Journal of Safety Research 87 (2023) 416–430

Contents lists available at ScienceDirect

Journal of Safety Research

journal homepage: www.elsevier.com/locate/jsr

An expert-novice comparison of lifeguard specific vigilance performance ☆

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ARTICLE INFO

Article history:
Received 3 February 2023
Received in revised form 22 May 2023
Accepted 28 August 2023
Available online 6 September 2023

Keywords:
Lifeguard
Expertise
Drowning detection
Vigilance
Perceived workload

ABSTRACT

Introduction: Lifeguards must maintain alertness and monitor an aquatic space across extended periods. However, lifeguard research has yet to investigate a lifeguard's ability to maintain performance over time and whether this is influenced by years of certified experience or the detection difficulty of a drowning incident. The aim of this study was to examine whether lifeguard experience, drowning duration, bather number, and time on task influences drowning detection performance. *Method:* A total of 30 participants took part in nine 60-minute lifeguard specific tasks that included 11 drowning events occurring at five-minute intervals. Each task had manipulated conditions that acted as the independent variables, including *bather number and drowning duration*. *Results:* The experienced group detected a greater number of drowning events per task, compared to novice and naïve groups. Findings further highlighted that time, bather number, and drowning duration has a substantial influence on lifeguard specific drowning detection performance. *Practical Applications:* It is hoped that the outcome of the study will have applied application in highlighting the critical need for lifeguard organizations to be aware of a lifeguard's capacity to sustain attention, and for researchers to explore methods for minimizing any decrement in vigilance performance.

1. Introduction

In 2019, drowning resulted in 236,000 deaths globally, constituting 7% of all injury-related deaths as reported by the World Health Organization (WHO, 2021). Despite evidence demonstrating the effectiveness of lifeguards in reducing water-related incidents (Avramidis et al., 2009), incidents of drowning in areas patrolled by lifeguards continue to occur (Pelletier & Gilchrist, 2011; Schwebel et al., 2011). When stationed at a poolside or beach, a lifeguard's primary task is to monitor bathers in case of a drowning scenario occurring (Hunsucker & Davison, 2008; Lanagan-Leitzel, 2012; Petrass & Blitvich, 2014) and to maintain this attentiveness across extended periods of time (Schwebel et al., 2011). Previous literature has demonstrated tasks that require the ability to recognize and integrate the most relevant information, with pre-existing knowledge, and appropriately select an adequate response (Marteniuk, 1976) are problematic for inexperienced individuals to perform effectively (Wolfe et al., 2005). This challenge is particularly notable in a lifeguard setting where the number of bathers fluctuates (Lanagan-Leitzel, 2021; Vansteenkiste et al., 2021), and the duration of a drowning event cannot be predicted (Carballo-Fazanes et al., 2020). The ability to process stimuli over time (e.g., bathers), while attempting to detect predetermined signals (e.g., a drowning victim), is referred to as a vigilance task (Davies & Parasuraman, 1982). Reductions in performance during extended monitoring tasks have been reported to be a regular occurrence (Killingsworth & Gilbert, 2010). In the context of a lifeguard, individuals can spend up to 60 minutes observing an aquatic scene without break (RLSS, 2017). Vigilance literature continues to demonstrate reductions after considerably shorter durations (Molley & Parasuraman, 2016; Nuechterlein et al., 1983; Teichner, 1974; Temple et al., 2000). This decline in performance during extended monitoring is labelled the vigilance decrement

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☆ Pre-registration as well as data are available on the Open Science Framework (https://osf.io/xh9zv/). The authors hold no conflicts of interest associated with the publication of the following manuscript. Ethical approval for the study protocol was awarded by the lead institution.

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https://doi.org/10.1016/j.jsr.2023.08.014
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(Warm & Parasuraman, 1987), and is currently an unexplored aspect of a lifeguard's role.

Vigilance decrements have been observed in automated vehicle operation (Young & Stanton, 2007), air traffic control (Langan-Fox et al., 2010), military surveillance and reconnaissance (Swanson et al., 2012), and during in-flight simulator tests (Wiggins, 2011). Researchers have reported reductions in performance past 20 minutes of real world and simulated driving (Thiffault & Bergeron, 2003; Verster & Roth, 2013) and after 10 minutes of student lectures (Risko et al., 2012; Young et al., 2009). Laboratory studies have showed reductions in performance in detection tasks after 10 minutes (Temple et al., 2000), 30 minutes (Molley & Parasuraman, 2016; Teichner, 1974), and 8 minutes (Nuechterlein et al., 1983). The time it takes for the onset of vigilance decrement appears to be entirely dependent on the individual task characteristics and demands placed (See et al., 1995). However, despite the history of literature exploring vigilance decrement, within laboratory and applied settings, there remains on-going debate into the primary causes of such declines in performance over time (e.g., task monotony or task underload). However, the predominant view within vigilance research (Esterman et al., 2014; Head & Helton, 2015; MacLean et al., 2009; Warm et al., 2008), often referred to as the attentional resource theory (Grier et al., 2003; Helton et al., 2005), describes how a vigilance decrement may occur due to the task's requirement for the continuous processing of stimuli, resulting in fatigue and cognitive resource depletion.

This overload account suggests that high task demand and workload negatively influences performance, as attentional lapses likely increase when the task at hand is objectively more challenging. For example, a lifeguard may consider their role challenging if the number of bathers increases. Increased bather numbers have been demonstrated to influence distractibility amongst lifeguards (Vansteenkiste et al., 2021). Such a view may help researchers understand the prevalence of false alarms amongst lifeguards (i.e., instances of incorrectly perceiving a drowning event), an infrequent, yet present occurrence in a real-world setting (RNLI, 2019) and a commonly explored aspect of drowning detection literature (Laxton, Crundall, et al., 2021; Laxton & Crundall, 2018). With an increase in task demand, lifeguards may not be able to divide their attention amongst all bathers simultaneously and instead utilize their limited capacity for cognitive processing to focus on a single bather that may appear in distress and make a misinformed decision regarding a rescue response (and subsequently waste organizational resources) or miss a true drowning victim in the meantime. However, prior research has suggested those with greater domain specific experience do see a reduction in false alarm rates (Borowsky & Oron-Gilad, 2013). There has yet to be an investigation exploring the aspects of a lifeguard's role that may challenge this overload account.

Alternatively, often referred to as mindlessness hypothesis, the underload account proposes lapses in attention are caused from tasks being under-stimulating (Helton & Russell, 2015; Manly et al., 1999). As a lifeguard's primary role appears to be monotonous by nature, it could provide a valuable environment to explore such account. Likewise, with literature suggesting that those with greater experience have an enhanced ability to respond to changes in stimuli, recognize patterns, and detect errors (Allard et al., 1980; Williams & Ford, 2008), it may not be surprising that novice lifeguards have been reported to be 4.9 times less likely to detect a drowning victim (Page et al., 2011), have slower response times to detect drowning scenarios (Laxton, Crundall, et al., 2021; Laxton, Guest, et al., 2021), and are more distracted by task irrelevant regions (Vansteenkiste et al., 2021) compared to experienced individuals. This underload account suggests that decrements in vigilance are attributed to withdrawal of conscious attention from the primary task. Interestingly, Thomson et al. (2015) discusses how the mindless account does not specify the redirection of attention. The mindlessness account suggests that attention is not directed towards a specific self-prescribed task and, instead, that the individual is mindless for a time. Authors suggested that attention is not simply lost but instead redirected to internal thought. This view relates to the mind-wandering hypothesis, which refers to the failure to hold attention on a primary task and instead attention shifts towards task-unrelated thought (McVay & Kane, 2009; Smallwood & Schooler, 2006). Such understanding may help researchers understand why vigilance decrements are considered a leading cause for occupational accidents (Edkins & Pollock, 1997). However, we must first understand the influence of different aspects of a lifeguard's role on the perception of workload (i.e., how challenging they consider the task demands). Specifically, do lifeguards consider an increase in task demands a challenge, or is the primary role of a lifeguard under stimulating? Such investigation would allow researchers to test the theoretical predictions of overload and underload.

