THE EFFECT OF STRESS ON CROSSMODAL INTERFERENCE DURING VISUAL SEARCH

P.A. Burton* and F. Morelli
U.S. Army Research Laboratory
Human Research & Engineering Directorate
Aberdeen Proving Ground, MD 21005-5425

ABSTRACT

A key factor in determining the efficiency of target detection is the influence of distracting information during the search process. Using a response competition paradigm, the present study examined how induced stress influences crossmodal links with respect to perceptual load in a visual search task under conditions of no stress versus induced stress. Individuals were tasked to perform both an easy and a hard visual search task while ignoring either auditory or visual distractors. Under conditions of no stress, previous research findings were replicated in that visual distractors produced greater costs in easy searches whereas compatible auditory distractors produced benefits while incompatible auditory distractors produced costs. However, under conditions of stress, auditory distractors caused greater costs, especially under hard search conditions, while benefits were only seen during easy searches. Visual distractors caused little interference under conditions of stress in either easy or hard searches. Levels of physiological and perceived stress were substantiated by measures of salivary α-amylase and scores on the Multiple Affect Adjective Checklist-Revised.

1. INTRODUCTION

When searching for a target, the ability to disregard distracting, irrelevant information becomes central to efficient target detection. It is generally accepted that the extent of resources needed in processing relevant information impacts the extent to which distracting information is also processed (Erikson, 1995). It has been shown that distractor effects are modulated by perceptual load. Under high load, when processing capacity is exhausted, distractors may pose little interference; under conditions of low load, spare processing capacity spills over to irrelevant distractors causing interference with the processing of relevant information.

An issue that has been addressed recently is whether the perceptual load model holds up across modalities. Using a response competition paradigm, Tellinghuisen & Nowak (2003) found differential modality effects on perceptual load when distractors were auditory versus visual. Understanding the effects of auditory inputs on visual processing and vice versa is imperative to the designers of audiovisual displays; however, this alone is not enough to assure optimal performance. The effects of stress on dual-modality processing must also be factored in, especially in hostile environments. One cannot assume that under stress, the effects of dual modality processing on perceptual load remain the same. That is, the pattern of benefits (or costs) associated with processing in a given modality may differ in cases of crossmodal sensory integration under stress. While several studies have demonstrated crossmodal links across vision and audition in attention tasks (Driver & Spence, 1998; Duncan, Martens & Ward, 1997; Rees, Firth, & Lavie, 2001), few have examined the effects of stress on crossmodal attention.

The purpose of the present experiment was to examine how induced stress influences crossmodal links with respect to perceptual load in a visual search task The manner in which stress may influence the compatibility effect when the target and distractors are of a different modality is not straightforward in that processing capacity may not be distributed across modalities equally.

In the current experiment, we added a stress condition to the same response-competition paradigm as used by Tellinghuisen and Nowak (2003) in which participants searched for a target among non-targets in the presence of auditory and visual distractors that could be either compatible or incompatible with the target response. Perceptual load was also manipulated by making the search easy or difficult.

Tellinghuisen and Nowak (2003) found that the degree to which auditory information influenced visual processing varied with the perceptual load of the visual processing task. They propose that the processing load of a task may have bearing on the degree to which distractors of the same modality are processed and also to what degree the processing of distractors in another modality is inhibited. However, stress may also impact processing capacity.

It has been shown that a moderate increase in stress level may result in a broadening of attention (McEwen & Sapolsky, 1995; Skosnik, Chatterton, Swisher & Park,

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
01 NOV 2006	**N/A**	**-**

4. TITLE AND SUBTITLE
The Effect Of Stress On Crossmodal Interference During Visual Search

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Research Laboratory Human Research & Engineering Directorate Aberdeen Proving Ground, MD 21005-5425

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM002075., The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**31**	

2000). Conversely, in some tasks, moderate levels of stress have been shown to narrow attention (Mendle, 1999). Whether stress results in a narrowing or broadening of attention appears to be task dependent. Predictions for either case can be made with regard to perceptual load in a visual response competition search task. If induced stress results in a broadening of attention, then it is hypothesized that visual distractors will result in response competition (costs) under conditions of both the high and low perceptual load. Conversely, if induced stress results in a narrowing of attention, then it is hypothesized that distracting visual information will not interfere under conditions of high or low load.

At first blush, one might assume that a broadening of attention may result in an increase in overall processing capacity. That is, there would be an increase in the resources available for processing visual information as well as an increase in the capacity to inhibit the processing of auditory stimuli that might interrupt visual processing. However, since processing capacity does not appear to be distributed across modalities equally, it may be that when the primary task is visual, more resources are allocated to the processing of visual stimuli than to the inhibition of auditory stimuli. The same argument can be made for a narrowing of attention and a decrease in resources as well.

The stressor we employed was a set of standardized photos that have been shown to increase levels of physiological arousal and elicit a stress response. The photographs were selected from the International Affective Picture System (IAPS), a set of normative stimuli designed for use in experiments examining emotion and attention (Lang, Bradley & Cuthbert, 1997). Participants in the control condition viewed low-arousal IAPS photographs designed not to elicit a stress response. The photographs utilized in the current study were rated in accordance with Lang's Self-Assessment Manikin (SAM) affect rating system (1980).

2. METHODOLOGY

2.1 Participants

Thirty-one volunteers were solicited from the employee population of the U.S. Army Research Laboratory at Aberdeen Proving Ground, Maryland. All participants were screened for normal or corrected-to-normal visual acuity and acceptable hearing level. Visual acuity was ascertained via a Snellen eye chart and participants' hearing was screened at a level of 20 db HL at octave frequencies 500 through 4000 Hz using a portable audiometer. In accordance with an HRED Human Use Committee mandate, a health screening form was also used to determine possible risk to participants. One participant was considered at risk due to a history of high blood pressure and excluded from participating in the experiment. The remaining 30 volunteers were randomly divided into two groups of 15; a stressed (experimental) group and a non-stressed (control) group.

2.2 Stimuli and Apparatus

The Today form of the Multiple Affect Adjective Checklist – Revised (Lubin & Zuckerman, 1999) was administered. This form consists of 5 primary subscales (Anxiety, Hostility, Depression, Positive Affect, and Sensation Seeking) derived from a one page list of 132 adjectives. Participants are instructed to check all words describing how they "feel right now", or "have felt since they last completed this form." A sixth subscale, Dysphoria, is an overall distress score and is calculated from the Anxiety, Depression, and Hostility scores. Because of its improved discriminant validity and control of checking the response set, the MAACL-R Today form has been found to be particularly suitable for investigations which postulate changes in specific affects in response to stressful situations.

To obtain a quantifiable physiological level of stress (Fatkin, Patton, Burton & Carty, 1999), the salivary amylase field test was administered. Amylase is an enzyme that hydrolyzes starch to oligosaccharides and then slowly to maltose and glucose. Salivary amylase concentrations are predictive of plasma catecholamine levels and can be used as a measure of stress (Chatterton, Vogelsong, Lu, Ellman & Hudgens, 1996; Skosnik, Chatterton, Swisher & Park, 2000). Measurement of amylase concentration in saliva includes the observation of chemical color changes according to standard photometric procedures developed by Northwestern University (Chatterton, et al., 1996). The concentration of amylase is then determined from a table of values relating time of color change to amylase activity.

