA DA INTERAÇÃO HUMANO-ANIMAL NO CONTROLO INIBITÓRIO: UM ESTUDO DE EEG

Participante nº _____

Questionário sociodemográfico

Ao participante

Por favor, leia e preencha com atenção todo o conteúdo deste documento. Solicite mais informações ao investigador se não estiver completamente esclarecido.

Idade: _____
Sexo: <input type="checkbox"/> Masculino <input type="checkbox"/> Feminino
Nacionalidade: _____
Naturalidade: _____
Habilitações literárias (último ano concluído): _____
Profissão/ocupação: _____
Foi submetido(a) a neurocirurgia: <input type="checkbox"/> sim <input type="checkbox"/> não
Tem alguma perturbação psiquiátrica: <input type="checkbox"/> sim <input type="checkbox"/> não
Tem alguma perturbação neurológica: <input type="checkbox"/> sim <input type="checkbox"/> não
Tem atualmente animais de estimação: <input type="checkbox"/> sim <input type="checkbox"/> não
Se sim, que espécie: <input type="checkbox"/> cão <input type="checkbox"/> gato <input type="checkbox"/> outro _____
Se sim, quantos: ___ cão ___ gato ___ outro _____
Se sim, descreva a interação: <input type="checkbox"/> diária <input type="checkbox"/> semanal <input type="checkbox"/> mensal <input type="checkbox"/> outro _____

Appendix B. The Pet Attitude Scale European Portuguese Adaptation

The Pet Attitude Scale

Ao participante

Por favor, responda a cada uma das seguintes questões o mais honestamente possível, no que diz respeito a como se sente neste momento. Este questionário é confidencial. Não existem respostas certas ou erradas, o importante é que expresse os seus verdadeiros pensamentos sobre cada questão.

Por favor, responda fazendo um círculo à volta de um dos seguintes sete números para cada pergunta:

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

Por exemplo, se está ligeiramente em desacordo com o primeiro item, iria fazer um círculo no número 3.

Obrigado pela sua colaboração.

1. Eu gosto mesmo de ver animais de estimação a desfrutarem da sua comida.

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

2. O meu animal de estimação tem mais significado para mim do que qualquer um dos meus amigos (ou teria se eu tivesse um animal de estimação).

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

3. Gostaria de ter ou de continuar a ter um animal de estimação em minha casa.

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

4. Ter animais de estimação é um desperdício de dinheiro.

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

5. Os animais de estimação em casa adicionam alegria à minha vida (ou adicionariam se eu tivesse um).

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

6. Sou da opinião que os animais de estimação deveriam sempre ser mantidos fora de casa.

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

7. Brinco todos os dias durante um tempo com o meu animal de estimação (ou brincaria se eu tivesse um).

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

8. Às vezes comunico com o meu animal de estimação e entendo o que ele me está a tentar expressar (ou comunicaria se eu tivesse um).

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

9. O mundo seria melhor se as pessoas parassem de perder tanto tempo a cuidar dos seus animais de estimação e, em vez disso, comesçassem a cuidar mais de outros seres humanos.

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

10. Gosto de alimentar animais com a minha mão.

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

11. Amo animais de estimação.

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

12. Os animais pertencem à natureza ou a zoológicos, não em casa.

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

13. Se mantém os animais de estimação em casa, poderá esperar muitos estragos na mobília.

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

14. Eu gosto de animais de estimação.

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

15. Os animais de estimação são divertidos, mas não justificam o trabalho de ter um.

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

16. Eu converso frequentemente com o meu animal de estimação (ou conversaria se eu tivesse um).

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

17. Eu odeio animais.

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

18. Os animais de companhia devem ser tratados com tanto respeito quanto o que terias por um membro humano da tua família.

1	2	3	4	5	6	7
Discordo totalmente	Discordo	Discordo ligeiramente	Não sei	Concordo ligeiramente	Concordo	Concordo totalmente

Appendix C. State-trace inventory for cognitive and somatic anxiety European Portuguese Adaptation

A INFLUÊNCIA DA INTERAÇÃO HUMANO-ANIMAL NO CONTROLO INIBITÓRIO: UM ESTUDO DE EEG Participante nº _____

STICSA-1

Abaixo encontra-se uma lista de frases que podem ser usadas para descrever como as pessoas se sentem. Ao lado de cada frase estão quatro números que indicam o grau com que cada frase pode descrever o seu humor ou o modo como se está a sentir neste momento (por exemplo, 1- Nada, 4 - Muito).

Por favor, leia cada frase atentamente e assinale o número que melhor indica **COMO SE SENTE NESTE MOMENTO**, neste preciso momento, mesmo que não seja a forma como se sente habitualmente.

