



Evaluation of Visual Alerts in the Maritime Domain

Study 2 - Program Modifications

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Defence R&D Canada – Atlantic

Contract Report
DRDC Atlantic CR 2008-268
February 2009

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In conducting the research described in this report, the investigators adhered to the policies and procedures set out in the Tri-Council Policy Statement: Ethical conduct for research involving humans, National Council on Ethics in Human Research, Ottawa, 1998 as issued jointly by the Canadian Institutes of Health Research, the Natural Sciences and Engineering Research Council of Canada and the Social Sciences and Humanities Research Council of Canada.

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Abstract

A Defence Research and Development Canada (DRDC) – Atlantic research program is in progress investigating human performance issues related to the use of automated visual alerts under high workload conditions. Previous research comparing performance of two distinct styles of visual alerts – ‘flashing border’ versus ‘static sidebar’ was completed by CAE Professional Services (CAE PS) for DRDC Atlantic. CAE PS was then contracted to modify the existing experimental software and assist in the resulting pilot and primary studies (Study 2). Specifically the software was modified to include static and flashing variables for both alert types and to modify the design and software to ensure that participants are visually attending to all three screens. The current report documents the work conducted by CAE PS for Study 2 and includes a review of the experiment procedure, setup, data collection method, and observations made during the pilot and primary studies.

Résumé

Un programme de recherche de Recherche et développement pour la défense Canada (RDDC) – Atlantique enquête présentement sur des questions de rendement humain reliées à l'utilisation d'alertes visuelles automatisées sous une charge de travail élevée. CAE Services professionnels (CAE PS) avait précédemment effectué pour RDDC Atlantique des recherches qui comparaient le rendement de deux types distincts d'alertes visuelles – bordure clignotante/barre d'état. CAE PS s'est ensuite vu octroyer un contrat pour modifier le logiciel expérimental existant et contribuer aux études pilote et primaire résultantes (2^e étude). Plus précisément, le logiciel et sa conception ont été modifiés pour inclure des variables statiques et de clignotement pour les deux types d'alertes et assurer la surveillance visuelle des trois écrans par les participants. Le présent rapport explique les travaux effectués par CAE PS pour la 2^e étude et comprend un examen de la méthode d'expérimentation, de sa préparation, de la méthode de recueil des données et des observations faites pendant les études pilote et primaire.

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Executive summary

Evaluation of Visual Alerts in the Maritime Domain: Study 2 - Program Modifications

Shelley Roberts, DRDC Atlantic CR 2008-268; Defence R&D Canada – Atlantic; February 2009.

Introduction

The Halifax Class Frigate operations room is a demanding, high intensity environment with automated systems implemented to warn operators of system and tactical states. Most of the alerting systems are auditory, but, due to their persistent and uninformative nature, operators tend to turn off the alerting system as part of the watch changeover procedure. A DRDC Atlantic research program is in progress to explore methods of enhancing the way operators are alerted in complex high intensity environments, like frigate operation rooms.

In a previous study, the detectability of two visual alerts was investigated. The alerts were a flashing border surrounding the screen, and a sidebar located in the perimeter of the screen. Since an operator's workstation will consist of three displays, presenting alerts on one or all three displays was also examined. Regardless of the location of the alerts, participants responded faster to the sidebar compared to the flashing border, with the quickest response time obtained from the sidebar alert when presented across all three screens simultaneously. The current project consisted of modifying the existing experimental software and assisting in the pilot and primary studies.

Results

The software was modified to include static and flashing variables for both alert types (border and sidebar) and to modify the experiment design and software to ensure that participants are visually attending to all three screens. The current report documents the work conducted by CAE PS and includes a review of the experiment procedure, setup, data collection method, and observations made during the pilot and primary studies

Significance

Results from these modifications will allow DRDC Atlantic to conduct further experimentation into whether visual alerts are a viable alternative in complex high intensity environments like the Halifax Class Frigate operations room.

Future plans

Future work will continue to investigate properties of visual alerts with the aim of providing operators with an informed tool for alerting to system and operational states. Research issues will include the following: location of the sidebar on the display and event based data capture. Findings will be applicable to any complex multi-display environment where the need to alert operators of system states exist, such as command posts and operations centers within the military domain.

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Evaluation of Visual Alerts in the Maritime Domain: Study 2 - Program Modifications

Shelley Roberts; DRDC Atlantic CR 2008-268; R & D pour la défense Canada – Atlantique; Février 2009.

Introduction ou contexte:

La salle des opérations des frégates de classe Halifax est un environnement très intense et exigeant, avec des systèmes automatisés mis en place pour alerter les opérateurs de l'état du système et de la situation tactique. La plupart des systèmes d'alerte sont auditifs mais, en raison de leur nature persistante et non informative, les opérateurs ont tendance à neutraliser le système d'alerte dans le cadre du processus de relève de quart. Un programme de recherche de RDDC Atlantique est en cours pour explorer les méthodes permettant d'améliorer la manière d'alerter les opérateurs dans des environnements très complexes et intenses, comme la salle des opérations des frégates.

Au cours d'une étude précédente, la détectabilité de deux alertes visuelles avait fait l'objet d'une recherche, les alertes consistaient en une bordure clignotante entourant le périmètre de l'écran, et en une barre d'état latérale placée dans le périmètre de l'écran. Comme un poste de travail d'opérateur consiste en trois écrans d'affichage, la présentation des alertes sur l'un ou tous les trois écrans a également fait l'objet d'un examen. Quel que soit l'emplacement des alertes, les participants réagissaient plus rapidement à la barre latérale par rapport à la bordure clignotante, le temps de réaction le plus rapide étant obtenu de l'alerte de barre latérale lors qu'elle s'affichait simultanément sur les trois écrans. Le projet courant consistait en la modification du logiciel expérimental existant et à la contribution aux études pilote et primaire.

Résultats:

Le logiciel et sa conception ont été modifiés pour comprendre des variables statiques et de clignotement pour les deux types d'alerte (bordure et barre latérale) et pour assurer la surveillance visuelle des trois écrans par les participants. Le présent rapport explique les travaux effectués par CAE PS et comprend un examen de la méthode d'expérimentation, de sa préparation, de la méthode de recueil des données et des observations faites pendant les études pilote et primaire.

Importance:

Les résultats de ces modifications permettront à RDDC Atlantique de mener d'autres expériences afin de déterminer si les alertes visuelles constituent une solution de rechange valable dans des environnements complexes et très intenses comme la salle des opérations des frégates de la classe Halifax.

Perspectives:

Les travaux futurs continueront à examiner les propriétés des alertes visuelles, dans le but de fournir aux opérateurs un d'alerte spécialisé sur l'état du système et la situation opérationnelle. Les sujets de recherche comprendront : l'emplacement de la barre latérale sur l'écran d'affichage

et la saisie de données sur des événements. Les faits constatés seront applicables à tout environnement complexe à écrans d'affichage multiples où existe le besoin d'alerter les opérateurs sur l'état d'un système, comme les postes de commandement et les centres d'opérations dans le domaine militaire.

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1 Introduction

1.1 Background

The Halifax Class Frigate operations room is a demanding, high intensity environment, manned by approximately twenty Navy personnel, most of whom are sensor operators. Automated systems to assist operators are a necessity in this busy environment and an automated auditory alerting system currently exists in the operations room to warn of impending system and tactical states. However, due to the persistent and uninformative nature of the alerts, operators tend to ignore them or turn off the alerting system as part of the watch changeover procedure.

