(2)

Recognition of Environmental Sounds

James A. Ballas

Center for Behavioral and Cognitive Studies
George Mason University
Fairfax, VA 22030

Final Report #ONR-89-1
Contract Period: June 1, 1987 to June 31, 1989

This research was supported by the Perceptual Science Program
Office of Naval Research.

November, 1989

Recognition of Environmental Sounds

James A. Ballas

Center for Behavioral and Cognitive Studies
George Mason University
Fairfax, VA 22030

Final Report #ONR-89-1
Contract Period: June 1, 1987 to June 31, 1989

This research was supported by the Perceptual Science Program
Office of Naval Research.

November, 1989

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No 0704-0188

1a REPORT SECURITY CLASSIFICATION: Unclassified	1b RESTRICTIVE MARKINGS: N. A.
2a SECURITY CLASSIFICATION AUTHORITY: N. A.	3 DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution unlimited
2b DECLASSIFICATION/DOWNGRADING SCHEDULE: N. A.	
4 PERFORMING ORGANIZATION REPORT NUMBER(S): Final Report ONR-89-1	5 MONITORING ORGANIZATION REPORT NUMBER(S): Same
6a NAME OF PERFORMING ORGANIZATION: George Mason University Dept. of Psychology; 6b OFFICE SYMBOL (If applicable):	7a NAME OF MONITORING ORGANIZATION: Office of Naval Research
6c ADDRESS (City, State, and ZIP Code): 4400 University Drive, Fairfax, VA 22030	7b ADDRESS (City, State, and ZIP Code): 800 N. Quincy Street, Arlington, VA 22217-5000
8a NAME OF FUNDING/SPONSORING ORGANIZATION: Office of Naval Research; 8b OFFICE SYMBOL (If applicable): Code 1142PS	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: N00014-87-K-0167
8c ADDRESS (City, State, and ZIP Code): 800 N. Quincy Street, Arlington, VA 22217-5000	10 SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO 61153N 42; PROJECT NO RR 04209; TASK NO 0420901; WORK UNIT ACCESSION NO 4424205

11 TITLE (Include Security Classification)
(U) Recognition of Environmental Sound

12 PERSONAL AUTHOR(S)
Ballas, J. A.

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Final	FROM 87/06/01 TO 89/06/30	89/11/15	12

16 SUPPLEMENTARY NOTATION

17 COSATI CODES		
FIELD	GROUP	SUB-GROUP

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Audition, Hearing, Classification, Complex Sound Choice Reaction Time, Identification.

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

Nine experiments were conducted, analyzed, and documented in the two-year period of this contract. The studies focused on two areas: 1) acoustic and perceptual-cognitive factors related to sound identification; and 2) the effects of context on identification of specific sounds. Results indicated that identification time and accuracy are related to causal uncertainty and to a construct called identifiability. Context was found to produce negative bias but not positive bias. Results were documented in five reports and sixoral presentations.

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION: Unclassified
22a NAME OF RESPONSIBLE INDIVIDUAL: John J. O'Hare	22b TELEPHONE (Include Area Code): (202) 696-4502; 22c OFFICE SYMBOL: Code 1142PS

DD Form 1473, JUN 86 — Previous editions are obsolete. — SECURITY CLASSIFICATION OF THIS PAGE

S/N 0102-LF-014-6603

Summary of Progress

Nine experiments were conducted, analyzed, and documented in the two-year period of this contract. The studies focused on two areas: 1) acoustic and perceptual-cognitive factors related to sound identification; and 2) the effects of context on identification of specific sounds. Results indicated that identification time and accuracy are related to causal uncertainty and to a construct called identifiability. This construct is broadly defined and includes factors that are antecedent to the identification process, such as the existence of a mental stereotype of a sound, as well as factors that describe the identification process itself, such as ease in forming a mental picture of the sound and ease in using words to describe the sound. Spectral acoustic variables computed on the sound as a whole are relatively minor factors in performance outcome and in perceived identifiability.

