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Acute stress is associated with increased auditory distraction: evidence from a cross-modal oddball task

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ABSTRACT

Attentional Control Theory suggests that acute stress reduces the efficiency of working memory and top-down control, increasing susceptibility to distraction. In contrast, Cognitive Reallocation accounts suggest that acute stress narrows attentional focus and potentially reduces distraction. We tested these competing predictions using a cross-modal oddball task, comparing participants exposed to an acute stressor, via a realistic firefighter training exercise, with an unstressed control group. Participants categorised visual targets preceded by either a standard sound or a rare deviant (a noise burst or a semantically congruent or incongruent word). Both groups were distracted by the deviant sounds, but the effect was larger in those exposed to the stressor, particularly early in the session. Over time, this difference diminished—consistent with recovery from stress exposure and stronger habituation in controls. These results indicate that acute stress is associated with heightened vulnerability to auditory distraction in a pattern resembling reduced working memory availability.

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Selective attention; auditory distraction; orienting response; oddball effect; acute stress

Introduction

High-stakes professions such as firefighting, law enforcement, and emergency medicine often place individuals under acute stress while requiring sustained attentional control. The ability to remain focused on task-relevant information while filtering out irrelevant or distracting stimuli is critical to performance, and lapses in this capacity can entail severe consequences. Selective attention—the process of prioritising task-relevant stimuli and filtering out, or suppressing, task-irrelevant stimuli (Cowan, 1988)—can be influenced by acute stressors. Exposure to stressors has been associated with sensory hypervigilance, enhancing the detection of potential threats but also increasing sensitivity to task-irrelevant stimuli (Henckens et al., 2012; Roelofs et al., 2007). Although the impact of chronic stressors on cognitive performance is well established (Lupien et al., 2009; Sandi, 2013), its specific effects on attentional control remain debated. Some research suggests that acute stress exposure enhances selectivity by narrowing attentional focus (Plessow et al., 2011; Qi et al., 2024), whereas other studies point to impairments in inhibitory and top-down control (Chajut & Algom, 2003; Roos et al., 2017), resulting in increased distraction by salient but task-irrelevant information (Arnsten, 2015). The present study aimed to adjudicate between these competing perspectives by examining how acute stress modulates susceptibility to auditory distraction. Most evidence to date comes from controlled laboratory stress manipulations. However, real-world high-demand environments (as that of firefighters and police officers for example) often involve complex physiological and cognitive stress responses that may not be fully captured in laboratory settings. The current study therefore examines stress exposure in a realistic operational training context to complement experimental findings.

We employed the cross-modal oddball paradigm to examine how acute stress modulates auditory distraction. In this paradigm, participants engage in a visual task—such as categorising left- or right-pointing arrows—while ignoring background sounds. Occasionally, a rare deviant sound is presented in place of the standard auditory stimulus. These deviant auditory

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events involuntarily capture attention, leading to slower responses to the visual target that immediately follows. The increase in reaction time on deviant trials, relative to standard trials, is known as the *oddball effect* and is thought to reflect a transient orienting response to unexpected input (Nöstl et al., 2012; Parmentier et al., 2011; Vachon et al., 2012). Because the oddball task captures automatic, stimulus-driven attentional shifts with millisecond precision, it provides a sensitive behavioural assay for detecting subtle disruptions in cognitive control—particularly under conditions of heightened stress or arousal (Cornwell et al., 2007; Elling et al., 2011). Unlike within-modality paradigms, where task-relevant and irrelevant stimuli compete with the same sensory stream, cross-modal paradigms cleanly separate them. This allows for clearer attribution of the interference to attentional capture rather than perceptual overlap (Marsh et al., 2017). The magnitude of the oddball effect serves as a behavioural marker of the balance between top-down control and stimulus-driven attentional capture (Hughes et al., 2013).

Oddball effects can be triggered by different types of deviation. In *acoustic oddball trials*, the deviant sound differs in its physical characteristics (e.g. a burst of noise among repeated tones). In *semantic oddball trials*, the deviant involves a categorical change in meaning (e.g. a spoken letter among spoken digits; Littlefair et al., 2022; Perham et al., 2023; Vachon et al., 2020). Semantic deviants can be congruent or incongruent with the required response. For instance, if the task is to press the left key for a left-pointing arrow, a spoken word "right" is semantically incongruent with the target response but congruent with the competing response. Such incongruent deviants may elicit response conflict by activating the incorrect response tendency, thereby producing a particularly large oddball effect (Parmentier et al., 2008).

The oddball effect is particularly pronounced during the early stages of the task, when deviant sounds are first introduced (Sörqvist et al., 2012). As the task progresses, the oddball effect typically diminishes—a process known as habituation, which reflects the increasing ability of goal-directed attention to suppress interference from task-irrelevant sounds. Previous research suggests that individuals with lower working memory capacity are more susceptible to auditory distraction than their higher capacity counterparts, as indexed by a larger oddball effect (Hughes et al., 2013; Sörqvist, 2010). Furthermore, habituation occurs more rapidly for individuals with higher working memory capacity (Sörqvist et al., 2012). This suggests that working memory capacity facilitates attentional adaptation. These findings raise the possibility that exposure to an acute stressor, through impairing cognitive control, may mimic the effects of low working memory capacity. Importantly, working memory capacity is shaped not only by stable trait-like differences (i.e. stable across time and tasks) but also by transient state-level fluctuations (Ilkowska & Engle, 2010). Here, we focus specifically on transient, state-based executive control processes rather than trait working memory capacity. We do not measure working memory in this study; instead, we draw on working memory capacity theory as a conceptual framework for understanding how acute stress may temporarily reduce the availability of executive attentional resources. In this context, we propose that acute stressors may increase susceptibility to auditory distraction by temporarily reducing the availability of state-based working memory capacity.

When an individual experiences an acute stress response, triggered by transient environmental challenges, it initiates a physiological response mediated by the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic-adrenal-medullary (SAM) system. These systems release hormones such as cortisol and noradrenaline, which mobilise energy and prepare the organism to manage immediate threats (Joëls et al., 2006). Cortisol crosses the blood-brain barrier and binds to receptors in brain regions implicated in cognitive control, particularly the prefrontal cortex (Lupien et al., 2007; Schwabe et al., 2012). This neurochemical cascade has been linked to cognitive consequences, including transient reductions in working memory (Qin et al., 2009; Robinson et al., 2008; Schoofs et al., 2009), reduced cognitive flexibility (Diamond, 2013), increased distractibility in sustained attention tasks (Pacheco-Unguetti et al., 2011), and diminished executive function (Arnsten, 2009).

In addition to these general cognitive effects, an acute stress response appears to modulate auditory processing (Asutay & Västfjäll, 2012; Domínguez-Borràs et al., 2017) , increasing the neural response to task-irrelevant sounds (Baas et al., 2006; Brandão et al., 2001). For example, it has been associated with heightened mismatch negativity (MMN) to deviant auditory stimuli—a well-established marker of involuntary attentional capture (Cornwell et al., 2007; Elling et al., 2011). These findings align with the Attentional Control Theory, which posits that acute stress impairs the efficiency of goal-directed cognitive control by reducing the availability of working-memory resources for executive regulation (Eysenck & Derakshan, 2011). This reduction is expressed primarily in processing efficiency, such as slower reaction times and increased distraction, rather than in processing effectiveness, such as accuracy, unless task demands exceed available resources (Eysenck et al., 2007). Thus, under acute stress, individuals may maintain accurate task performance but show increased susceptibility to distraction, particularly early in task performance when stress-related cognitive load is highest. Therefore, in the oddball task, Attentional Control Theory predicts larger oddball effects in RT under acute stress without necessarily predicting decrements in accuracy. This hypothesis is tested in the present study. Further, the current study will examine when the stress-related attentional disruption is most pronounced, as research suggests that the effect of exposure to an acute stressor on cognitive performance can be time-dependent (Shields et al., 2016). If the effects of acute stress mirrors that of a reduced availability of state-based resources for top-down cognitive control, the effect should be most pronounced immediately following the stress-inducing activity (i.e. in the beginning of the oddball task).