To expand on this, taxonomy proposed by Parasuraman and Davies (1977) outlines four dimensions that may each influence an individual's perceptual capacity to detect stimuli including discrimination type, event rate, sensory modality, and source complexity (Koelega, 1996; See et al., 1995). With respect to a lifeguard environment these dimensions fluctuate continuously (e.g., occurrence of a drowning event, bather number, drowning duration) and are, while not controlled, considered in prior literature. For example, various bather numbers have been considered previously ranging between 3 and 63 (Laxton, Guest, et al., 2021; Laxton & Crundall, 2018; Page et al., 2011; Vansteenkiste et al., 2021). However, the contexts presented in these studies represent a snapshot into the considerable range of scenarios observed by lifeguards. Highlighting the potential for larger bather numbers to negatively influence performance, Vansteenkiste et al. (2021) reported the number of patrons has a substantial influence on lifeguard behavior (i.e., time spent looking at the swimming region). Authors reported that novice lifeguards (those with less experience) were more distracted as patron numbers increased. While the nature of such investigation may have not allowed for the control of patron numbers, findings may be explained further by the attentional resource theory. Specifically, the increase in patron numbers contributes to the task becoming objectively more challenging, and hence increasing the prevalence of attentional lapses. Lanagan-Leitzel (2021) also noted that lifeguards may experience challenges when presented with busy environments. The challenge for research includes there being no typical range of bathers in an aquatic space, hence empirically justifying an optimal set size (number of active bathers) has yet to be reported amongst lifeguard literature. However, we note that numerous bather-to-lifeguard ratios are adopted globally (e.g., Canadian Red Cross, 2017; Lifesaving Society Canada, 2012; West Bend, 2021). Further, the drowning durations (i.e., how long it takes an individual to submerge) adopted by recent drowning research appears to not coincide with observational drowning research. For example, previous literature has included drowning durations between 2–19 seconds (Laxton, Crundall, et al., 2021; Laxton, Guest, et al., 2021; Page et al., 2011). Due to the relatively scarce number of real-life observations of drowning scenarios reported in such literature (Carballo-Fazanes et al., 2020), selecting an appropriate drowning duration does present some difficulty. However, research suggests that a drowning victim may begin to slip under the surface of the water within 20–60 seconds, with children becoming submerged within 20–30 seconds (Pia, 1974). More recent observational literature assessing footage of 24 drowning persons reported the median length until disappearance as 90 seconds. In some cases, disappearances were almost immediate with no visible drowning behavior (six seconds; Carballo-Fazanes et al., 2020). The safety implications of observing an aquatic area of varying contexts (e.g., number of bathers and varying drowning durations) has yet to be explored. Such a study may allow for the evaluation of performance that is more representative of real-world lifeguarding and test our theoretical understanding of workload (i.e., overload vs. underload).

In line with prior literature, and conforming with the overload account, it would be anticipated that an increase in bather number and shorter drowning durations would be considered subjectively more challenging for lifeguards. If found, future research may then aim to test the attentional resource theory in relation to performance being influenced by increases in task difficulty. However, if either manipulation has no influence on the perception of workload, then this would fall in line with the underload account. Outside of lifeguard literature, such findings have been demonstrated using the NASA-Task Load Index (NASA-TLX; Hart & Staveland, 1988), a multidimensional scale that identifies a global score and subsets of perceived mental workload sustained during a task, suggesting the imposed mental burden caused by task difficulty appears to be associated with performance (Warm et al., 2008; Warm & Dember, 1998). While numerous multidimensional subjective workload assessments are used across literature, including the Cooper-Harper Scale (Cooper & Harper, 1969), the Subjective Workload Assessment Technique (Reid & Nygren, 1988), and the Bedford Scale (Roscoe, 2010), an evaluation of such instruments suggest the NASA-TLX may hold the greatest predictive utility in predicting performance (Rubio et al., 2004). With respect to elements of Parasuraman and Davies' taxonomy, the NASA-TLX may be used to investigate the imposed mental workload experienced by a lifeguard to extend the field's understanding of task demands. Elevated levels of mental demand and frustration have been reported to accompany vigilance tasks of increasing difficulty (Finomore et al., 2013; Warm et al., 2008). Determining how each manipulation is subjectively perceived by lifeguards may provide further clarity into why drowning detection literature appears to report such inconsistent findings (e.g., the influence of visual search on lifeguard performance). Particularly when the manipulations (e.g., bather numbers) adopted by prior literature have such variation.

The primary aims of this study were three-fold: (1) Determine the experience related differences in lifeguard specific drowning detection performance. (2) Determine the influence of drowning duration and number of bathers on lifeguard specific drowning detection performance and false alarms. (3) Determine the influence of time on lifeguard specific drowning detection performance. Comparisons were made to compare the degree to which an experienced group differs from their less experienced counter parts by manipulating drowning durations (10 seconds, 30 seconds, and 90 seconds) and bather number (16, 32, and 48 swimmers) across a 60-minute task. We hypothesized, based on previous literature (Lanagan-Leitzel & Moore, 2010; Laxton, Crundall, et al., 2021; Page et al., 2011), that the most experienced lifeguards will outperform those with less experience. We predicted that there will be a main effect of time on performance (i.e., successfully detecting a drowning victim), where performance decreases over time. Such decline is consistently reported across prior literature (Risko et al., 2012; See et al., 1995; Thiffault & Bergeron, 2003; Verster & Roth, 2013). A secondary goal was to test theoretical predictions of overload and underload accounts, by determining if task manipulations induce noticeable changes in perceived workload across participants. Such knowledge may help lifeguards and lifeguarding organizations better understand the impact of varying contextual challenges on drowning detection performance, and why these challenges may influence lifeguard attentiveness.

2. Method

2.1. Participants

A total of 30 participants aged 18 to 38 years (M_{age} = 23.4, SD = 4.8 years), consisting of 11 females and 19 males, took part in the study. Following the direction of previous literature, grouping criteria followed a similar methodology to Page et al. (2011). Ten were considered experienced ($M_{\text{lifeguard employment}}$ = 111.8, SD = 62.8 months), 10 were considered novice ($M_{\text{lifeguard employment}}$ = 2.1, SD = 0.88 months), and the remainder had no lifeguarding experience (n = 10). The experienced group (holding more than three-months of certified lifeguarding experience) was comprised of individuals that had personally been involved in the rescue of incidents that would have otherwise led to full submersion ($M_{\text{active rescues}}$ = 6.1, SD = 4.11), and had played a passive role (e.g., clearing the aquatic space) where an individual would have drowned without rescue ($M_{\text{passive rescue}}$ = 5.4, SD = 5.37). Remaining groups had no experience, nor had ever witnessed a drowning event. At the time of the study, all lifeguards were actively employed across a range of lifeguarding roles. The experienced group consisted of beach (private = 4, surf = 2) and poolside lifeguards (recreational = 4). Similarly, the novice group (holding three-months or less of certified lifeguarding experience) also consisted of beach (private = 3, surf = 3) and poolside (recreational = 4) lifeguards. G*Power 3.1.9.4 software (Faul et al., 2007) was used to perform an a priori calculation of sample size. For a power (1-β) of 0.95 and a two-tailed α of 0.05, 30 participants were required to detect a medium within-subject main effect (f^2 = 0.15). Our calculation was centered on the disadvantage of *a priori* calculations when determining the minimum sample required to detect interactions within a study working with expert individuals (Moreau, 2019; Campitelli, 2019). Likewise, a medium effect was selected to highlight the magnitude of the differences that may be found, while ensuring our *a priori* calculation provided a realistic sample size given the expert population we intended to recruit (McAbee, 2018; McAbee & Oswald, 2017). Sample size estimates closely resemble previous studies (Aglioti et al., 2008; Repp & Knoblich, 2016; Robson et al., 2021) in which experts were tested for their perceptual abilities. Ethical approval for the study protocol was awarded by the lead institution. The study was pre-registered prior to data collection and analysis on the Open Science Framework, which can be viewed here: [https://osf.io/ve78k]. All participants provided informed consent prior to the onset of the data collection. Participants were not financially compensated for their involvement in the study.

2.2. Instruments

Bobbing Along. Bobbing Along is a lifeguard specific drowning detection tool that simulates the maximum vigilance task presented to a certified lifeguard (Fig. 1). The task was created through Unreal Engine 4 (UE4). The tool was produced using customized C++ code to create the functionality needed for a normal paradigm task, along with built-in blueprints that helped simplify the creation and tracking of the 3D environment (Hill, 2021). Nine videos were produced for this study. For each, the environment was divided into 16 navigation meshes with one, two, or three actors ('bathers') per mesh depending on the task condition (see Fig. 1). Actors moved ('swam') within the mesh in a randomized fashion. Upon the event of a 'drown' the pre-established 'bather' treadswater and begins drowning (i.e., gradually submerging) over a specified period (see procedure and task design). In line with the Instinctive Drowning Response (Pia, 1974), the 'bather' does not follow an active drowning (e.g., arms flailing, splashing the water,