A previous study (Study 1) by Defence Research and Development Canada (DRDC) – Atlantic and CAE Professional Services (PS) explored methods of enhancing the way operators are alerted in complex high intensity environments, like a frigate operations room [1]. This experiment compared user response performance using two distinct styles of visual alerts – ‘flashing border’ versus ‘sidebar’. The flashing border style consisted of a flashing, thick solid red line around the perimeter of the display (see Figure 1.A). The sidebar alert used a similar line style (thick solid red), but did not flash, and was limited to a single vertical line segment at the display’s upper left perimeter (see Figure 1.B). Additionally, as the operator’s workstation is expected to consist of three displays, whether to present visual alerts on one or all of the displays was also investigated in this study. To mimic a high intensity workload, participants were provided with information regarding targets and required to identify them as hostile or neutral depending on the information provided. Results indicated that, regardless of alert location, participants responded faster to the static sidebar compared to the flashing border, with the fastest response time to the static sidebar alert when it was presented across all three screens at one time.

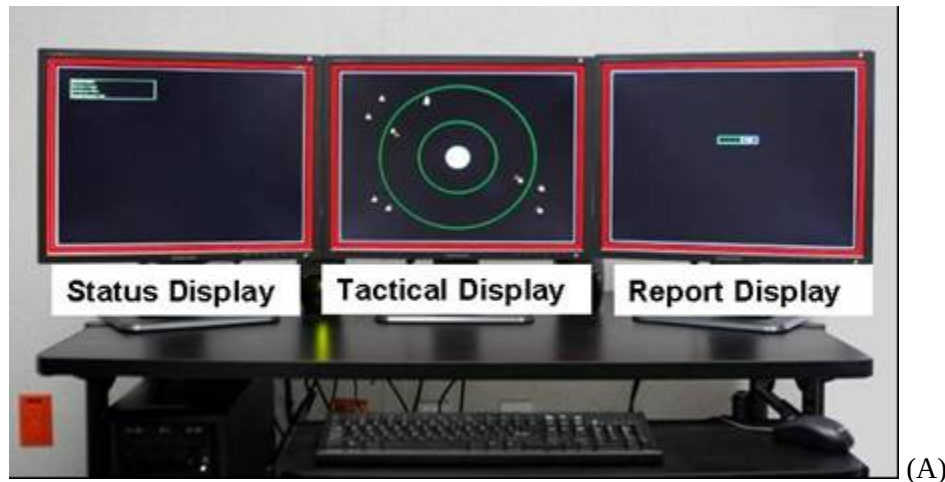




Figure 1. Screen capture of the Flashing border (A) and Sidebar (B) alerts displayed on all three screens.

1.2 Scope of Current Work

The current study (Study 2) is a continuation of effort to further investigate the properties of visual alerts with the aim of providing operators with an informed tool for alerting to system and operational states. Based on the finding in previous work, where static sidebar alerts were detected faster than flashing border alerts, the present study was designed to tease apart the effect found by examining each attribute of the alert stimuli. Thus the attributes of alert behaviour (flashing vs static) as well as alert type (border vs sidebar) were investigated.

Specifically CAE PS was contracted to:

1. Modify the experiment software program;
 - a. Add flashing and static parameters within the experimental software to control the behaviour of both the existing border and sidebar style alerts, and
 - b. Increase the number of target types from 2 (hostile, neutral) to 3 (hostile, neutral, friendly).
2. Conduct a pilot study;
 - a. Complete any needed modifications based on the results of the pilot study; and
3. Assist in running the primary study.

Tasks for both the pilot and primary studies included briefing participants; administering each participant through the experiments; reimbursing participants; and collecting data. This final report provides documentation of the experimental modifications, procedure, data collection method, and any relevant observations made during the pilot and primary studies. All modification that resulted in differences between Study 1 [1] and Study 2 as well as those that resulted in differences between Study 2's pilot and primary studies are discussed in this document.

2 Documented Modifications

2.1 Experimental Software Modifications

Through consultation with the Scientific (SA) and Technical Authorities (TA) an understanding of the required modifications to the existing experimental design was attained and a plan was developed to complete these modifications.

Within the E-Prime environment, there are two areas that required changes; the E-Basic script and the end-user E-Studio environment. E-Basic is nearly identical to Visual Basic for Applications™ and works as the underlying scripting language of E-Prime. The graphical representations of experiments are prepared in E-Studio and are automatically compiled, creating a run-time file. E-Basic is useful when the experiment requires operations that are not supported by the E-Studio end-user visualization tools. The current study would account for a non-standard operation as it spans across three screens and is a dynamic and interactive environment not readily supported by the E-Studio environment. The following sections describe the changes made to the relevant areas of E-Basic and E-Studio.

2.1.1 Parameters Added to Software

Parameters for controlling the flashing and static behaviour of the existing border and sidebar alerts were added to the software. The new parameter was programmed so that the experimenter can select the alarm type (static versus border) and alert behaviour (static versus flashing) within the E-Studio environment. To change the parameters, a list titled “BlockList” within the E-Studio file can be used. To change the type of alert the parameters titled “AlarmType”, “AlarmTypeDesc”, “AFlashCond1” and “AFlashCond1Desc” are changed. Table 1 describes these parameters. A screen shot of the BlockList E-Studio object that contains these parameters can be found in Figure 2.

Table 1. Parameters provided to control for alarm types. Note that this is found in the E-Studio end-user object called “BlockList”.

Alarm	AlarmType	AlarmTypeDesc	AFlashCond1	AFlashCond1Desc
Static Side bar	1	Side Bar	0	Static
Static Border	2	Border	0	Static
Flashing Side bar	1	Side Bar	1	Flashing
Flashing Border	2	Border	1	Flashing

A parameter was added that allows the experimenter to select the number of blocks participants will receive. This parameter is also found in the “BlockList” object within the end-user E-Studio environment. This is denoted by the “weight” column provided in the ‘BlockList’ object (see

Figure 2). In the example provided in Figure 2 participants would receive 4 blocks of each type of alert, a total of 16 blocks, as denoted by the weighting of each row however this column may be modified by the experimenter.

