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Über die Wechselwirkung zwischen Pupillenweite und Perimetrie

Eine Untersuchung am Tübinger Computer Campimeter (TCC) unter Verwendung heller und dunkler statischer Stimuli

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Originalartikel

Die Ergebnisse meiner Dissertation über die gegenseitige Beeinflussung von Pupillenweite und Perimetrie an der Universitäts-Augenklinik Tübingen wurden als Artikel bei der Zeitschrift „Vision Research“ unter dem Titel:

Reciprocal effects of pupil size and perimetry

A Pharmacological Model using Increment and Decrement Stimuli

eingereicht.

Auf den folgenden Seiten ist die englische Originalfassung, so wie sie eingereicht wurde, abgedruckt.

Anschließend folgen eine deutsche Zusammenfassung und zusätzliche Diagramme, die in der eingereichten Fassung aus Platzgründen nicht Eingang finden konnten.

Title Page

Reciprocal effects of pupil size and perimetry. A Pharmacological Model using Increment and Decrement Stimuli.

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Abbreviated title: Pupil and Perimetry.

Abstract

The influence of natural and pharmacologically induced pupil size fluctuations on differential luminance sensitivity threshold (DLS) was examined with increment and decrement stimuli in 12 healthy subjects using phenylephrine 2%, dapiprazole 0.5%, and placebo. Pupil size was recorded by infra-red video camera without and with visual field examination (Tübingen Computer Campimeter). We found campimetric examination itself had a stabilizing effect on pupil size fluctuations. Pupil size affected DLS on its own (slope 0.21 dB/mm; 95%-CI: 0.09 to 0.33 dB/mm), differently at different stimulus locations, and 0.13 dB/mm (95%-CI: 0.00 to 0.26 dB/mm) more with increment than with decrement stimuli.

Key Words: pupil, pupil size, perimetry, target, psychophysics

Introduction

Early perimetric studies suggest that the naturally occurring inter-individual differences in pupil diameter do not influence perimetry results (Aspinall, 1967;Williams, 1983;Brenton & Phelps, 1986;Flammer *et al*, 1984). In contrast, pharmacologically (Day & Scheie, 1953;Engel, 1942;Harrington, 1981;McCluskey *et al*, 1986;Mikelberg *et al*, 1996;Forbes, 1966;Fitting & Mermoud, 1992;Rebolleda *et al*, 1992;Wood *et al*, 1988;Lindenmuth *et al*, 1989;Lindenmuth *et al*, 1990) or physically (Gleissner & Lachenmayr, 1992) induced intra-individual differences in pupil diameter do seem to have an effect. This effect appears to be more marked in glaucoma patients (Day & Scheie, 1953;Engel, 1942;Harrington, 1981;Forbes, 1966;Fitting & Mermoud, 1992;Rebolleda *et al*, 1992) than in normal subjects (McCluskey *et al*, 1986;Mikelberg *et al*, 1996;Wood *et al*, 1988;Lindenmuth *et al*, 1989;Lindenmuth *et al*, 1990), where some authors judged it to be clinically negligible (Mikelberg *et al*, 1996;Wood *et al*, 1988). Both pharmacological contraction (Lindenmuth *et al*, 1989;Fitting & Mermoud, 1992) and dilation (Lindenmuth *et al*, 1990;Rebolleda *et al*, 1992) of the pupil appear to cause an increase in mean defect. This suggests an optimal pupil size for perimetry. However, the applied medications may have affected other visual functions such as visual acuity or accommodation (Lindenmuth *et al*, 1989;Mordi *et al*, 1986;Wilcox *et al*, 1995). In none of the above studies was the pupil size measured throughout the perimetric session.

Pupillographic studies have shown that pupil size and pupil size fluctuations are altered by a number of influences, including vigilance, fatigue, systemic medication and accommodation (Wilhelm *et al*, 1998;Lüdtke *et al*, 1998). It is thus probable, that the

perimetric examination itself has an influence on the pupil. Yet pupil size changes during a perimetric session have not been addressed to date. In fact, the above studies only report pupil measurements taken at the beginning of the session, using simple rulers or gauges.