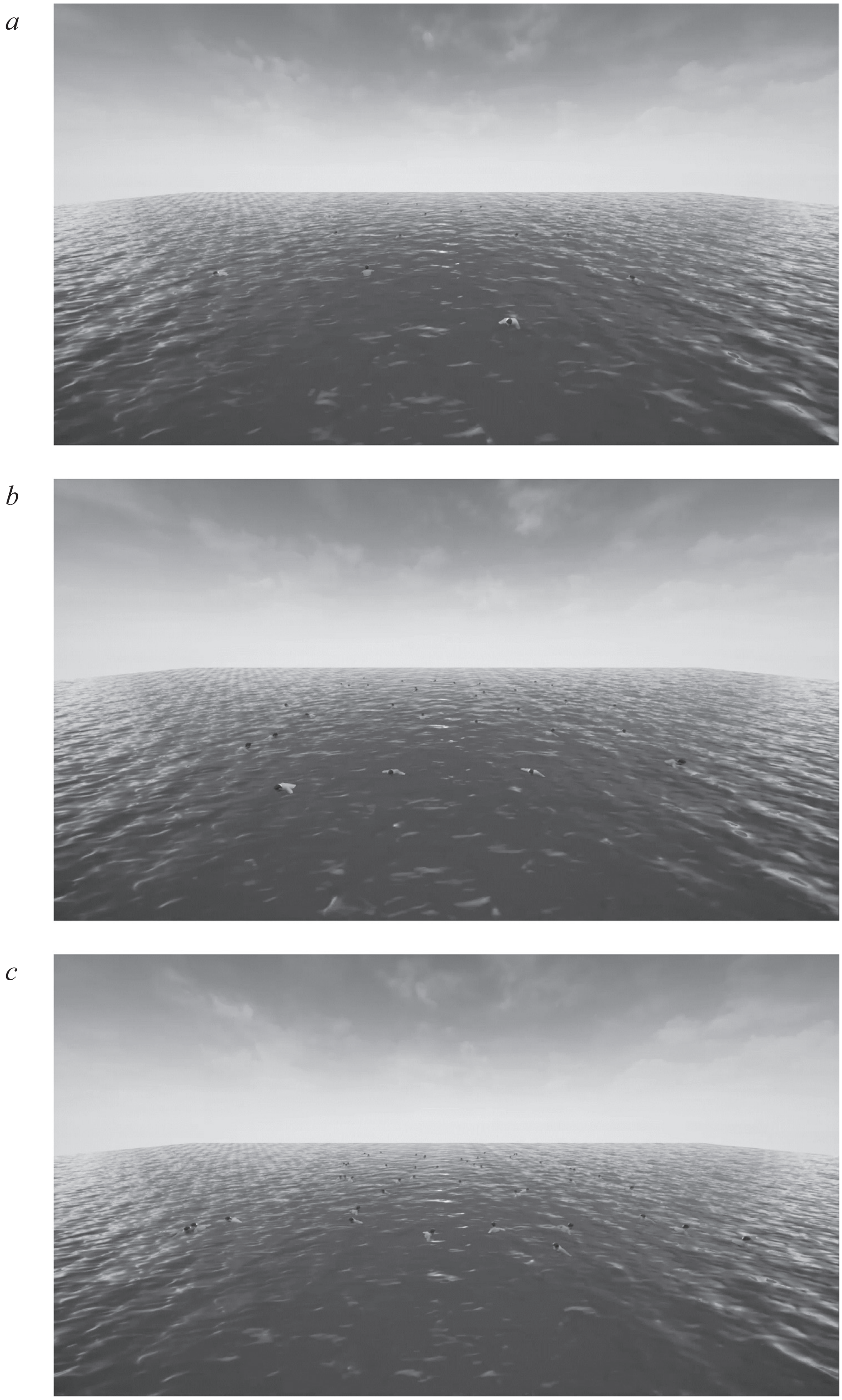

Fig. 1. Screen captures of the '*Bobbing Along*' task manipulations including a 16^{a}, 32^{b} and 48^{c} bather count, respectively.

and/or swimmer gasping for air) and instead follows a behavior more typical to the description of a passive drowning. Specifically, the 'bather' transitions from treading water to full submersion without any change in behavior over the specified time (i.e., 10, 30, or 90 seconds). The decision was made to avoid active drowning behaviors within the animation as to remove the possibility of a lifeguard's attentional bias towards specific taught behaviors influencing their detection performance (see Carballo-Fazanes et al., 2020 for discussion). At no point did the 60-minute task re-start, pause, or re-set bather positions. Once the bather had submerged entirely, the bather re-emerged after 10 seconds and continued their randomized swim pattern. Therefore, there was no opportunity for delayed detection beyond 10 seconds. Within the nine videos, the swim patterns, drowning locations, and drowning timings were identical. The continuous nature of the task aimed to replicate the real-world setting of a lifeguard's role (i.e., to monitor all bathers within an aquatic space).

NASA-Task Load Index. The NASA-Task Load Index (NASATLX; (Hart & Staveland, 1988) measures perceived workload across six dimensions including: mental demand (how much mental activity was required), physical demand (how much physical activity was required), temporal demand (sense of time pressure), performance (feeling of success), effort (how hard you had to work), and frustration (feelings of insecurity, discouragement, stress, or irritation). Participants provided a rating (0 –100) in a multiple of 5 for each scale. Such index is commonly discussed as the most effective measure of perceived mental workload (Rubio et al., 2004). In line with prior literature (Finomore et al., 2013; Warm et al., 2008), we solely adopted mental demand and frustration for all analysis. The scales internal consistency reliability (α) ranged from 0.80 to 0.90.

2.3. Procedure and task design

All testing was carried out within normal working hours (7am-5 pm) and task conditions were presented in a random order to avoid potential order effects. Participants took part in a single 60-minute task per day to avoid a multi-testing related vigilance decrement. All participants took part in the nine conditions across a consecutive nine-day period. Participants were first asked to complete the consent form, demographic questionnaire, and then observe a practice trial to ensure they understood the target stimuli (i.e., drowning event) and could clearly see the display. The practice trial consisted of a 1-minute segment of task where a bather begins to drown from the onset of the video. All participants detected the drowning event within the practice trial without prompting. Following the practice trial, participants were given time to ask questions and be seated. Participants were asked to respond if they thought they could see a drowning event unfolding – recorded through a response clicker that provided the researcher with *Hit* (successfully detecting the individual prior to re-emerging) or *False Alarm* (responding to a stimulus that was not present). By failing to respond to a drowning event prior to full submersion the task was recorded as a *Miss*. The participant was able to make multiple responses, and vocalized their decisions (e.g., 'a drowning is occurring in the bottom left of the scene'). A researcher was present in all testing conditions to ensure these detections were accurate (i.e., not responding to a false alarm during an actual drowning event). As each task comprised of 11 drowning events, the total number of successful *Hits* (Hits = 1, Misses = 0) allowed the researchers to calculate a *Performance Score* ranging from 0 to 11. The tasks were presented 2 m away from the participant on a 16ft × 9ft high definition (4 K) SAMSUNG widescreen 16:9 projector via an ASUS gaming computer (GEFORCE GTX 980). Unknown to the participant, all drowning events occurred at five-minute intervals in a pre-established location consisting of 11 drowning events (see Fig. 2). Drowning locations were selected at random (i.e., back middle, front left, middle right etc.) and did not follow a linear path (e.g., front, middle, then back). Each participant observed an identical version of each task. Participants were unaware of the number of drowning events occurring throughout the tasks. Other than the researcher, participants completed the task alone, in a quiet and artificially lit room. The room remained darkened from natural light so that illumination could be controlled ($M_{\text{Horizonal}}$ = 28.07, SD = 2.72 Lx; M_{Vertical} = 46.82, SD = 4.35 Lx) across all testing (recorded through the LUX LIGHT APP). On completion of each task, participants were asked to complete the NASA-TLX. The task length remained constant at precisely 60 minutes for all conditions with no interruptions (i.e., the participant continued to monitor the aquatic space for the entirety of the tasks).

2.4. Task conditions

The lifeguard-specific drowning detection vigilance task was utilized to allow the experimenters to manipulate the bather number (16, 32, and 48 bathers; see Fig. 2) across three drowning duration conditions (10, 30, and 90 seconds). As such, nine tasks were produced that consisted of each drowning duration condition being repeated for the three bather numbers (e.g., condition one was repeated with 16, 32 and 48 bathers). Bather numbers were selected to reflect the varying contextual differences experienced by lifeguards when observing their zones (Griffiths et al., 1998) and fall between that of previous drowning detection literature (Laxton & Crundall, 2018; Page et al., 2011). ***Condition One.*** The drowning duration lasted 10 seconds, following previous lifeguard literature (Laxton, Crundall, et al., 2021; Laxton, Guest, et al., 2021; Laxton & Crundall, 2018; Page et al., 2011). This also falls within the recommended time limit to scan and detect a drowning person in distress or submerged, based on the 10/20 protection rule introduced by Ellis and White (1994). ***Condition Two.*** The drowning duration was 30 seconds, in line with the reported duration for an adult (20–60 seconds) and child (20–30 seconds) to fall below the watered surface during a drowning scenario (Pia, 1974). ***Condition Three.*** The drowning duration was 90 seconds, following recent observational drowning literature (Carballo-Fazanes et al., 2020).

2.5. Data analysis

Data for each observed variable were screened for univariate normality using skewness and kurtosis ratios (Fallowfield et al., 2005). Skewness and kurtosis for all measures met criteria for normality (i.e., Skewness < 2 and Kurtosis < 4; Kline, 1998). Data were screened for outliers using boxplots. No univariate or multivariate outliers were identified. A four-way mixed design ANOVA was used to analyze the effect of group (Expert vs. Novice vs. Naïve), drowning duration (10 s vs. 30 s vs. 90 s), bather number (16 vs. 32 vs. 48) and time (drowning scenario order, 1–11) on drowning detection performance. As one drowning event occurred at set intervals (e.g., 5 minutes, 10 minutes, 15 minutes…) a binary system was used to represent performance at each timepoint (i.e., 1 = Hit, 0 = Miss). Three separate mixed design ANOVA analyzed the effect of group (Expert vs. Novice vs. Naïve), drowning duration (10 s vs. 30 s vs. 90 s), and bather number (16 vs. 32 vs. 48) on total false alarms, perceived mental demand, and perceived frustration. Post hoc repeated measure ANOVA analysis was employed to explore simple effects. A Bonferroni adjustment was employed when multiple comparisons were being made, to lower the significance threshold and avoid Type I errors (McLaughlin & Sainani, 2014). Violations of sphericity were corrected for by adjusting the degrees of freedom using the Greenhouse Geisser correction when epsilon was less than 0.75 and the Huynh-Feldt correction when greater than 0.75 (Girden, 1992). The alpha level (p) for statistical significance was set at 0.05, partial eta squared (ηp^2) was used to measure effect size for all ANOVA analysis with Cohen's d used for pairwise comparisons (Cohen, 1988).