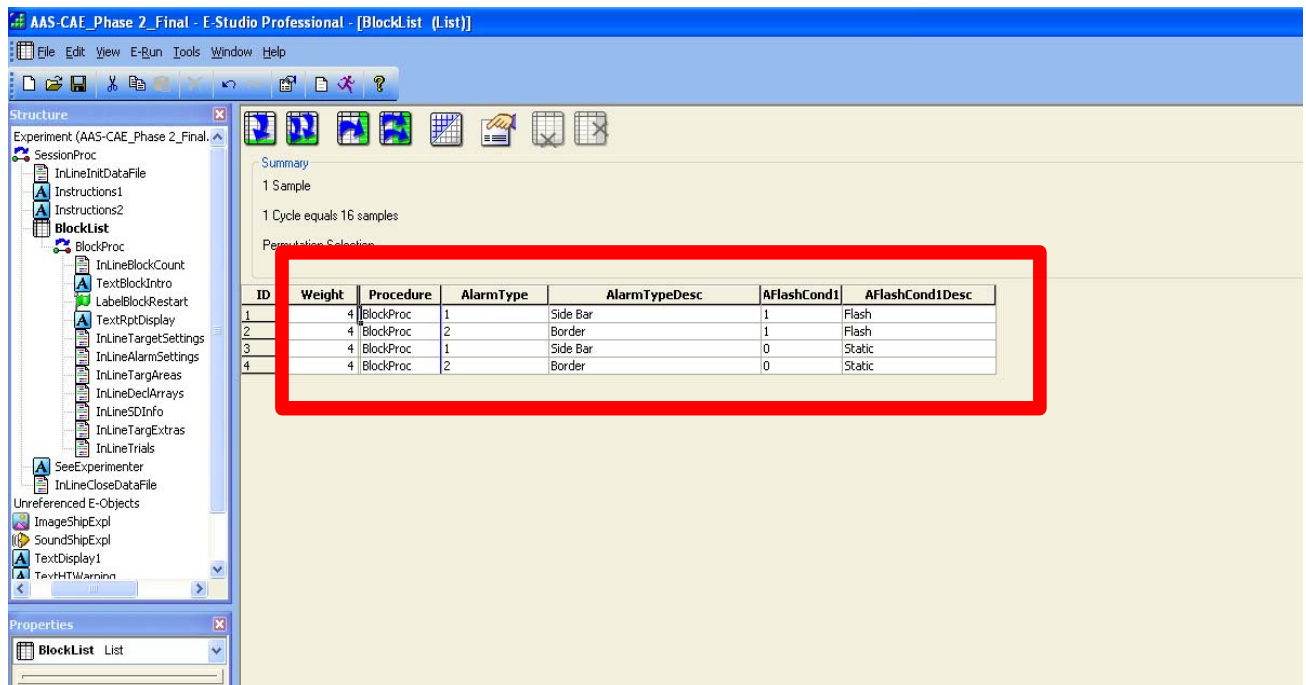


Figure 2. A screen shot of the E-Studio end user BlockList object containing the new parameters that control alert type. The four parameters that experimenters can change are labelled in Table 1 and surrounded with the red box in the current figure.

2.1.2 Addition of Target Type “Friendly”

A concern about the experimental design emerged based on observations from, and discussion about Study 1 [1]. This concern was that participants could feasibly enter an answer (e.g. “asd”), followed by feedback that they were wrong, and without consulting the Status screen again enter the alternate answer (“qwe”). That is, the need to consult the Status (left-hand) screen to classify targets was minimal as the selection was binary and participants could succeed by guessing. Various recommendations and decisions were made, as described in the following paragraphs.

The first suggestion to manage this procedural concern was that a third target classification ‘friendly’ be added to the existing two targets types, ‘hostile’ and ‘neutral’. It was hoped that including a third choice in the decision making task would provide participants with a stronger incentive to use the Status Display in making their decision regarding assigning a category to a target and decrease the rate of chance from 50% to 33%.

A fourth characteristic of the targets, called ‘flag’ would also be added to the existing three characteristics; size, speed and weapons. ‘Flag’ would have two options, Canadian or Other. Alone, ‘flag’ would determine whether or not a target was classified as ‘Friendly’. A Canadian flag would indicate ‘Friendly’ no matter what the original three characteristics dictated, therefore

it would veto any other characteristic listed. This action was chosen to reduce task difficulty. The intention of including an additional target type was not to increase task difficulty but merely to ensure participants were using the Status display to make target identification decisions. An “Other” Flag classification would indicate that the participant would need to refer to the three characteristics, size, speed and weapons, to determine if the target was ‘hostile’ or ‘neutral’. This modification of adding another target type and category (see Table 3) was chosen as a viable option as it is similar to the paradigm used in Study 1 [1] (see Table 2). Because it could be quite easy for participants to classify ‘friendly’ targets it was also decided that 1/3 of targets would be friendly. Therefore, although it would be easy for participants to clear the 1/3 friendly targets, the other 2/3 of targets would be more difficult to clear.

An effort by CAE PS was made to add the ‘Friendly’ target classification and the ‘Flag’ characteristic. However, because a significant amount of time was spent attempting to incorporate these changes to the E-Basic script the SA and TA were notified as to the difficulties.

Following discussion with the SA and TA it was decided that the number of target types be increased from 2 (hostile, neutral) to 3 (hostile, neutral, friendly). This scheme is very similar the previously proposed scheme however the fourth characteristic “Flag” was removed and the target classification “friendly” was introduced across all characteristics (size, speed and weapons). This decision was made in the hope that decreasing the chance of being correct based on guessing would encourage participants to consult the Status display prior to classifying the selected targets as ‘hostile’, ‘unknown’ (previously ‘neutral’) or ‘friendly’. This is similar to the first suggestion, however a fourth target type ‘Flag’ would not be implemented and the number of target types would increase from 2 (neutral and hostile) to 3 (neutral, hostile and friendly). The target characteristics would also be altered to incorporate the third target type ‘friendly’. The target types and classification scheme used in Study 1 [1] can be found in Table 2 and the proposed target types and classification scheme for Study 2 can be found below in

Table 4.

Table 2. Target types and classification scheme used in Study 1.

Target Type	Size	Speed	Weapons	Response
Neutral	Large	Slow	No	QWE
Hostile	Small	Fast	Yes	ASD

Table 3. First proposed target types and classification scheme.

Target Type	Size	Speed	Weapons	Flag	Response
Neutral	Large	Slow	No	Other	QWE
Hostile	Small	Fast	Yes	Other	ASD
Friendly	Large/Small	Slow/Fast	Yes/No	Canadian	Undecided

Table 4. Second proposed target types and classification scheme.

Target Type	Size	Speed	Weapons	Response
Unknown (previously know as “Neutral”)	Medium	Variable	Possibly	ASD
Friendly	Large	Slow	No	QWE
Hostile	Small	Fast	Heavily	ZXC

Upon further discussion with the SA and TA, and testing the program, it was determined that the addition of a third target type would not likely resolve the previous experimental design concerns. Specifically the participant could still feasibly enter one answer (e.g. “asd”), followed by feedback that they were wrong, and without consulting the Status screen enter a second answer (“qwe”) followed by the third “zxc” if the second answer was wrong. To the reader this may seem like a lengthy pattern of behaviours to follow, but with practice this could lead to the least amount of work for the participant to endure. The issue was further discussed and an alternate approach, that would address both concerns, was agreed upon. The procedure is discussed below.

To address the concern that participants may not be equally attending to all three screens, two buttons were added to the Status display; one labelled hostile and one labelled neutral (see Figure 3). The E-Basic environment was modified so that prior to entering a response into the Reporting display, participants were required to select their answer by mouse clicking on the correct button on the Status display (see Figure 3). This additional step ensured that the Status Display was attended to.

As previously discussed, the second concern was that participants could feasibly enter one answer (e.g. “asd”), be provided feedback that they were wrong, and without consulting the Status screen again enter the other answer (“qwe”). This concern was addressed by modifying the E-Basic environment so that the selected target was un-selected following an incorrect answer into the Reporting display. Therefore, if participants were incorrect they would have to repeat the entire categorization task by re-selecting a target, selecting the appropriate button on the Status display and then entering their answer into the Reporting display. This modification also has the potential to increase the amount of attention the participants were giving to each screen.



Figure 3. Screen capture of the modified Status display. The red arrows indicate the “neutral” and “hostile” buttons.

2.1.3 Additional Modifications

Additional changes to the experiment, including any new or modified script files, modules, functions, subroutines, parameters, and output formats are listed below:

1. In Study 1 [1] the ratio of hostile to neutral targets was configured to be 30:70. Following the pilot for Study 2 and a discussion with the SA and TA it was decided that the ratio of hostile to neutral targets be equal and therefore it was changed to 50:50. This is a parameter that can be controlled by the experimenter within the E-Basic script.
2. Targets, symbolized as yellow triangles, originated in the periphery of the tactical display and moved toward the ownship, located at the centre of the display represented by a light grey circle (See Figure 4). Participants were warned that keeping targets from the ownship was critical, because if a target reached the ownship, it would be destroyed. If a target (hostile or neutral) met with the ownship the program was immediately halted, an audio file of an explosion was played, and a picture of a ship being destroyed was displayed on the middle screen for a pre-set duration (see Figure 5). The session then started over, with the targets originating in the periphery of the tactical display and moving towards the ownship again.