To serve as a stressor, participants in the experimental group were shown a set of standardized IAPS photos[1] rated as high-arousal/negative-valence in accordance with Lang's SAM affect rating system (1980). The photos in this set have been shown to evoke both physiological arousal and emotional response (Lang, Bradley, &

1 To assure that the high-arousal/negative-valence IAPS elicited the expected stress response relative to the low-arousal/neutral-valance photos, a group of pilot participants were exposed to a set of 24 photos and salivary amylase was measured (Chatterton, Vogelsong, Lu, Ellman & Hudgens, 1996). Those viewing the disturbing photos showed a moderate increase in stress levels.

Cuthbert, 1997). Participants in the control group were shown a set of standardized photos rated as low-arousal/neutral-valence in accordance with Lang's SAM rating system. That is, these photos are associated with neither pleasant nor unpleasant material.

2.3 Design and Procedure

Stimuli were presented on a computer-controlled color video monitor placed 60 cm from the participant. Stimuli consisted of a circular array of six equally-spaced letters with each letter subtending 2.58° of visual angle from a centrally-located fixation cross. The distance between adjacent letters also subtended 2.58°. In the easy condition, the letter O appeared randomly in five positions and the target letter occupied the sixth position. In the hard condition, the letters H, Y, Z, K, and V appeared randomly in five positions and the target letter in the sixth position. In both experimental conditions the target letter appeared equally as often in each of the six positions of the circular array. The letters N and X were used as target letters and each appeared an equal number times as the target stimulus. All letters were white presented in uppercase Ariel font on a black background.

In addition, on half of the trials a distractor item appeared to the immediate left or right of the circular array, subtending 4.95° of visual angle from fixation. The target letters and the distractor subtended a visual angle of 0.86° vertically and horizontally. The visual distractor was always the letter "N", "X", or a dot-filled square (see Figure 1).

On half of the trials, the distractor item was presented via headphones. On auditory trials, no visual distractor was presented with the letter array. The auditory distractor was the spoken letter "N", "X", or a burst of white noise (60 dB SPL) presented to both ears simultaneously via headphones. The letters were presented in a female voice at a 60 dB SPL. The spoken stimuli was manipulated such that each letter used the minimum duration needed to include all portions of the vocalization of each letter necessary to make it comprehensible.

The distractor could be compatible, incompatible, or neutral in relation to the target letter. Compatible distractors are identical to that of the target letter, incompatible distractors are the opposite response of the target letter (i.e., X when N is the target or vice verse). Neutral trials consist of a distractor that is not associated with a response. Each of the distractor conditions (compatible, incompatible, or neutral) were presented equally as often in each modality.

Each display began with a 100 ms beep (65 dB) followed by a fixation cross appearing in the center of the screen for a duration of 800 ms. The target display then appeared for 100 ms. The distractors, whether visual or auditory appeared simultaneous with the target array. Participants were asked to ignore the distractors to the best of their ability while making a speeded reaction time response to the presence of the target letter ("X" or "N") within the search array.

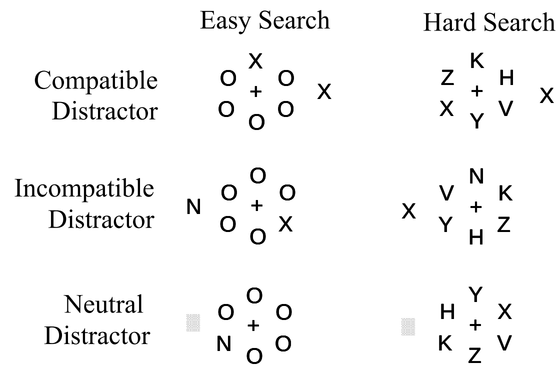


Figure 1. Example of an easy [low perceptual load] search (left) and a hard [high perceptual load] search (right). The target letter N or X is present on every trial.

On half of the trials, a single distractor letter or symbol appears to the left or right of the array. On the other half, the distractor is not present on the visual display, but presented through headphones. The distractors may be compatible, incompatible, or neutral relative to the target letter, presented visually or orally, and the search may be hard or easy resulting in 12 experimental conditions.

All participants were asked to read a Volunteer Agreement Affidavit and were reminded that they could refuse or withdraw from the study at any time without penalty. In addition, volunteers completed a brief health screening form. Although the set of physiologically arousing IAPS photographs do not produce sustained heart rate or blood pressure changes, to err on the side of safety, if an individual answered "yes" to any of the questions on the health screening form, they were precluded from participation in the experiment.

Baseline MAACL-R and salivary amylase measures were collected prior to informing the participant of the nature of the photos they would be viewing. That is, at the time of the baseline measures, participants did not know which set of photos they would be viewing. In administering the MAACL-R, participants were asked to check all words on the list that describe how they "feel right now." Following the baseline MAACL-R and saliva collection, the search task was demonstrated and participants completed a 1-minute practice block. Upon completion of the practice block, six blocks of 96 trials each were completed. Prior to blocks 4, 5 and 6, both groups were asked to view a series of IAPS photos. Prior to viewing, participants were informed of the nature of the photos. Those in the stress group were told that they may find the photos disturbing, while those in the non-stress group were simply asked to view the photos. Salivary amylase and MAACL-R data were collected prior to beginning the experiment (baseline) and after viewing each set of photos.

2.4 Data Analysis

To determine if the negative-valence photographic stimuli increased physiological stress, the measured levels of salivary α-amylase concentrations were submitted to a mixed factors analysis of variance with IAPS exposure (pre, post 1, post 2, post 3) as a within-subjects factor and group (stressed vs. non-stressed) as the between-subject factor .

Similarly, to verify that the negative-valance photographic stimuli increased perceived stress as measured by the 4 subscales of the MAACL-R (anxiety, depression, hostility, and dysphoria), a 2 (non-stressed vs. stressed group) x 4 (IAPS exposure) multivariate analysis of variance (MANOVA) was conducted. The positive affect and sensation seeking subscales were not used in the analysis.

To evaluate performance, separate ANOVAs were run on the accuracy and on the reaction time data. A 2 x 2 x 3 x 2 x 3 mixed design was employed with experimental condition (stressed or non-stressed) as a between group factor and IAPS exposure (pre vs. post), sequential trial block (1, 2, 3), distractor modality (visual vs. auditory), level of difficulty (easy vs. hard), and distractor type (compatible, incompatible, vs. neutral) as within-subject factors. Correct only responses were used in the analysis of the reaction time data. Of the total trials presented, 89% of the trials resulted in correct responses.

3. RESULTS

Results of the mixed-factor analysis conducted on the salivary α-amylase data is shown graphically in Figure 2. The analysis revealed a significant between-subject main effect of group (stress, non-stressed) [$F(1, 28) = 73.2$, $p < .001$] and a significant within-subjects main effect of IAPS exposure (pre, post 1, post 2, post 3) [$F(3,84) = 102.6$, $p < .001$]. Additionally, a two-way interaction was found between group and IAPS viewing [$F(3, 84) = 89.3$, $p < .001$].

There was no difference in amylase levels between pre- and post-exposure in the non-stressed group. That is, there was no increase in physiological stress after viewing the neutral-valance photos. However, those in the stressed group showed a moderate level of increased salivary α-amylase after viewing the negative-valance photos.