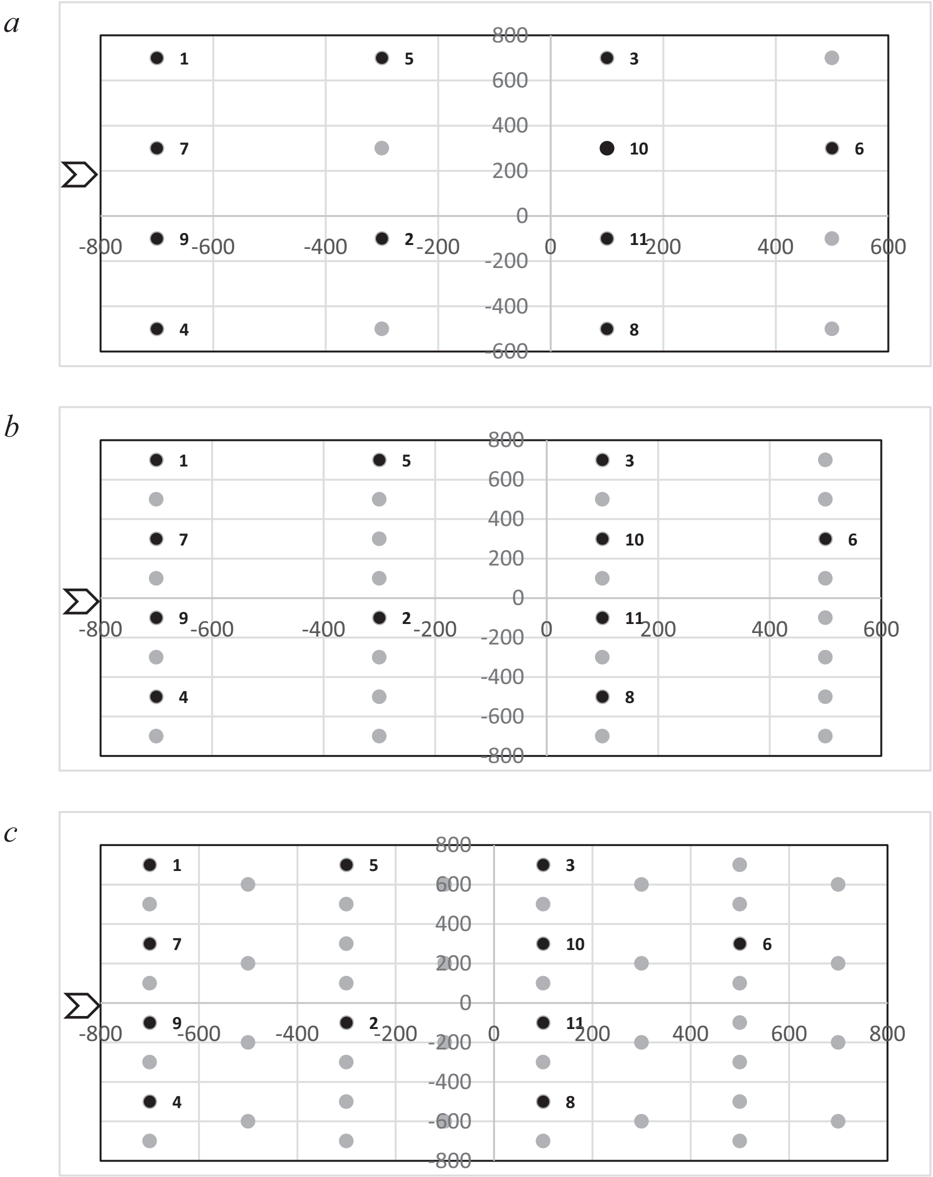

Fig. 2. Data matrix of the Bobbing Along bather locations for the 16[a], 32[b] and 48[c] bather count, respectively. Black datapoints indicate drowning locations. Grey data points indicate other bathers. Bold numbers indicate drowning event order. Arrow indicates the computerised viewing position (i.e., the angle participants observed the scene).

3. Results

3.1. Drowning detection performance

Main Effects. There was a significant main effect of group on total drowning detection performance ($F(2, 27) = 52.177$, $p < .001$, $\eta p^2 = 0.794$). The experienced group performed greater than novice ($p < .001$, $d = 1.563$) and naïve groups ($p < .001$, $d = 1.663$). Further, novices did not demonstrate an overall advantage over the naïve group ($p > .05$). Percentage and mean total performance scores for all conditions are presented in Table 1.

There was a significant main effect of bather number ($F(2, 54) = 1801.986$, $p < .001$, $\eta p^2 = 0.985$) and drowning duration ($F(2, 54) = 69.673$, $p < .001$, $\eta p^2 = 0.721$) on total drowning detection performance. Performance was greater when there were 16 bathers ($M = 7.98$, $SD = 0.11$), compared to 32 ($M = 2.622$, $SD = 0.13$, $p < .001$, $d = 8.202$) and 48 bather conditions ($M = 1.19$, $SD = 0.14$, $p < .001$, $d = 10.397$). Overall performance was also greater when drowning durations lasted 90 seconds ($M = 4.67$, $SD = 0.15$), compared to 30 ($M = 3.86$, $SD = 0.11$, $p < .001$, $d = -1.243$) and 10 second conditions ($M = 3.27$, $SD = 0.12$, $p < .001$, $d = -2.146$). There was a significant main effect of performance across time points ($F(10, 270) = 96.89$, $p < .001$, $\eta p^2 = 0.782$). On average performance began to deteriorate as time progressed.

Interaction Effects. Experience had a significant interaction with bather number ($F(4, 54) = 25.294$, $p < .001$, $\eta p^2 = 0.652$) and drowning duration ($F(4, 54) = 3.366$, $p < .01$, $\eta p^2 = 0.200$). Three separate post hoc repeated measure ANOVAs demonstrated the differences in performance scores for each bather condition were significant for experienced ($F(2, 18) = 368.240$, $p < .001$, $\eta p^2 = 0.976$), novice ($F(2, 18) = 830.195$, $p < .001$, $\eta p^2 = 0.989$), and the naïve group ($F(2, 18) = 736.662$, $p < .001$, $\eta p^2 = 0.988$). Further, post hoc repeated measure ANOVAs indicated that differences in the performance scores for each drowning duration condition was significant for experienced ($F(2, 18) = 30.682$, $p < .001$, $\eta p^2 = 0.773$), novice ($F(2, 18) = 21.851$, $p < .001$, $\eta p^2 = 0.708$) and

Table 1
Percentage (%) and Mean (SD) performance scores (*0–11*) for bather number and drowning duration conditions across experience groups.

Bather Number	Drowning Duration	Group	% $_{\text{Performance}}$	*M* $_{\text{Performance}}$	*SD*
16	**10 s**	**Experienced**	74	8.10	1.20
		Novice	65	7.20	0.79
		Naïve	64	7.00	0.67
	30 s	**Experienced**	77	8.50	0.85
		Novice	70	7.70	0.68
		Naïve	68	7.50	0.85
	90 s	**Experienced**	87	9.60	0.84
		Novice	75	8.20	0.79
		Naïve	73	8.00	0.82
32	**10 s**	**Experienced**	37	4.10	0.74
		Novice	5	0.50	0.71
		Naïve	5	0.60	0.70
	30 s	**Experienced**	45	4.90	0.57
		Novice	14	1.50	0.85
		Naïve	11	1.20	0.63
	90 s	**Experienced**	56	6.20	1.14
		Novice	22	2.40	1.35
		Naïve	20	2.20	1.48
48	**10 s**	**Experienced**	15	1.60	1.27
		Novice	1	0.10	0.32
		Naïve	2	0.20	0.42
	30 s	**Experienced**	23	2.50	0.97
		Novice	5	0.50	0.71
		Naïve	4	0.40	0.70
	90 s	**Experienced**	35	3.90	1.52
		Novice	8	0.90	0.74
		Naïve	5	0.60	0.52

the naïve group ($F(2, 18) = 17.921$, $p < .001$, $\eta p^2 = 0.666$). Performance declined as bather number increased (see Fig. 3) and drowning duration decreased (see Fig. 4), yet those with greater experience maintained a higher performance compared to their less experienced counterparts.

