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13. SUPPLEMENTARY NOTES

14. ABSTRACT

Painful blunt impact from a low-mass, high-speed projectile has been considered as a possible non-lethal weapon for deterring weakly- or moderately-motivated approach toward protected locations. The potential effectiveness of blunt impact as an avoidance motivator or approach deterrent was tested in an experiment in which human volunteers were asked to approach a protected site under both non-threat conditions and paintball repeated-threat conditions. No incentive was offered for completing the approach and shooting task. The motivation for escape or avoidance was manipulated by varying the threat of blunt impact from a paintball at three levels: no threat, a hit from a single gun during each approach, and potentially multiple hits during each approach from a multi-gun array. Blunt impact compelled only 25% of subjects to escape (i.e. to terminate their participation in further approaches). The threat of blunt impact did not increase avoidance, induce hesitation, nor impair shooting accuracy. Blunt impacts produced varied pain ratings, but pain was not a predictive factor in any escape, avoidance, or performance measure. Subjects who chose not to continue their approach trials did not differ on any measure from those who completed all approach trials under threat. Prior paintball experience did not predict escape likelihood. Probable selection biases suggest that these results best generalize to intrinsically motivated individuals who are not risk-averse and may be familiar with blunt impact pain.

15. SUBJECT TERMS
Non-lethal weapons, blunt impact, pain, escape, avoidance, evasion, threat, paintball, motivation, intrinsic motivation, extrinsic motivation, projectile, human behavioral experimentation, human behavior, Target Behavioral Response Laboratory

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Can Repeated Painful Blunt Impact Deter Approach Toward a Goal?

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Introduction

- Military commanders would like a non-lethal, minimally-injurious blunt impact force to deter targeted individuals from approach
- Apply Field Theory, which portrays environment as a force that pulls and pushes the person to behave according to changing motivation gradient
- Question: What painful blunt impact force is required to control individuals' movements & approach/avoidance choices?
- A prior study had been conducted that incorporated:
  - explicit social and monetary rewards
  - more layers of protection and shot paintballs to blanket area, from greater distance, at lower velocity
  - But very few people escaped!
- This study uses blunt impact tools in a way no recorded study has. It serves an important exploratory and follow-up purpose:
  - Assess the effectiveness of blunt impact force on deterrence
  - Use greater force, on people who are not rewarded for approaching, in a simple approach task, with more blunt impact hits on subjects.

Method

Figures 1 & 2: Long narrow approach arena with paintball threat at far end & subject's targets & shooting stations along the way

Figures 3 & 4: Approach end of arena with single & multiple paintball threat sources, feedback screen, subject shooting stations, & targets

Procedure

- Approach:
  - participant traversed four locations
  - used paintball gun to shoot targets at each location
- Approach Motivation:
  - no tangible incentive – same compensation if stopped immediately
  - undefined "points" awarded for speed & accuracy
- Avoidance Motivation: Subjects were shot at with paintballs on some trials
  - Three threat levels:
    - No threat (Level 0)
    - Single shot per traverse (Level 1)
    - Multiple, clustered shots (3) per traverse (Level 2)
- Subjects were only hit while traversing, not while at shooting station
- Each subject repeated up to 2 of each threat trials and 3 no-threat trials

Method (cont.)

Subjects

- Twenty males between ages 18-52 volunteered, from all walks of life
- Full range of age, shooting, & paintball experience
- All subjects consented
- Wearing only t-shirt & jeans (head & groin protected)

Figure 5: Subject approaching threat area, traversing from one shooting station to the next, and vulnerable to paintball hits from marksman.

Figure 6: Subject (right) shooting at targets. Marksman's station (paintball threat source) with single and multi-gun array at left.

Materials

- Test bed: long narrow approach arena with paintball targets for subject
- Shooter at approach end aiming paintballs at subject
- Instrumented to record movement times, number of shots, target hits

Measure

- Most important:
  - Did they escape? (leave the arena)
  - Did they avoid? (hesitate continued approach)
- Also measured: latency to escape, blunt impact velocity, & number of hits per approach
- Avoidance: measured avoidance response with pressure-sensitive pads on the floor of each station; hesitation, latency, and number of impacts, were detected and recorded
- Sensitive pain magnitude (Borg CR-10) scores were recorded after each trial to evaluate participant's subjective experience of each blunt impact

Results

Escape

- 75% completed all 4 threat rounds, yielding 16.9 paintball hits total
- Those who quit received 6.4 total hits on average before terminating
- Each subject received 4.25 paintball hits (avg) per completed approach

Approach Completion: Subject Response

Figures 7 & 8: The few subjects who Escaped (25%), quit more often during or preceding the single paintball threat condition, Threat 1.