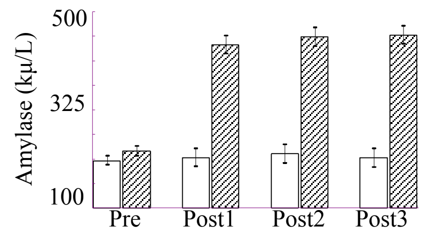


Figure 2. Mean salivary α-amylase concentrations were equal in each group prior to viewing the IAPS. Following exposure to the negative-valence photos, the stress group revealed significantly increased levels of salivary α-amylase.

The MAACL-R indicated significant differences in the stress perception of the negative affect subscales of hostility and depression between those viewing the negative-valence photos and those viewing the neutral-valence photos (See Figure 3). There was a significant main effect of group [$F(1, 28)=12.10$, $p<.002$] and of IAPS exposure [$F(3, 84)=7.29$, $p<.00$] along with group x exposure x subscale interaction [$F(9,252)=1.99$, $p<.05$].

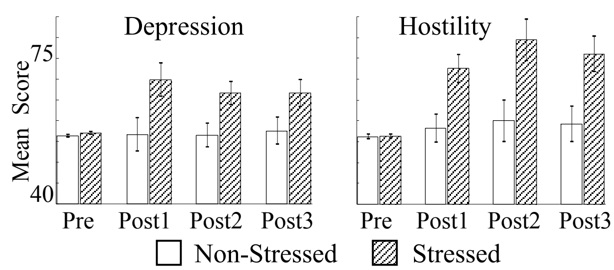


Figure 3. Prior to IAPS viewing, there was no difference in stress perception between groups; however, after viewing the negative-valence IAPS photos, the stressed group revealed elevated levels of depression and hostility.

The principal measures of performance were mean reaction time (RT) and accuracy in identifying the target letter within the search array. Results of a mixed-model ANOVA applied to the reaction time data revealed significant, within-subject main effects of IAPS viewing (pre, post) [$F(1, 28) = 11.1$, $p < .002$], sequential trial block (1, 2, 3) [$F(2, 56) = 8.9$, $p < .001$], modality (visual, auditory) [$F(1,28) = 20.1$, $p < .001$], level of difficulty (easy, hard) [$F(1,28) = 208.5$, $p < .001$], and distractor type (compatible, incompatible, vs. neutral) [$F(2,56) = 27.3$, $p < .001$]. Additionally, two-way interactions were found between viewing and level of difficulty [$F(1, 28) = 4.2$, $p < .05$] and between modality and compatibility [$F(2,56) = 8.6$, $p< .001$]. Three-way interactions were found between modality, difficulty, and group [F(1,28) = 7.1, p < .05] and between block, modality, and difficulty [F(2,56) = 3.4, p < .05]. Finally, a four-way interaction of IAPS exposure, modality, difficulty, and group [F(1,28) = 4.3, p < .05] was revealed.

Results of a mixed-model ANOVA applied to the accuracy data revealed significant, within-subject main effects of modality (auditory, visual) [F(1, 28) = 8.8, p < .01], [F(2, 56) = 8.9, p < .001], level of difficulty (easy, hard) [F(1,28) = 56, p < .001], and distractor type (compatible, incompatible, neutral) [F(2,56) = 22.8, p < .001]. Additionally, two-way interactions were found between IAPS viewing and modality [F(1, 28) = 12.2, p < .01] and between level of difficulty and distractor type [F(2,56) = 14.6, p< .001]. Three-way interactions were found between modality, difficulty, and group [F(1,28) = 7.1, p < .05] and between IAPS viewing, modality, and difficulty [F(1,28) = 4.7, p < .05].

Overall, error rates were higher for hard searchers than for easy and when the distractors were visual rather than auditory. Additionally, error rates were higher when incompatible distractors were present as compared to compatible or neutral distractors.

Results of a mixed-model ANOVA applied to the reaction time data revealed significant, within-subject main effects of IAPS viewing (pre, post) [F(1, 28) = 11.1, p < .002], sequential trial block (1, 2, 3) [F(2, 56) = 8.9, p < .001], modality (auditory, visual) [F(1,28) = 20.1, p < .001], level of difficulty (easy, hard) [F(1,28) = 208.5, p < .001], and distractor type (compatible, incompatible, vs. neutral) [F(2,56) = 27.3, p < .001]. Additionally, two-way interactions were found between viewing and level of difficulty [F(1, 28) = 4.2, p < .05] and between modality and compatibility [F(2,56) = 8.6, p< .001]. Three-way interactions were found between modality, difficulty, and group [F(1,28) = 7.1, p < .05] and between block, modality, and difficulty [F(2,56) = 3.4, p < .05]. Finally, a four-way interaction of IAPS exposure, modality, difficulty, and group [F(1,28) = 4.3, p < .05] was revealed.

To best understand how distractor compatibility influences RT as a function of modality and as a function of stress, the magnitude of the RT differences for the various conditions was calculated (Lavie and Cox, 1997). Benefits were calculated by subtracting the mean RT for compatible trials from the mean RT for neutral (baseline) trials. Costs were calculated by subtracting the mean RT for neutral trials from the mean RT for incompatible trials. Compatibility effects were calculated by subtracting the mean RT for compatible trials from the mean RT for incompatible trials. The mean benefits and costs are presented in Figure 4 and the compatibility effects are presented in Figure 5.

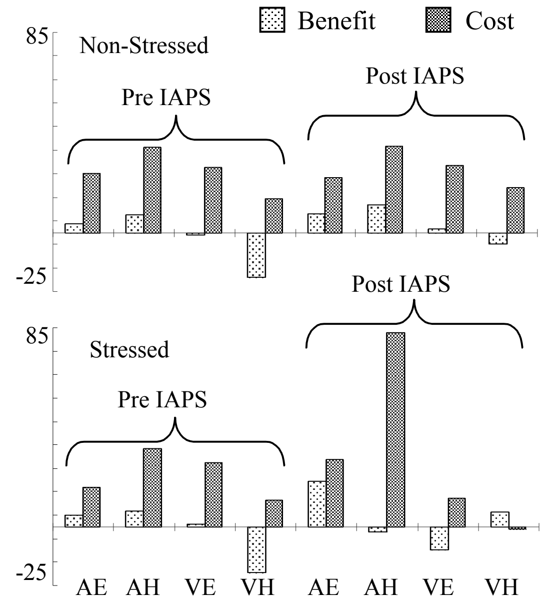


Figure 4. Mean benefits and costs (RT difference in milliseconds) for auditory (A) and visual (V) distractors presented for easy (E) and hard (H) searches before and after IAPS exposure.

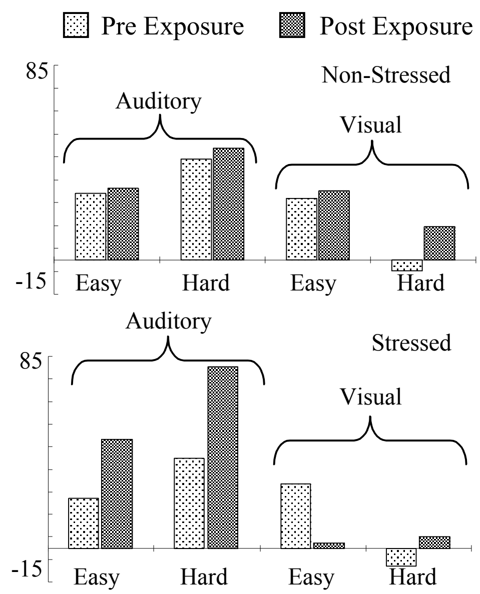


Figure 5. Mean compatibility effects (in milliseconds) for auditory and visual distractors presented for easy and hard searches before and after exposure to IAPS.