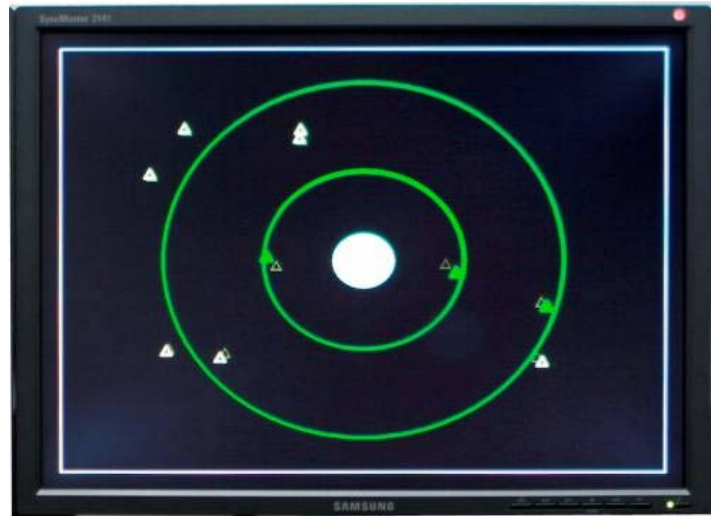


Figure 4. Screen capture of the Tactical (middle) display.



Figure 5. Screen capture of a 'ship explosion'.

In Study 1 [1] each 'ship explosion' was displayed for 5 seconds (500ms). There was a possibility that the duration of 5 seconds could have interfered with the number of alerts that participants' experienced in each block. That is, if the ship explosion took 5 seconds and an alert was displayed at the same time, participants would not experience that alert. Furthermore, the duration of a block was time-based (3 minutes), rather than being event-based. Consequently, the number of alerts presented in each block could vary depending on the number of ship explosions that occurred during a 3 minute period. Following discussion with the SA, the 'ship explosion' time was reduced from 5 seconds to 3 seconds (300ms), thereby increasing the likelihood that all alerts would be experienced within a given block (see recommendations). Decreasing the ship explosion pause time also decreased the amount of time participants waited for the task to restart – this was seen as a positive improvement as some participants in Study 1 [1] commented that the break before re-starting block trials was too long.

2.2 Method Modifications

This section documents any modifications made to the method including the participants, apparatus, stimuli, tasks, procedure, and performance measures.

2.2.1 Participants

The methods of recruitment and reimbursement used for the current pilot and primary studies were identical to those in Study 1 [1] and therefore only the items that differed are explained in this section.

Six participants (5 males, 1 female) were recruited for the pilot study which took approximately 90 minutes to complete. Participants mean age was 45.5 (SD=21.07) with a range of 20 to 70 years. One participant was left-handed and all six had indicated that they had previous experience with multiple displays while multitasking.

Twenty-four participants (15 males, 9 females) were recruited for the primary study which also took approximately 90 minutes to complete. Participants' mean age was 41.25 (SD=12.45) with a range of 22 to 70 years. All reported normal or corrected-to-normal vision, and 79% were right-handed. Five of the 24 participants indicated that they had previous experience with multiple displays while multitasking.

2.2.2 Apparatus and Materials

The apparatus used for the current pilot and primary studies were identical to those in Study 1 [1]. The recruitment posters can be found in Annex A and Annex B. The recruitment poster found in Annex A included experimenter contact information on tabs that could be torn off by potential participants.

The consent form, found in 0, was modified to include the latest contact information and experimenters involved in Study 2. The debriefing used in Study 2 can be found in 0.

2.2.3 Stimuli

The stimuli used for the current pilot and primary studies were identical to those in Study 1 [1] except for the following.

1. Status (left) display – provides information on a selected target in the form of text. Information included: speed (fast/slow), size (small/large), and weapons onboard (yes/no). The current study was modified to include two buttons on the status display; one labelled hostile and one labelled neutral (see Figure 6). Refer to section 2.1.2 for a more detailed description of these changes.

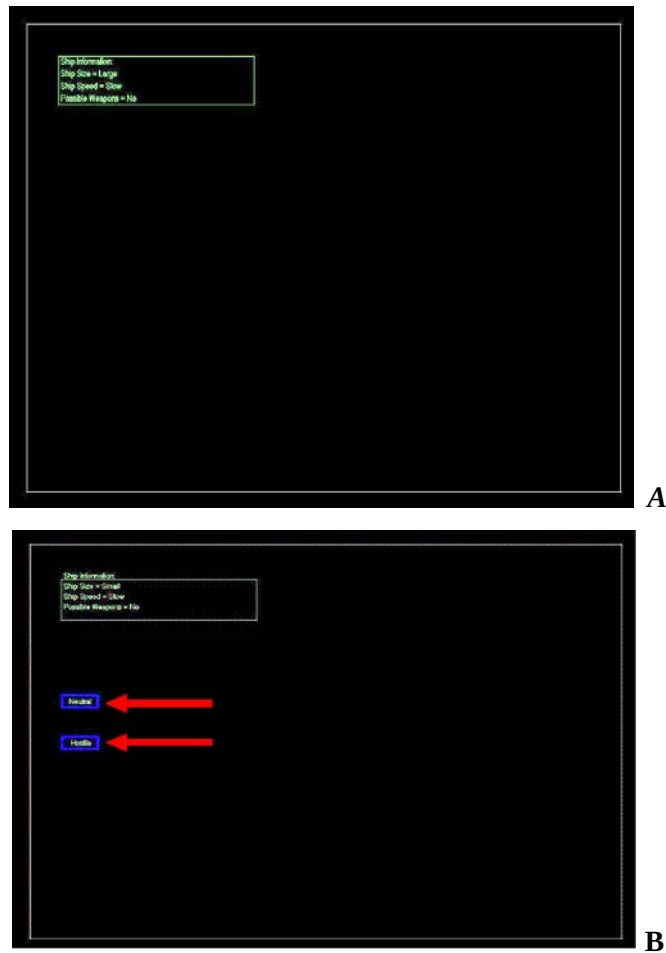


Figure 6. Screen capture of the Status (left) display. Figure A is a screen capture of the original Status display and Figure B is the modified version used in the current study.

2.2.4 Task

The tasks participants were required to complete for the current pilot and primary studies were identical to those in Study 1 [1] with the exception of the following.

2.2.4.1 Alerts

Throughout the categorization task four alert types, flashing border, static border, flashing sidebar and static sidebar (See Figure 6), were presented intermittently on one (right, middle or left) or all 3 displays, depending on the experimental condition. Participants were still required to attend to the alert as quickly as possible by pressing the spacebar on the keyboard. If an alert was missed it would cancel out after 4 seconds and be recorded as Missed.

2.2.4.2 Identify Targets

As in Study 1 [1], participants were instructed to place the mouse cursor over a target on the tactical display to obtain information related to the target's attributes which would then appear on the status display. Three attributes were assigned to each target (size, speed, and weapons on board). Certain attribute values represented hostile characteristics while others represented neutral (see Table 5).

Table 5. Possible target attributes presented on the Status display.