In contrast to theories predicting increased distractibility under stress, a body of research suggests that stress can actually reduce susceptibility to distraction (Booth & Sharma, 2009; Chajut & Algom, 2003; Plessow et al., 2011; Qi et al., 2024; Wirkner et al., 2019). These findings broadly align with Easterbrook's (1959) cue-utilisation hypothesis, which proposes that heightened arousal leads to a narrowing of attentional focus. As arousal increases, the range of environmental cues an individual attends to becomes restricted, which can reduce the processing of task-irrelevant information. This narrowing effect is thought to enhance selective attention by filtering out distractions and directing cognitive resources toward goal-relevant input (Callaway & Dembo, 1958; Plessow et al., 2011). In line with this view, some researchers have interpreted reduced distraction under stressor exposure as evidence for a cognitive reallocation mechanism (e.g. Chajut & Algom, 2003; Wirkner et al., 2019), wherein attention is concentrated on central task demands. According to this framework, participants experiencing an acute stress response should have a smaller oddball effect as attention is shielded from deviant irrelevant sounds.

Current study

We tested the effects of acute stressor exposure on susceptibility to auditory distraction by inducing a stress response through a strenuous firefighting simulation (Hancock & Szalma, 2008). After this, participants completed a cross-modal oddball task. Stress response levels were indexed both physiologically (via salivary cortisol) and subjectively (via self-report). The group of firefighters were compared with a control group (comprising university students and staff members) who did not undergo stress-inducing activity. While this quasi-experimental field design does not permit complete control over pre-existing group differences, it affords unique ecological validity and enables theoretical predictions to be tested under realistic occupational stress exposure. Accordingly, our interpretation focuses on converging evidence consistent with theoretical predictions rather than asserting mechanistic causation.

Based on Attentional Control Theory (Eysenck & Derakshan, 2011; Eysenck et al., 2007), we hypothesised that individuals exposed to the acute stressor would show an increased oddball effect, consistent with reduced availability of top-down attentional control processes under acute stress. Given evidence that lower working-memory capacity increases vulnerability to distraction (Hughes et al., 2013; Sörqvist, 2010), and that an acute stress response is associated with temporarily impaired working-memory processes (Arnsten, 2015; Qin et al., 2009; Schoofs et al., 2009), we predicted a particularly large oddball effect early in the session when stress levels were highest, followed by a reduction over time as cognitive control recovered and distraction habituated (Sörqvist et al., 2012).

Importantly, the cognitive consequences of acute stress are also time-dependent, with impairments in executive function often emerging shortly after stress exposure and then diminishing as physiological arousal subsides (Shields et al., 2016). We therefore treat time-dependent stress effects as conceptually distinct from habituation: time-dependence reflects recovery of executive control following stressor offset, whereas habituation reflects learning-based suppression of distractor processing through repeated exposure. Accordingly, our hypotheses addressed both (i) an initial stress-related increase in distraction and (ii) the rate at which distraction attenuates over the course of the task.

Consistent with Attentional Control Theory, we expected this effect to be reflected primarily in reaction-time costs, with no strong prediction regarding accuracy, as the task does not impose substantial working-memory load. Although we did not measure working-memory capacity directly, we use this theoretical framework to motivate predictions about transient state-based executive control under acute stress.

In contrast, the Cognitive Reallocation Theory—derived from Easterbrook's (1959) cue-utilisation hypothesis—predicts that acute stress narrows attentional focus, thereby preserving goal-directed processing and reducing distraction (Chajut & Algom, 2003; Wirkner et al., 2019). On this account, participants in the stress condition should show smaller oddball effects compared to controls, particularly early in the session when arousal is strongest. However, as stress levels subside, attentional narrowing may relax, potentially allowing distraction to increase over time—a trajectory opposite to that predicted by Attentional Control Theory.

Finally, we examined whether the magnitude of the oddball effect differed as a function of deviant type: either a semantically meaningless acoustic change (e.g. a novel sound) or a spoken word that was either semantically congruent (e.g. "left") or semantically incongruent (e.g. "right") with the target response (e.g. when responding to a left-pointing arrow). Given that semantic incongruence introduces a response conflict, Attentional Control Theory predicts these deviants to be especially disruptive under stress, whereas the Cognitive Reallocation Theory might predict a general suppression of distraction across deviant types, with some residual vulnerability to semantically relevant interference.

Method

Participants

A total of 36 volunteers (2 female) were recruited via opportunity sampling from an advanced firefighting training course at Fleetwood Nautical College, UK (mean age = 22.11 years, $SD = 4$, range = 17–35). An additional 30 control participants (2 female) were recruited from staff and students at the University of Lancashire, UK (mean age = 21.7 years, $SD = 3.43$, range = 19–37; $t(64) = 0.44$, $p = .66$, CI 95% [−1.44, 2.26]). Firefighters were recruited from a rigorous firefighting simulation involving physically and mentally demanding stress exposure. The sample size was determined by the practical constraints of recruiting firefighters during their advanced training. While the sample size is modest due to the practical constraints of recruiting this specialised group, the recruitment of firefighters provides substantial ecological validity and aligns the research with real-world contexts of acute stress in high-stakes environments. While the modest sample size may limit statistical power, post hoc analyses indicated approximately 70–80% power to detect medium effects ($d = 0.5$).

Participants were screened using a modified version of the Blood Services screening and medical questionnaire and excluded if they: had active infections, jaundice in the past year, hepatitis, haemophilia, or tested HIV antibody-positive; exhibited flu-like symptoms or had recent close contact with flu-infected individuals; had undergone dental treatments (e.g. tooth extraction) within the last 24 h; had high levels of gum disease causing bleeding gums; had a history of neurological or psychiatric illness; or were taking medications known to affect brain function or cortisol levels (e.g. antidepressants). All participants self-reported as non-smokers without acute illnesses. Body mass index (BMI) was comparable between groups (firefighters: $M = 24.92$, $SD = 3.11$; controls: $M = 23.33$, $SD = 3.47$; $t(64) = 1.95$, $p = 0.056$, 95% CI [−0.038,3.2]). This health screening was required for safety reasons given the physically demanding and high-temperature firefighting environment, and to protect physiological data validity. Conditions and medications that influence immune function or hypothalamic–pituitary–adrenal axis activity (e.g. Kudielka & Wüst, 2010; O'Connor et al., 2009) were excluded to avoid medical risk and ensure reliable cortisol-based stress measurement. Variables known to influence biological responses to stress (Dickerson & Kemeny, 2004; O'Connor et al., 2009) were thus minimised or monitored within the study. Mean wake-up time for the control group was later (06:46; $SD = 17$ min) than for the firefighters (06:02am; $SD = 1$ min), $t(34.90) = -5.40$, $p < .001$, Cohen's $d = -1.44$. The very low variability in the firefighter group reflects the regimented wake schedule during residential training. Importantly, all testing sessions occurred at the same time of day for both groups, attempting to reduce circadian confounds in cortisol levels. All oddball tasks began at approximately 11:45, placing cognitive testing well within the descending limb of the diurnal cortisol cycle and shortly before the typical 20–30 min post-stressor cortisol peak window, ensuring both groups were tested within a comparable circadian phase. This study was approved by the University of Lancashire Psychology Ethics Committee. All procedures adhered to national ethical standards and the Declaration of Helsinki. All participants provided written informed consent and were free to withdraw at any time without penalty.