As can be noted in Figure 4, there was little difference in the pattern of results between pre- and post IAPS exposure in the non-stressed group and the pre-exposure stress group. In keeping with previous research, visual distractors resulted in costs only, which were greater for easy searches than for hard. Moreover, auditory distractors produced both benefits and costs, with costs being greater for hard searches. However, as seen in Figure 4, after exposure to the IAPS, the stress group displayed reduced costs associated with visual distractors, increased benefits associated with auditory distractors on easy searches and increased costs associated with auditory distractors in hard searches. The implications are discussed below.

4. CONCLUSIONS

Prior research has shown that perceptual load in a visual search task differentially influences the ability to ignore auditory and visual distractors. In keeping with previous research, under conditions of no stress, visual distractors influenced easy searches but had little effect on hard searches. Also, as previously shown, when the distractors were auditory, significant compatibility effects were found for both easy and hard searches. That is, under normal “no-stress” conditions, visual distractors produced only costs whereas compatible auditory distractors produced benefits while incompatible auditory distractors produced costs.

This pattern of results can be seen in the non-stressed group and as would be expected, in the stressed group prior to IAPS viewing. In keeping with Lavie's (1995) perceptual load model, any attentional capacity not allocated to performing the visual search task spills over to the processing of the visual distractors. Consequently, easy searches result in greater distractor interference than hard searches. However, as shown here and by Tellinghuisen and Nowak (2003) a different pattern of results occur when the distractors are auditory. Response-compatible auditory distractors have a priming effect and produce benefits not present with the visual distractors. Conversely, response-incompatible auditory distractors result in costs, particularly in hard searches.
However, following exposure to the stressor, the stressed group showed a very different pattern of results. First, auditory distractors produced large costs with respect to hard searches and significantly increased benefits with respect to easy searches. Secondly, visual distractors had no effect on hard searches and little influence on easy searches.

The perceptual load model may still be used to explain the reduction in costs associated with visual distractors under the condition of induced stress. It is not unreasonable to assume that stress increases the perceived perceptual load. Consequently, as shown in Figure 4, during easy searches the costs are greatly reduced and during non-existent during hard searches as processing capacity is further diminished following exposure to the stressor. However, this alone does not explain the effects of the auditory distractors. These data are far more complex and difficult to reconcile. Several possible explanations can be forwarded, but the present effort alone is insufficient to support any one explanation.

Another possibility is that in addition to the capacity theory associated with the perceptual load model, it is possible that cross-modal inhibition may account for the pattern of results associated with auditory distractors. During stress, the auditory distractors may be inhibited less and therefore, interference from the irrelevant modality may be greater. Moreover, task load may further confound the efficacy of inhibition. Future research is necessary to tease out the effects of crossmodal interference during stress.

REFERENCES

Driver, J., & Spence, C. (1998). Crossmodal attention. Current Opinion in Neurobiology, **8**, 245-253.

Duncan, J., Martens, S., & Ward, R. (1997). Restricted attentional capacity within but not between sensory modalities. Nature, **387**, 808-810.

Chatterton, R. T.,Vogelsong, K. M., Lu, Y., Ellman, A. B. & Hudgens, G. A. (1996). Salivary amylase as a measure of endogenous adrenergic activity. *Clinical Psychology,* **16**, 433-448.

Eriksen, C.W. (1995). The flankers task and response competition: A useful tool for investigating a variety of cognitive problems. Visual Cognition, **2**, 101-118.

Lavie, N. (1995). Perceptual load as a necessary condition for selection: Journal of Experimental Psychology: Human Perception & Performance, **21**, 451-468.

Lavie, N., & Cox, S. (1997). On the efficiency of visual selective attention: Efficient visual search leads to inefficient distractor rejection. Psychological Science, **8**, 395-398.

Lang, P.J. (1980). Behavioral treatment and bio-behavioral assessment: computer applications. In J.B. Sidowski, J.H. Johnson & T.A.Williams (Eds.). *Technology in mental health care delivery systems.* Norwood, NJ: Albex Publishing Corp.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). *International Affective Picture System: Technical Manual and Affective Ratings.* Gainesville, FL. The Center for Research in Psychophysiology, University of Florida.

Lubin, B. & Zuckerman, M. (1999). *Manual for the Multiple Affect Adjective CheckList--Revised*. San Diego, CA: Educational and Industrial Testing Service.

Rees, G., Frith, C.D., & Lavie, N. (2001). Processing of irrelevant visual motion during performance of an auditory attention task. Neuropsychologia, **39**, 937-949.

Skosnik, P.D., Chatterton, R..T., Swisher, T., & Park, S. (2000). Modulation of attentional inhibition by norepinephrine and cortisol after psychological stress. *International Journal of Psychophysiology*. **36**, 59-68.

Tellinghuisen, D.J. & Nowak, E.J. (2003). The inability to ignore auditory distractors as a function of task perceptual load. Perception & Psychophysics **65**(5), 811-828.

The effect of induced stress on crossmodal interference during visual search

Cognitive Sciences Branch
Human Research & Engineering Directorate
Army Research Laboratory
Aberdeen Proving Ground, MD 21005

Pam Burton, Ph.D.
pburton@arl.army.mil
410-278-5972

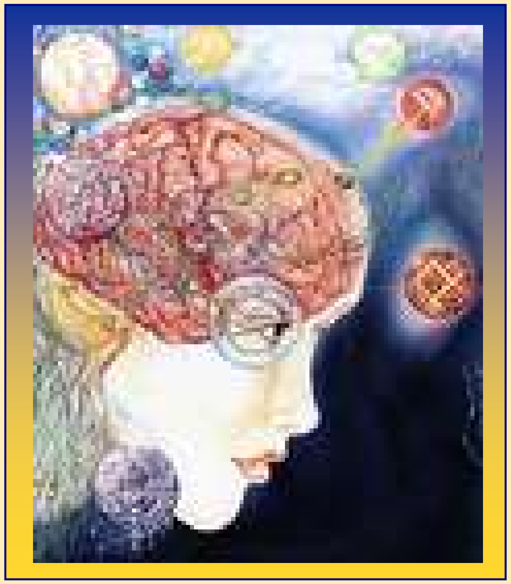
Frank Morelli, M.A.
fmorelli@arl.army.mil
410-278-5844

The modern Warfighter is fitted with both visual and auditory enhancing equipment

The question of when and how dual modality information enhances or interrupts performance remains unanswered

A key factor in efficient target detection is the ability to filter out distracting, irrelevant information

To reduce the risk of sensory overload, selective attention isolates behaviorally relevant information from the multitude of information impinging upon our sensory systems at any given time

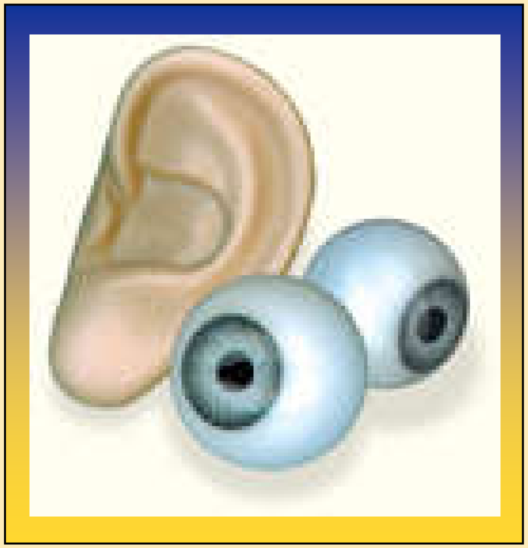


It has long been established that stress can alter attentional processes

We cannot assume that stress influences processing in dual modality tasks in the same manner in which it influences each modality when presented alone

One issue that has been addressed recently is whether the perceptual load model holds up across modalities

To explore this issue further, we manipulated perceptual load during a visual search task under conditions of no stress and under conditions of induced stress



Does induced stress influence crossmodal links with respect to perceptual load in a visual search task?