Bather number also revealed a 2-way interaction effect with drowning duration ($F(4, 108) = 3.298$, $p < .05$, $\eta p^2 = 0.109$). Three separate post hoc repeated measure ANOVAs demonstrated the differences in performance scores for each bather condition was significant for the 16 ($F(2, 54) = 21.540$, $p < .001$, $\eta p^2 = 0.444$), 32 ($F(2, 54) = 45.734$, $p < .001$, $\eta p^2 = 0.629$), and 48 bather conditions ($F(2, 54) = 31.180$, $p < .001$, $\eta p^2 = 0.536$). Equally, separate post hoc repeated measure ANOVAs demonstrated the differences in performance scores for each condition was significant for the 10 ($F(2, 54) = 1064.990$, $p < .001$, $\eta p^2 = 0.975$), 30 ($F(2, 54) = 1135.615$, $p < .001$, $\eta p^2 = 0.977$), and 90 second conditions ($F(2, 54) = 552.462$, $p < .001$, $\eta p^2 = 0.953$). Irrespective of bather number or drowning duration, performance declines were observed when either condi-

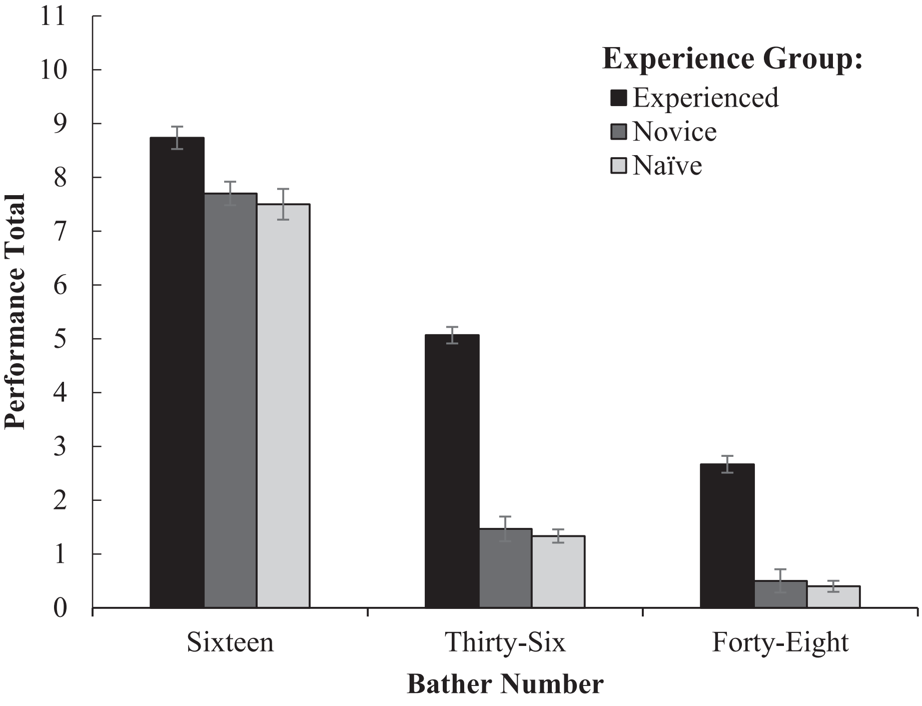

Fig. 3. The influence of experience and bather number on mean total drowning detection performance (with *SE bars*).

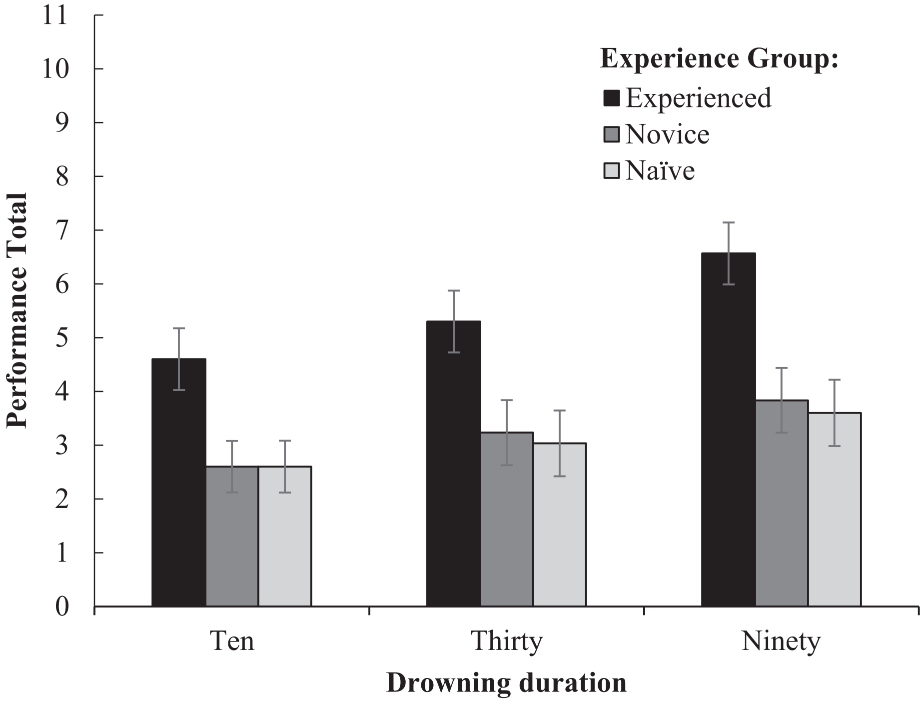

Fig. 4. The influence of experience and drowning duration on mean total drowning detection performance (with *SE bars*).

tion was manipulated (see Fig. 5). No 3-way interaction was revealed between bather number, duration, and experience ($F(8, 108) = 1.364$, $p > .05$, $\eta p^2 = 0.920$).

Vigilance had a 2-way significant interaction effect with experience ($F(20, 270) = 4.143$, $p < .001$, $\eta p^2 = 0.235$) and bather number ($F(20, 540) = 10.668$, $p < .001$, $\eta p^2 = 0.235$), but not duration ($F(20, 540) = 0.792$, $p > .05$, $\eta p^2 = 0.028$). Three separate post hoc repeated measure ANOVAs demonstrated the differences in performance scores across time points were significant for experienced ($F(10, 90) = 60.227$, $p < .001$, $\eta p^2 = 0.870$), novice ($F(10, 90) = 23.387$, $p < .001$, $\eta p^2 = 0.722$), and the naïve group ($F(10, 90) = 21.679$, $p < .001$, $\eta p^2 = 0.707$). Those with greater experience maintained their performance for longer periods of time (Fig. 6). Three separate post hoc repeated measure ANOVAs demonstrated the differences in performance scores across time points were significant for the 16 ($F(10, 180) = 43.343$, $p < .001$, $\eta p^2 = 0.616$), 32 ($F(10, 180)$

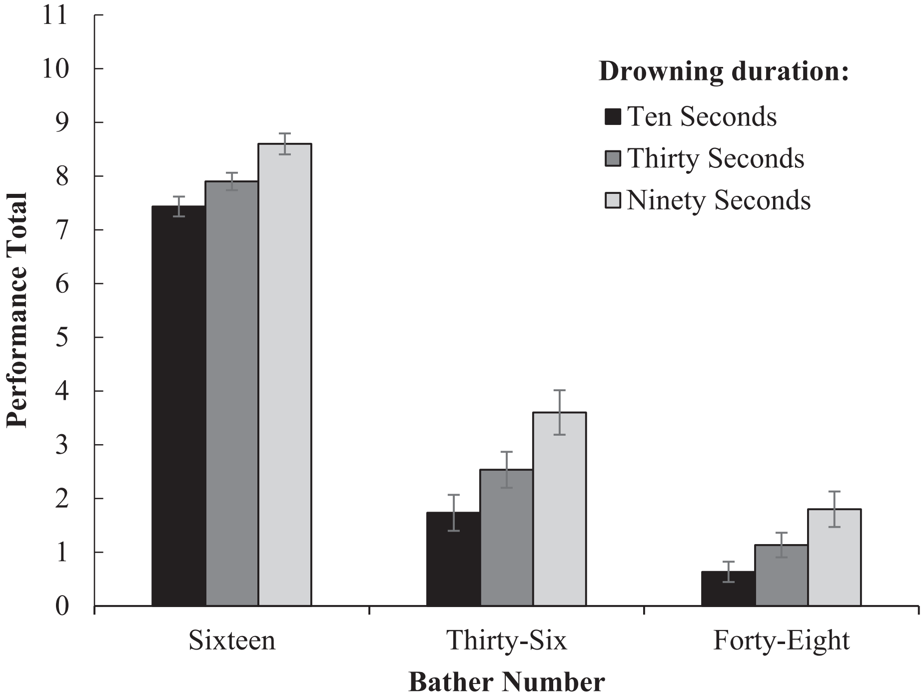

Fig. 5. The influence of drowning duration and bather number on mean total drowning detection performance (with *SE bars*).