Equipment and materials

Low Mood Questionnaire (CES-D)

The Centre for Epidemiological Studies Depression scale (CES-D) is a 20-item self-report questionnaire designed to assess depressive symptoms, including somatic symptoms, depressed affect, lack of positive affect, and interpersonal difficulties. Participants rate the frequency of symptoms in the past week on a 4-point Likert scale ranging from 0 ("rarely or none of the time") to 3 ("most or all of the time"). Total scores range from 0 to 60, with higher scores indicating more frequent depressive symptoms. The CES-D demonstrates high internal reliability (Cronbach's Alpha = 0.85 for the general population; 0.90 for clinical populations).```

Stress and Arousal Checklist (SACL)

The Stress and Arousal Checklist (SACL; Mackay et al., 1978) measures subjective stress and arousal levels using 34 mood-related adjectives split into two subscales: Stress (19 items) and Arousal (15 items). Participants rate their current state on a 4-point scale ranging from "Definitely Feel" to "Definitely Do Not Feel." Positive adjectives marked as "Definitely Feel" or "Slightly Feel" are scored as 1, while negative adjectives marked as "Cannot Decide" or "Definitely Do Not Feel" are also scored as 1. Total scores range from 0 to 19 for Stress and 0–15 for Arousal, with higher scores indicating higher subjective states.

NASA-TLX perceived workload

The NASA Task Load Index (NASA-TLX; Hart, 2006) assesses six dimensions of subjective workload: Mental Demand, Physical Demand, Temporal Demand, Performance, Effort, and Frustration. Participants rate their experience on a 10 cm visual analogue scale, with marks converted to numerical scores (e.g. a mark at 4.3 cm equals a score of 43). Higher scores indicate higher perceived workload.

Oddball task

A computer-based oddball task (adapted from Parmentier et al., 2008) was implemented using E-Prime 2.0 software. Participants categorised left- or right-facing arrows by pressing the corresponding keyboard arrow key with their dominant hand as quickly and accurately as possible. Auditory stimuli were presented throughout the task but were irrelevant to the categorisation task. Stimuli included a 200 ms sinewave tone (440 Hz) as the "standard," and three types of deviant sounds (all also 200 ms in duration): a white noise burst and the words "left" and "right" spoken by a male voice. All sounds included 10 ms rise and fall ramps, were normalised, and were presented binaurally through headphones at approximately 65 dB(A). Each trial began with the 200 ms sound. One hundred milliseconds after the sound's offset, a left- or right-pointing arrow appeared for 200 ms. The arrow was replaced by a 100 ms visual mask consisting of an 8 × 8 grid of randomly arranged black and white squares. A central fixation cross remained visible at all other times and reappeared after the mask for approximately 550 ms before the next trial began automatically. Participants had a maximum of 850 ms from arrow onset to categorise its direction by pressing the corresponding keyboard arrow key with their dominant hand. Participants completed 1,008 trials divided into four blocks (252 trials per block). In each block, there were 12 warm-up trials (discounted from analyses), followed by 240 experimental trials. Of the experimental trials 168 (70%) contained the standard tone and 72 trials (30%) where deviant trials (24 for each deviant type). Deviant sounds were followed equally often by left- and right-pointing arrows. The software recorded response accuracy and reaction times (RTs). Responses faster than 100 ms (anticipations) or slower than 850 ms (responses occurring after the next trial's onset) were excluded from analysis, consistent with previous cross-modal oddball studies (e.g. Parmentier et al., 2008). The task lasted approximately 20 min in total.

Procedure, design and analysis

A between-within subjects mixed design was used, with stress exposure condition as the between-subjects factor. Within-subjects factors were trial type (standard vs. deviant) and trial block (Block 1–4). Experimental participants completed the advanced fire-fighting training: a 30-minute search-and-rescue exercise at Fleetwood Nautical College. Conducted in a ship galley mock-up, the exercise involved wearing full turnout gear, including self-contained breathing apparatus (SCBA), in temperatures between 60°C and 130°C amid thick black smoke. This training is physically and psychologically demanding (Throne et al., 2000) and has been shown in prior research to elicit acute stress responses (Hancock & Szalma, 2008). Control participants did not undertake the exercise but instead engaged in one hour of office or classroom activities.

Data collection followed a strict procedure (Table 1). All participants completed baseline measures (CES-D, SACL, NASA-TLX) and provided a baseline saliva sample one hour before the firefighting task. After the exercise/control period, firefighters returned to the testing room (∼10 min transition time) and a second saliva sample was collected immediately upon arrival, followed by the SACL and NASA-TLX. Participants then completed the oddball task (∼20 min). Immediately after the task questionnaires were administered and a final saliva sample was collected. This sampling schedule ensured that the second and third samples fell within

Table 1. Experimental timeline and saliva sampling schedule.

Stage	Duration & approx. time	Saliva sample
Baseline measures	∼60 min pre-task – 10:00	Sample 1
Firefighting exercise/control period	∼30 min/∼60 min – 11:00	–
Transition to resting room	∼10–15 min – 11:30	
Post-exercise/pre-task measures	∼11:40	Sample 2
Oddball task	∼20 min – 11:45	–
Post-task measures	∼5 min – 12:10	Sample 3

Table 2. Mean (*SE*) stress, arousal, workload and cortisol values by session and group.

Measure	Session	Firefighters *M* (*SE*)	Controls *M* (*SE*)
Stress	S1	5.08 (0.72)	4.30 (0.71)
	S2	8.94 (0.75)	2.77 (0.42)
	S3	5.53 (0.76)	4.87 (0.73)
Arousal	S1	11.56 (0.40)	8.00 (0.72)
	S2	11.22 (0.54)	9.53 (0.63)
	S3	7.06 (0.71)	6.90 (0.83)
Workload (NASA-TLX)	S1	288.36 (22.69)	179.33 (16.15)
	S2	445.66 (16.61)	173.23 (20.05)
	S3	295.28 (19.28)	304.20 (21.46)
Cortisol (nmol/L)	S1	5.75 (0.70)	10.28 (2.01)
	S2	9.88 (1.24)	4.70 (0.76)
	S3	14.79 (2.32)	4.15 (0.56)

the expected 20–30-minute post-stressor cortisol rise window (Dickerson & Kemeny, 2004; Kirschbaum et al., 1993). Participants were then debriefed. Procedures and timing were identical for the control group.

Saliva samples were collected using Salivette devices (Sarstedt Ltd., Leicester, UK). Participants provided unstimulated samples by holding the Salivette under their tongue for two minutes. Samples were stored at −40° C, thawed at room temperature for 15 min, and centrifuged (1500 rpm for 15 min). Cortisol concentrations (nmol/L) were analysed using high-sensitivity salivary cortisol enzyme immunoassay kits, and values for each group at each session are reported in Table 2.