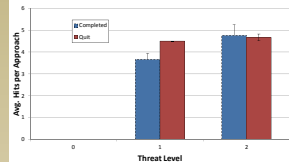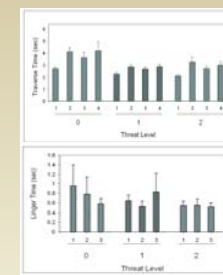## Results (cont.)

Escape

Figure 9: Neither the number of blunt impacts received nor the true threat condition (single or clustered impacts) predicted Escape [F$_{(1, 14)}$ = 3.23, p = .09]
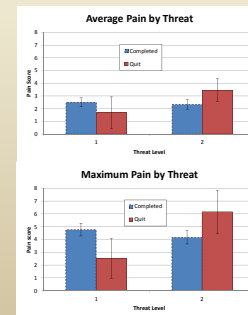
Avoidance

Figures 10 & 11: Two measures that capture deterrent effectiveness related to avoidance, Traverse Time from one station to the next, and Linger Time on the "safe" shooting station, did not differ with threat level [F$_{(2,28)}$ = 2.67, p <.08] or with distance from the paintball source (station numbers, where higher station numbers are closer to the marksman). Closer approaches also represent higher impact velocities.
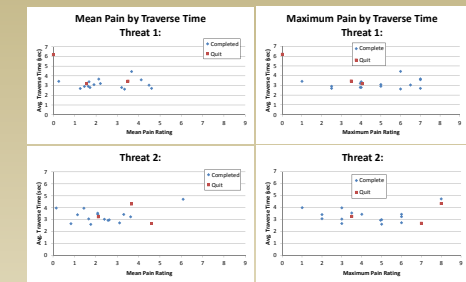
Pain & Escape

Figure 12: Neither the subject's eventual Escape response, nor the Threat level in which the blunt impacts were experienced, was related to either Average or Maximum of all Pain self-evaluations (on an open-ended scale with 10 representing maximum pain ever endured in lifetime) [ps>.20]

Results (cont.)

Pain & Avoidance

Figures 13-16: Pain responses, either average (left panels) or maximum (right panels) were not related to the avoidance measure of traverse time, either in the single-shot approach trials (top panels) or the multi-shot approach trials (bottom panels). [All rs≤.29, no more than 8% of variance in traverse times accounted for by pain scores]

Discussion and Conclusions

- No evidence that blunt impact from a paintball strike *typically* deters a nominally weakly-motivated approach response
  - No effect on avoidance, either traverse time or lingering at safe points
    - Time to traverse/approach between shooting locations actually decreased as the threat of blunt impact increased.
  - Only 25% showed escape behavior
    - Unclear why the 5 subjects quit, or why they quit when they did
- Pain was not a factor in any performance measure
  - No difference in pain was measured between those who quit and those who completed the task
  - Stronger blunt impact might work, but then risk of serious injury increases
  - Blunt impact that does not rely on pain may be more promising (knock-down rounds)
- Sample bias likely influences results
  - Advertised as a study that involves paintball pain, so self-selecting for high intrinsic motivation, risk tolerance
    - But highly-motivated subject pool not afraid of pain is likely target population for blunt impact intervention in unruly crowds or other civilian conflicts
  - 75% of subjects admitted to have at least some paintball experience; more accustomed to a paintball hit
    - But 3 of the 5 who quit had paintball experience, so no clear relationship experience with pain and deterrent effectiveness
- Question still remains: What type and level of blunt impact force is required to control these individuals?

- **Deterrence of approach may not be easy to achieve using pain-mediated blunt impact projectiles against a task-engaged, intrinsically motivated individual**

TBRL

Gathering empirical data on real human behavior in response to non-lethal weapons & systems in tactically relevant situations