The introduction of static dark (light decrement type) stimuli has shown promising results in the area of high-accuracy campimetry, such as revealing field losses missed by conventional luminance (light increment type) stimuli of equal size and duration (Mutlukan, 1993;Mutlukan, 1994). Dark stimuli, cause less scatter inducing diffuse retinal illumination, which is suspected to play a major role in the effect of pupil size on perimetric results obtained with bright stimuli (McCluskey *et al*, 1986;Gleissner & Lachenmayr, 1992;Lindenmuth *et al*, 1989). However, there is no literature pertaining to the effect of pupil size on perimetry using dark (decrement) stimuli.

This study has three objectives: (I) To examine the naturally occurring fluctuations in pupil size within a campimatric (visual field) session, (II) to assess whether campimetric sessions affect the fluctuations in pupil size, and (III), to assess the effect of pupil size on the DLS of computer campimetry with bright (increment) as well as with dark (decrement) stimuli, using drugs to induce changes in the order of those naturally occurring during campimetric sessions.

Participants and methods

Twelve healthy volunteers, who had given informed written consent, were recruited according to the following inclusion criteria: age 20-30 years; corrected near visual acuity (Birkhäuser reading test and OCULUS-Landolt-Ring test, 33 cm distance) ≥1.0 (20/20); spherical ametropia between -2 and +2 diopters; cylindrical ametropia between -1 and +1 diopters; applanatory intraocular pressure below 20 mmHg; pupils isocoric, no relative afferent pupillary defect (RAPD) in the swinging flashlight test. No pathology in the anterior eye segments; especially no central opacities (slit lamp); neither central nor peripheral pathologies in the fundus (direct und indirect ophthalmoscopy, dilated pupils), normal stereoscopic vision (all figures recognized in the LANG-(II)-stereotest), no manifest strabism (cover-test), no motility disorders, no double-vision. Only the leading eye, established by the Rosenbach fixation test (Rosenbach, 1903), of each subject was examined. For the analysis of the results, the stimulus locations of the left-eyed subjects were mirrored along the vertical meridian to transform them into right-eyed positions.

The Tübinger Computer Campimeter (TCC) consists of a calibrated high-resolution stimulus-presentation monitor (BARCO Kalibrator, German Distributor: BARCO, Kippenheim; 72 dpi; 1024×768 Pixel; 21 inch diagonal width; max. luminance L = 64 cd/m^2) and a personal computer. To guarantee constant 10 cd/m^2 background illumination throughout all sessions, weekly calibration measurements were done on 32 points of the screen with a Minolta Luminance Meter LM 100 (Minolta, Osaka, Japan). In these calibration sessions, stimulus intensity was also controlled (Dietrich *et al*, 1996). For reasons of luminance stability, the monitor was always switched on at

least 45 minutes before the first examination. The distance between monitor and cornea was 30 cm, so that the monitor represented a rectangular area of about 34° horizontal and 25° vertical "radius". The subject sat in front of the high-resolution monitor and looked at the virtual center between four fixation dots in the center of the screen. These four dots, sized 24.0 arc minutes, were located at 1° eccentricity and had a luminance of 17.75 cd/m^2. The head of the subject was brought into position with the help of a combined chin-forehead support system with integrated infrared CCD camera (resolution 256 x 256 pixels) and infrared-LED panel for illumination of the eye. The examiner monitored the position of the subject's eye and fixation behavior by a small video display showing the input of the infrared CCD camera. The optical system of the camera included a position cross with millimeter scaling. A frame-grabber card digitally registered the pupillographic recording every 40 ms (25 Hz) and analyzed it in real-time, calculating pupil diameter and position (x/y).

DLS was measured at 9 locations within the central 20° with the TCC (Figure1) using either bright or dark 26 min-of-arc stimuli (10 cd/m^2 background luminance, 4-2-1-dB-thresholding-strategy, 4 reversals). A stimulus lasted 200 ms and was always accompanied by an acoustic signal preceding it by 60 ms. The next stimulus presentation followed independently of the subject's answer after a predefined interval of 1000 ms according to the "yes/time-out" method (Lutz *et al*, 2001). A 10-second mock-test of the central DLS threshold was performed at the beginning of each session.