PERCEPTUAL LOAD MODEL

If all one's processing capacity is utilized in processing the relevant information, then no additional processing resources are available to allocate to the processing of distracting information.

HIGH LOAD

search is **difficult**

little interference from distracting info

processing capacity exhausted

LOW LOAD

search is **easy**

distractors often interfere with task

processing capacity **not** exhausted
spare capacity spills over to distractors

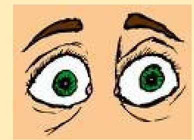
Lavie & Cox, 1997; Lavie & Tsal, 1994

Previous Research

Tellinghuisen & Nowak (2003)

HIGH LOAD

No effect



VISUAL DISTRACTORS

Even **greater** costs and benefits

Produced **only** response competition (costs)

AUDITORY DISTRACTORS

Produced costs and benefits

LOW LOAD

General Procedure

15 Non-stressed participants **15 Stressed participants**

↓

Complete stress-perception questionnaire & saliva collection

Stress Measure

The Multiple Affect Adjective Checklist – Revised (MAACL-R) was used to assess stress.

A D H
PA SS

1 ☐ active	45 ☐ fit	89 ☐ peaceful
2 ☐ adventurous	46 ☐ forlorn	90 ☐ pleased
3 ☐ affectionate	47 ☐ frank	91 ☐ pleasant
4 ☐ afraid	48 ☐ free	92 ☐ polite
5 ☐ agitated	49 ☐ friendly	93 ☐ powerful
6 ☐ agreeable	50 ☐ frightened	94 ☐ quiet
7 ☐ aggressive	51 ☐ furious	95 ☐ reckless
8 ☐ alive	52 ☐ lively	96 ☐ rejected
9 ☐ alone	53 ☐ [illegible]	97 ☐ rough
10 ☐ amiable	54 ☐ glad	98 ☐ sad
11 ☐ amused	55 ☐ gloomy	99 ☐ safe
12 ☐ angry	56 ☐ good	100 ☐ satisfied
13 ☐ annoyed	57 ☐ good-natured	101 ☐ secure
14 ☐ awful	58 ☐ grim	102 ☐ shaky
15 ☐ bashful	59 ☐ happy	103 ☐ shy
16 ☐ bitter	60 ☐ healthy	104 ☐ soothed
17 ☐ blue	61 ☐ hopeless	105 ☐ steady
18 ☐ bored	62 ☐ hostile	106 ☐ stubborn
19 ☐ calm	63 ☐ impatient	107 ☐ stormy
20 ☐ cautious	64 ☐ incensed	108 ☐ strong
21 ☐ cheerful	65 ☐ indignant	109 ☐ suffering
22 ☐ [illegible]	66 ☐ inspired	110 ☐ sullen
23 ☐ [illegible]	67 ☐ interested	111 ☐ sunk
24 ☐ contented	68 ☐ irritated	112 ☐ sympathetic
25 ☐ contrary	69 ☐ jealous	113 ☐ tame
26 ☐ [illegible]	70 ☐ joyful	114 ☐ tender
27 ☐ cooperative	71 ☐ kindly	115 ☐ tense
28 ☐ critical	72 ☐ lonely	116 ☐ terrible
29 ☐ cross	73 ☐ lost	117 ☐ terrified
30 ☐ cruel	74 ☐ loving	118 ☐ thoughtful
31 ☐ daring	75 ☐ low	119 ☐ timid
32 ☐ desperate	76 ☐ lucky	120 ☐ tormented
33 ☐ destroyed	77 ☐ mad	121 ☐ understanding
34 ☐ devoted	78 ☐ mean	122 ☐ unhappy
35 ☐ disagreeable	79 ☐ meek	123 ☐ unsociable
36 ☐ discontented	80 ☐ merry	124 ☐ upset
37 ☐ discouraged	81 ☐ mild	125 ☐ vexed
38 ☐ disgusted	82 ☐ miserable	126 ☐ warm
39 ☐ displeased	83 ☐ nervous	127 ☐ whole
40 ☐ energetic	84 ☐ obliging	128 ☐ wild
41 ☐ enraged	85 ☐ offended	129 ☐ willful
42 ☐ enthusiastic	86 ☐ outraged	130 ☐ wilted
43 ☐ fearful	87 ☐ panicky	131 ☐ worrying
44 ☐ fine	88 ☐ patient	132 ☐ young

SAMPLE ONLY
MAACL-R Stress perception forms must be purchased from the Educational and Industrial Testing Service

Participants check all those adjectives that describe how they felt while performing the task. The data provide a mean score of stress perception across the following subscales:

Anxiety

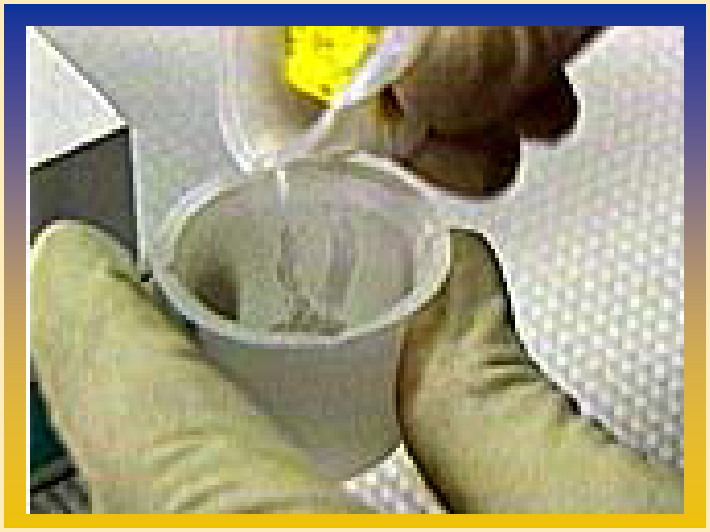
Depression

Hostility

Dysphoria (Negative Affect)

Physiological Stress Measure

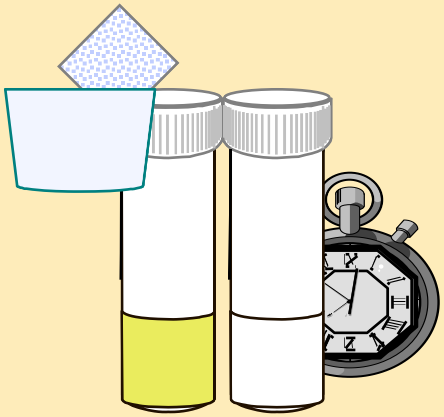
Salivary Amylase



Amylase is an enzyme found in saliva that is predictive of catecholamine levels and can be used as a measure of stress.