Context was found to produce negative bias but not positive bias. The results indicated that context could bias the response against the correct response, but did not raise performance above the level found in identifying the test sounds in isolation. Performance was consistently poorest in biased context and best in both isolated and consistent context. Performance in random context depended upon the paradigm and the performance measure. A signal detection analysis indicated that sensitivity in detecting a sound that is out-of-context remains constant for different paradigms, and that response bias is conservative, especially with a free response paradigm. Labels added to enhance context generally did not change the effects of context, suggesting that sounds alone are usually sufficient to generate these contextual effects.

Results of the research have been documented in the following reports:

Ballas, J. A. (1989). *Acoustic, and perceptual-cognitive factors in the identification of 41 environmental sounds.* (Tech. Rep.ONR-89-2).

Fairfax, VA: Center for Behavior and Cognitive Studies, George Mason University.

Ballas, J. A., & Mullins, R. T. (1989). *Effects of context on the classification of everyday sounds.* (Tech. Rep. ONR-89-1). Fairfax, VA: Center for Behavior and Cognitive Studies, George Mason University.

Ballas, J. A. (1987). *Implicit knowledge in the identification of environmental sound: causal uncertainty and stereotypy.* (Tech. Rep. ONR-87-2). Fairfax, VA: Center for Behavior and Cognitive Studies, George Mason University.

Ballas, J. A., & Barnes, M. (1988). Everyday sound perception and aging. In *Proceedings of the 32nd Annual Meeting of the Human Factors Society* (pp. 194-197). Santa Monica, CA: Human Factors Society.

Mullins, R. T. (1988). Causal uncertainty and contextual cues in the recognition of environmental sounds. In Proceedings *of the 32nd Annual Meeting of the Human Factors Society* (pp. 247-251). Santa Monica, CA: Human Factors Society.

Experiment 1

Everyday sounds were rated by listeners on a series of scales that assessed perceptual-cognitive dimensions found important in previous research on timbre judgments about everyday sounds and in research on recognition of single words. Three factors emerged in a principal components analysis: identifiability, timbre quality, and uniqueness. A cluster analysis of the 41 sounds using scores on these three factors produced four interpretable clusters. Factor scores on these factors were correlated with identification performance measures including identification time and accuracy. Acoustic analyses of the sounds were performed to determine the role of acoustic factors in identification performance.

Experiment 2

Previous studies had shown that a measure of causal uncertainty can be calculated from the alternative causes listeners give after hearing a sound, and that this measure correlates significantly with identification time, and direct estimates of the number of alternative causes. In this experiment, listeners were asked to generate alternative causes after reading a label describing the actual cause of the sound, but without hearing the sound. These alternative causes were used to calculate the measure of causal uncertainty. This measure did not correlate significantly with identification performance, suggesting that causal uncertainty is related to the acoustics of the sound, not to the nature of the cause.

Experiment 3

In several of the experiments in this project, a set of 41 sounds has been used. Reviews of the research have questioned the discriminability of these sounds, suggesting that some results were due to the discriminability of the stimuli. An ABX discrimination was conducted to assess the discriminability of every possible pair (n=820) within the set of 41 sounds. The order of the pairs was determined randomly. Two listeners made ABX judgments with feedback. Performance was 99.8% for both listeners, which was two errors in 820 judgments. None of the errors involved similar pairs of sounds, and the listeners reported that they resulted from an attention lapse. Thus the sounds *are easily discriminable.*

Experiment 4

The effect of causal probability on identification time had been previously tested in a priming study in which a possible cause is presented before the sound, and the listener is asked to judge whether the sound could have been produced by the primed cause. In this experiment, the joint effect of causal probability and sound stereotypy was tested. Two levels of probability were combined with two levels of sound stereotypy, in a priming paradigm. Typical and non-typical sounds were defined using descriptions and imitations of stereotypical versions of sounds, and were verified by ratings of typicality from independent listeners. Results indicated that both variables have a significant effect on identification time.