DLS thresholds were estimated by the "maximum likelihood method", based on a logistic regression model ("logit-analysis"). Clinical perimetry DLS thresholds are

presented on a dB scale based on the difference ΔL between the respective stimulus intensity and the maximum intensity. To produce clinically comparable DLS values despite the comparatively low maximum intensity of the monitor, the DLS thresholds were related to the maximum intensity L_R = 1000 cd/m^2 of the Tübinger Automatic Perimeter (TAP):

$$DLS \quad [dB] = 10 \log\left(\frac{L_R}{\Delta L}\right) = 10 \log\left(\frac{1000\ cd\ /\ m^2}{|\Delta L|}\right)$$

Each subject was examined four times (E1-4; see Table) on three separate days (Day 1-3; each separated by at least three days to allow sufficient washout period of the eye drops). All examinations took place between 9 and 12 AM. All sessions began with a 5-minute adaptation time to the 10 cd/m^2 background illumination. In this time the exact procedure of the respective examination was again explained. Following adaptation, baseline pupillary size and fluctuations were recorded for five minutes in the first examination (E1) while the subjects sat in font of the campimeter, fixating the 10 cd/m^2 screen without perimetric testing. Then, one drop of the medication was placed in the subject's leading eye. A different medication was applied on each examination day in blinded blockwise randomized order: the mydriatic phenylephrine 2% (Neosynephrin POS®; alpha-1 receptor agonist), the miotic dapiprazole 0.5% (Remydrial®; alpha-receptor antagonist), or placebo (Isopto®-Naturale; isotonic saline solution). Two campimetric examinations (E2 and E3), one with bright and one with dark stimuli (in blockwise randomized order), were performed 25 and 35 minutes after drug application. The fourth examination (E4) took place 45 minutes after medication and was identical

to E1. Refraction (NIDEK Auto Refractometer AR-600) and near visual acuity (OCULUS-Landolt-Ring test, 33 cm distance) were measured prior to as well as 20 and 50 minutes after medication. Pupil size was recorded every 40 ms throughout every session.

Statistics

The statistical evaluation was performed in cooperation with the Institute of Medical Biometry of Tübingen University, using JMP 4.0.5 (SAS Institute Inc., SAS Campus Drive, Cary, NC, USA; http:// www.jmp.com/).

The pupil diameter recordings were plotted against time and the artifacts (e.g. anatomically impossible pupil diameters) removed from the data set. The remaining artifacts were left in the graphical display of pupil diameter by time but removed for statistical analysis.

The mean pupil diameter per examination (here called Pupil Size) and its standard deviation (here called Pupil Fluctuation) were secondary outcome measures. Determinants of Pupil Size were established in an analysis of variance (ANOVA) with factors medication, stimulus, and their interaction, and subject (random factor). The width of the 95%-confidence intervals (CI) for mean differences to placebo was adjusted as in Dunnett's test (aCI). Only the examinations following medication application (E2 to E4) were included in this analysis. Baseline measurements were analyzed separately. The same procedure was used to explore the determinants of Pupil Fluctuation.

For the analysis of the primary outcome measure DLS, Pupil Size was defined as the average pupil diameter - measured simultaneously to each stimulus presentation - per stimulus location and examination. An Analysis of Covariance (ANCOVA) was used to estimate the effects of stimulus type and location, Pupil Size, and their three two-way interactions, as well as day, and subject (random factor), on DLS. Inter- and intra-individual effects of Pupil Size were separated by adjusting for subject, the known confounder, in a second run. Medication was assumed to have no direct effect on DLS besides that propagated by Pupil Size.

Assumption of the linear model was checked by Box-Cox-transform, residual by predicted plot and quantile-quantile plot.