	Nada	Um pouco	Moderadamente	Muito
1. O meu coração bate rápido	1	2	3	4
2. Os meus músculos estão tensos	1	2	3	4
3. Sinto-me agoniado com os meus problemas	1	2	3	4
4. Eu penso que os outros não me aprovarão	1	2	3	4
5. Eu sinto que me vou perdendo porque não consigo decidir-me atempadamente	1	2	3	4
6. Sinto-me tonto	1	2	3	4
7. Sinto fraqueza nos meus músculos	1	2	3	4
8. Sinto-me trémulo e instável	1	2	3	4
9. Eu por perspetivo algumas desgraças futuras	1	2	3	4
10. Não consigo tirar alguns pensamentos da minha cabeça	1	2	3	4
11. Tenho dificuldade em lembrar coisas	1	2	3	4
12. Sinto a minha face quente	1	2	3	4
13. Eu penso que o pior vai acontecer	1	2	3	4
14. Sinto que os meus braços e pernas estão hirtos	1	2	3	4
15. Sinto a garganta seca	1	2	3	4
16. Eu esforço-me a evitar pensamentos desconfortáveis	1	2	3	4
17. Não me consigo concentrar sem a intrusão de pensamentos irrelevantes	1	2	3	4
18. A minha respiração é rápida e superficial	1	2	3	4
19. Preocupo-me por não conseguir controlar os meus pensamentos tão bem como eu gostaria	1	2	3	4
20. Tenho borboletas no estômago	1	2	3	4
21. Sinto as palmas das mãos húmidas	1	2	3	4

STICSA-2

Abaixo encontra-se uma lista de frases que podem ser usadas para descrever como as pessoas se sentem. Ao lado de cada frase estão quatro números que indicam com que frequência cada frase é verdadeira para si (por exemplo, 1- Nada, 4 - Muito).

Por favor, leia cada frase atentamente e assinale o número que melhor indica **COM QUE FREQUÊNCIA, EM GERAL, A FRASE É VERDADEIRA PARA SI.**

	Nada	Um pouco	Moderadamente	Muito
1. O meu coração bate rápido	1	2	3	4
2. Os meus músculos estão tensos	1	2	3	4
3. Sinto-me agoniado com os meus problemas	1	2	3	4
4. Eu penso que os outros não me aprovarão	1	2	3	4
5. Eu sinto que me vou perdendo porque não consigo decidir-me atempadamente	1	2	3	4
6. Sinto-me tonto	1	2	3	4
7. Sinto fraqueza nos meus músculos	1	2	3	4
8. Sinto-me trémulo e instável	1	2	3	4
9. Eu por perspetivo algumas desgraças futuras	1	2	3	4
10. Não consigo tirar alguns pensamentos da minha cabeça	1	2	3	4
11. Tenho dificuldade em lembrar coisas	1	2	3	4
12. Sinto a minha face quente	1	2	3	4
13. Eu penso que o pior vai acontecer	1	2	3	4
14. Sinto que os meus braços e pernas estão hirtos	1	2	3	4
15. Sinto a garganta seca	1	2	3	4
16. Eu esforço-me a evitar pensamentos desconfortáveis	1	2	3	4
17. Não me consigo concentrar sem a intrusão de pensamentos irrelevantes	1	2	3	4
18. A minha respiração é rápida e superficial	1	2	3	4
19. Preocupo-me por não conseguir controlar os meus pensamentos tão bem como eu gostaria	1	2	3	4
20. Tenho borboletas no estômago	1	2	3	4
21. Sinto as palmas das mãos húmidas	1	2	3	4

Appendix D. Informed consent

A INFLUÊNCIA DA INTERAÇÃO HUMANO-ANIMAL NO CONTROLO INIBITÓRIO: UM ESTUDO DE EEG

Participante nº _____

Consentimento informado, livre e esclarecido para participação em investigação de acordo com a Declaração de Helsínquia e a Convenção de Oviedo

Ao participante

Por favor, leia com atenção todo o conteúdo deste documento. Solicite mais informações ao investigador se não estiver completamente esclarecido. Se entender que a informação é clara, se compreender o que lhe vai ser pedido na sua participação e estiver de acordo em participar, então assine este documento.

Título do estudo: “A INFLUÊNCIA DA INTERAÇÃO HUMANO-ANIMAL NO CONTROLO INIBITÓRIO: UM ESTUDO DE EEG.”

Enquadramento: Estudo desenvolvido no âmbito da *dissertação de mestrado em Neurociências Cognitivas e Neuropsicologia* da Universidade do Algarve e sob supervisão da docente Doutora Filomena Inácio e do docente Doutor João Correia.