Experiments 5-9

This series of experiments examined the effects of context on identification of sounds. Context was generated in two ways: 1) by embedding the sound within a series of other everyday sounds; and 2) by providing the listener with a phrase describing the environmental scene in which the sound could occur. Three types of context conditions were used, consistent with the correct identification, inconsistent with the correct identification (but consistent with an alternative identification), and neutral with a random arrangement of sounds. The results indicated that context could bias the response against the correct response, but did not raise performance above isolated classification performance. Performance was consistently poorest in biased context and best in both isolated and consistent context. Performance in random context depended upon the paradigm and the performance measure. In the free response paradigm, biased sequences produced responses that were appropriate for the context but incorrect as classifications of the sound. A signal detection analysis indicated that sensitivity in detecting a sound that is out-of-context remains constant for different paradigms, and that response bias is conservative, especially with a free response paradigm. Labels added to enhance context generally did not change the effects of context, suggesting that sounds alone are usually sufficient to generate these contextual effects.

Report Abstracts

Ballas, J. A. (1989). *Acoustic, and perceptual-cognitive factors in the identification of 41 environmental sounds.* (Tech. Rep.ONR-89-2). Fairfax, VA: Center for Behavior and Cognitive Studies, George Mason University.

This paper addresses acoustic and perceptual-cognitive factors that correlate with aspects of identification performance. A previous study produced causal uncertainty values and identification times for 41 scunds. Acoustic attributes of the sounds and perceptual-cognitive ratings of the sounds were correlated with the uncertainty values and identification time. In addition, the ratings were correlated with the acoustic measures. Factor analyses of the perceptual-cognitive judgments and the acoustic attributes were also performed. Cluster analyses of the sounds using the factor scores and an index of causal confusion were performed. Results showed that identification time is related to causal uncertainty, to a perceptual-cognitive factor which incorporates aspects of perceived identifiability, and to some acoustic attributes of the sounds. The cluster analyses produced a cluster of water related sounds, a cluster of impact sounds, and other clusters depending on the variables being clustered.

Ballas, J. A., & Mullins, R. T. (1989). *Effects of context on the classification of everyday sounds*. (Tech. Rep.ONR-89-1). Fairfax, VA: Center for Behavior and Cognitive Studies, George Mason University.

The effects of context on the classification of everyday sounds was examined in five experiments. Context was produced by meaningful sounds and by phrases describing an environmental scene. All experiments presented listeners with pairs of test sounds that are confused in identification, but which are discriminable. These test sounds were presented for classification in isolation, and embedded in sequences of other everyday sounds. Three types of embedding sequences were used: 1) sequences consistent with the correct response; 2) sequences biased toward an incorrect choice; and 3) neutral sequences composed of randomly arranged sounds Two paradigms, binary-choice and free classification were used. The results indicated that context could bias the response against the correct response, but did not raise performance above isolated classification performance. Performance was consistently poorest in biased context and best in both isolated and consistent context. Performance in random context depended upon the paradigm and the performance measure. In the free response paradigm, biased sequences produced responses that were appropriate for the context but incorrect as classifications of the sound. A signal detection analysis indicated that sensitivity in detecting a sound that is out-of-context remains constant for different paradigms, and that response bias is conservative, especially with a free response paradigm. Labels added to enhance context generally did not change the effects of context, suggesting that sounds alone are usually sufficient to generate these contextual effects.

Ballas, J. A. (1987). *Implicit knowledge in the identification of environmental sound: causal uncertainty and stereotypy*. (Tech. Rep. ONR-87-2). Fairfax, VA: Center for Behavior and Cognitive Studies, George Mason University.

Two aspects of listeners' implicit knowledge about environmental sound were investigated: multiple causality and stereotypy. Several studies have demonstrated that the time required to identify an environmental is a function of the number of alternative causes, which defines causal uncertainty (CU). The procedure used to estimate causal uncertainty requires the collection and sorting of identification responses from a group of listeners. The number of unique responses is then used to calculate CU. Because the cognitive process implied by the role of CU assumes that listeners are informed about alternative causes, it was hypothesized that they might be able to directly estimate the number of alternative causes. In the first experiment, listeners were asked to estimate the number of alternative causes for a sound. These estimates correlated significantly with previous estimates of CU and sound identification times obtained from different listeners. In a second experiment listeners were given anchors for the number of possible causes of the sounds based upon the results of previous research. With anchors, the range of the estimates increased. These estimates correlated significantly with previous estimates of CU including estimates from the first experiment. Correlation of these estimates with identification time was significant but not different from the first experiment. Results from both experiments demonstrated the reliability of CU for specific sounds with changes in methods and listeners.