	Categorized as Hostile	Categorized as Neutral
Size	Small	Large
Speed	Fast	Slow
Weapons	Yes	No

Participants were required to derive from the attribute information a categorization judgement as to whether a target was neutral or hostile: 2 or more hostile values = hostile; 2 or more neutral values = neutral. At this stage of the target identification task there were no modifications. The current study was modified so that once a decision had been made the choice was then selected on the status display (see Figure 6) followed by reporting the answer on the reporting display to the right of the tactical display as “asd” for “hostile” and “qwe” for “neutral”. The report was immediately verified by the system as correct or incorrect and, as in Study 1 [1], participants were given immediate feedback on the reporting display. If the target was correctly identified it would disappear off the screen and a new target would enter from the periphery of the tactical display, thus alleviating the number of targets on the screen that were located close to the ownship. However, unlike Study 1 [1], if a target was incorrectly identified the target would be deselected and continue to move towards the ownship until it was re-selected and correctly tagged using the mouse, identified, and reported.

If a target (hostile or neutral) met with the ownship, represented by a light grey circle in the middle of the Tactical display, the program was immediately halted, an audio file of a “explosion” was played, and a picture of a ship being destroyed was displayed on the middle screen for 3 seconds. The session would then start over, with the targets originating in the periphery of the tactical display, moving towards the ownship again.

2.2.5 Modifications to Procedure

The procedure followed for the current pilot and primary studies was identical to that in Study 1 [1] with the exception of the following:

The practice session began with a set of instructions identical to those used in Study 1 [1] with the addition of the following:

“Small or fast targets are considered hostile because hostile ships can use a “swarm” technique, which requires ships be manoeuvrable and quick. Large or slow ships are considered neutral because these ships often pose little threat to combat ships. To protect your own ship you will determine whether targets approaching your ownship are hostile or neutral.”

The instructions were followed by a practice session consisting of four blocks. Each block consisted of one of the four alert types (flashing border, static border, flashing sidebar, static sidebar). Within each block alerts were displayed 16 times across 4 locations (4 alerts on each of the right, middle, left and all three displays). The order in which the alert appeared on the 4 locations within a block was randomly selected via E-Prime.

The main experiment directly followed the practice session and consisted of sixteen blocks (lasting approximately 3 minutes each). Each participant received 4 blocks of each alert type and alert behaviour (4 flashing sidebar and 4 flashing border, 4 static sidebar and 4 static sidebar), with the order of the blocks controlled for using a Latin square design.

2.3 Modifications to Data Collection

The type and manner in which data were collected is described in this section. There are two subsections, the first (2.3.1), describes the modifications made within the E-Studio environment and the second (2.3.2) describes the modifications and observations made within the E-Basic environment.

2.3.1 Data Collection via E-Studio

2.3.1.1 Demographics Collection

The following demographics were collected via the E-Studio environment within the ‘StartupInfo’ screen (see Figure 5) which can be altered for future experiments. All but “Time spent reading” was included in Study 1 [1] and therefore will be discussed in more detail below.

1. Subject number;
2. Age;
3. Gender;
4. Handedness; and
5. Time spent reading per week.

2.3.1.1.1 Time Spent Reading

Previous research has found that a “good” reader (or at least someone who practices and enjoys reading) has a more efficient saccadic movement than a person who doesn’t practice reading on a regular basis [2]. One might hypothesize that larger and more frequent saccadic movements (typical of a practiced reader) would perform better at scanning the displays for alerts. Therefore each participant was asked how much time they spent reading for pleasure on a weekly basis. This demographics question was added to the E-Studio environment within the experimental ‘StartupInfo’ screen (see Figure 7).

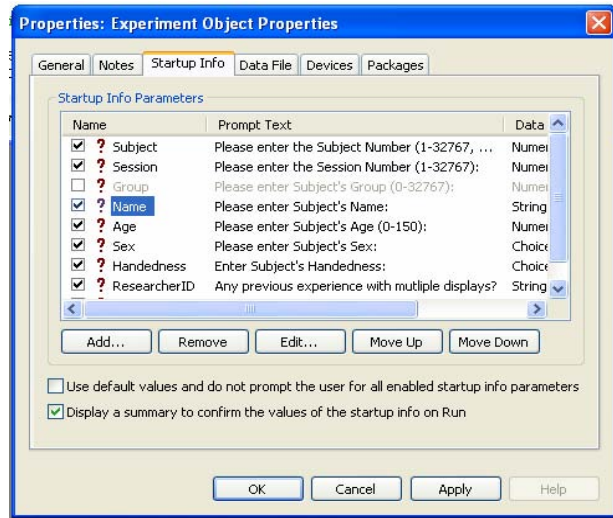


Figure 7. Screen capture of the E-Studio environment's Startup Info

Because demographics were collected via the E-Studio environment the data are saved as an E-DataAid 2.0 file for each participant. The demographics are the only data that are collected via E-Studio with the rest of the data being collected by E-basic and written to an external (from E-DataAid) data file.

2.3.2 Data Collection via E-Basic

Although there are 63 variables that are collected by the E-Basic script, to simplify this document only the variables that are used to organize and analyze the data of interest to the analyses are described below. In 0 four columns are used to classify and describe each variable and are listed below:

1. Variable Name: This is the name of the variable, found in the first row of the data file;
2. Manipulated by Experimenter: This provides the reader with information regarding whether or not the variable is easily changed. Refer to the last column titled "Possible Values" for values of variables that can be manipulated;
3. Description: This column describes the variable; and
4. Values: This column lists the current value(s) of each variable (e.g., the number of targets on the Tactical display at any one time is currently set to 10. The value can be easily changed in the script by the experimenter).

2.3.2.1 Performance Measures

This section documents modifications and technical hitches for the performance measures observed during the pilot and primary studies.

2.3.2.1.1 Hits, Misses and False Hits

Participants were required to press the spacebar key when they noticed any type of alert which was categorized as a “Hit”. If participants did not respond to the alert while it was still visible, this was categorized as a “Miss”. A third behaviour, categorized as a “False Hit” occurred when participants pressed the space bar while there was no alert present. In Study 1 [1], a False Hit was analyzed together with Misses. It was the hope of the project team that in Study 2 the number of False Hits could be parsed out as a separate performance measure from the Misses. However, the manner in which data is collected presently does not decipher between a False Hit and a Miss, as they are each given the same value.

With the aid of the project TA a script was written to parse out the two different types of responses. More specifically, if the participant responds immediately after an alert has left the display there will be a response time after the alarm offset time, and the response will be classified as a Miss. However, if it is a False Hit there will be a response time but no obvious alarm to link it to. It was through this difference in the data files that False Hits were distinguished from Misses

2.3.2.1.2 Alert Responses

Upon testing the software and inspection of the pilot study data files it was revealed that there were two issues. The first was that the Hit data was not consistently recorded. The program collected data in a time-based manner in 2 second windows and there were instances where a participant could respond more than once to an alert within that 2 second time span. Ideally, the first response should be recorded as a Hit, and the second as a False Hit. However in Study 1 [1] the second response would overwrite the first and therefore the actual Hit data was inaccurate. A review of the data from Study 1 [1] revealed that the number of times this instance occurred was low. Nevertheless the software was modified for Study 2 so that the first response (Hit) was recorded and not overwritten by the second response (False Hit). However, the limitation of one response per 2 second window remained meaning that responses after the initial Hit (False Hits) were not recorded. This problem will be corrected in future work by applying more in-depth modifications to the software so that data is collected in an event-based manner instead of time-based.