Results

Refraction and Visual Acuity

After medication, near visual acuity decreased by one line in two of the 36 sessions (in both cases from 1.4 to 1.25; placebo sessions), and by two lines in one session (from 1.4 to 1; phenylephrine session). Refraction changed by +0.25 diopters in 7 sessions (1 dapiprazole, 4 placebo, and 2 phenylephrine sessions) and by +0.5 diopters in one session (dapiprazole), by -0.25 diopters in 6 sessions (2 dapiprazole, 1 placebo, and 3 phenylephrine sessions) and by -0.5 diopters in 1 session (dapiprazole). Thus the medication did neither have any systematic effect on visual acuity nor on refraction.

Pupil Diameter

The pupil diameter recordings were plotted against time and the artifacts (e.g. anatomically impossible pupil diameters, resulting mostly from blinking) removed from the data set (3% of all measurements). The remaining artifacts, (0.7% of all measurements: pupil diameter changing at >5 mm/s and graphically visualized outliers, usually also due to blinking) were left in the 144 graphs of pupil diameter by time but removed for statistical analysis.

Baseline Pupil Size and Fluctuation

The mean Pupil Size of all baseline (E1, prior to medication) examinations was 5.4 mm (SD 1.2 mm; range 2.4 mm - 8.7 mm). There was a marked inter-individual variation in baseline Pupil Size, which ranged from 3.4 mm to 7.7 mm. In contrast, *intra*-individual

range in baseline Pupil Size was small (median 0.9 mm, range 0.2 mm – 1.8 mm). The SD of Pupil Fluctuation was 0.11 mm within and 0.12 mm between subjects.

Pupil Size on medication

The model for 108 examinations fitted the data well, achieving an adjusted coefficient of determination (aR^2) of 0.83. Residual standard deviation was 0.60 mm, the grand mean Pupil Size was 5.7 mm. Dapiprazole 0.5% led to an average decrease in pupil diameter of 1.1 mm (aCI: -1.4 to -0.8 mm), and phenylephrine 2% to an average increase in pupil diameter of 0.4 mm (aCI: 0.1 mm to 0.7 mm), compared with placebo. The stimulus type (increment / decrement) did not affect pupil size (95%-CI: -0.4 to +0.5 mm). Intra-individual variance was 21%, and inter-individual variance 79% of random variance, respectively.

Pupil Fluctuation on medication

The model produced an aR^2 of 0.64. Geometric mean of Pupil Fluctuation was 0.27 mm. The residual coefficient of variation was 27%. Dapiprazole 0.5% led to an average decrease in Pupil Fluctuation by -22% (aCI: -33% to -10%), and phenylephrine 2% to an average decrease in Pupil Fluctuation of -12 % (aCI: -23% to +1.6%), compared with placebo, where Pupil Fluctuation was 0.48mm (95%-CI: 0.19 mm to 0.86 mm). Pupil Fluctuation was 35% higher (CI: 21% to 50%) when a subject is merely fixating the screen center as opposed to undergoing perimetric examination. Indeed, the 144 graphs of pupil diameter by time for each session showed that in most

subjects the fluctuation in pupil diameter was greater in the purely pupillographic sessions without stimuli (E1 and E4) than in the perimetry sessions (E2 and E3). We first thought this phenomenon (Figure 2) was due to the medication, but found that on placebo days Pupil Fluctuation was increased by 63% (CI: 35% to 96%) when a subject is merely fixating the screen (Figures 3 and 4). Accordingly, the median range of pupil diameter within one examination was 2.0 mm (max. 4.0 mm) in the examinations without perimetry as opposed to 1.4 mm (max. 2.8 mm) in the examinations with perimetry. The suppressive effect of the perimetric examination on Pupil Fluctuation was slightly greater with dark stimuli than with bright stimuli (Figure 3).