Previous work has shown that the time required to verify the category of a word is related to both the conjoint frequency of the category label and the word as well as the typicality of the word as a member of the category. The first effect has been found with sound identification in testing for the time taken to verify a cause of a sound; less probable causes take longer to verify. The second effect would require manipulation of the typicality of the sounds. In order to manipulate typicality in a later identification experiment, listeners were asked to describe their stereotypical notions of 20 sounds, both in words and by imitation of the sounds. Analysis revealed that the sounds varied in strength of stereotypy. For later research, the characteristics of stereotypical tokens of these sounds were obtained.

Ballas, J. A., & Barnes, M. (1988). Everyday sound perception and aging. In *Proceedings of the 32nd Annual Meeting of the Human Factors Society* (pp. 194-197). Santa Monica, CA: Human Factors Society.

Age related hearing loss is extensively documented in both longitudinal and cross-sectional studies but there are no direct studies of the ability of older persons to perceive everyday sounds. There is evidence suggesting some impairment. Vanderveer (1979) observed that older listeners had difficulty interpreting environmental sounds but did not report any performance data. Demands imposed by the stimulus properties of this type of sound and by the perceptual and cognitive processes found to mediate perception of this sound in college-aged listeners may present difficulty for older listeners. Forty-seven members of a retired organization were given a subset of sounds that had been used in previous identification studies. *H* values for the same set of sounds had been previously obtained from high school and college students (Ballas, Dick, & Groshek, 1987). The ability of the aged group to identify this set of sounds was not significantly different from the ability of a student group. In fact, uncertainties were closely matched except for a few sounds. Directions for future research are discussed.

Mullins, R. T. (1988). Causal uncertainty and contextual cues in the recognition of environmental sounds. In Proceedings *of the 32nd Annual Meeting of the Human Factors Society* (pp. 247-251). Santa Monica, CA: Human Factors Society.

Previous research has supported the hypothesis that the recognition of environmental sounds is complicated by uncertainty caused by the number of potential causes of that sound. In natural settings, contextual cues often help to specify the source of ambiguous sounds. This proposes the question of whether contextual cues can overpower auditory information to establish causal certainty of otherwise ambiguous environmental sounds. A study was conducted to examine this possibility. The results showed that contextual cues could have powerful effects on the judgment of the causal event of auditory stimuli. This result could have implications for tasks which are dependent on discrimination of auditory events. In particular, if a discrimination between two auditory events is critical, the effects of auditory context suggest that two or more possible alternatives might be indistinguishable in context and should be isolated for purposes of contrast.

Oral Presentations

Ballas, J. A. (1989). Identification of everyday sounds. Presentation at the Information Technology Division, Naval Research Laboratory, Washington, D. C.

Ballas, J. A. (1988). Everyday sound perception and aging. Presentation at the 32nd Annual Meeting of the Human Factors Society, Anaheim, CA.

Mullins, R. T. (1988). Causal uncertainty and contextual cues in the recognition of environmental sounds. Presentation at the 32nd Annual Meeting of the Human Factors Society, Anaheim, CA.

Ballas, J. A. (1988) Perception of everyday sounds. Presentation to the Northern Virginia Chapter, National Association of Retired Federal Employees, Vienna, VA.

Ballas, J. A. (1987). Causal inference in the identification of environmental sounds. Presentation to the Department of Psychology, George Mason University, Fairfax, VA.

Ballas, J. A. (1987). Failure to identify "identifiable" sounds. Presentation at the 31st Annual Meeting of the Human Factors Society, New York, NY.