A second issue with alert responses and data collection was that the ability to detect all alerts and associated Misses accurately. When alerts were present on the screen(s) and not associated with any participant behaviour or alert data, the data file sometimes defaulted to a string of 0's, resulting in an exclusion of all alerts and Misses. Therefore, upon analysis this would result in a lower number of alerts than actually experienced by the participant and intended by the experimenter (16 per block), referred to as “ghost alerts” as well as an incorrect frequency of Misses. This second issue has been repaired by associating which screen the alert was displayed on and categorizing each instance as a Miss.

2.3.2.1.3 Simultaneous Target Identification and Alert Response

Following the pilot study the data files were examined and it was revealed that when participants were simultaneously identifying targets, i.e. typing in “asd” or “qwe” in the Report display, and responding to an alert at the same time, the spacebar response to the alert was not collected by the system. This was corrected by CAE PS and the changes are documented in the E-Basic script so that during the primary study captured all the alert and target identification responses even when they occur at the same time.

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3 Recommendations

1. One of the main findings from Study 1 [1] was that the sidebar resulted in a significantly faster response when compared to the flashing border alert. In this study the sidebar alert was located on the top left hand side of the screen across all conditions. One problem with presenting the sidebar on the top-left corner of the screen is that when the sidebar is presented on the left and right displays the sidebar is not equidistant from the center display. Therefore it is recommended that the location of the sidebar alert should be investigated further to determine whether the faster response is dependent on the location in which it is presented. For example a further study could compare the response times to a sidebar presented on the top left, top right, top middle, bottom middle, left middle, and right middle screen locations.
2. In complex environments attention to alerts or warnings usually needs to be followed by an understanding of the number presented, their priorities, importance, identification and localizability [3]. To provide more ecologically valid results it is recommended that the tasks and paradigms used in future studies better reflect real-life operational situations that could occur. For example, there may be situations in which visual and auditory signals are given together rather than as alternatives to each other in alerting human operators alongside a cluttered display. For this type of setup, signals of the auditory and visual modalities may be provided separately or simultaneously, synchronously or asynchronously to operators. For combined display of visual and auditory signals, the interactive effects are not yet known and there are no useful research results or practical ergonomic guidance available for use by industrial designers to date [4]. Additional ecologically valid paradigms might include investigating various alert types and locations on multiple operators working in a collaborative environment [5], and also in interacting with cluttered and dynamic displays [6].
3. Participants were to receive 16 alerts within each block. Upon review of the data files it was determined that the number of alerts experienced within each block was not consistent. This artefact should be investigated prior to a further experiment to equalize the number. Although it was originally thought that the ship explosions were interfering, there are cases in the current pilot study where there were no explosions and there were less than 16 alerts within a block. This may also be caused by a second issue discussed in section 2.3.2.1.2. To reiterate, in the data file it was noticed that there were alerts present on the screen(s) but were not written to the data files correctly resulting in “ghost alerts”. Therefore it is possible that participants are experiencing the intended number of alerts per block but the data file is not collecting this correctly. It is recommended that once the “ghost alerts” are added to the data to be analyzed that experimenters should ensure that the intended number of alerts per block is 16.
4. Of particular interest is an understanding of what activity participants are actually engaged in while alerts are presented. For example are participants about to classify a target, deciding what target to select, or deciding what to classify the selected target as. In future studies it might be useful to investigate the data files for artefacts of participants selecting a target (variable=“ActiveTargType”) but not following up on the report display immediately.

5. Currently the software that collects the data sends the information regarding what behaviours have occurred every 2 seconds to a data file. Given this method, it is possible that some information about participants' behaviour is lost, as this method of data collection is time-based not event driven. Therefore it is recommended that prior to further experimentation a new method of data collection be implemented that is event driven not time-based.

4 Conclusions

A previous study comparing human behaviour performance to various types of visual alerts was completed by CAE PS for DRDC Atlantic. CAE PS was then contracted to modify the existing experimental software and assist in the resulting pilot and primary studies. The current report documented the work conducted by CAE PS including a review of the modifications made to the experiment procedure, setup, data collection method, and recommendations that emerged through observations made during the pilot and primary studies.

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Annex A Study 2 Recruitment Poster with Tabs



RESEARCH PARTICIPANTS REQUESTED RESEARCH & DEVELOPMENT CANADA STUDY

PARTICIPANTS:

Males and females, between the ages of 18 and 60 years, with normal or corrected to normal vision.

OBJECTIVES:

The study is designed to investigate how a maritime-based high intensity task impacts detection of visual alerts, especially when the task requires monitoring more than one display. The task involves classifying and reporting targets on a tactical display as hostile or neutral while also detecting and responding to visual alerts presented on one or all of the displays.

RISKS:

Participants will be required to remain vigilant and alert throughout session. No unusual risks are anticipated other than possible eyestrain and fatigue.

BENEFITS:

Participants may benefit from the experience by gaining knowledge of the maritime environment and in receiving exposure to the defence related research.

WHEN:

October 9 – 16 2008

WHERE:

DRDC Atlantic, 9 Grove Street, Dartmouth, Nova Scotia, B2Y 3Z7

COMPENSATION:

Participants will be compensated according to DRDC guidelines

If interested please contact:

Jeffrey Beardsall 426-3100 x342 Jeffrey.beardsall@drdc-rddc.gc.ca
Jeffrey Beardsall 426-3100 x342 Jeffrey.beardsall@drdc-rddc.gc.ca
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Annex B Study 2 Recruitment Poster



HUMAN FACTORS STUDY PARTICIPANTS NEEDED

Who?

We require participants who have normal or corrected to normal vision. We also require that you're 18 – 60 years of age. Participants may be internal (to DRDC Atlantic) or external.

What?

You will be required to complete an identification task spread over three computer LCD displays. You will also be required to respond to mock visual alarms, also spread over three computer LCD displays

When?

Thursday, October 9th to
Thursday, October 16th,
2008.

How long?

Approximately 1 hour and
30 minutes.



What do you get out of it?

Participants will be reimbursed for their time according to DRDC regulations. You may also find benefit in exposure to DRDC human factors research.

Who should you contact if you're interested?

Please contact **Jeff Beardsall** at 426-3100 x 342, or email at jeffrey.beardsall@drdc-rddc.gc.ca

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Annex C Study 2 Voluntary Consent Form for Human Subject Participation

VOLUNTARY CONSENT FORM FOR HUMAN SUBJECT PARTICIPATION

Protocol Number: L-623 Amendment #1

Research Project Title: Evaluating visual alerts in the maritime domain

Principal Investigator: Dr. Jacquelyn Crebolder

Co-Investigators: Jeffrey Beardsall

Shelley Roberts - CAE Professional Services

Technical Authority: Don Coady

I, _____ (name) of _____ (address and phone number) hereby volunteer to participate as a subject in the study,
“ _____ ”

(Protocol #L623 Amendment #1). I have read the information package on the research protocol, and have had the opportunity to ask questions of the Investigator(s). All of my questions concerning this study have been fully answered to my satisfaction. However, I may obtain additional information about the research project and have any questions about this study answered by contacting Dr. Jacqui Crebolder (902) 426-3100 x296.

I have been told that I will be asked to participate in one session totaling approximately one hour and 30 minutes in duration.

The task is a computer-based task that consists of monitoring a central display for targets, gathering information on those targets from a second display, and reporting the nature of those targets on a third display.

I have been told that the principal risks of the research protocol are: possible minor eyestrain and fatigue. Also, I acknowledge that my participation in this study, or indeed any research, may involve risks that are currently unforeseen by DRDC Atlantic.