Statistical analysis

Reaction time data were analysed using mixed-design analysis of variances (ANOVAs) with trial type (standard vs. deviant) and block (1–4) as within-participant factors and group (firefighter vs. control) as the between-participant factor. Greenhouse–Geisser corrections were applied when sphericity assumptions were violated. Planned comparisons examined group differences in the oddball effect at each block, with a focus on Block 1 as the point at which acute stress effects were predicted to be maximal.

For salivary cortisol and subjective measures (stress/arousal, workload), analyses focused primarily on within-group change across the three sampling/assessment points, as recommended for quasi-experimental field stress designs where groups differ in waking time and diurnal hormonal profiles. Between-group means are reported descriptively to avoid overstating differences influenced by circadian factors. Paired-samples tests assessed within-group change over time. This strategy ensured valid interpretation of stress-response trajectories while still allowing theoretical predictions to be tested.

This analysis plan was specified a priori to examine (a) whether acute stress exposure increased auditory distraction and (b) how distraction and stress markers evolved over time, particularly early in the oddball task when stress effects were expected to be strongest.

Results

We first verified the effectiveness of the stress manipulation using self-report, workload, and salivary cortisol measures. As expected, the firefighting group showed a clear acute stress response that resolved over time, whereas the control group did not. A concise summary is provided in Table 2, with full statistics reported below. We then analysed reaction times in the cross-modal oddball task to test whether acute stress exposure was associated with greater distraction, particularly early in the session.

Manipulation checks (full statistics reported for transparency)

Detailed results for mood, stress/arousal, workload, and cortisol are reported below; descriptive highlights appear in Table 2.

CES-D (low mood) scores were comparable between firefighters ($M = 8.97$, $SD = 7.33$) and controls ($M = 10.07$, $SD = 6.29$), $t(64) = 0.64$, $p = .52$, 95% CI [−4.49, 2.30], Cohen's $d = 0.16$. Therefore, firefighters and controls did not differ in the level of self-reported low mood.

Self-reported stress and arousal (Stress and Arousal Checklist, SACL) were measured at three time points (pre-task, post-exercise/control, post-oddball task; see Table 1). At baseline (Session 1), groups did not differ in stress, $t(64) = 0.77$, $p = .44$, 95% CI [−1.25, 2.82], Cohen's $d = .19$, although firefighters reported higher arousal than controls, $t(64) = 4.52$, $p < .001$, 95% CI [1.98, 5.13], Cohen's $d = 1.12$, consistent with anticipatory arousal prior to the training exercise.

Immediately after the exercise/control period (Session 2), firefighters reported significantly higher stress, $t(64) = 6.82$, $p < .001$, 95% CI [7.72, 10.16], Cohen's $d = 1.69$, and arousal, $t(64) = 2.05$, $p = .045$, 95% CI [10.11, 12.33], Cohen's $d = 0.51$, than controls. By Session 3, stress and arousal ratings no longer differed between groups (stress: $t(64) = 0.62$, $p = .538$, 95% CI [−1.47, 2.79], Cohen's $d = 0.15$; arousal: $t(64) = 0.14$, $p = .887$, 95% CI [−2.02, 2.33], Cohen's $d = 0.04$), indicating recovery in the firefighter group over the course of the oddball task.

Within-group changes confirmed this pattern. Among firefighters, stress increased sharply from Session 1 to Session 2 ($M_{diff} = 3.86$, $SE = 0.84$), $t(35) = 4.61$, $p < .001$, 95% CI [2.16, 5.56], Cohen's $dz = 0.77$, and then declined from Session 2 to Session 3 ($M_{diff} = 3.42$, $SE = 0.95$), $t(35)$

= 3.59, p = .001, 95% CI [1.49, 5.35], Cohen's dz = 0.60, returning to baseline by Session 3 relative to Session 1 (M_{diff} = −0.44, SE = 0.95), t(35) = −0.47, p = .64, 95% CI [−2.73, 1.48], Cohen's dz = 0.08. Controls showed a modest reduction in stress from Session 1 to Session 2 (M_{diff} = 1.53, SE = 0.67), t(29) = 2.29, p = .029, 95% CI [0.16, 2.90], Cohen's dz = 0.42, followed by an increase from Session 2 to Session 3 (M_{diff} = −2.10, SE = 0.69), t(29) = −3.06, p = .005, 95% CI [−3.50, −0.70], Cohen's dz = 0.56, with no difference between Sessions 1 and 3 (M_{diff} = 0.57, SE = 0.67), t(29) = 0.84, p = .41, 95% CI [−0.81, 1.95], Cohen's dz = 0.15.

Arousal showed a different pattern across groups. Among firefighters, arousal did not change from Session 1 to Session 2 (M_{diff} = −0.33, SE = 0.65), t(35) = −0.51, p = .613, 95% CI [−1.66, 0.99], Cohen's dz = 0.09, but declined sharply from Session 2 to Session 3 (M_{diff} = 4.17, SE = 0.74), t(35) = 5.63, p < .001, 95% CI [2.66, 5.67], Cohen's dz = 0.94, and from Session 1 to Session 3 (M_{diff} = 4.50, SE = 0.69), t(35) = 6.56, p < .001, 95% CI [3.12, 5.89], Cohen's dz = 1.09. This indicates that arousal was high before and immediately after the firefighting exercise but declined during the oddball task.

In contrast, controls showed a transient rise in arousal prior to the task. Arousal increased from Session 1 to Session 2 (M_{diff} = 1.53, SE = 0.61), t(29) = 2.50, p = .018, 95% CI [0.28, 2.79], Cohen's dz = 0.46, then decreased from Session 2 to Session 3 (M_{diff} = 2.63, SE = 0.75), t(29) = 3.51, p = .002, 95% CI [1.10, 4.17], Cohen's dz = 0.64, with no difference between Sessions 1 and 3 (M_{diff} = 1.10, SE = 0.81), t(29) = 1.36, p = .183, 95% CI [−0.55, 2.75], Cohen's dz = 0.25. This suggests a modest anticipatory arousal increase prior to testing that normalised during the oddball task.

Perceived workload (NASA-TLX) demonstrated the expected stress-related pattern. Firefighters reported higher workload than controls at baseline, t(60.65) = 3.92, p < .001, 95% CI [53.33, 164.73], Cohen's d = .93, and substantially higher workload after the firefighting exercise, t(63) = 10.56, p < .001, 95% CI [220.85, 323.99], Cohen's d = 2.63. By Session 3, ratings no longer differed between groups, t(64) = −0.31, p = .758, 95% CI [−66.47, 48.63], Cohen's d = 0.08.

Within-group comparisons confirmed these changes. Among firefighters, workload rose sharply from Session 1 to Session 2 (M_{diff} = 159.14, SE = 23.45), t(34) = 6.79, p < .001, 95% CI [111.48, 206.80], Cohen's d_z = 1.15, and then declined from Session 2 to Session 3 (M_{diff} = 150.40, SE = 22.75), t(34) = 6.61, p < .001, 95% CI [104.18, 196.62], Cohen's d_z = 1.12, returning to baseline (Session 1 vs Session 3: M_{diff} = 6.92, SE = 27.68, t(35) = 0.25, p = .804, 95% CI [−49.28, 63.12], Cohen's d_z = 0.04).

