Target Effects Based Requirements Generation
The Role of the ARDEC Target Behavioral Response Laboratory

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DEFINING SCALEABLE EFFECTS WEAPONS

ARDEC Target Behavioral Response Laboratory

TECHNICAL POSSIBILITIES
FROM DEVELOPERS
- R&D Labs
- COTS

WHAT MUST BE ACCOMPLISHED
FROM THE USERS
- Military Services
- Law Enforcement

ACTUAL TARGET EFFECTS DATA
FROM ARDEC-TBRL

REQUIREMENTS
CAPABILITIES
EFFECTS
UTILITY
UNDERSTANDING HOW PEOPLE RESPOND...

ARDEC TARGET BEHAVIORAL RESPONSE LABORATORY

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CURRENT PROGRAMS

- GRANT TO STUDY SUPPRESSION TECHNIQUES
- DEVELOP MATRIX OF POTENTIAL PERSONNEL EFFECTS FROM VARIOUS ENERGY SOURCE PILOT EXPERIMENTS
- STUN EFFECTS
- OBSCURATION/ LIGHT SOUND
- AVERSIVE ACOUSTIC EFFECTS
- BLUNT IMPACT MUNITION EFFECTS

CAPABILITIES FOR FUTURE WORK

- MULTI-LEVEL FACILITY OR AREA PROTECTION SYSTEMS
- TACTICAL FOG APPLICATIONS FOR MAN-PORTABLE AND NLOS DELIVERY
- CAPABILITY FOR STUDY OF CHRONIC STRESS, FATIGUE AND SUSTAINED PERFORMANCE
SUPPRESSION:
The degree of inability to carry out a task effectively because of a physical or psychological response.
Suppression: Heuristic

- Initial State
- INTERVENTION
- Simple Effects
- OUTCOME
Effects

- **Sensory**
  - Primary Senses
  - Pain
  - Perception

- **Cognitive**
  - Concentration
  - Command
  - Communication
  - Attention

- **Emotion**

- **Motor Activity**
Outcomes

- Accumulation of Simple Effects
  - Accretive
    - Additive
    - Multiplicativ
  - Negating

- Metrics
  - Proportion
  - Degree
  - Latency

- Evaluated with Respect to Task Goal
  - Drive away
  - Make remain
  - quiet
Program Directions

Technologies $\rightarrow$ Simple Effects $= \text{Outcome}$

Technologies $\rightarrow \Sigma \text{Simple Effects} = \text{Outcome}$
Critical Needs:

**Empirical Data**

**Experimental analogs**

- Specific to different initial states
  - Problem without bounds?
- Individual behavior
- Crowd behavior

**Ethics**

- Human
- Animal

**Setting**
The TBRL Laboratory Team

- **The Target Behavioral Response Laboratory (TBRL):** ARDEC personnel collaborating with scientists and MDs.

- Collaborations currently established with the VA New Jersey Health Care System-East Orange and other institutions.

- **The TBRL will provide effects DATA to:**
  - Use in development of requirements
  - Support effectiveness, modeling, safety and training issues
  - Support weapon development, testing and fielding
Effects: Collaborating Labs

Scientific experiments “fill the gaps” in knowledge of basic effects

- No specific relationship to “weapons”
- Single individuals
- Environments and manipulations limited to institutional laboratories
  - VA NJHCS-EO
  - Affiliated institutions
Effectiveness: ARDEC Site

Application experiments at ARDEC

- Addresses OUTCOME of effects through demonstrations and experiments
- Up to groups of 20-30 people
- Significant environments and manipulations possible (within limits of approved protocols)
- Closer to realistic situations
- Protocol approval through the Medical Research and Materiel Command at Ft. Detrick
Motion Tracking System

Vicon Motion Systems

- Small lightweight markers
- Tracked and recorded in 3D space
- Accurate joint angles are quickly and conveniently reported.
Physiological Data Collection

- Electrophysiology
  - Electrocardiogram (ECG)
  - Electroencephalogram (EEG)
- Respiration
- Temperature
- Skin Conductance
- Blood Pulse Volume (BPV)
- Blood Pressure
Current Experiments

Customer Projects
- Stun for USMC (predates TBRL formation)
- Blunt Impact Target Effects for PM-CCS (first TBRL effort)

ARDEC-funded Pilot Projects which were recommended from the initial SMBI studies
- Aversive Acoustic
- Obscurants w/Light & Sound
Paintball Marker Array

An array: a horizontal linear mounting of 8 semi-automatic paintball markers, computer controlled:

- Synchronous Fire
- Random Fire
- Cued Fire
- Single or Semi-automatic
Synthetic Fog:

Deionized water, propylene glycol, and glycerol
Produced by an electro-mechanical unit that contains a heating exchanger
Rate: 30,000 feet³/min
A large room fills in 30 sec
Strategy

- Phase Ia - Determine the safety of synthetic fog for extended period
- Phase Ib – Determine changes in perception of light and sound in fog
- Phase Ic - Determine the physics of fog and its interaction with varying levels of light and sound
- Phase II - Determine psychophysiological impact of synthetic fog in combination with light and sound
TACTICAL FOG - A Non-Toxic obscurant for tactical and training use

Indirect-fire-delivered tactical fog cloud is placed immediately on a group of mixed combatants and non-combatants severely limiting their capability to maneuver and shoot.

Man-portable tactical fog cloud is placed into an enclosed space on a group of mixed combatants and non-combatants severely limiting their capability to maneuver and shoot.