Explicação dos objetivos do estudo e dos procedimentos:

- O objetivo central do estudo é investigar o controlo inibitório;
- Para isso, ser-lhe-á pedido para preencher um questionário sociodemográfico com informações pessoais e relevantes para a pesquisa e o preenchimento do questionário de caracterização da interação humano-animal (*The pet attitude scale*);
- Ser-lhe-á também pedido que realize uma tarefa de controlo inibitório em simultâneo com o registo do EEG;
- Por último, irá preencher a Escala STICSA (*State scale of State-Trait Inventory for Cognitive and Somatic Anxiety*);
- A informação recolhida será utilizada no estudo de forma confidencial e anónima.

Condições e financiamento:

- A participação neste estudo é voluntária e o participante pode retirar-se do estudo a qualquer altura, ou recusar participar, não resultando daí qualquer prejuízo;
- Este estudo não implica qualquer despesa para os participantes.

Confidencialidade e anonimato:

- A cada participante será atribuído um código de identificação (ID), que garante o anonimato e a confidencialidade dos dados fornecidos. Apenas o grupo de investigação terá acesso aos dados pessoais, sendo o código ID a única identificação transmissível;
- Os dados recolhidos serão inseridos numa base de dados (formato digital) e anexados ao ID único do participante, numa unidade de armazenamento externa, por tempo indefinido. O acesso a esta unidade é restrito ao Grupo de Investigação em Neurociências Cognitivas;
- Os investigadores envolvidos no projeto garantem que toda a informação recolhida para a realização do estudo será mantida confidencial e utilizada exclusivamente para fins científicos. A identificação do participante não será tornada pública em nenhum momento do estudo.

Para solicitar qualquer informação, apresentar reclamações e pedidos de retirada de consentimento ou requerer o exercício de direitos é favor contactar fcinacio@ualg.pt ou jmcorreia@ualg.pt.

Os responsáveis pela investigação,

Filomena Inácio (fcinacio@ualg.pt) e João Correia (jmcorreia@ualg.pt)

Termo de receção de informação e confirmação de consentimento para participação em estudo comportamental e de EEG

Declaro ter compreendido os objetivos do que me foi explicado e proposto pelo investigador que assina este documento. Foi-me dado oportunidade de fazer todas as perguntas sobre o estudo em causa e para todas elas obtive respostas. Foi-me igualmente dado tempo para refletir sobre a proposta de participação.

Compreendi e declaro ter dado respostas honestas às seguintes afirmações:

Já tive episódio(s) de ataque epilético: sim não

Fui submetido a neurocirurgia: sim não

Sofro de claustrofobia: sim não

Estou ou suspeito estar grávida: sim não

Tenho alergia a cães: sim não

Tenho fobia de cães: sim não

E que, em face das informações aqui prestadas e nos referidos termos e condições:

Aceito participar voluntariamente no estudo

Não aceito participar voluntariamente no estudo

Localidade: _____ Data: ____/____/____

Nome: _____

Assinatura: _____

Assinatura do Recetor

____/____/____

Appendix E. Data privacy requirements information

A INFLUÊNCIA DA INTERAÇÃO HUMANO-ANIMAL NO CONTROLO INIBITÓRIO: UM ESTUDO DE EEG Participante nº _____

INFORMAÇÃO DE REQUISITOS DE PRIVACIDADE DE DADOS

Termos e Condições Gerais de Privacidade de Dados

A Faculdade de Ciências Sociais e Humanas (FCHS) da Universidade do Algarve, com sede em Campus da Penha, 8005 139, Faro, Portugal, telefone +351289800100, está a realizar o questionário sociodemográfico no âmbito do estudo “A influência da interação humano-animal no controlo inibitório: um estudo de EEG”, no período entre 30 de abril de 2022 e 30 de setembro de 2023, e tem como responsáveis pelo estudo Professora Doutora Filomena Inácio e Professor Doutor João Correia.

O principal objetivo do estudo é compreender se a Interação Humano-Animal influencia o desempenho comportamental e/ou neurofisiológico em tarefas de controlo inibitório. Este questionário/inquérito é realizado através do suporte em papel e registo em Excel.

Os dados pessoais previstos a tratamento no âmbito da Dissertação de Mestrado “A influência da interação humano-animal no controlo inibitório: um estudo de EEG” são: nome, email, idade, sexo, formação académica, ocupação, dados de saúde, informações sobre interação com animais de companhia, sendo que a categoria dos titulares a recolher os dados será alunos(as) universitários ou população académica ou não académica em geral.