Future Research

Much has been learned about the identification of everyday sounds in this project and the one which preceded it. The contributions are methodological, empirical, and theoretical. Methodologically, for example, a variety of established paradigms have been applied effectively to the study of everyday sound identification. Empirically, a clustering of everyday sounds on acoustic and perceptual-cognitive dimensions has been produced, and a study of a wide variety of everyday sounds that combined data in three domains, acoustic analyses, identification performance, and perceptual-cognitive ratings has been completed.

Theoretically, the studies have provided additional insight into the nature of the identification process itself. Three factors were significantly correlated to identification time and accuracy: causal uncertainty, sound typicality, and perceived identifiability. Causal uncertainty is calculated from the identification responses and is a measure of response equivocation. It is thus an outcome of the identification process. That is, as identification responses to a sound become more variable, calculated causal uncertainty increases. On the other hand, the responses have been found to be reasonable and not wild guesses, and thus reflect the listener's knowledge about alternative causes. Thus the measure is also an outcome of prior experience with sound and its causes. A reasonable inference is that causal uncertainty relates to performance because sounds with higher values of causal uncertainty have a larger number of potential causes.

The studies also demonstrated that sound typicality--the degree to which a sound matches the stereotype--relates to identification time. This variable is one component of a construct called perceived identifiability. The construct was defined broadly, and included variables related to the antecedents of the identification process (existence of a mental stereotype) as well as outcomes of the identification process (ease in describing the sound in words, ease in forming a mental picture of the event causing the sound). The separation of these components--antecedents verses outcomes--is important in forming a theory of everyday sound identification. One factor that was established as influencing the outcome of identification was context. Surrounding sounds and descriptive labels for the scene will bias identifications of single sounds toward the meaning of the context.

The research confirmed the assessment of Warren and Verbrugge (1984) that spectral variables computed on the sound as a whole will relate weakly to identification performance. Acoustic analysis must focus on temporal-spectral variables, aimed at developing an event-based analysis of the acoustics of everyday sound and address the question of how events are encoded in acoustic information. There is little known about the acoustics of events, especially in the psychological literature. Much of the research has used average spectral properties to characterize the acoustics of the sound. This research has shown that acoustic properties important for identification are not captured in average spectral analyses such as a 1/3 octave profile of the sound as a whole, or discrete properties such as the peak amplitude. Future analysis should take two directions, one which focuses on identifying acoustic segments associated with event identification, and one which focuses on temporal-spectral pattern analysis, commonly used in speech research.

Two approaches are available to define the segments associated with events. The first is the gating paradigm used in speech research (e.g., Elliott, Hammer, & Evan, 1987; Luce, 1986; Warren & Marslen-Wilson, 1987). The second is a computational approach based upon measures of spectral change (e.g., Chen, 1983) . Each might be successfully used. In the gating paradigm, the speech signal is presented to the listener incrementally from the beginning. The listeners task is to report what they think the word is or will be once they hear the complete word. The task is used to determine the point at which the sound uniquely specifies the correct word. This point is called the *uniqueness point* or *optimal discrimination point.* In speech research, the paradigm is used to assess the role of accumulating speech cues in word recognition. To assess the encoding of events in everyday sound, the procedure could be modified to not only continually increment the signal, but also to move the starting position of the gate. In this manner, one could isolate segments important for event identification that are in the middle or end of the sound.

Several analyses could be used to determine the acoustic properties of an event segment. Spectrograms of the segments should be analyzed to determine the dynamic spectral properties within the segment, and specific to the segment compared to the surrounding wave. Once the spectral and temporal properties of an event segment have been tentatively identified, these properties should be used to define parameters to synthesize the sound. The synthesized sounds should be tested for identification to validate the definition of the acoustic properties in the segment that convey event information.

A second approach is to segment the sound using segmentation algorithms. Chen (1983) reports that an entropy distance measure produces good segmentation of transient signals. This measure is $d = -\ln l$ where l is the likelihood ratio (of the joint likelihood functions of the two segments being compared) that they have identical autoregressive models. Segments determined using this approach could be compared to the segments found psychophysically. The results should produce an understanding of the acoustic elements necessary for the identification of the selected sounds. Follow-up studies could use the same procedure but with different sounds selected on the basis of the clustering results from these studies and additional work that identifies other clustering schemes.