Differential luminance sensitivity (DLS)

The model for 647 observations (aR^2 0.73) led to an estimated residual standard deviation of 1.15 dB. (One of 648 DLS values - day 1, E3, bright stimulus, dapiprazole, ID9 - was unfortunately missing because the respective subject only gave positive responses at that location.) The SD between the subjects was 0.83 dB (13 % of total variance). The main determinant of DLS was the stimulus location, explaining 55% of total variance. Mean DLS did not differ between stimulus type (CI: -0.20 to 0.16 dB for the difference of increment stimuli DLS to decrement stimuli DLS) overall, but decrement stimuli led to a 1.55 dB (CI: 1.02 to 2.09 dB) decrease in the visual field center (ID9). The training effect from day 1 to day 3 was minimal (0.2 dB; CI: -0.02 to 0.42 dB). Pupil Size affected DLS on its own (slope 0.21 dB/mm; CI: 0.09 to 0.33 dB/mm), differently at different stimulus locations, e.g. in the center (ID9), where slope was 0.39 dB/mm (CI: 0.18 to 0.60 dB/mm), and to a greater extent when

increment stimuli were used (slope difference when using increment as opposed to decrement stimuli: 0.13 dB/mm; CI: 0.00 to 0.26 dB/mm). Figures 5a and 5b show the direct relationship between DLS-threshold and pupil diameter at each location, for increment and decrement stimuli, respectively. The effect of Pupil Size on DLS was largely due to intra-individual variations as were mainly caused by medication: after subtracting subjects' mean Pupil Size and DLS, a similar model revealed practically the same effects; only interactions took different values. Particularly, DLS was 0.22 dB higher for every 1 mm of pupil size.

Discussion

Former studies on the effect of pupil size on perimetry used the fairly crude method (Schmitz *et al*, 2003) of a millimeter rule or the reticule of perimetric devices, and only assessed pupil size at the beginning of the session (Aspinall, 1967;Williams, 1983;Brenton & Phelps, 1986;Flammer *et al*, 1984;Day & Scheie, 1953;Engel, 1942;Harrington, 1981;McCluskey *et al*, 1986;Mikelberg *et al*, 1996;Forbes, 1966;Fitting & Mermoud, 1992;Rebolleda *et al*, 1992;Wood *et al*, 1988;Lindenmuth *et al*, 1989;Lindenmuth *et al*, 1990;Gleissner & Lachenmayr, 1992). Our recordings of pupil size every 40 milliseconds allow not only "continuous" assessment of pupil size but thereby also of its fluctuations throughout sessions with and without perimetry. Our results show that the fluctuations in pupil size are reduced by more than 1/3 when a subject is undergoing a perimetric session as opposed to merely gazing at the screen center. This reduction in pupil size fluctuation is likely to reflect a more focused state and even level of concentration of the subjects during perimetry (Wilhelm *et al*, 1998;Lüdtke *et al*, 1998). Thus, the pupil behaves differently during perimetry than before perimetry and should hence be measured during perimetric examination.

Earlier pharmacological studies on the influence of pupil size on perimetry applied relatively strong medication (phenylephrine 10% (Wood *et al*, 1988;Rebolleda *et al*, 1992;Pinkerton & Reifel, 1971), pilocarpine 2% (McCluskey *et al*, 1986;Lindenmuth *et al*, 1989;Rebolleda *et al*, 1992), tropicamide 1% (Lindenmuth *et al*, 1990), thymoxamine 0.5% (Wood *et al*, 1988;Mikelberg *et al*, 1996)), possibly affecting other visual functions such as visual acuity or accommodation via alteration of muscle tonus, blood flow, or retinal sensitivity (Lindenmuth *et al*, 1989;Mordi *et al*, 1986;Wilcox *et*

al, 1995). In this study the medication dosage was kept low to minimize interference regarding accommodation or visual acuity and to keep pupillary size within the range encountered in normative studies (Wabbels *et al*, 1995). Both verum drugs (phenylephrine and dapiprazole) act on the smooth muscle of the pupil dilator. They also act on the ciliary body vasculature, but for young subjects the dosage used is unlikely to affect the constant accommodation required for fixation at the campimetric distance of 30 cm (Mordi *et al*, 1986;Wilcox *et al*, 1995). Indeed, we found no systematic effect of the medication on refraction or near visual acuity. Furthermore, the maximum intersession changes were completely within the physiological range (≤2 lines for visual acuity and ≤ 0.5 diopters for refraction). Thus the medication neither had a systematic nor clinically relevant effect on refraction or visual acuity.