For Canadian Forces (CF) members only: I understand that I am considered to be on duty for disciplinary, administrative and Pension Act purposes during my participation in this experiment and I understand that in the unlikely event that my participation in this study results in a medical condition rendering me unfit for service, I may be released from the CF and my military benefits apply. This duty status has no effect on my right to withdraw from the experiment at any time I wish and I understand that no action will be taken against me for exercising this right.

I have been advised that the experimental data concerning me will be treated as confidential ('Protected B' IAW CF Security Requirements), and not revealed to anyone other than the DRDC Atlantic Investigator(s) or external investigators from the sponsoring agency without my consent except as data unidentified as to source. Also, I understand that my name will not be identified or attached in any manner to any publication arising from this study. Moreover, should it be required, I agree to allow the experimental data to be reviewed by an internal or external audit

committee with the understanding that any summary information resulting from such a review will not identify me personally.

I understand that I am free to refuse to participate and may withdraw my consent without prejudice or hard feelings at any time. Should I withdraw my consent, my participation as a subject will cease immediately, unless the Investigator(s) determine that such action would be dangerous or impossible (in which case my participation will cease as soon as it is safe to do so). I also understand that the Investigator(s), their designate, or the physician(s) responsible for the research project may terminate my participation at any time, regardless of my wishes.

I have been informed that the research findings resulting from my participation in this research project may be used for commercialization purposes.

I understand that for my participation in this research project, I am entitled to remuneration in the form of a stress allowance in the amount of \$16.68 (plus \$15.00 for travel if I am coming from outside DRDC Atlantic) for completing one session. Stress remuneration is taxable. T4A slips are issued only for amounts in excess of \$500.00 paid during a year.

Secondary Use of Data: I consent/do not consent (delete as appropriate) to the use of this study's experimental data involving me in unidentified form in future related studies provided review and approval have been given by DRDC HREC.

Volunteer's Signature: _____ Date: _____

I have informed the Principal Investigator that I am currently a subject in the following other DRDC Atlantic research project(s): _____
(cite Protocol Number(s) and associated Principal Investigator(s)), and that I am participating as a subject in the following research project(s) at institutions other than DRDC Atlantic:
_____ (cite name(s) of institution(s))

I understand that by signing this consent form I have not waived any legal rights I may have as a result of any harm to me occasioned by my participation in this research project beyond all risks I have assumed.

Volunteer's Name _____

Signature: _____ Date: _____

Name of Witness to Signature: _____

Signature: _____ Date: _____

Section Head/Commanding Officer's Signature: _____
(see Notes blow)

CO's Unit: _____

Principal Investigator: _____
Signature: _____ Date: _____

Notes:

For other military personnel: All other military personnel must obtain their Commanding Officer's signature designating approval to participate in this research project.

For civilian personnel at DRDC Atlantic: Signature of Section Head is required designating that volunteer subject is considered to be at work and that approval has been given to participate in this research project.

FOR SUBJECT ENQUIRY IF REQUIRED:

Should I have any questions or concern regarding this project before, during, or after participation, I understand that I am encouraged to contact Defence R&D Canada – Atlantic (DRDC Atlantic), 9 Grove Street, Dartmouth, Nova Scotia, B2Y 3Z7. This contact can be made by surface mail at this address or in person, by phone or e-mail, to any of the DRDC Atlantic numbers and addresses listed below:

Principle Investigator or Principal DRDC Atlantic Investigator:
Dr. Jacquelyn Crebolder, (902) 426-3100 x296, jacqui.crebolder@drdc-rddc.gc.ca

Or to the Chair of the DRDC Human Research Ethics Committee (HREC)
Dr. Jack Landolt, (416) 635-2120, jack.landolt@drdc-rddc.gc.ca

I understand that I will be given a copy of this consent form so that I may contact any of the above-mentioned individuals at some time in the future should that be required.

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Annex D Study 2 Debriefing Form

A Study Investigating Alerts and Multiple Displays in the Halifax Class Frigate.

The operations room in a frigate is a busy environment where sensor information, such as radar and sonar data, is translated into a meaningful picture so that ship commanders can understand what is going on above water, under water, and in the air around them. The operations room is a demanding, high intensity environment, manned by about twenty Navy personnel, most of whom are sensor operators. Automated systems to assist operators are a necessity in this busy environment and an automated auditory alerting system is currently in place in the operations room to warn of impending system and tactical states. However, due to the persistent and uninformative nature of the alerts operators tend to ignore or turn off the alerting system as soon as they come on duty. The Halifax Class Frigate is undergoing a complete modernization upgrade and the current study is designed to explore methods of enhancing the way operators are alerted in the new operations room.

Subject matter experts have suggested static or flashing borders around the operator's computer screen as an alternative to auditory alarms. Another common visual alerting technique used in other environments is a static or flashing sidebar, located in the perimeter of the screen. The border and sidebar are two alerting techniques that were investigated in this study. The study also investigated the behaviours of the alerts (static or flashing). Additionally, since the operator's workstation is expected to consist of three displays, whether to present visual alerts on one or all of the displays was also of interest.

One of these alerts may be easier to detect than another and data was collected on how fast each was detected while you were performing the categorization task. We also measured response time to the alerts as a function of the display the alert appeared on to see whether it is worth showing the alerts on all the displays or whether one display would be ample. Additionally, response times and accuracy in the categorization task were recorded as a function of the alert behaviour (static or flashing). Results from this study will provide insight into whether visual alerts are a viable alternative in the Halifax Class Frigate operations room and the findings will provide an initial step in determining what types of alerting techniques might be most suitable.

Thank you for your participation in this study. We appreciate your time and effort!

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Annex E Study 2 Participant Instructions and Scenario

Prior to reading the on screen instructions participants were read the following:

“You are a control operator on a Navy ship. Your primary responsibility is to attend and respond to visual alerts that appear on your displays. Your secondary task is to determine whether targets approaching your ownship are neutral or hostile.

I will have you read the first screen for instruction and then we will continue...”

Participants then read the following on the middle screen:

“There are two types of visual alerts that will appear on your displays; a red bar that will always appear on the left top area of the display and a red border that surrounds the periphery of your screen. Only one type of display will appear at a time. The displays may appear on the left display, middle display, right display or all three at once.

When you hit the space bar the alert will disappear immediately. Alerts, if not responded to will disappear after a short duration.

Just to remind you – it is your primary task to respond to alerts.

Any target, whether it is neutral or hostile will destroy your ownship if it reaches the center of the screen. You do not have to move the cursor inside the textbox to enter your answer – you may just type. However, you will need to move the cursor over the enter button on the right screen and click enter with the mouse. You are not able to enter your answer using the “enter button” on the keyboard.

To summarize: Responding to alerts is your primary task, your secondary task is to identify whether approaching targets are neutral or hostile.

Do you have any questions?”

