Pupillary responses to thermal pain stimulation in healthy volunteers

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Introduction

- Pain = "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage".1
- The autonomic nervous system (ANS) is activated in response to pain.2 The parasympathetic nervous system (PNS) and the sympathetic nervous system (SNS) comprise the ANS, and physiologically respond to pain in various ways.2

Fig. 1 Schematic of pupil response to pain

- PNS: Circular muscles contract
- SNS: Radial muscles contract

Increased pupil dilation (PD) has correlated with increases in:
- Pain intensity.3,4,5,7,8
- Temperature.6
- Pain ratings.9,10
- Length of painful stimulus.4

Questions

- Do increases in temperature elicit increases in pupil dilation?
- Do increases in pain ratings reflect increases in pupil dilation?
- Does duration of thermal pain stimulation affect pupil dilation?
- Do pupil dilation responses differ by sex?

Methods

Pain Stimulus

Fig. 2b Medoc Heat Thermode

Rating Reliability

Fig. 2c Time-course of Pain rating reliability x temp

Visual Analog Pain Scale (VAS Pain)

0 = No sensation
1 = Warmth, No Pain
2 = Slight Pain
3 = Moderate Pain
4 = Most Pain Tolerated
Above 5 = Worst Pain

Interpolated Pupil Data with Blink And Artifact Removal

Fig. 2d Process of removing blinks and artifacts

Pain Ratings and PD

Mean centered VAS pain rating on average PD (n = 14)

Fig. 2e Group Avg

Fig. 2f Individuals

Sex Differences in PD

Mean centered VAS pain rating on average PD across sex (Females: n = 8; Males: n = 6)

Fig. 2g Group Avg

Fig. 2h Individuals

Pain Duration Differences in PD

Mean centered VAS on average PD across length of trial (Long – Short) (Long: n = 11, Short: n = 3)

Fig. 2i Group Avg

Fig. 2j Individuals

Results

Pupil dilation increases as temperature increases; Pupil dilation increases as pain rating increases; Pupil dilation revealed no sex or duration differences when correlated with VAS pain rating

Temperature Effects on PD

Mean centered temperature on average PD (n = 13)

Intercept: ß = 861.29, t = 3.7, p < .01
As temperature increases by 1° Celsius, pupil dilation increases by 12.86 A.U.

Fig. 3a Group Avg

Fig. 3b Individuals

Pain Ratings and PD

Mean centered VAS pain rating on average PD (n = 14)

Intercept: ß = 867.96, t = 2.87, p < .05
As VAS pain rating increases by 1 until, average pupil size increases by 11.16 A.U.

Fig. 3c Group Avg

Fig. 3d Individuals

Questions

- Pain ratings varied with VAS pain rating

Mean centered VAS pain rating on average PD across sex (Females: n = 8; Males: n = 6)

Intercept: ß = -24.04, t = 2.87, p < .05
As VAS pain rating increases by 1 unit, mean centered pupil dilation increases by 12.86 A.U.

Fig. 3e Group Avg

Fig. 3f Individuals

Sex Differences in PD

No differences in VAS pain rating and average PD between men and women

Fig. 3g Group Avg

Fig. 3h Individuals

Pain Duration Differences in PD

No differences in VAS pain rating and average PD for long versus short duration of heat stimulus

Fig. 3i Group Avg

Fig. 3j Individuals

Mean centered VAS pain rating on average PD across length of trial (Long – Short) (Long: n = 11, Short: n = 3)

Intercept: ß = -0.0, t = -0.08, p = 0.40

Fig. 3k Group Avg

Fig. 3l Individuals

Pain Duration Differences in PD

Intercept: ß = -0.15, t = -0.01, p = .99

Fig. 3m Group Avg

Fig. 3n Individuals

Questions

- Pain ratings varied with VAS pain rating

Discussion

Pupil dilation revealed no sex or duration differences when correlated with VAS pain rating

Summary

- The magnitude of pupil dilation is related to increases in temperature and increases in pain ratings
- No sex or heat duration group differences in VAS pain on average PD; no sex differences in pain ratings or temperatures given

Implications

- Our findings suggest that pupil dilation is a promising method for measuring pain, especially when subjective reports cannot be measured
- Physiological measures are an attractive alternative to imaging techniques for measuring pain

Further research

- PD in relation to other physiological measures during thermal pain stimulation
- PD and Expectancy effects
- PD and other forms of eye-data (saccades, interest areas)

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References