We have assessed the naturally occurring degree of pupil size fluctuation during campimetric measurements and found that, in our study using low pharmacological doses, induced changes in mean pupil size and fluctuation were within the naturally occurring spectrum. Stronger doses of medication than the ones used in this study will lead to greater changes in pupil size, which in turn may have a more marked effect on visual thresholds, but also potentially on accommodation.

A contractive effect of pupillary constriction on the visual field was already assumed in 1862 (Haffmans, 1862). Yet empirical examinations suggested that the inter-individual differences in pupil size have only a negligible effect on the kinetic visual field thresholds (Aspinall, 1967;Williams, 1983). Examinations with static perimetry also led to the conclusion that in normal eyes pupil size does not have a significant influence on

mean sensitivity (Aspinall, 1967;Brenton & Phelps, 1986). In normal subjects, pupil size did not affect short-time fluctuation (SF), whereas in glaucoma patients the latter was affected by miotic therapy (Flammer *et al*, 1984). Pharmacologically induced alterations in pupil size do seem to have a stronger effect on perimetric results. Drug-induced miosis led to a contraction of manually assessed visual field isopters in healthy subjects as well as in glaucoma patients (Day & Scheie, 1953;Engel, 1942;Harrington, 1981). Medically induced miosis has further been reported to cause visual field defects that mimic those found in glaucoma patients, and to worsen glaucomatous visual field defects (Day & Scheie, 1953;Forbes, 1966). McCluskey et al. have analyzed the effect of miosis caused by pilocarpine 2% in 16 healthy subjects aged 24 to 57 years using kinetic perimetry: they found that a pupil diameter below 2 mm correlated with a significant reduction of kinetic isopter area (McCluskey *et al*, 1986). Mikelberg et al. studied the effect of thymoxamine 0.5% on 22 eyes of volunteers aged 24 to 67 years using the Octopus Program G1. Mean pupil diameter decreased by 2.0 mm, (SD 0.7 mm) but this did not exert a significant effect on mean sensitivity, mean defect, correlated loss variance, or short-term fluctuation. However, they noted a high correlation between baseline pupil diameter and changes in pupil diameter, and further established a significant relationship between proportionate change in pupil diameter and proportionate change in mean sensitivity (Mikelberg *et al*, 1996). Wood et al. studied the effect of phenylephrine 10% and thymoxamine 0.5% on mean sensitivity and short-term fluctuation (Dicon AP3000 perimeter) of 10 healthy young adults and expressed the results in terms of eccentricity. The effect of pupil size was greater at peripheral angles outside 10° and was reported to reach a maximum value of 7 dB for a pupil size difference of 3.7 mm. However, the authors concluded that within the normal

range of pupil sizes the effect of pupil size is clinically negligible (Wood *et al*, 1988). Lindenmuth et al. studied 20 healthy subjects on the Humphrey Field Analyzer before and after the application of one drop of pilocarpine 2%. Mean pupil area decreased from 16.3 mm^2 (SD 6.1 mm^2) to 4.3 mm^2 (SD 1.9 mm^2) and was accompanied by a worsening of the mean defect by 0.7 dB (SD 0.7 dB). Here, too, the effect of pupil constriction on differential luminance sensitivity was stronger in the periphery. They explained this effect in terms of reduced retinal illumination and diffraction (Lindenmuth *et al*, 1989). Gleissner und Lachenmayr ruled out pharmacological side-effects in their experiment by placing pinholes of 1, 2, 3 and 4 mm diameters, respectively, in front of the eyes of normal subjects. In both, perimetry (Humphrey Field Analyzer) and flicker perimetry, pinhole size reduction led to a logarithmic reduction in DLS threshold values, whereby the effect was particularly marked when the artificial pupil was smaller than 2 mm in diameter. This effect was interpreted as being purely a function of retinal illumination (Gleissner & Lachenmayr, 1992). After pausing miotic medication, the pupil diameter of 8 glaucoma patients studied by Fitting and Mermoud increased by 2.0 mm (SD 0.8 mm), together with a reduction of the mean defect by 1.9 dB (SD 1.5 dB) (Fitting & Mermoud, 1992).