In controls, workload did not change from Session 1 to Session 2 (M_{diff} = −6.10, SE = 15.89), t(29) = 0.38, p = .704, 95% CI [−38.59, 26.39], (Cohen's d_z = 0.07), but increased during the oddball task (Session 2 vs Session 3: M_{diff} = −130.97, SE = 18.93, t(34) = 6.92, p < .001, 95% CI [−169.68,−92.26], Cohen's d_z = 1.26, and was higher at Session 3 than Session 1 (M_{diff} = −124.87, SE = 23.32), t(35) = 5.25, p < .001, 95% CI [−172.57, −77.16], Cohen's d_z = 0.98).

Collectively, these results confirm greater perceived workload following the stressor and recovery over time, whereas controls showed increased workload only during the cognitive task.

Cortisol analyses were based on participants with complete saliva datasets (24 firefighters, 19 controls). Samples were lost for 12 firefighters and 11 controls due to insufficient saliva or blood contamination. Cortisol showed a robust stress-response profile. At baseline (Session 1), controls had higher cortisol than firefighters, t(22.39) = −2.13, p = .044, 95% CI [−8.95, −0.12], Cohen's d = 0.71. After the exercise, firefighters showed higher cortisol than controls at Session 2, t(36.82) = 3.57, p = .001, 95% CI [2.24, 8.13], Cohen's d = 1.03, and Session 3, t(25.65) = 4.46, p < .001, 95% CI [5.73, 15.55], Cohen's d = 1.23.

To account for diurnal variability in cortisol, between-group means are treated descriptively, and emphasis is placed on within-group trajectories, which clearly show an acute stress response in the firefighter group and a decline across sessions in controls.

Within-group comparisons confirmed a delayed cortisol peak among firefighters: Session 1 < Session 2, t(23) = 3.41, p = .002, 95% CI [−6.64, −1.63], Cohen's dz = 0.70; Session 1 < Session 3, t(23) = 3.69, p = .001, 95% CI [−14.12, −3.97], Cohen's dz = 0.75; Session 2 < Session 3, t(23) = 2.34, p = .028, 95% CI [−9.25, −0.56], Cohen's dz = 0.48. This trajectory is consistent with acute HPA-axis stress responses, where cortisol peaks 20–30 min after stressor offset. Given the procedural timeline (stressor ending approximately11:30, second sample at 11:40, and third sample at ∼12:10), the observed rise corresponds closely to the expected physiological latency of cortisol release. This further supporting the validity of the timing structure reported in Table 1.

Controls showed the opposite pattern: cortisol decreased from Session 1 to Session 2, t(18) = 2.56, p = .020, 95% CI [0.99, 10.18], Cohen's dz = 0.59, remained stable from Session 2 to Session 3, t(18) = 0.96, p = .348, 95% CI [−0.64, 1.73], Cohen's dz = 0.22, and was lower at Session 3 than Session 1, t(18) = 2.93, p = .009, 95% CI [1.73, 10.53], Cohen's dz = 0.67.

In sum, these findings confirm a clear physiological stress response in the firefighter group and declining cortisol across the same interval in controls.

Oddball task

Accuracy was generally high, with an average accuracy above 90% in all conditions. Most importantly, firefighters and controls did not differ in accuracy. There was no difference between groups and no interactions between sound condition and group. Because of this, the analysis focused on response times (RTs) for correct responses, analysed for the standard, noise burst, semantically congruent novel and semantically incongruent novel conditions respectively. When calculating the average RTs for the standard condition, all responses to targets that followed a standard sound were included except trials with standard sound that followed immediately after a deviant trial. This is because these post-deviant standard trials are typically influenced by a post-deviant effect (Bendixen et al., 2007). Acoustic novelty distraction was defined as the difference in performance between the noise burst novel condition and the standard condition. The semantic effect was defined as the difference in performance between the congruent and incongruent novel conditions. In the analyses below, Greenhouse-Geisser procedure was applied on every within-subject effect for which the sphericity assumption was violated.

Distraction by an acoustically novel noise burst

We first analysed the oddball effect produced by the acoustically novel noise burst across blocks and groups. The firefighter group was more susceptible to distraction in the beginning of the task (Block 1), but this susceptibility diminished over time. Figure 1, panel A, shows RTs for standard and oddball trials across the four blocks. Figure 1, panel B, shows how the magnitude of the oddball effect changed across blocks, with a larger oddball effect in firefighters in the beginning, but no difference between groups at the end. This early-session peak aligns with the timing of the expected post-stressor cognitive impact, which occurs shortly after physiological arousal begins to escalate, before full cortisol recovery. A mixed-design analysis of variance was conducted with trial block (Blocks 1-4) and trial type (standard vs. acoustic novel noise burst) as within-participant factors, group (firefighter vs. control) as a between-participants factor, and reaction time (RT) as the dependent variable.

The analysis revealed a significant main effect of trial type, $F(1, 64) = 64.03$, $p < .001$, $\eta_p^2 = .50$. This indicated a robust overall oddball effect of acoustic novelty. There was also a significant interaction between trial type and block, $F(3, 64) = 15.12$, $p < .001$, $\eta_p^2 = .19$, suggesting that the magnitude of the oddball effect attenuated across blocks. Crucially, a significant three-way interaction was observed between trial type, block, and group, $F(3, 192) = 3.10$, $p = .028$, $\eta_p^2 = .05$, indicating that the oddball effect was initially larger in the firefighter group but became similar to the control group over time. Planned comparisons confirmed that the oddball effect in Block 1 was significantly greater for the firefighter group ($M_{\text{diff}} = 41.34$ ms, $SE = 5.87$) than for the control group ($M_{\text{diff}} = 22.94$ ms, $SE = 4.19$), $t(60.77) = 2.55$, $p = .013$, 95% CI [3.98, 32.82], Cohen's $d = 0.61$. By Block 4, the oddball effect no longer differed between groups: firefighter group ($M_{\text{diff}} = 12.34$ ms, $SE = 4.39$) vs. control group ($M_{\text{diff}} = 10.84$ ms, $SE = 3.77$), $t(64) = 0.25$, $p = .801$, 95% CI [−10.33, 13.33], Cohen's $d = 0.06$.

Distraction by semantically incongruent novels

Next, we analysed the oddball effect produced by semantic incongruency. As shown in Figure 2, there was a clear incongruency effect, but group differences were less pronounced than for the acoustic oddball. Figure 2, panel A, shows RTs for standard trials, semantically congruent oddball trials, and semantically incongruent oddball trials across the four blocks. Figure 2, panel B, shows how the magnitude of the oddball effects (operationalised as the difference in RTs between congruent/incongruent trials and standard trials) changed across blocks. A repeated-measures analysis of variance was conducted with trial block (Blocks 1-4) and trial type (standard vs. incongruent oddball vs. congruent oddball), as within-participant factors, group (firefighter vs. control) as a between-participants factor, and reaction time (RT) as the dependent variable. The analysis revealed a significant effect of trial type, $F(2, 128) = 69.59$, $p < .001$, $\eta_p^2 = .52$, driven primarily by slower RTs on incongruent trials (see Figure 2). A significant interaction between trial type and block emerged, $F(6, 384) = 10.67$, $p < .001$, $\eta_p^2 = .14$, indicating that the semantic oddball effect attenuated over time. However, the three-way interaction (trial type x block x group) was not significant, $F(6, 384) = 1.53$, $p = .168$, $\eta_p^2 = .02$, suggesting that semantic distraction did not follow the same group-dependent pattern as the acoustic oddball effect.