Todos os dados são recolhidos apenas para efeitos da Dissertação de Mestrado “A influência da interação humano-animal no controlo inibitório: um estudo de EEG” estando garantida a confidencialidade do seu tratamento e a exclusiva utilização pela Universidade do Algarve, com um período de retenção dos dados sendo o mínimo necessário para a realização do estudo, e sendo o seu tratamento realizado nos termos e condições da Política de Proteção de Dados que se encontra acessível em www.ualg.pt.

Se necessitar de algum esclarecimento adicional em relação à participação ou ao preenchimento do questionário, é favor contactar pelos emails fcinacio@ualg.pt ou jmcorreia@ualg.pt.

Eu aceito os termos e as condições acima descritos. Da mesma forma, como titular de dados, aceito as condições gerais e os termos das Políticas de Proteção de Dados da Universidade do Algarve.

Assinatura _____ Data ___/___/_____

Consentimento para Tratamento de Dados

Autorizo expressamente o tratamento dos dados pessoais pela Universidade do Algarve, para efeitos de estudo realizado na Dissertação de Mestrado “A influência da interação humano-animal no controlo inibitório: um estudo de EEG”, de acordo com os termos de informação sobre tratamento de dados e a Política de Proteção de Dados que se encontram disponíveis em www.ualg.pt. Estou consciente de que posso retirar o consentimento ou exercer os direitos de proteção de dados, designadamente os direitos de reclamação, acesso, retificação, oposição, limitação do tratamento ou apagamento, através de contacto com o Encarregado da Proteção de Dados da Universidade do Algarve pelo correio eletrónico rgpd@ualg.pt, e caso assim o considere necessário, apresentar reclamação à Comissão Nacional de Proteção de Dados, através dos contatos disponíveis em www.cnpd.pt.

Assinatura _____ Data ___/___/_____

Appendix F. GDPR Compliance

30/05/22, 10:06

Correio – DAIANA KAREN FERREIRA – Outlook

Re: Declaração do Encarregado de Proteção de Dados da UAlg

Regulamento Geral da Proteção de Dados <rgpd@ualg.pt>

qua, 25/05/2022 18:45

Para: DAIANA KAREN FERREIRA <a70229@ualg.pt>

Cc: Filomena Café Inácio <fcinacio@ualg.pt>; João Miguel Mendonça Correia <jmcorreia@ualg.pt>

Estimada Diana Ferreira

Na qualidade de Encarregado da Proteção de Dados da UALG e na sequência da continuidade do Vosso pedido de Parecer sobre a Conformidade RGPD do questionário no âmbito do estudo "A influência da interação humano-animal no controlo inibitório: um estudo de EEG ", confirmo encontrar no estudo as condições necessárias para evitar possíveis situações que possam responsabilizar a UAlg em termos de falta de cumprimento de requisitos de conformidade de privacidade de dados conforme o RGPD e LPDP.

Mais informo que para garantir a conformidade RGPD o documento de Informação Prévia de Privacidade de Dados deve ser apresentado a cada participante requisitando a sua leitura, tomada de conhecimento e assinatura para os termos e condições e termo de consentimento.

Este email representa parecer do EPD sobre tratamentos de dados pessoais e pode ser apresentado para Parecer da Comissão de Ética da Ualg.

Para mais informação e guias de ajuda, aconselho vivamente consultar a área de "Proteção de Dados" na Intranet da Ualg em <https://ualgnet.ualg.pt/servicos#protecao-de-dados> .

Ao dispor para eventuais esclarecimentos ou informações adicionais.

Melhores Cumprimentos

Júlio Fernandes - na qualidade de EPD da UAlg

From: DAIANA KAREN FERREIRA <a70229@ualg.pt>

Sent: Wednesday, May 25, 2022 5:57 PM

To: Regulamento Geral da Proteção de Dados <rgpd@ualg.pt>

Cc: Filomena Café Inácio <fcinacio@ualg.pt>; João Miguel Mendonça Correia <jmcorreia@ualg.pt>

Subject: Declaração do Encarregado de Proteção de Dados da UAlg

Exmo. Sr. Encarregado de Proteção de Dados da UAlg

Encontro-me atualmente a organizar o pedido de apreciação do estudo de dissertação de mestrado à comissão de ética.

Para a aquisição da declaração do Encarregado de Proteção de Dados da UAlg, envio em anexo os documentos solicitados:

i. Modelo de requisitos de privacidade de dados

ii. Descritivo e apresentação do inquérito

Obrigada pela ajuda.

Com os melhores cumprimentos,

Daiana Ferreira

Appendix G. ERPs of the remaining ROIs