With a better understanding of the dynamic acoustic properties that are important for sound identification, progress can be made in developing a theory of everyday sound perception. Although this theory might be patterned after current theories of visual pattern perception or theories of speech perception, it is likely a hybrid theory might be required because of the wide variety of everyday sounds. Theoretical explanations for the recognition of some sounds might be different from explanations for the recognition of others. For example, the recognition of signalling sounds such as a telephone ringing might be a envelope matching process whereas the recognition of impact sounds might involve analysis of subtle spectral features to determine the density and form of the objects impacting. Identification of sounds with high causal uncertainty may require reference to contextual information. Other aspects of a hybrid theory may involve stages of analysis. For example, if the categories found in this research imply a hierarchical identification process then initial stages of identification may be based upon an analysis of envelope to distinguish impact events from continuous events, and later stages of to specify the type of event within the category.

Personnel

James A. Ballas
Principal Investigator

R. Timothy Mullins
Graduate Research Assistant

Blair Dodds
Graduate Research Assistant

Stuart Gittleman
Graduate Research Assistant

References

Ballas, J. A., Dick, K. N., & Groshek, M. R. (1987, October). Failure to identify "identifiable" sounds. *Proceedings of the 31st Annual Meeting of the Human Factors Society* (pp. 144-146). Santa Monica, CA: Human Factors Society.

Chen, C. H. (1983). Pattern recognition processing in underwater acoustics. *Pattern Recognition*, **16**(6), 627-640.

Elliott, L. L., Hammer, M. A., & Evan, K. E. (1987). Perception of gated, highly familiar spoken monosyllabic nouns by children, teenagers, and older adults. *Perception & Psychophysics*, **42**(2), 150-157.

Luce, P. A. (1986). A computational analysis of uniqueness points in auditory word recognition. *Perception & Psychophysics*, **39**(3), 155-158.

Vanderveer, N. J. (1979). Ecological acoustics: Human perception of environmental sounds. *Dissertation Abstracts International*, **40:** 4543B. (University Microfilms No. 8004002)

Warren, P. & Marslen-Wilson, W. (1987). Continuous uptake of acoustic cues in spoken word recognition. *Perception & Psychophysics*, **41**(3(, 262-275.

Warren, W. H., & Verbrugge, R. R. (1984). Auditory perception of breaking and bouncing events: A case study in ecological acoustics. *Journal of Experimental Psychology: Human Perception and Performance*, **10** , 704-712.

1989/06/21

Technical Reports Distribution List

Dr. Earl A. Alluisi
OUSDR (A)/R&A(E&LS)
Pentagon 3D129
Washington, DC 20301-3080

Mr. Charles Bates
Director, HE Division
USAF AAMRL/HE
WPAFB, OH 45433

Dr. Kenneth R. Boff
AAMRL/HE
WPAFB, OH 45433

Mr. Luiz Cabral
Naval Underwater Sys. Ctr.
Code 2212
Bldg 1171/1
Newport, RI 02841

Cdr. Robert C. Carter USN
Naval Research Laboratory
Code 5530
Washington, DC 20375-5000

Dr. Stanley C. Collyer
Office of Naval Technology
Code 222
800 N. Quincy Street
Arlington, VA 22217-5000

Commanding Officer
Naval Biodynamics Lab
Michoud Station
Box 29407
New Orleans, LA 70189

Commanding Officer
Navy Health Research Ctr.
P.O. Box 85122
San Diego, CA 92138

Commanding Officer
Navy Personnel R&D Center
San Diego, CA 92152-6800

Director
Technical Information Div.
Code 2627
Naval Research Laboratory
Washington, DC 20375-5000

US Naval Test Center
Aircrew Systems Branch
Systems Engineering Test
Directorate
Patuxent River, MD 20670