Visual inspection of Figure 2 suggests that the groups responded differently to incongruent oddballs across the session. An exploratory analysis comparing incongruent trial RTs between groups across blocks revealed a significant interaction, $F(3, 192) = 2.29$, $p = .0395$ (one tailed), $\eta_p^2 = .04$. In the firefighter group, the semantic oddball continued to capture attention throughout the task, whereas in the control group, the effect appeared to attenuate over time.

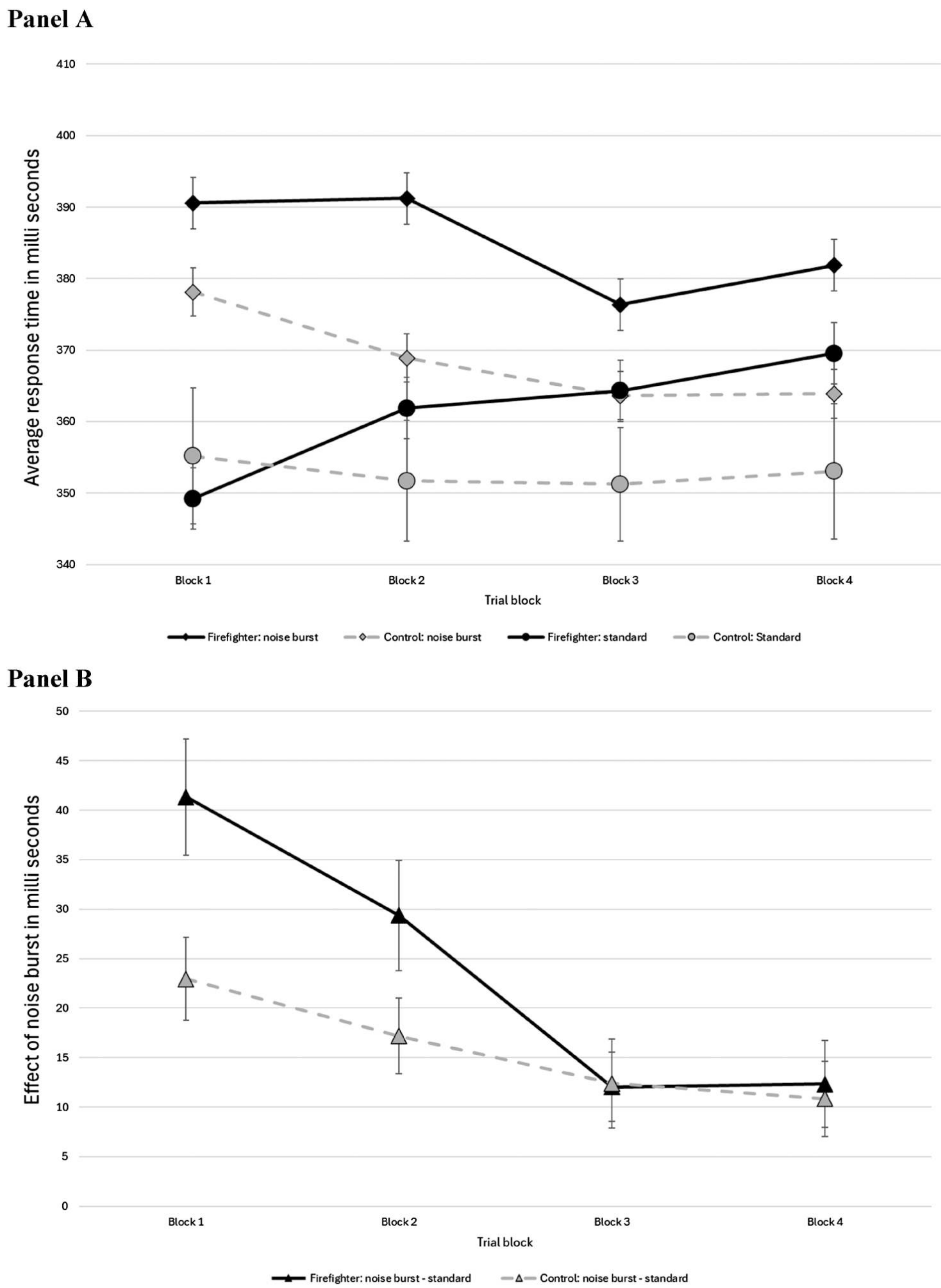

Figure 1. Average response time to targets that follow a standard sound or a rare noise burst (oddball), in firefighters (who conducted a stress-induction exercise prior to the oddball task) and in controls. The data are divided in 4 consecutive blocks (240 trials in each block). Panel B shows the same data as Panel A but depicts the magnitude of the effect for the two groups. Error bars represent standard error of means.

Discussion

Participants exposed to the firefighting exercise were more susceptible to auditory distraction at task onset than controls, particularly for acoustically novel stimuli, with this difference diminishing across time as stress levels recovered. These findings align with the predictions associated with reduced availability of goal-directed attentional control under acute stress and can be considered within broader theoretical perspectives on stress and attention. Attentional Control Theory (Eysenck & Derakshan, 2011) proposes that acute stress is associated with reduced efficiency of top-down regulation and greater reliance on stimulus-driven processing, which would manifest as stronger distraction effects early in the task. In contrast, Cognitive Reallocation accounts (Chajut & Algom, 2003; Plessow et al., 2011; Wirkner et al., 2019), drawing on Easterbrook's (1959) cue-utilisation hypothesis, suggest that heightened arousal can narrow attentional focus and