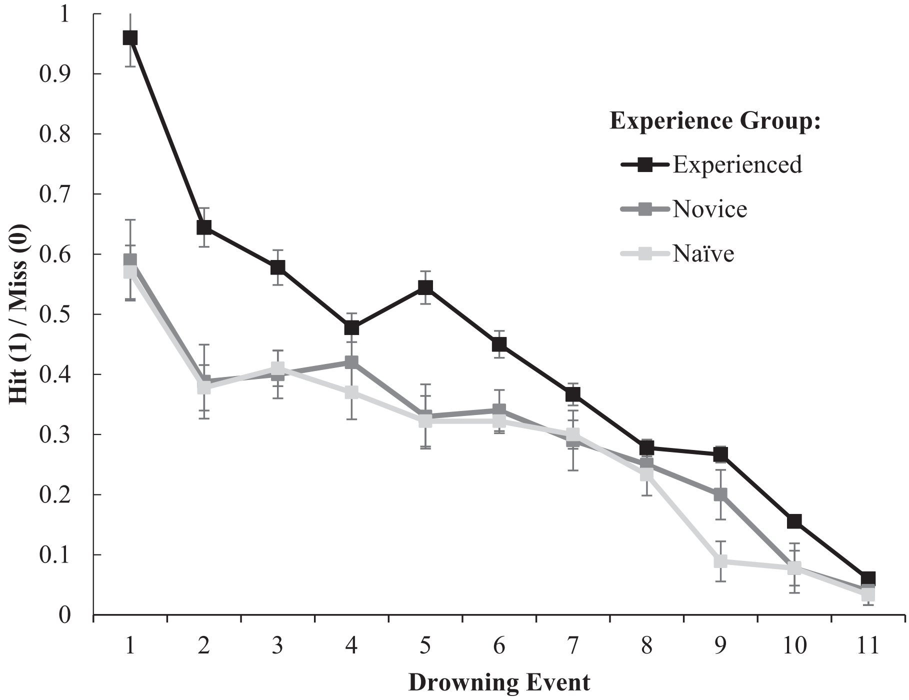

Fig. 6. The influence of experience and time on drowning detection performance (with *SE bars*). Drowning events occurred every five minutes (e.g., 1 = 5 minutes, 2 = 10 minutes…).

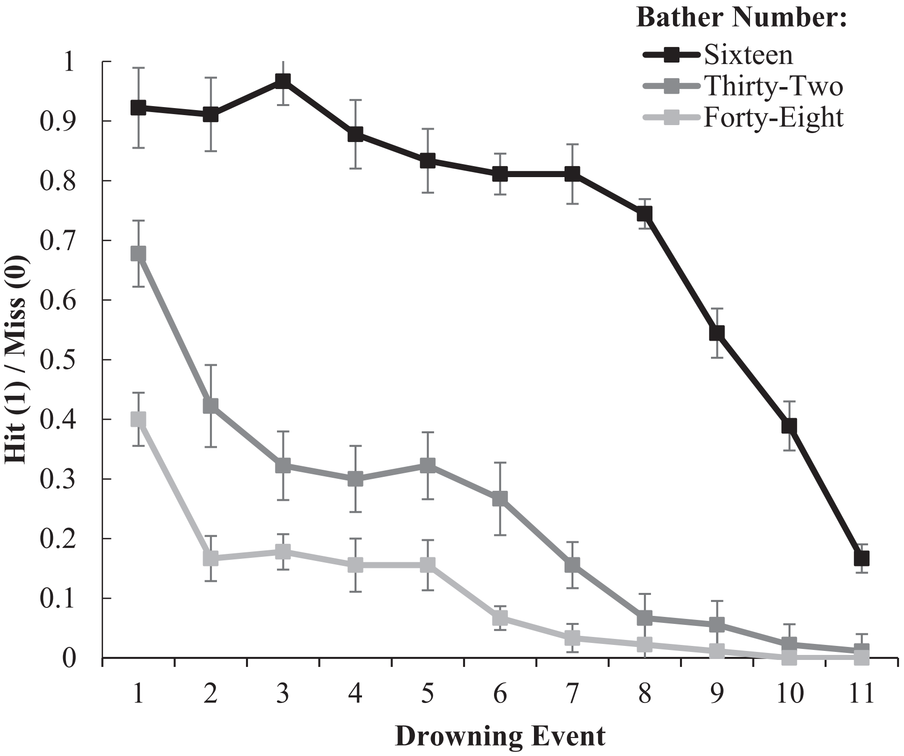

Fig. 7. The influence of bather number and time on drowning detection performance (with *SE bars*).

= 35.908, $p < .001$, $\eta p^2 = 0.571$), and 48 bather condition ($F(10, 180)$ = 20.586, $p < .001$, $\eta p^2 = 0.433$). Performance diminished to a greater extent as bather number increased (Fig. 7).

3.2. False alarms

Main Effect. There was a significant main effect of group on false alarm rate ($F(2, 27) = 4.230$, $p < .001$, $\eta p^2 = 0.239$). The experienced group had less false alarms than the novice group (*p* <.05, *d* = 0.520). No significant differences were revealed between remaining experience groups (*p* >.05). Significant within-subject main effects were revealed for bather number (*F(2, 54)* = 71.048, *p* <.001, ηp^2 = 0.725) and drowning duration (*F(2, 54)* = 15.226, *p* <.001, ηp^2 = 0.361) on total false alarms. A greater number of false alarms were reported when bather number increased and drowning duration decreased.

Interaction Effect. Experience had a 2-way significant interaction effect with bather number (*F(4, 54)* = 3.138, *p* <.05, ηp^2 = 0.189), but not drowning duration (*F(4, 54)* = 1.557, *p* >.05). Three separate post hoc repeated measure ANOVAs demonstrated the differences in false alarms for each bather condition were significant for experienced (*F(2, 18)* = 53.873, *p* <.001, ηp^2 = 0.857), novice *(F(2, 18)* = 22.199, *p* <.001, ηp^2 = 0.712), and the naïve group (*F(2, 18)* = 24.607, *p* <.001, ηp^2 = 0.732). There were no 2-way interaction effects between bather number and drowning duration on false alarms (*F(2.359, 63.704)* = 3.965, *p* >.05), and no 3-way interaction effect amongst variables on false alarms *(F(4.719, 63.704)* = 4.975, *p* >.05).

3.3. Subjective mental demand

Main Effect. There was a significant main effect of group on subjective mental demand (*F(2, 27)* = 99.443, *p* <.001, ηp^2 = 0.880). Refer to Table 2 for mean mental demand task scores. The experienced group reported less mental demand than the novice group (*p* <.05, *d* = 2.070) and naïve group (*p* <.05, *d* = 2.361). No significant differences were revealed between the novice and naïve group (*p* >.05). Significant within-subject main effects were revealed for bather number (*F(1.601, 43.233)* = 1988.147, *p* <.001, ηp^2 = 0.987) and drowning duration (*F(1.769, 47.768)* = 32.736, *p* <.001, ηp^2 = 0.620) on mental demand. Mental demand was lower when drowning duration lasted 90 seconds (*M* = 68.44, *SD* = 15.86), compared to 30 (*M* = 73.94, *SD* = 12.88, *p* <.001, *d* = 0.649) and 10 second conditions (*M* = 78.28, *SD* = 9.82, *p* <.001, *d* = 1.474). Mental demand was also significantly lower for 32 bathers compared to 48 bathers (*p* <.001, *d* = 0.824). Perceived mental demand was lower in the 16-bather condition (*M* = 35.89, *SD* = 21.02), compared to 32 (*M* = 89.61, *SD* = 11.01, *p* <.001, *d* = -4.116) and 48 bather conditions (*M* = 95.17, *SD* = 6.53, *p* <.001, *d* = 3.044). No significant difference in mental demand was observed between the 32 bather and 48 bather conditions (*p* >.05).

Interaction Effect. Experience had a 2-way significant interaction effect with bather number (*F(3.202, 43.233)* = 62.865, *p* <.001, ηp^2 = 0.823) and drowning duration (*F(3.538, 47.768)* = 5.972, *p* <.001, ηp^2 = 0.307) on subjective mental demand. Three separate post hoc repeated measure ANOVAs demonstrated that the differences in mental demand for each bather condition were significant for experienced (*F(2, 18)* = 2508.628, *p* <.001, ηp^2 = 0.996), novice *(F(2, 18)* = 436.009, *p* <.001, ηp^2 = 0.980), and the naïve group (*F (2, 18)* = 299.503, *p* <.001, ηp^2 = 0.971). Mental demand increased across all groups as bather number increased. Three separate post hoc repeated measure ANOVAs demonstrated the differences in mental demand for each drowning duration condition were significant for experienced (*F(2, 18)* = 78.938, *p* <.001, ηp^2 = 0.898), novice *(F(2, 18)* = 4.197, *p* <.05, ηp^2 = 0.318), and the naïve group (*F(2, 18)* = 8.355, *p* <.05, ηp^2 = 0.481). Mental demand increased across all groups as bather number increased and drowning duration decreased. There were no 3-way interaction effects amongst variables on mental demand *(F(5.344, 72.147)* = 3.850, *p* >.05). Bather number and duration had a 2-way significant interaction effect on mental demand (*F(2.672, 72.147)* = 13.456, *p* <.001, ηp^2 = 0.333). Three separate post hoc repeated measure ANOVAs demonstrated the differences in workload across bather conditions were significant for the 16 (*F(1.655, 47.995)* = 7.550, *p* <.001, ηp^2 = 0.207), 32 (*F(1.580, 45.806)* = 28.314, *p* <.001, ηp^2 = 0.494) and 48 bather condition (*F(1.530, 44.363)* = 19.933, *p* <.001, ηp^2 = 0.407). Equally, separate post hoc repeated measure ANOVAs demonstrated the differences in mental demand for each drowning condition was significant for the 10 (*F(1.110, 32.204)* = 288.602,

Table 2
Mean (SD) mental demand and frustration task load scores for bather number and drowning duration conditions by group.

