**The relation between affective touch and pupil size**

**METHODS**

Twenty-eight subjects were recruited for this study(*M* = 19.14 years, *SD* =10.02 years, 11 male). Participants could choose either a monetary reward or course credits for compensation. All participants gave written informed consent for participation. Inclusion criteria were normal vision or corrected to normal vision with contact lenses.

# Apparatus and stimuli

The right eye was recorded with the EyeTribe tracker, an infrared based eye-tracker sampling at 30Hz. Stimuli were presented on a 20 inch monitor (Samsung 2032BW, 1680 x 1050px, 60Hz). Stimulus presentation was controlled with OpenSesame (Mathôt, Schreij, & Theeuwes, 2012). Visual stimulus consisted of a black fixation dot on gray background, at a fixed luminance of 21.0 cd/m2.

# Procedure and design

Viewing distance (55cm) was kept constant across participants by the use of a chinrest. The experiment started with a 9-point eye tracker calibration. Before each trial, a manual 1-point recalibration (“drift correction” by space bar press) was performed. In each trial a fixation dot was presented in the center of the screen for 18s. Instructions were to keep the eyes fixated on the dot and blink as little as possible. At 3s, a tone (440Hz, type ‘sawtooth wave’; 92ms decay; length 100ms) was played as indication for the experimenter to start stroking for the remaining 15 seconds. Stroking was applied with a foundation brush (goat hair; conducted pressure approx. 11,5 Pa). Stroking velocities were either optimal (3cms-1) or suboptimal (0.3cms-1, 30cms1) for targeting CT-fibers and thereby eliciting affective experience (Löken, 2009; Van Stralen et al., 2014). Stroking velocities for trials were randomly assigned a priori so that each participant underwent the same trial sequence.

After each trial, participants rated the tactile experience with an adjusted version of the Touch Perception Task (TPT; Guest et al., 2011). The Dutch translation of these words was used (Martens, 2014), containing eight words of the TPT with highest proportion of variance accounted for by the factor ‘comfort’ and least covariance accounted for by the factor ‘arousal’ (Guest et al., 2011), see Table 1. Hedonic valence categorization was adapted from Ackerley and colleages (Ackerley, Saar, McGlone, & Wasling, 2014). Ratings were assessed with a digital version of the Visual Analogue Scale (VAS-scale), handling scores in slider format ranging from 0, not at all descriptive, to 100, highly descriptive.

# Data analysis

For behavioral data analysis, repeated-measures ANOVAs were conducted using SPSS 20 (SPSS Inc., Chicago, IL, USA) for each of the TPT-items, using stroking velocity as within-subjects factor. Paired samples t-tests were performed as post-hoc tests, α=.05.

Pupillometry data was analyzed with linear mixed-effects modeling (LMM) using stroking velocity as fixed and participant as random effect. The library lmerTest for R (Kuznetsova, Brockhoff, & Christensen, 2015) was used to obtain 95%-confidence intervals (CIs) and corresponding *p*-values. Pupil size during blinks was reconstructed cubic-spline interpolation (Mathôt, 2013). Baseline pupil size was defined as the average pupil size of 1350ms prior to the tone (1650-3000ms). Pupil size during stroking period was defined as the 15000ms from the tone onwards (3000-18000ms) and was divided by baseline per trial to obtain the relative signal needed for statistical analysis. This is needed, because basal pupil sizes can occur as a function of fatigue (Peavler, 1974), are affected by circadian and ultracircadian rythms (Lavie, 1979) and change with a variety of contextual, psychological and task-determined influences (Tyron, 1975).

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| English | Dutch | Hedonic valence description |
| Enjoyable Comfortable | Aangenaam Comfortabel |  |
| Soothing | Geruststellend | Positive affect |
| Calming | Kalmerend |  |
| Relaxing | Ontspannend |  |
| Pleasant | Prettig |  |
| Irritating | Irritant | Negative affect |
| Discomfortabel | Oncomfortabel |  |

**Table 1**

*Used TPT-items with highest proportion of variance accounted for by the factor ‘comfort’ and least covariance accounted for by the factor ‘arousal’, described by hedonic valence (as adapted from Ackerley et al., 2014).*

# DISCUSSION

Stroking velocity was expected to have a significant effect on TPT-item scores. Specifically, words representing positive affect were hypothesized to be rated higher, and words representing negative affect to be rated lower, during 3cms-1 (affective) stroking compared to both 0.3 and 30cms-1 (non-affective) stroking. The results supported this hypothesis. This indicates that affective touch was indeed experienced as affective, thereby replicating results of previous studies on affective touch (e.g. Ackerley et al., 2014).

The main goal of this study was to investigate how pupil size alters during affective- and non-affective touch conditions. Results revealed a significant main effect of stroking velocity on pupil size. At  1-2.8s, and 3.8-10s after stroking onset, 30cms-1 stroking resulted in a significantly larger pupil size than during 3 and 0.3cms-1 stroking. At 2.8-3.8s after stroking onset, both 3 and 30cms-1 stroking resulted in larger pupil size than 0.3cms-1 stroking.

It can be stated that 30cms-1 stroking on average caused the highest arousal, as pupil size is argued to result from sympathetic activity, and arousal has been found to be associated with pupil dilation for different modalities (e.g. Steinhauer et al., 1983; Aboyoun & Dabbs, 1998; Partala & Surrakka, 2003). The initial hypothesis that affective touch would elicit larger pupil size was based on the notion that CT-fibers that are activated are directly associated with processing hedonic valence via insular and OFC activity, and thus with emotional arousal. An explanation for the fact that 30cms-1 stroking claims the largest effect could be that the negative experience (as indicated by the TPT ratings) that resulted from 30cms-1 stroking elicited more arousal than the positive arousal caused by 3cms-1 stroking could achieve. This indicates a positive-negative asymmetry effect, describing when equal measures of good and bad are present, the psychological effects of the bad ones outweigh the good ones. This effect is present in a broad range of psychological phenomena, as reviewed by Baumeister and colleagues (2001). Specifically, the physiological reaction to negative events is more severe than to positive events, as described by Taylor (1991), which would explain the difference in pupil size. Indeed, the effect of affective touch on pupil size was only present for 1s (Fig. 4), whereas the effect of 30cms-1 lasted approx. 10s (Fig. 3).

To assess subjective emotional arousal, pupil sizes were correlated with TPT-item scores. Results only revealed (almost) significant effects in the CT specific touch condition. Possibly, CT-activation is able to amplify pupil dilation. This would mean a unique relation between affective touch and pupil size.

conclusies:

* pupil dilation lijkt gerelateerd aan arousal, waarbij negatieve stimuli meer arousal lijken op te wekken dan positieve.
* een effect van affective touch op pupil size is daarmee niet uitgesloten.