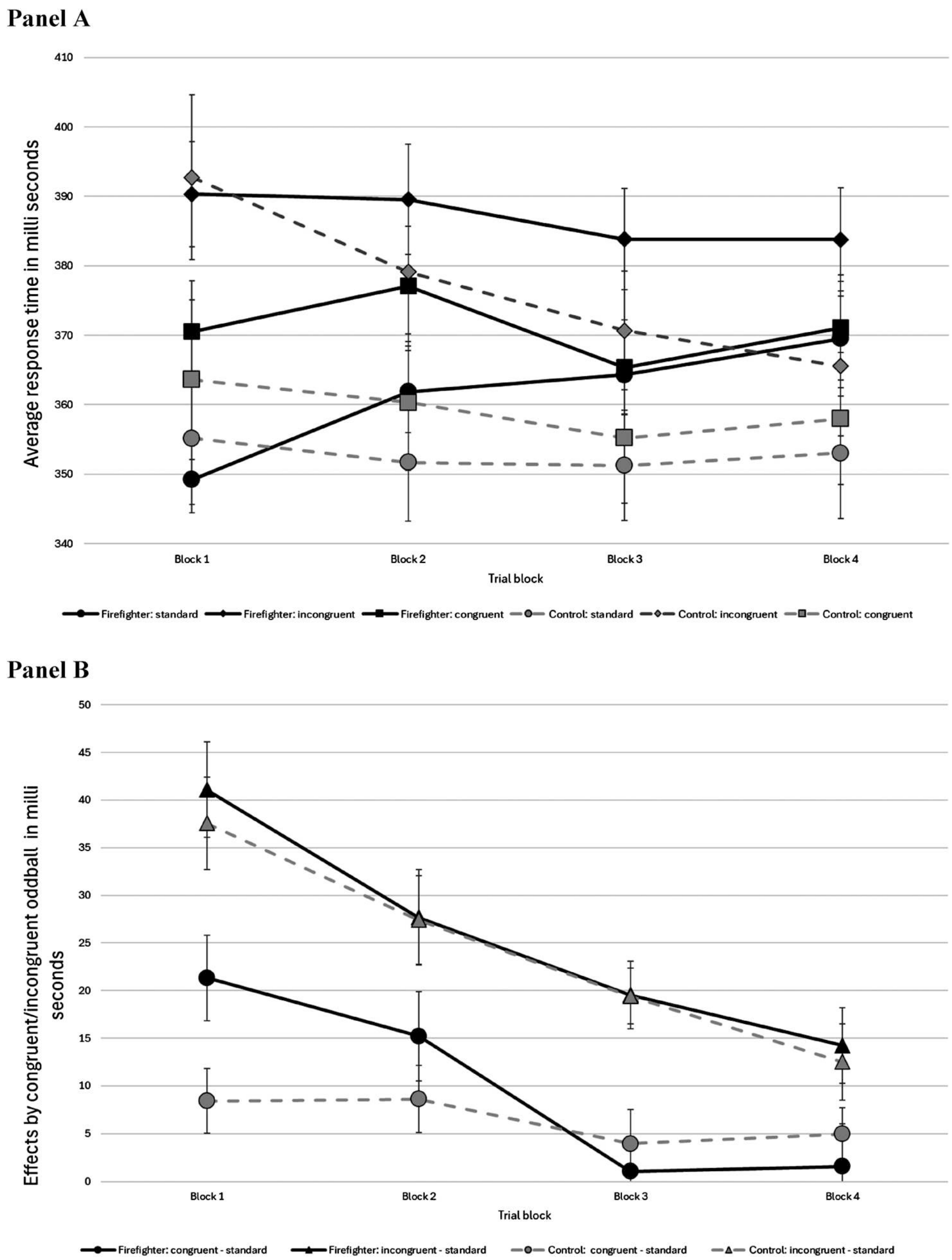

Figure 2. Average response time to targets that follow a standard sound, a rare oddball sound that is semantically incongruent with the target response, or a rare oddball sound that is semantically congruent with the target response, in firefighters (who conducted a stress-induction exercise prior to the oddball task) and in controls. The data are divided in 4 consecutive blocks (240 trials in each block). Panel B shows the same data as Panel A but depicts the magnitude of the effects for the two groups. Error bars represent standard error of means.

potentially reduce distraction by shielding processing from task-irrelevant input.

Consistent with predictions derived from Attentional Control Theory, participants exposed to the firefighting exercise showed greater distraction at the start of the oddball task—particularly for the acoustically novel stimuli—before gradually converging toward the control group across time. This pattern is consistent with the idea that acute stress exposure is associated with reduced efficiency in top-down attentional control, especially at task onset when regulatory demands are highest. The absence of early distraction reduction and subsequent rebound, as would be expected under a Cognitive Reallocation account, provides no support for the attentional narrowing prediction in this context.

It is important to note that Attentional Control Theory primarily predicts reductions in processing efficiency (e.g. slower responses, increased distractor interference) rather than decrements in processing effectiveness (e.g. accuracy), particularly when task demands remain manageable (Eysenck & Derakshan, 2011; Eysenck et al., 2007). This gels with the present findings: acute stress altered the magnitude and time-course of distraction effects in reaction time, without producing clear accuracy impairments. Thus, the behavioural profile observed here fits the efficiency-cost prediction that is central to Attentional Control Theory.

Taken together, the pattern of results appears more consistent with predictions derived from the Attentional Control Theory (Eysenck & Derakshan, 2011) than with the Cognitive Reallocation perspective ``(Easterbook, 1959; Plessow et al., 2011). According to Attentional Control Theory, acute stress exposure is associated with reduced efficiency of the goal-directed attentional system thereby increasing reliance on stimulus-driven processing. This was evident in the heightened oddball effect observed in the firefighter group at the start of the task and in their prolonged vulnerability to distraction across blocks. Taken together, the results may indicate disrupted top-down control, especially in contexts where adaptive regulation is challenged by acute stress. The effect was clearest for the acoustically deviant noise bursts and less so for semantically incongruent words. This partly supports the prediction that stress disrupts early, stimulus-driven attentional capture more reliably than response-conflict effects.

In contrast, the Cognitive Reallocation perspective predicts that acute stress narrows attentional focus and protects task-relevant processing by filtering out distractions. On this view, stress should initially reduce distraction, with a potential rebound in oddball effects as arousal diminished over time. These predictions were not supported by the present findings. The firefighter group displayed greater distraction early on and did not show a reliable rebound pattern. Furthermore, the lack of robust habituation in the firefighter group mirrors findings from Sörqvist et al. (2012), where individuals with lower working memory capacity failed to habituate to distraction across time, unlike their higher-capacity counterparts. The similarity suggests that stress may temporarily reduce the availability of cognitive control resources in a way that mimics low working memory capacity, further supporting the view that stress impairs, rather than enhances, attentional adaptation.

We next consider the physiological stress response. Self-report and salivary cortisol measures indicated that the firefighting task was associated with an acute stress response. Firefighters reported elevated arousal and stress immediately after the exercise, followed by a return to baseline levels during the oddball task. Cortisol concentrations increased across measurement points, consistent with delayed HPA-axis activation (Dickerson & Kemeny, 2004; Kirschbaum et al., 1993) and aligning with evidence that cognitively demanding post-stressor tasks can maintain elevated physiological arousal (Joëls et al., 2006; Schwabe et al., 2012).

Interestingly, control participants showed higher cortisol levels at baseline than firefighters. This variation is likely due to circadian influences on cortisol, with control participants potentially having later waking times (O'Byrne et al., 2021). Of note, the control group did not exhibit a cortisol increase during the oddball task, suggesting that the task alone was not sufficiently stressful to activate the HPA axis in unstressed individuals. In contrast, the firefighter group may have entered the task with an already elevated physiological state, and the cognitive demands of the task may have sustained or contributed to prolonged arousal, delaying recovery. This interpretation is supported by evidence that cognitively demanding post-stressor tasks can prolong cortisol elevation in a still-activated system (Joëls et al., 2006; Schwabe et al., 2012).

While exploratory analyses found no correlation between cortisol levels and behavioural distraction effects, the absolute cortisol concentrations (Table 2) confirm that our stress induction was biologically effective. From a biological perspective, it remains plausible that changes in circulating cortisol may have influenced brain function and, consequently, task performance. However, our pattern of results does not align with a simple cortisol-driven mechanism (i.e. peak cortisol corresponding to peak impairment), and instead is consistent with a cognitive-level explanation rooted in reduced availability of top-down control (see also Robinson et al., 2008). These findings complement those of Robinson et al. (2013), who observed that working memory impairments did not coincide directly with peak cortisol levels in a similar firefighter simulation. In that study, impairments were more pronounced some 20 min post-exercise, suggesting a dissociation between cortisol concentration and cognitive impact. Such results are consistent with the idea that cortisol is a marker of stress reactivity but not necessarily a direct driver of cognitive disruption.