Bather Number	Drowning Duration	Group	Mental Demand		Frustration	
			M	*SD*	*M*	*SD*
16	**10 s**	**Experienced**	10.50	5.50	8.00	3.50
		Novice	50.00	4.71	13.50	5.30
		Naïve	53.50	9.44	36.00	23.78
	30 s	**Experienced**	7.50	2.64	8.00	4.22
		Novice	46.00	7.38	11.50	4.74
		Naïve	53.00	9.49	27.50	19.33
	90 s	**Experienced**	6.50	2.42	6.50	2.42
		Novice	46.50	6.69	9.00	3.94
		Naïve	49.50	6.85	15.50	16.24
32	**10 s**	**Experienced**	92.50	9.79	29.00	9.07
		Novice	99.50	1.58	93.00	15.67
		Naïve	100.00	0.00	93.50	15.64
	30 s	**Experienced**	79.50	7.62	21.50	6.26
		Novice	92.50	7.91	69.00	24.13
		Naïve	99.00	3.16	86.50	16.68
	90 s	**Experienced**	64.50	7.98	15.50	4.97
		Novice	89.00	13.70	66.00	27.16
		Naïve	90.00	10.80	76.50	25.83
48	**10 s**	**Experienced**	98.50	3.38	75.00	19.44
		Novice	100.00	0.00	98.00	6.33
		Naïve	100.00	0.00	99.00	3.16
	30 s	**Experienced**	90.50	7.98	52.50	17.36
		Novice	98.50	4.74	93.00	10.33
		Naïve	99.00	3.16	96.50	5.80
	90 s	**Experienced**	80.00	7.07	47.00	14.38
		Novice	93.00	10.33	84.50	18.63
		Naïve	97.00	6.75	89.50	10.12

Note: M = Mean, SD = Standard Deviation.

$p < .001$, $\eta p^2 = 0.909$), 30 ($F(1.229, 35.655) = 344.285$, $p < .001$, $\eta p^2 = 0.922$), and 90 second conditions ($F(1.599, 46.379) = 320.542$, $p < .001$, $\eta p^2 = 0.917$).

3.4. Subjective frustration

Main Effect. There was a significant main effect of group on subjective frustration ($F(2, 27) = 53.752$, $p < .001$, $\eta p^2 = 0.799$). Refer to Table 2 for mean frustration task scores. The experienced group reported less frustration than the novice ($p < .05$, $d = 1.389$) and naïve group ($p < .05$, $d = 1.808$). No significant differences were revealed between the novice and naïve group ($p > .05$). Significant within-subject main effects were revealed for bather number ($F(1.942, 52.432) = 312.091$, $p < .001$, $\eta p^2 = 0.920$) and drowning duration ($F(1.874, 50.606) = 56.064$, $p < .001$, $\eta p^2 = 0.675$) on frustration. Perceived frustration was lower in the 16-bather condition ($M = 15.06$, $SD = 14.28$), compared to 32 ($M = 61.17$, $SD = 33.47$, $p < .001$, $d = 2.107$) and 48 bather conditions ($M = 81.67$, $SD = 21.186$, $p < .001$, $d = 3.044$). Likewise, frustration was significantly lower for the 32-bather condition compared to 48 bather condition ($p < .001$, $d = 0.937$). Frustration was also lower when drowning duration lasted 90 seconds ($M = 45.56$, $SD = 22.82$), compared to 30 ($M = 51.78$, $SD = 23.41$, $p < .001$, $d = 1.132$) and 10 second conditions ($M = 60.56$, $SD = 22.71$, $p < .001$, $d = 1.935$). Perception of frustration was significantly lower for 32 bathers compared to 48 bathers ($p < .001$, $d = 0.803$).

Interaction Effect. Experience had a 2-way significant interaction effect with bather number ($F(3.884, 52.432) = 17.530$, $p < .001$, $\eta p^2 = 0.565$), but not drowning duration ($F(3.884, 52.432) = 0.833$, $p > .05$) on subjective frustration. Three separate post hoc repeated measure ANOVAs demonstrated the differences in frustration for each bather condition were significant for experienced ($F(1.260, 11.338) = 122.494$, $p < .001$, $\eta p^2 = 0.932$), novice ($F(2, 18) = 175.018$, $p < .001$, $\eta p^2 = 0.951$), and the naïve group ($F(2, 18) = 78.592$, $p < .001$, $\eta p^2 = 0.897$). Frustration increased across all groups as bather number increased. There were no 3-way interaction effects amongst variables on frustration ($F(8, 108) = 4.830$, $p > .05$). No 2-way interaction effect was present between bather number and duration on frustration ($F(2.963, 85.928) = 2.530$, $p > .05$, $\eta p^2 = 0.080$). As seen in Table 2, increased bather numbers had a substantial influence on mental demand and frustration. Irrespective of bather number and drowning duration, the experienced group reported the lowest perceived workload.

4. Discussion

The study aimed to examine whether individuals with varying lifeguard experience differ in lifeguard-specific drowning detection performance. The influence of bather number and drowning duration was further explored to test theoretical predictions of overload and underload (Helton & Russell, 2015; Esterman et al., 2014; Head & Helton, 2015) and help determine their impact on false alarms and perceived workload. To achieve these aims we used a newly established lifeguard-specific drowning detection vigilance tool, titled '*bobbing along,*' which allowed for the manipulation of bather number and drowning duration across a series of 60-minute tasks. Measuring the participant's ability to detect drowning victims across durations reflective of a real-world scenario allowed us to explore the influence of time on drowning detection performance. The study's approach provided a means to explore the experience related differences in performance under conditions of varying aquatic scenarios that are reflective of a lifeguard's ever-changing scene (Carballo-Fazanes et al., 2020; Lanagan-Leitzel et al., 2015; Smith, 2016).

Group-based findings supported the prediction that the experienced group would outperform those with less experience, consistent with previous literature (Lanagan-Leitzel & Moore, 2010; Laxton, Crundall, et al., 2021; Page et al., 2011). Our data revealed those with minimum experience held no difference in performance over non-lifeguards. Comparably, previous literature has reported lifeguards with practical and theoretical-based training, advanced water safety certification, and lifeguard experience have little advantage over those that have been briefly provided a list of drowning behaviors prior to experimentation (Lanagan-Leitzel & Moore, 2010). However, the present findings suggest that lifeguards develop a performance advantage across an extended period of active employment, and not their initial training to become a certified lifeguard. Future investigations must direct focus on determining the attributes that appear to be developed during these extended periods. The controlled attention theory of working memory capacity (WMC) may help explain such performance differences, suggesting WMC may reflect an individual's ability to control attention under high cognitive load (Kane et al., 2001; Unsworth & Engle, 2007). While conflicting findings exist (Furley & Memmert, 2012; Vestberg et al., 2017), experienced lifeguards may possess a greater cognitive ability that allows for a better control of attention than less experienced groups (Laxton et al., 2022). Using the attentional resource theory, experienced lifeguard may have simply developed a greater reliance on cues (e.g., behaviors that have been developed through real-world experience) and utilize less cognitive resources due to a reliance on prior memory (i.e., less of a need to encode new information compared to their lesser experienced counterpart). As such, it would have been expected that novice lifeguards would fail to outperform naïve individuals. Perhaps such explanation may provide justification for a greater inclusion of drowning detection specific training (e.g., cue-based training, cue processing, exposure to drowning footage) in real-world and/or virtual settings during lifeguard certification (e.g., Al-Moteri et al., 2017; D. Lim et al., 2023; Wiggins et al., 2023).

Data revealed a decrease in detection performance as drowning duration decreased and bather number increased, irrespective of lifeguard experience. In line with the taxonomy proposed by Parasuraman and Davies (1977), the complexity of the task demonstrated a substantial influence on performance. Findings support the attentional resource theory that suggests high task demand negatively influences vigilance performance (Warm et al., 2008; Warm & Parasuraman, 1987), while challenging underload accounts (Helton & Russell, 2015). Those with the greatest lifeguarding experience were able to outperform their less experienced counterparts across all conditions. Yet with observational research reporting cases of drownings occurring with durations of six seconds or less (Carballo-Fazanes et al., 2020), and bather counts within a natural environment consistently changing, this may still highlight an opportunity for development for drowning detection researchers and lifeguard organizations alike. It should be noted that even the most experienced lifeguards would not detect all drowning scenarios (Laxton, Crundall, et al., 2021). However, the significant decline in performance highlights a critical need for occupations to be aware of the dangers associated with high task demand and extended monitoring. Findings point toward high performing individuals holding a superior underlying ability that allows for the maintenance of attention under conditions of high task load, consistent with prior literature (Unsworth & Robison, 2020; Wood et al., 2016). To extend our understanding of vigilance, and to reduce the occurrence of a vigilance decrement contributing to occupational accidents (Edkins & Pollock, 1997), researchers must aim to better understand cognitive mechanisms (e.g., WMC, executive function) that may inhibit the negative consequences of high task demand.