Typically, saliva samples for amylase assay are obtained before and during a stressful event or set of tasks.

The amylase assays are administered concurrently with a set of self-report measures that identify the components of stress (e.g., anxiety, depression, etc).



General Procedure

15 Non-stressed participants → 15 Stressed participants

↓

Complete stress-perception questionnaire & saliva collection

↓

Perform flanker task under condition of no stress (3 blocks)

Stimulus Array

O
O O
+
O X
O

Search for the letter X or N in a circular array of letters

Make a speeded response by pressing the letter X or N
on a standard keyboard

Easy Search

O
O O
+
O X
O

Hard Search

K
Z H
+
X V
Y

Compatible

K
Z H
+
X V X
Y

Incompatible

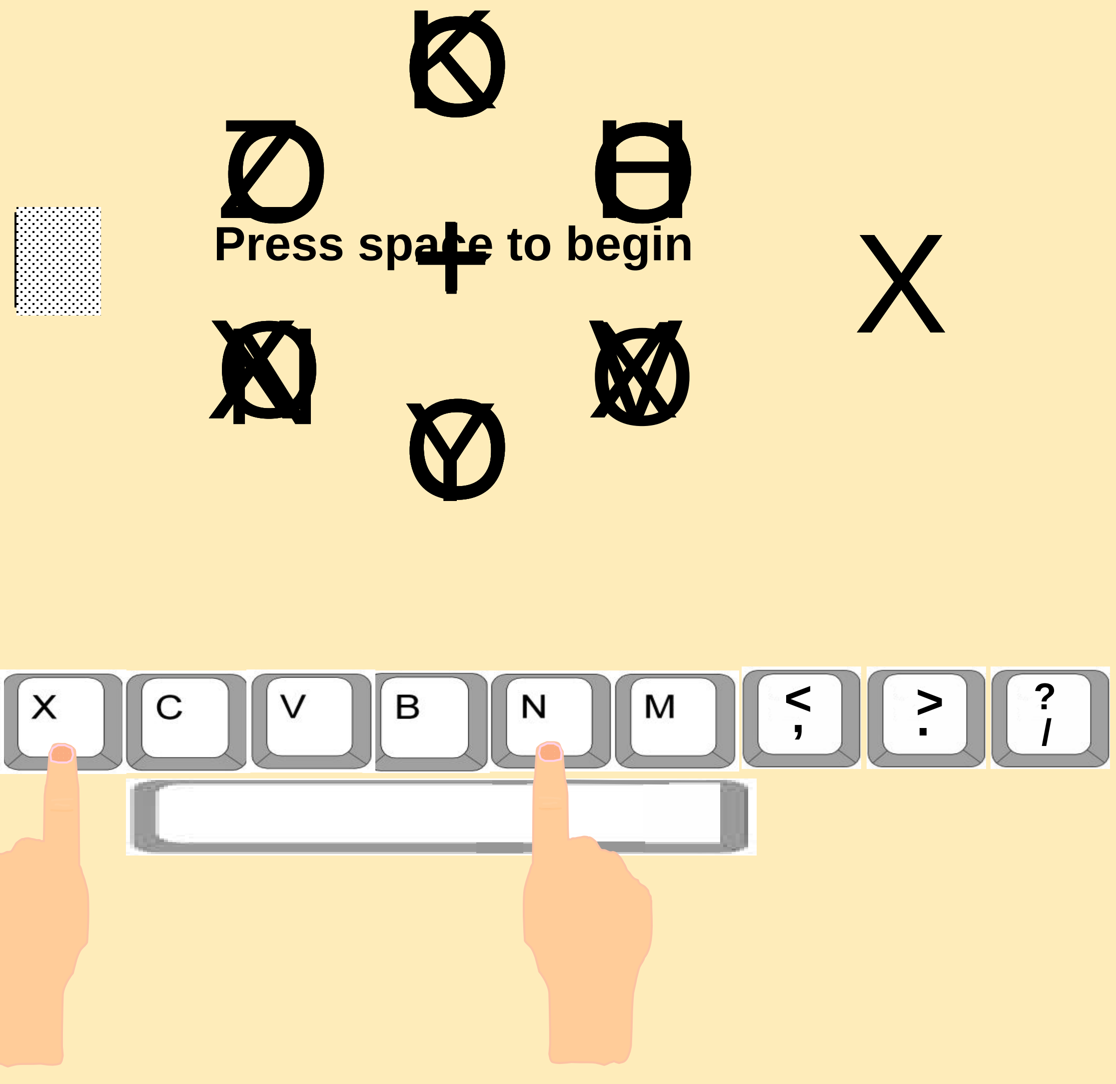
O
O O
N +
O X
O

Neutral

O
O O
+
N O
O

Distractors could be visual or spoken
Presentation order was fully randomized

Stimuli in the visual condition



General Procedure

15 Non-stressed participants — **15 Stressed participants**

↓

Complete stress-perception questionnaire & saliva collection

↓

Perform flanker task under condition of no stress (3 blocks)

↓

View Neutral Valance Photos | **View Negative Valance Photos**

The Stressor

The standardized International Affective Picture System (IAPS) was used to induce stress.

These are a set of normative stimuli designed for use in experiments examining emotion and cognition (Lang, Bradley & Cuthbert, 1997). The photos have been rated in accordance with Lang's Self Assessment Manikin (SAM) affect rating system (1980).

Non-stressed group viewed neutral valance IAPS photos

Stress group viewed negative valance IAPS photos

WARNING!

Graphic Photo

General Procedure

15 Non-stressed participants | **15 Stressed participants**

↓

Complete stress-perception questionnaire & saliva collection

↓

Perform flanker task under condition of no stress (3 blocks)