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Annex F Variables Used in E-Basic

Variable Name	Manipulated by Experimenter	Description	Values
Experiment	Yes (via E-studio)	E-prime Experiment name.	Any
Subject	Yes (via E-studio)	Subject number	Any Note: 0 is saved for testing E-prime files without data collection.
Block	Yes	Block number	1 to Block n
Trial	No	Trial number. This number represents every 2 seconds of the 180s block.	1-90
BlockDurnSec	Yes	Block Duration (in seconds) Note: this is approximate, the program calculates the number of "trials" based on the block duration and rounds that number; also, the actual trial time is usually greater than the expected trial time	180
TotalTargets	Yes	Total targets on screen at one time. on screen at one time	10
TotalHTargets	Yes	Total hostile targets	5
TotalNTargets	No	Total neutral targets (total targets - hostile targets)	5
HostInst	Yes	Number of hostile instances to deem a target hostile (i.e., if hi=2 it takes 2/3 or more hostile instances for a target to be considered hostile)	2
TrialOnset	No	Trial Onset Time (to determine actual trial duration as the BlockDurnSec is set to be approximately 180)	Should increase by approximately 2000ms (2seconds) between each trial.
TrialOffset	No	Trial Offset Time (to determine actual trial duration); Note: this does not include the time it takes to write data to the data file	Should increase by approximately 2000ms (2seconds) from the TrialOnset variable. TrialOffset should = the TrialOnset time of the following trial.
TrialDurn	No	Trial Actual Duration (TrialOffset - TrialOnset)	TrialOnset-TrialOffset=approximately 2000ms

TotAlrms	Yes	Total number of alarms	16: Manipulated in the E-Studio environment. (See Figure 2)
AlrmFDur	Yes	Alarm flashing duration (in milliseconds)	300ms
AlrmDur	Yes	Alarm duration (in milliseconds)	4000ms
AlrmFlash	Yes (via E-studio)	Set whether border alarms are flashing	This is an old variable and not in use for the current study (see Table 1 to control alarm types): 1=Yes 0=No
AlrmCond	Yes (via E-studio)	Alarm condition	This is an old variable and not in use for the current study (see Table 1 to control alarm types): 1=alarm type is the same within a block 2=alarm type varies within a block Currently set to 255, 0, 0
AlrmCColour	Yes	Alarm colour	If changing, refer to http://www.web-source.net/216_color_chart.htm
AlrmBarWidth	Yes	Alarm Width (Side Bars)	Shouldn't be larger than 100 pixels
AlrmBorWidth	Yes	Alarm Width (Borders)	Shouldn't be larger than 100 pixels
AlrmBarLength	Yes	Alarm Length (Side Bars)	
TotAlrmSBar	Yes (via E-studio)	Number of side bar alarms set manually	This is an old variable and not in use for the current study. See Table 1 to control number of alarms presented.
TotAlrmBord	No (via E-studio)	Number of border alarms set manually	This is an old variable and not in use for the current study. See Table 1 to control number of alarms presented.
AlrmExpOnset	No	Alarm expected onset time (in milliseconds)	The time the alarm has been designated to appear on the display(s)
AlrmOnset	No	Alarm onset time (in milliseconds)	The actual time the alarm appears on the display(s). Should be identical to AlrmExpOnset
AlrmExpOffset	No	Alarm expected offset time (in milliseconds)	The time the alarm has been designated to disappear from the display(s) This value should be approximately 4000ms later than the AlrmExpOnset and AlrmOnset.

AlrmOffset	No	Alarm offset time (in milliseconds)	This is the actual time the alarm disappears from the display(s). This value is based on the alarm disappearing after the time has run out, not when the alarm has disappeared due to a response from the participant. This is an old variable and not in use for the current study. See Table 1 to control for alarm type. 1 = left/status 2 = middle/tactical 3 = right/report 4 = all) Clock.Read at time participant hits spacebar AlarmRespTime - AlarmOnsetTime 1. alarm accuracy = 2 a. If it is a False Hit, i.e. participant responds before or after an alarm, there will be a response time but no obvious alarm to link it to. b. If a Miss (response after alarm has left the display): there will be a response time after the alarm offset time 2. alarm accuracy = 1 a. If it is a Hit, i.e., participant responds while alarm is on display. There will be a response time, an alarm onset time but no alarm offset time. 3. alarm accuracy = 0 a. If there is no response to an alarm. There will be an alarm onset and offset time but no response time. qwe = neutral asd = hostile In the future this might be useful to see examples of participant clicking on a target but not directly following this action with an
AlrmType	Yes (via E-studio)	Alarm type	
AlrmCurrMon	No	Alarm current screen	
AlrmRespTime	No	Alarm response time	
AlrmRT	No	Alarm reaction time	
AlrmAccuracy	No	Alarm Accuracy	
ActiveTargType	No	Active target type selected	

RDRsp	No	Report display response	answer on the report display. See recommendations.
RDCorrResp	No	Report display correct response	qwe = neutral asd = hostile
RDAccuracy	No	Report display accuracy	qwe = neutral asd = hostile 1=correct 2=incorrect
Expl	No	Ship Explosion	0=no ship explosion 1=ship explosion

List of symbols/abbreviations/acronyms/initialisms

CAE PS	CAE Professional Services
DRDC	Defence Research & Development Canada
SA	Scientific Authority
TA	Technical Authority

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3. TITLE (The complete document title as indicated on the title page. Its classification is indicated by the appropriate abbreviation (S, C, R, or U) in parenthesis at the end of the title) Evaluation of visual alerts in the maritime domain. Study 2 – Program Modifications (U) Évaluation des alertes visuelles dans le domaine maritime : 2e étude – modifications au programme. (U)		
4. AUTHORS (First name, middle initial and last name. If military, show rank, e.g. Maj. John E. Doe.) Roberts, S.		
5. DATE OF PUBLICATION (Month and year of publication of document.) February 2009	6a NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.) 58	6b. NO. OF REFS (Total cited in document.) 6
7. DESCRIPTIVE NOTES (The category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of document, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.) Contract Report		
8. SPONSORING ACTIVITY (The names of the department project office or laboratory sponsoring the research and development – include address.) Sponsoring: Tasking: DRDC Atlantic		
9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant under which the document was written. Please specify whether project or grant.) 12oi03		9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.) W7707-08-8116
10a. ORIGINATOR'S DOCUMENT NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document) DRDC Atlantic CR 2008-268		10b. OTHER DOCUMENT NO(s). (Any other numbers under which may be assigned this document either by the originator or by the sponsor.)
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- (U) A Defence Research and Development Canada (DRDC) Atlantic research program is in progress investigating human performance issues related to the use of automated visual alerts under high workload conditions. Previous research comparing performance of two distinct styles of visual alerts – ‘flashing border’ versus ‘static sidebar’ was completed by CAE Professional Services (CAE PS) for DRDC–Atlantic. CAE PS was then contracted to modify the existing experimental software and assist in the resulting pilot and primary studies (Study 2). Specifically the software was modified to include static and flashing variables for both alert types and to modify the paradigm and software to ensure that participants are visually attending to all three screens. The current report documents the work conducted by CAE PS for Study 2 and includes a review of the experiment procedure, setup, data collection method, and observations made during the pilot and primary studies.
- (U) Un programme de recherche de Recherche et développement pour la défense Canada (RDDC) – Atlantique enquête présentement sur des questions de rendement humain reliées à l'utilisation d'alertes visuelles automatisées sous une charge de travail élevée. CAE Services professionnels (CAE PS) avait précédemment effectué pour RDDC Atlantique des recherches qui comparaient le rendement de deux types distincts d'alertes visuelles – bordure clignotante/barre d'état. CAE PS s'est ensuite vu octroyer un contrat pour modifier le logiciel expérimental existant et contribuer aux études pilote et primaire résultantes (2e étude). Plus précisément, le logiciel et sa conception ont été modifiés pour inclure des variables statiques et de clignotement pour les deux types d'alertes et assurer la surveillance visuelle des trois écrans par les participants. Le présent rapport explique les travaux effectués par CAE PS pour la 2e étude et comprend un examen de la méthode d'expérimentation, de sa préparation, de la méthode de recueil des données et des observations faites pendant les études pilote et primaire.

14. **KEYWORDS, DESCRIPTORS or IDENTIFIERS** (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

(U) alerts; alarms; visual; command and control; maritime; interface

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