Rapid declines in performance occurred over time, continuing the trend demonstrated amongst vigilance literature (Molley & Parasuraman, 2016; Risko et al., 2012; Swanson et al., 2012; Temple et al., 2000; Verster & Roth, 2013). With individual performance declining as time progressed, data suggests vigilance performance is dependent on an individual's ability to sustain attention. Sustained attention is a mechanism that enables the maintenance and engagement on a vigilance task (Robertson & Garavan, 2010). On average, a vigilance decrement was observed across all groups, independent of experience indicating a decline of such ability. In line with our hypothesis, the experienced group detected more drowning scenarios overall, although a performance decline occurred throughout the 60-minute tasks. While the presence of a vigilance decrement may be unavoidable after prolonged periods, findings do highlight an advantage held by those with greater experience. Such an advantage may suggest the presence of a hidden mechanism that is currently unexplored within a lifeguard population. Prior research has suggested cognitive abilities, such as WMC and executive function, have associations with aspects of sustained attention, distraction avoidance, and hazard perception (Furley & Memmert, 2012; Jacobson & Matthaeus, 2014; Unsworth et al., 2012). Vigilance literature may look toward cognitive factors to help determine the cause for the performance advantage held by individuals with domain-specific experience. Such exploration may further highlight the dangers associated with highly demanding vigilance tasks. From a practical standpoint, our findings highlight the critical need for lifeguards and lifeguard organizations to be actively aware of the limits of human attention. If the role of a lifeguard cannot be adjusted, researchers must look toward methods to facilitate the sustainment of attention (e.g., Lim et al., 2013; Ross et al., 2014).

The perceived workload placed on participants appeared to be dependent on the task. The subscale of mental demand revealed the most substantial difference between task conditions, consistent with previous literature (Temple et al., 2000). Bather number had the greatest contribution to mental demand, beyond the drowning duration. Findings provide support for the overload account, suggesting increased bather numbers and shorter drowning durations are subjectively more challenging. The 10 second drowning condition remained the greatest cause for frustration over the longer drowning duration conditions. Frustration is a consistent dimension that demonstrates imposed workload on an individual (Warm et al., 2008). With data suggesting experienced and novice lifeguards are aware of the difficulties associated with bather number, it may be suggested that lifeguards could be given further autonomy when assessing the safety of an aquatic space (e.g., an active lifeguard determining when they require an accompanying lifeguard), in addition to the recommendations made by lifeguarding organizations. The NASA-TLX could be a useful tool for the on-going assessment of workload within organizational environments (Finomore et al., 2013). Perhaps the tool can also provide preliminary insight into the influence of experience on a lifeguard's capacity to perform effectively during monitoring tasks. However, given that experienced and novice groups were influenced by the changes in task difficulty, future research may wish to explore why such perceptions changed (e.g., change in cognitive resources, anxiety, fatigue).

4.1. Implications for applied research, practice, and theory

An important implication of the current study includes the insight into the influence of bather number, drowning duration, and time on lifeguard performance. As the influence of each condition revealed a substantial influence on detection performance, it may be argued that future lifeguard research may wish to adopt similar within-subject designs. To date, bather number is the primary condition of focus across prior literature (Laxton & Crundall, 2018; Page et al., 2011), while drowning duration and extended monitoring have yet to be directly explored. As such, the manipulated tasks presented in the current study may have applied application in determining lifeguards most/least likely to perform optimally (i.e., potentially highlighting lifeguards that require additional assistance), knowledge (e.g., demonstrating the substantial influence of bather number and drowning duration), and training (i.e., a means to practice the maintenance of detection performance over extended periods), if explored further.

Performance during the 16 bather conditions appeared to present a vigilance decrement after durations of 35 minutes, while the remaining bather-conditions demonstrated a gradual reduction in performance after only five minutes. With lifeguards observing an aquatic space for a maximum of 60 minutes (RLSS, 2017), and given that prior lifeguard literature has not empirically explored a lifeguard's ability to maintain optimum vigilance (Smith, 2016), lifeguarding organizations may wish to review current practices. The RLSS UK National Pool Lifeguard Qualification (NPLQ) has suggested lifeguards may rotate between positions across 15-, 20-, or 30-minute periods to ensure alertness is maintained, and while no empirically backed research supports such claims, our data may tentatively support such recommendations.

Within the 10 second drowning conditions, experts detected 74% of drownings in the 16-bather condition and this decreased to 15% in the 48-bather condition. To combat this decline, some sources have suggested bather-to-lifeguard ratios as 30:1 (Canadian Red Cross, 2017), 40:1 (Lifesaving Society Canada, 2012), and 25:1 (West Bend, 2021). However, to date, limited discussion has empirically evaluated the risk to performance associated with bather number. As missing or delaying the detection of a drowning victim may result in death or life changing injury through prolonged submersion (Lanagan-Leitzel et al., 2015), the importance of filling this gap cannot be understated. For example, the experienced lifeguards detected on average 87% of drowning scenarios during the condition with the least difficulty (i.e., 16 bathers with 90 second drowning durations), suggesting a ratio of even 16:1 could be questioned. Research must attempt to further our understanding of this performance reduction and determine unified guidance to ensure all aquatic spaces can avoid such risk associated with increases in bather count.

The overload account appears to be consistent with our findings (i.e., adjusting task conditions influences the perception of workload). Future research may wish to directly explore the influence of workload on lifeguard performance. Specifically, such research should aim to test the attentional resource theory in relation to the influence of increased task difficulty on performance. While not the aim of this article, the perception of mental demand appeared to mirror performance. When individuals perceived a task as highly mentally demanding, fewer drowning events were detected, and an increased rate of false alarms were reported. However, it may remain the case that, irrespective of task manipulations, the duration of the task caused a reduction in performance. In relation to underload accounts, it may be suggested that the extended nature of the task did in fact influence the participants' likelihood to experience lapses in attention. Such lapses may have led to the presence of mind-wandering, and so further providing rationale behind the study of cognitive ability in a lifeguard population given the repeated evidence of individual differences in working memory capacity (WMC) predicting the tendency for an individual to shift in this attentional focus (Kane et al., 2016; Unsworth & McMillan, 2013). Particularly, those scoring higher in WMC may have a greater capacity to inhibit a loss of focus, and such mechanisms has shown some promise of being trainable (Brehmer et al., 2012; Metzler-Baddeley et al., 2017; Owen et al., 2010; Owens et al., 2013). Given the turnover rate of lifeguards is typically shorter than most professions, perhaps a means to upskill individuals quickly, as opposed to extended lengths of active exposure, could be an invaluable line of enquiry.

4.2. Limitations

Ecologically valid task designs allow researchers to explore the differences between expert and novice groups; however, the problem with expertise research includes the prevalence of small samples sizes (Harwell & Southwick, 2021; Moreau, 2019) and the way in which 'experts' are categorized (Swann et al., 2015). Sample size is a notable challenge when working with expert samples, particularly when there is a rarity of individuals within a given region or the total population is by definition small. This is an issue outlined across lifeguard literature (Vansteenkiste et al., 2021). This study is no different and we advise caution when interpreting interaction effects due to our low sample size. This limitation stems from the previously discussed disadvantage of *a priori* calculations in expertise literature (i.e., the inability to obtain the minimal sample required within an 'expert' category), and why expertise literature has suggested retiring statistical significance all together (Amrhein et al., 2019). As noted by Campitelli (2019), our discoveries regarding interactions may not influence the entire field on its own, but instead provide enough information for other researchers to collect an equal number of expert lifeguards so we can collectively draw consensus.

When observing the gradual decline in performance as time-on-task progressed, data demonstrates a brief increase in the experienced group's performance 25 minutes (drowning event 5) before a vigilance decrement returns. Such a change may be representative of a drowning event that is easier to recognize and so highlighting a potential flaw in the task. It may be predicted that attention may have temporarily returned from distraction to the primary task (e.g., mind-wandering hypothesis). However, we wish to express caution to any interpretation given the challenges associated with the small sample size. Irrespective of our speculation, the current study may present the same methodological concern as discussed in previous literature (Laxton et al., 2020; Page et al., 2011), namely the lack of naturalistic footage. Given the conflicting findings reported throughout lifeguard literature, it is argued that there is value in first exploring the mechanisms underlying lifeguard performance across tasks that are not fully representative (i.e., controllable scenarios), but do elicit expertise effects, to ensure specific research questions can be answered with greater confidence.

Finally, while the testing conditions were counterbalanced to address potential vigilance decrements and order effects, the study was limited by the absence of baseline measurements of individual mental states, such as fatigue. This is particularly noteworthy given previous research has consistently demonstrated that various factors associated with fatigue can significantly affect cognitive performance (Behrens et al., 2023; Brahms et al., 2022). The present study could have drawn stronger inferences regarding the impact of prolonged task durations on drowning detection performance had it recorded participant baseline states. Therefore, future research should aim to record such variables to enhance the validity of findings in this area.

4.3. Conclusion

This study examined whether individuals with varying lifeguard experience differ in drowning detection performance. This novel investigation is the first to explore bather number, drowning duration and time on lifeguard-specific drowning performance across a duration that is representative of a lifeguard's role. Experienced lifeguards outperformed those with little or no experience. Lifeguard performance decreased as drowning duration decreased, the number of bathers increased, and as time progressed across the 60-minute task. The condition that placed the greatest demand on performance, self-perceived workload, and false alarm rate included the 48-bather condition with a 10 second drowning duration. The findings highlight that even the most experienced lifeguards have an inability to independently detect all drowning scenarios at any given time during this excessively complex scenario, and that overall bather number and drowning duration has a substantial influence on detection performance. The current findings present numerous directions for vigilance research, including the assessment and training of lifeguard drowning detection during extended monitoring periods.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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