↓

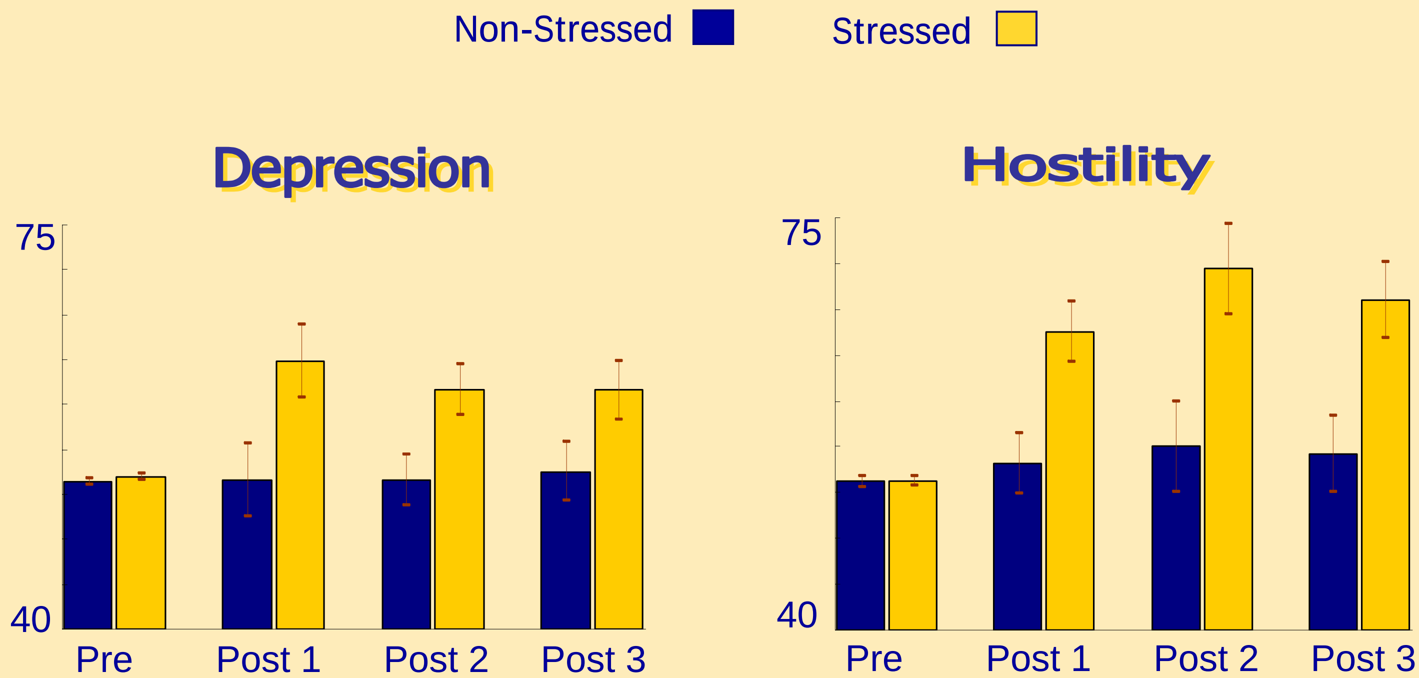
View Neutral Valance Photos | **View Negative Valance Photos**

↓

Perform flanker task (3 blocks)
Complete stress perception questionnaire & collect saliva after each viewing

Results

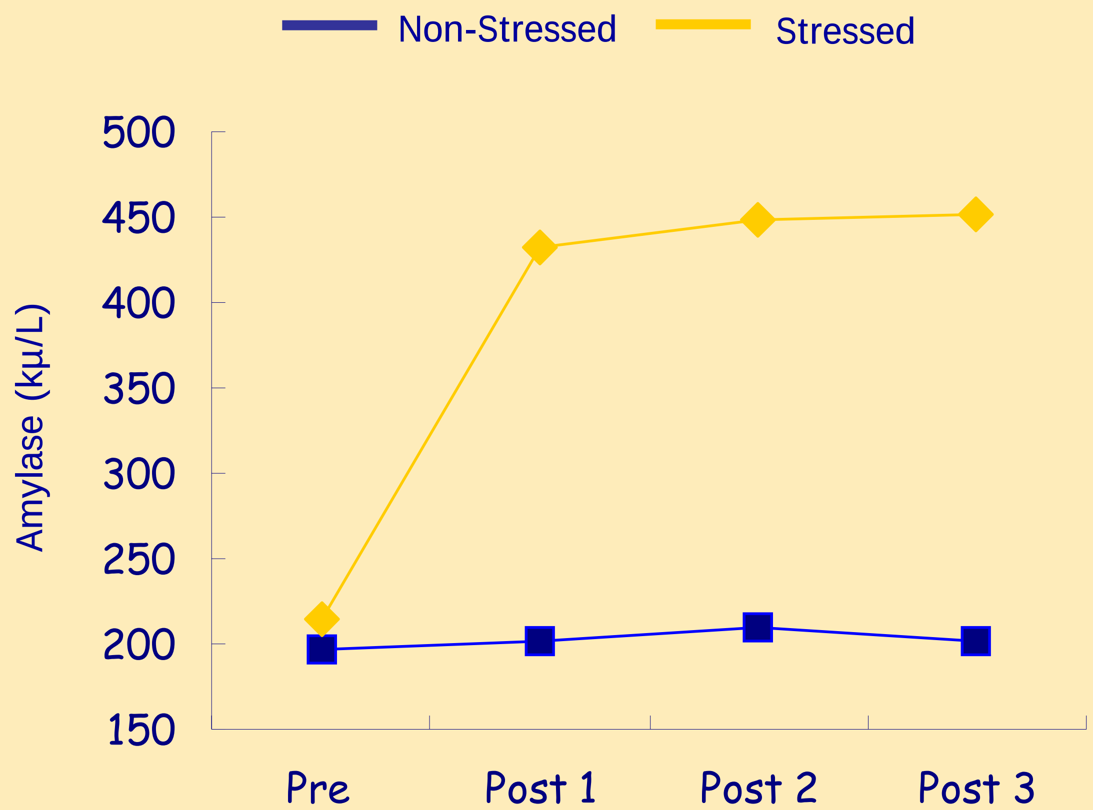
MAACL-R



Results showed that those in the stress group displayed higher scores on the depression and hostility scales of the MAACL-R relative to the non-stressed group and relative to pre-exposure.

Results

Salivary Amylase (Stress Response)



Results showed that those in the stress group displayed heightened levels of salivary amylase relative to the non-stressed group and relative to pre-exposure.

Results

Interactions resulting from repeated measures ANOVA on RT

Modality x difficulty x compatibility	F(2, 56)=12.735, p=.00003
Modality x difficulty x group	F(1, 28)=5.2496, p=.02968
Pre-post x modality x difficulty	F(1, 28)=4.4161, p=.04473
Pre-post x difficulty x group	F(1, 28)=17.945, p=.00022
Pre-post x modality x compatibility	F(2, 56)=3.5750, p=.03458
Pre-post x modality x difficulty x group	F(1, 28)=6.2445, p=.01860
Pre-post x modality x compatibility x group	F(2, 56)=5.8491, p=.00493

How does distractor compatibility influence RT as a function of modality and what impact does induced stress have upon this interaction?

To better address this, the magnitude of differences between RTs was calculated.