Individuals are easily separated and put under control.
Stress and Motivated Behavior Institute
New Jersey Medical School
NeuroBehavioral Research Laboratory
VA New Jersey Health Care System, East Orange, New Jersey

Stun Effects of Flash-Bang Munitions: After Images on Saccadic Eye Movements

J.B. Crabbe, Ph.D.
Kevin Beck, Ph.D.
Tara Alvarez, Ph.D.
Rick Servatius, Ph.D.

Research supported by the Department of Defense
Questions

Flash-bang grenades cause momentary stun effects

What energies produced by flash-bang grenades cause changes in behavior that could be produce a “stun-like” reaction?

Are there other means of causing similar suppression in behavior by changing the energy characteristics of the stimuli?

How does the stun occur?
Light Exposure: No Sound

Martin Professional: MiniMac Profile
(150 W / 1950 lumens)

Distance (m or ft)

Illuminance (lux or fc)
Light Flashes: Varying Locations
Video Games

Accuracy to hit specific stimulus-classes

Accuracy to hit a specific stimulus-type
Outcomes:

Performance was diminished by white light flashes:

*Latency* to shoot when “flashed” with white light was increased more than 50% in 7 / 20 volunteers

*Accuracy* was reduced in the dynamic class identification task from 38.5% to 20% (4 out of 20)
Hypothesis: Visual Tracking Is Disabled by Flash (i.e., WHY?)

Eyes must fixate on a target when aiming.
If a light flash changes the timing or speed characteristics of visual tracking movements this will yield information to improve devices that disrupt or stun human performance.

The goal of this line of research is to understand these changes to promote increased delay and/or decreased speed in target acquisition.
Experiment:
Light Effects on Saccade

Control: No Flash saccade
15 deg left or right

Saccade Right (pos)
Saccade Left (neg)
Initial Target

Flash Center saccade
15 deg left or right

Flash Right Visual Field saccade 15 deg left or right

Flash Left Visual Field saccade 15 deg left or right
Limbus Infrared Eye Movement Monitor

[Diagram showing infrared emitting diodes and photodetectors]
Time to ± 1 deg of Target

Right Saccade No Flash Subj:001

Right Saccade Right Flash Subj:001
Subjective Reports

- "Targets Disappeared" when the flash was to the side where target movement occurred.
- Report of "disappearance" of target increased for multi-flash compared to single flash stimuli.
- One subject S004 who does not show substantial changes stated he plays a lot of "first person shooter" video games that have a "flash bang" device.
Outcome

White flash(es) affect the amount of time for subjects to acquire target within +/- 1 deg of stimulus.

Stimuli with flashes required approximately 2 seconds to be within +/- 1 deg of stimulus target where controls required only 1 second.
Development of Aversive Audible Sounds

J.B. Crabbe, Ph.D.
Bronya Vaschillo, M.D.
Evgeny Vaschillo, Ph.D.
Rick Servatius, Ph.D.

Research supported by the Department of Defense
Main Goal

Develop universally aversive sounds for use as a non-lethal weapon against terrorists, to disperse a crowd etc.
Universally Aversive Sounds

- Should be stressful enough to elicit an escape response (terminate the sound).
- Should elicit an escape response in at least 80% of exposed people.
Escape response determines sound aversiveness

- **Press Button Rate**: % of subjects who stopped the sound
- **Latency**: Time passed before terminating
Initial Goals

- Understand what features of a sound make it aversive
- Investigate and characterize behavioral, psychological, and physiological responses to pleasant, unpleasant and aversive sounds
- Investigate physical structure of sounds.
25 Sounds / 2 Sets

**Set 1:** 16 environmental sounds (pleasant, neutral, and unpleasant).

**Set 2:** 9 synthetic sounds chosen as the most unpleasant from 362 sounds created in our lab.

*All 25 sounds played through headphones at the intensity of 82 dB.*
Examples of Sounds

Dentist Drill Reversed
Examples of Sounds

 Synthetic
Methods

- Sixty-five participants
- Instructed to listen to the sound for 120 seconds
- Could terminate the sound at any time for any reason
- Recorded behavioral, psychological, and physiological responses to define the features of aversive sound
Synthetic sounds were significantly less recognizable, had significantly higher press button rate and shorter latency than environmental unpleasant sounds.
Some Initial Conclusions

- Sounds with lower recognition had higher aversiveness.
- Sounds with infrasound components were most aversive.
- Aversive behavior does not necessarily relate to unpleasantness rating.
Next Step

- Evaluate aversive sounds in open space.
- Determine the differences in responses to sounds between headphone and speaker presentation.
Methods

- Twenty-two participants
- Presented the same 25 sounds at 82 dB via
- Four speakers placed around the subject at the same distance and at head level.
Headphones and open space sounds were rated by subjects as equally unpleasant.
Results

Sounds in *open space* elicited aversive activity almost *twice as much* as the same sounds via headphones.
Conclusions

- The same sounds in open space were more aversive than from headphones.
- Most aversive sound presented in open space, press button rate was 63 %, latency was 25.7 s.
- The same sound emitted from headphones, press button rate was 40 %, latency was 48.2 s.
Future Directions

- Sound intensity (102 dB)
- Infrasound (brain waves)
- Effect on task cognitive and physical performance
- Effect on physiological processes, e.g., cardiovascular
Thank You

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Additional Slides
Single White Flash Time (sec) when person is within +/- 1 deg of target

All Subjects
Multi White Flash Time (sec) when person is within +/- 1 deg of target

All Subjects

Flash Protocols

Time When +/- 1 Degree from Target

N=164  N=182  N=168  N=172  N=164  N=175  N=170  N=165  N=140  N=151

RS NF Con  LS NF Con  RSNF  RSRF  RSCF  RSLF  LSNF  LSLF  LSCF  LSRF