Commanding Officer
Naval Weapons Center
Human Factors Branch
Code 3152
China Lake, CA 93555

Dr. Michael Letsky
Office of the Chief of
Naval Operations
OP-01B7
Washington, DC 20350

Dr. Thomas E. Hanna
Naval Sub Med Res Lab
Behavioral Scienced Dept
Naval Submarine Base
Groton, CT 06349-5900

Prof. James H. Howard, Jr.
Department of Psychology
Human Performance Lab
Catholic University
Washington, DC 20064

Dr. Edgar M. Johnson
Technical Director
US Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333-5600

Capt T. E. Jones, MSC, USN
Aviation Medicine & Human
Performance (Code 404)
Naval Medical R & D Cmd
National Capital Region
Bethesda, MD 21814-5044

Dr. Michael Kaplan,
Director, Office Basic Res
US Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333-5600

Office of Naval Research
Perceptual Science Program
Code 1142PS Rm 823
800 N. Quincy Street
Arlington, VA 22217-5000
(3 copies)

Dr. Jesse Orlansky
Inst. for Defense Analyses
1801 N. Beauregard Street
Alexandria, VA 22311

Lt. Dennis McBride, USN
Pacific Missile Test Center
Human Factors Branch
Pt. Mugu, CA 93042

Dr. W. A. Rizzo
Head, Human Factors Div.
Naval Training Systems Ctr
12350 Research Parkway
Orlando, FL 32826-3224

Prof. James A. Simmons
Department of Psychology
Brown University
Providence, RI 02912

LCdr. Timothy Singer, USN
Naval Air Development Ctr
Human Factors Engrg Div.
Warminster, PA 18974

Mr. Nelson F. Steele
Advanced Res Dev Corp
5457 Twin Knolls Road
Columbia, MD 21035

Defense Tech. Info. Center
Cameron Station, Bldg 5
Alexandria, VA 22314
(2 copies)

Dr. Robert A. Fleming
Naval Ocean Systems Center
Human Factors Support Grp.
1411 South Fern Street
Arlington, VA 22202-2896

Mr. Dan Greenwood
Netrologic, Inc.
5080 Shoreham Place
Suite 201
San Diego, CA 92122

Jeffrey Grossman
Naval Ocean Systems Center
Code 4403
Bldg. 334
San Diego, CA 92152

Naval Aerospace Medical
Research Laboratory
Sensory Division Code 23
Pensacola, FL 32508

Commanding Officer
Naval Air Systems Command
Crew Station Design
NAVAIR 5313
Washington, DC 20361

Dr. John Tangney
AF Office of Sci. Res.
Life Sciences Directorate
Bldg. 410
Bolling AFB, DC 20332-6448

Dr. Martin A. Tolcott
Decision Science Consortium
1895 Preston White Drive
Suite 300
Reston, VA 22091-4369

Dr. Harold P. Van Cott
Committee on Human Factors
NAS-National Res. Council
2101 Constitution Ave., N.W.
Washington, DC 20418

Dr. Charles S. Weaver
MAXIM Technologies, Inc.
3000 Patrick Henry Drive
Santa Clara, CA 95054

Dr. John Weisz
Technical Director
US Army Human Engineering
Laboratory
Aberdeen P. G., MD 21005

Dr. Milton A. Whitcomb
NAS-National Res. Council
CHABA
2101 Constitution Ave., N.W.
Washington, DC 20418

Prof. Gregory R. Lockhead
Department of Psychology
Duke University
Durham, NC 27706

Dr. Richard Loutitt
National Science Foundation
Division of Behavioral &
Neural Sciences
1800 G Street, N. W.
Washington, DC 20550

Capt. William Moroney, USN
Naval Air Development Ctr
Code 602
Warminster, PA 18974

Dean of the Academic Dept.
U. S. Naval Academy
Annapolis, MD 21402-5018

Office of the Chief of
Naval Operations
OP-933D3
Washington, DC 20350-2000

Office of Naval Research
Special Asst. for Marine
Corps Matters
Code 00MC
800 N. Quincy Street
Arlington, VA 22217-5000