The effect of pharmacologically induced pupil dilation has also been examined. An increase in mean pupil area from 17.8 mm^2 (SD 4.3 mm^2) to 47.1 mm^2 (SD 7.0 mm^2) using tropicamide 1% is reported to have increased the mean defect by 0.8 dB (SD 0.9 dB) in 18 healthy subjects (Lindenmuth *et al*, 1990). Similar results were also obtained in glaucoma patients: in 18 patients with open-angle-Glaucoma on pilocarpine 2% treatment, one drop of phenylephrine 10% led to an increase in pupil area from 2.9 mm^2 (SD 1.8 mm^2) to 26.1 mm^2 (SD 14.0 mm^2), which was paralleled by

an average increase in mean defect of 3.1 (SD 2.6 dB). However, no significant effect on the foveola threshold was found; the effect increased markedly with increasing eccentricity (Rebolleda *et al*, 1992).

Our study shows that for the central 20° in normal young subjects the effect of pupil diameter in the order of magnitude of natural size fluctuatuations on DLS thesholds is not relevant intra-individually, as the intra-individual median range of 0.9 mm causes only a 0.2 dB DLS change. We thus agree with the authors who judged the effect of pupil size on DLS to be negligible in serial examinations in young healthy subjects (Mikelberg *et al*, 1996;Wood *et al*, 1988). The pupil is probably not the cause for the inter-test variation of up to 4 dB (Wilensky & Joondeph, 1984) found in such subjects. The effect of pupil size on DLS using bright stimuli found in our study is in the lower range of those found in former pharmacological studies in healthy subjects (0.2 dB to 3.1 dB (Mikelberg *et al*, 1996;Lindenmuth *et al*, 1989;Lindenmuth *et al*, 1990), with a maximum of 7.0 dB (Wood *et al*, 1988)). This may in part be due to the stronger medication in these studies affecting also accommodation (Lindenmuth *et al*, 1989;Mordi *et al*, 1986;Wilcox *et al*, 1995). The stronger medication in former studies may also account for the apparently contradictory results between these studies and the ones in which pupil size was not pharmacologically modulated (Aspinall, 1967;Brenton & Phelps, 1986;Flammer *et al*, 1984). It may also explain why both, miotic medication (Day & Scheie, 1953;Engel, 1942;Harrington, 1981;Forbes, 1966;McCluskey *et al*, 1986;Mikelberg *et al*, 1996;Wood *et al*, 1988;Lindenmuth *et al*, 1989) and mydriatic medication (Lindenmuth *et al*, 1990;Rebolleda *et al*, 1992), led to a deterioration of visual field indices (Engel, 1942;Day & Scheie, 1953;Forbes, 1966;Harrington,

1981;McCluskey *et al*, 1986;Mikelberg *et al*, 1996;Wood *et al*, 1988;Lindenmuth *et al*, 1989;Lindenmuth *et al*, 1990;Rebolleda *et al*, 1992), whereas pausing miotic medication in glaucoma patients led to a reduction of the mean defect by 1.9 dB (Fitting & Mermoud, 1992). An alternative – or additional – explanation is that every individual has their own optimal pupil size for a particular perimetric situation, so that any artificial miosis or mydriasis would lead to suboptimal sensitivity.