At the beginning of the oddball task (Block 1), we expected to see the purest effect of stress on auditory distraction. This prediction was grounded in the study timeline: the oddball task began approximately 15 min after stressor offset, coinciding with the window in which cognitive consequences of acute stress typically emerge before cortisol reaches its delayed physiological peak (Dickerson & Kemeny, 2004; Kirschbaum et al., 1993; Shields et al., 2016). Looking only at these trials, we see a larger oddball effect in the firefighter group in comparison with the control group, at least for noise bursts. The overall result pattern suggests that stress increases susceptibility to auditory distraction, particularly in the early stages of task engagement. In Block 1, which arguably provides the clearest window into the immediate cognitive consequences of the stress induction, the firefighter group showed a significantly larger oddball effect for the acoustically novel noise burst compared to controls (Figure 1). This aligns with predictions derived from Attentional Control Theory (Eysenck & Derakshan, 2011), which holds that an acute stress response impairs top-down control and increases the influence of stimulus-driven attention. The effects were less consistent with semantically meaningful oddballs (Figure 2), possibly reflecting different underlying mechanisms or ceiling effects in distraction elicited by meaningful stimuli.

Examining changes in distraction across the task reveals important group differences in habituation. While distraction decreased across blocks in both groups, this pattern likely reflects two complementary processes: (i) time-dependent recovery of executive control following stress exposure, and (ii) habituation to deviant sounds through repeated exposure. The former reflects restoration of cognitive control as physiological arousal normalises, whereas the latter represents learning-based suppression of orienting responses. Notably, the firefighter group showed reduced habituation relative to controls, suggesting that acute stress exposure was associated with more sustained stimulus-driven attentional capture and a slower reduction in distraction over time. For the acoustically novel oddballs, both groups showed a reduction in the oddball effect over time, indicative of habituation. However, the trajectory of this habituation differed. In the firefighter group, the reduction stemmed from a gradual speeding of responses on deviant trials, coupled with a relative slowing on standard trials. In contrast, the control group showed relatively stable responses to standard trials while becoming progressively faster on deviant trials. The firefighter group demonstrated consistently slower reaction times to oddballs throughout the task. A similar, though less pronounced pattern, was observed for semantically incongruent oddballs. Taken together, these results suggest that while controls showed clear habituation to distraction, the firefighter group did not fully suppress the orienting response to the deviants. This pattern is consistent with the interpretation that acute stress exposure was associated with reduced habituation to distraction.

Limitations and future directions

Several limitations should be acknowledged. First, the sample size was small. This may have reduced statistical power and the stability of effects, limiting the reliability and generalisability of the findings. This may also account for the somewhat inconsistent or ambiguous result patterns observed. Nonetheless, the modest sample reflects the practical constraints of recruiting firefighters and conducting field-based research of this kind. Despite these constraints, the present findings still offer valuable insight into how stress, habituation, and distraction may interact. As such the study provides a foundational contribution to the literature and a platform for future investigations with larger and more diverse samples.

Second, participants were also not randomly assigned to experimental conditions. As this was a quasi-experimental field design and group membership was not randomly assigned, this pattern should be interpreted as reflecting associations with acute stress exposure rather than definitive causal effects. This limits the causal inferences that can be drawn about the effects of the stress induction. A more rigorous future design would compare firefighters assigned to a stress induction versus a no-stress condition to isolate the specific effect of acute stress beyond occupational background. On a related note, working memory capacity was not measured, not in the firefighters nor in the controls. Theoretical claims about the similarity in effects of stress and low working memory capacity on auditory distraction/habituation would be more firmly grounded if participants' working memory capacity were measured and controlled in future work. Accordingly, we interpret our effects in terms of state-based executive attentional control and selective attention, rather than trait working-memory capacity per se. Although we drew on working memory theories to motivate hypotheses about susceptibility to distraction, the absence of a direct working memory capacity measure means we cannot speak to individual differences in capacity, and future work should incorporate objective working memory capacity assessments to more rigorously test this proposed mechanism.

Third, circadian factors warrant consideration. Firefighters woke significantly earlier than controls during the residential training period, resulting in less variability in wake-up times and a more regimented sleep–wake schedule. Although all participants were tested at the same time of day, and thus the primary circadian confound for cortisol measurement was minimised, earlier waking could contribute to baseline cortisol differences due to the cortisol awakening response (e.g. Dickerson & Kemeny, 2004; O'Byrne et al., 2021). Importantly, however, the behavioural distraction effect was largest immediately after the stressor and dissipated over time —a trajectory inconsistent with a simple circadian explanation. Moreover, anticipation and workload ratings aligned with the expected psychological stress trajectory. Nonetheless, future work should standardise wake-time or directly measure time-since-awakening to more precisely isolate the contribution of diurnal rhythms to stress-related changes in attention.

Fourth, the present study focused exclusively on acute stress. The effects of chronic stress, which may accumulate over time and have more profound effects on both cognitive control and physiological regulation, remain unexplored. Longitudinal research is required to clarify how the impact of stress on attentional control unfolds across time and across repeated exposures.

Finally, the study relied primarily on reaction time measures. While RTs are informative, they may overlook finer-grained dynamics of attention. Future research would benefit from incorporating neuropsychological indices such as mismatch negativity (MNN)—a component known to reflect pre-attentive detection of deviant auditory events (Näätänen et al., 2007), and event-related potentials (ERPs) more broadly. These can index both early sensory encoding and later cognitive control processes (Escera et al., 2000; SanMiguel et al., 2008). These methods offer greater temporal resolution and can clarify whether stress modulates early perceptual stages, later stages of attentional reorienting, or both. Incorporating such techniques could provide deeper insights into the neural mechanisms underpinning distraction and habituation under stress.

Applied implications and conclusions

The present findings may have important implications for understanding attentional control in high-stress occupations. The heightened susceptibility to distraction observed in the firefighter group suggests value in developing interventions that promote cognitive resilience. Training programmes aimed at enhancing working memory capacity or developing strategies for managing complex distractors may improve performance in high-stakes environments. Additionally, the reduced habituation to distractors in the firefighter group highlights the importance of task-specific training to support attentional adaptation under stress. The physiological findings further emphasise the value of monitoring stress biomarkers in occupational settings. Cortisol assessments may offer a practical window onto the dynamic interaction between physiological arousal and cognitive functioning, providing opportunities for early detection and intervention to mitigate long-term effects.

This study underscores the dynamic relationship between acute stress, attentional control, and task demands. When individuals are exposed to high-stress environments—such as those simulated in this study—there is greater susceptibility to attentional capture by unexpected, task-irrelevant stimuli. These findings are consistent with Attentional Control Theory which suggests that acute stress exposure is associated with reduced efficiency in the top-down regulation of attention, increasing reliance on stimulus-driven processing. The attenuated habituation observed under stress is also consistent with reduced adaptive attentional modulation over time. Together, the results deepen our understanding of how stress exposure can affect selective attentional efficiency and highlight the need for interventions that bolster cognitive resilience, particularly in safety-critical occupations. Future research should continue to integrate behavioural, physiological, and neurocognitive approaches to develop a more comprehensive framework for understanding stress-related attentional disruption.

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No potential conflict of interest was reported by the author(s).

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Data availability statement

The datasets generated and/or analysed during the current study are available from https://uclandata.uclan.ac.uk/id/eprint/603.

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