Results

Task Performance

Benefits = RT for Compatible Trials minus Neutral Trials

Costs = RT for Neutral Trials minus Incompatible Trials

Under conditions of no stress

Auditory distractors produced both benefits and costs

Visual distractors produced only costs

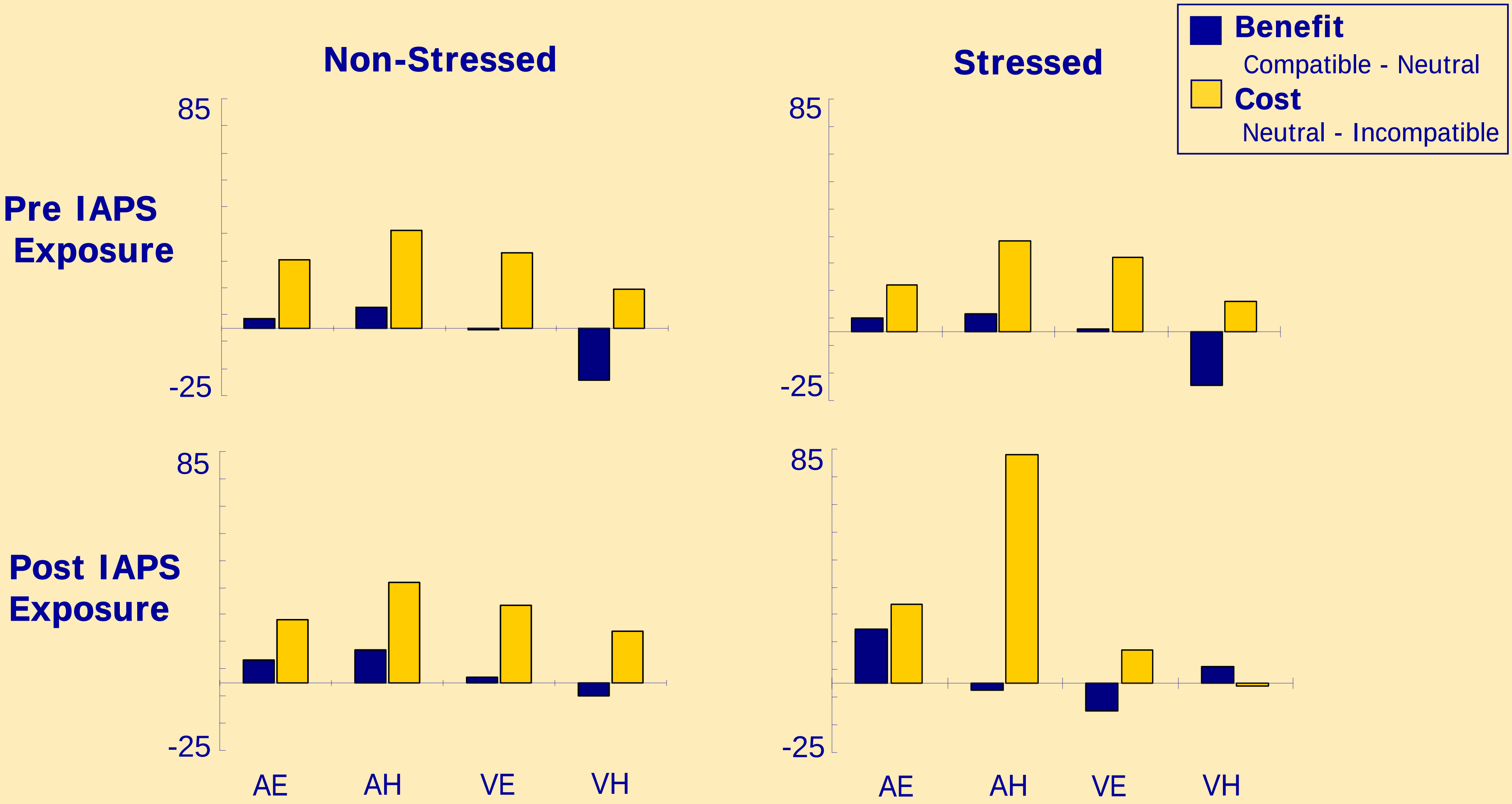
Under conditions induced stress

Auditory distractors produced greater benefits & costs during easy search, but only costs during hard searches

Visual distractors had little effect

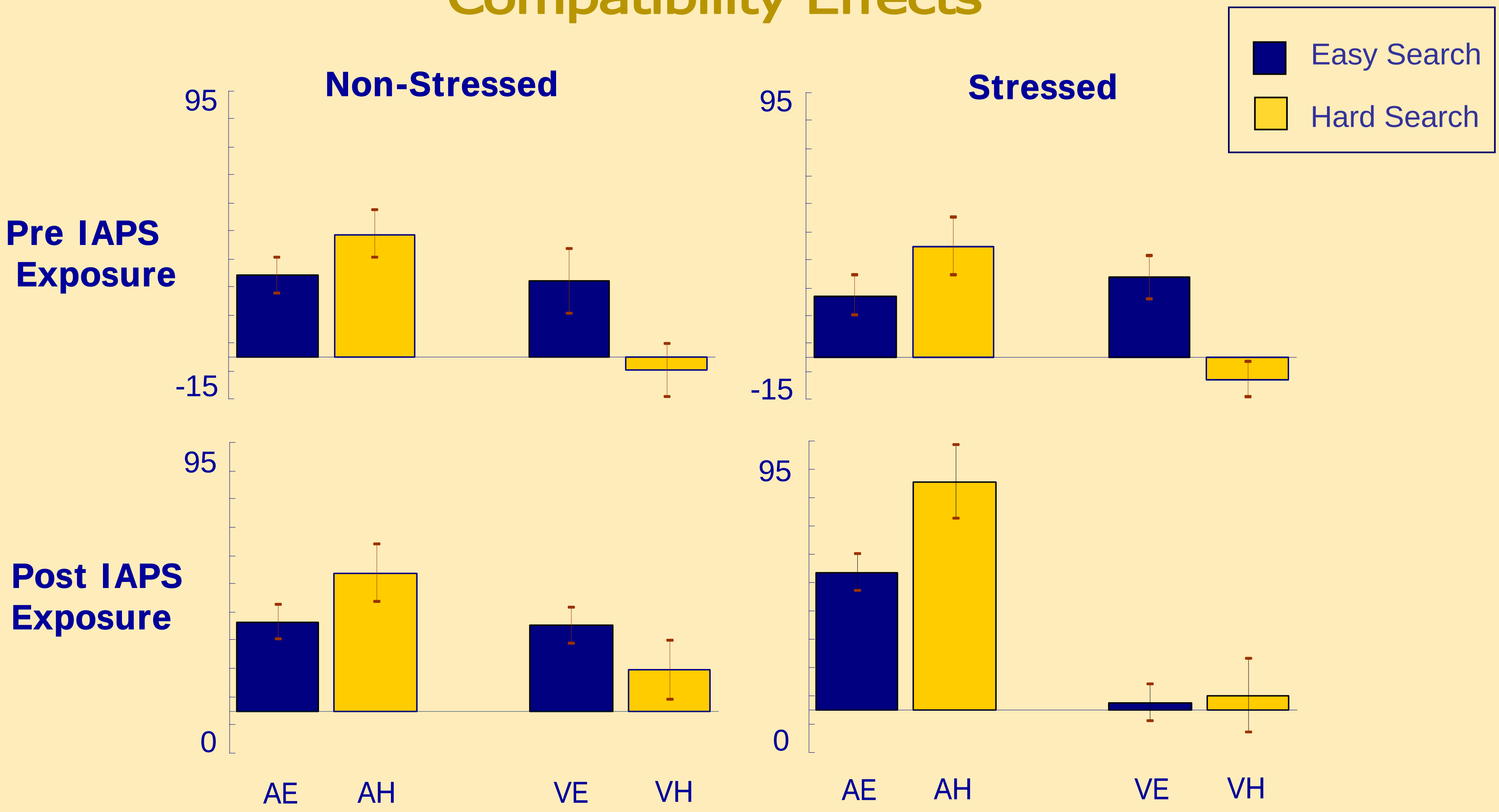
Results

Task Performance



Results

Compatibility Effects



Compatibility Effect = Mean RT for Compatible from Mean RT for Incompatible Trials

Conclusions

Modality effects on perceptual load in a visual search task differ when distractors are auditory versus visual.

Moreover, under conditions of induced stress, these differences are even more disparate.

In addition to processing information in the task-relevant modality, processing capacity may also be used to inhibit the processing of information in an irrelevant modality. Hence, when capacity is exhausted, as in the case of high perceptual load, visual distractors may be processed less, but auditory distractors may be inhibited less.

Consequently, irrelevant auditory information influences responses to visual stimuli and the magnitude of this response would be greater under conditions of high load and greater still under conditions of induced stress.