A strength of our models were residual standard deviations that were very close to the measurement error of repeated measurements under constant conditions, thus they seem to have caught all existing systematic effects. On the other hand, twelve subjects may not be representative. We also failed to show an increasing effect of pupil size on DLS with increasing eccentricity, as has been reported to various degrees in some earlier studies (Wood *et al*, 1988;Lindenmuth *et al*, 1989;Rebolleda *et al*, 1992). This may be due to the fact that we only examined the central 20° of the visual field. We found no relevant training effect from day 1 to day 3. This may in part be doe to the fact that we "primed" our subjects with a 10-second mock-test of the central DLS threshold at the beginning of each session. The effect of training in perimetry is a controversial matter: some authors report a 1.3 to 1.4 dB improvement of mean sensitivity (Searle *et al*, 1991;Heijl *et al*, 1989) while others found no systematic change with experience (Aulhorn & Harms, 1972;Gloor *et al*, 1981;Lutz *et al*, 2001).

Inter-individual differences in mean pupil size per examination were substantial, ranging from 3.4 mm to 7.7 mm in our study, and may theoretically be responsible for inter-individual differences in DLS, but our results indicate that this is not the case, as

was inferred indirectly by considering the difference between the unadjusted and adjusted estimates of slope. Thus inter-individual differences in pupil diameter should not play a clinically relevant role in inter-individual DLS differences.

The stronger effect of pupil size on DLS thresholds with bright stimuli than with dark stimuli is in agreement with the theory that decrement stimuli cause less diffraction and diffuse retinal illumination (Mutlukan, 1994), which are suspected to play a major role in the effect of pupil size on perimetric results obtained with bright stimuli (Lindenmuth *et al*, 1989;Gleissner & Lachenmayr, 1992). It is unclear whether the Off-system, which may be the main target of decrement stimuli (Wabbels *et al*, 1995), plays a role in this stimulus-related difference of the effect of pupil size on DLS.

Conclusion

Pupil size and pupil size fluctuations vary considerably between young subjects. We show for the first time that campimetric examinations have a stabilizing effect on pupil size fluctuations. Pupil size affects DLS with bright stimuli more than with dark stimuli. In normal young subjects the effect of pupil size in the range of natural size fluctuation on DLS is not relevant for clinical or normative studies.

References

Aspinall,P.A. (1967) Variables affecting the retinal threshold gradient in static perimetry. Master of Science. Thesis. Department of Psychology, University of Edinburgh.

Aulhorn, E. & Harms, H. (1972). Visual perimetry. In: H. Autrum, R. Jung, W.R. Loewenstein, C. Mackay, & H.L. Teuber (Eds.), *Handbook of sensory physiology Vol. VII/4 Visual Psychophysics* (pp. 102-145). Berlin: Springer.

Brenton, R. S., & Phelps, C. D. (1986). The normal visual field on the Humphrey Field Analyser. *Ophthalmologica, 193,* 56-74

Day, R. M., & Scheie, H. G. (1953). Simulated progression of Visual field defects of glaucoma. *Arch.Ophthalmol., 50,* 418-433

Dietrich, T. J., Selig, B., Friedrich, M., Benda, N., & Schiefer, U. (1996) Calibration routines for video display units for perimetric examinations. *German Journal Ophthalmology, 5; Suppl.1,* 125 (Abstract).

Engel, S. (1942). Influence of a constricted pupil on the field in glaucoma. *Arch.Ophthalmol., 27,* 1184-1187

Fitting, P. L., & Mermoud, A. (1992). Modifications du champ visuel lors de l'interruption temporaire du traitement myotique [Modification of the visual field during temporary interruption of miotic treatment]. *Klin Mbl Augenheilk,* 481-483

Flammer, J., Drance, S. M., Fankhauser, F., & Augustiny, L. (1984). Differential light threshold in automated static perimetry. Factors influencing short-term fluctuation. Arch Ophthalmol 102:876-879. *Arch.Ophthalmol., 102,* 876-879

Forbes, M. (1966). Influence of miotics on visual fields in glaucoma. *Invest.Ophthal.Vis.Sci., 5,* 139-145

Gleissner, M., & Lachenmayr, B. J. (1992). Lichtsinn- und Flimmerperimetrie. Einfluss von Fehlrefraktion, artifiziellen Medientrübungen und Pupillenweite [Light perception and flicker perimetry. Effect of refractive error, artificial media opacities and pupillary size]. *Ophthalmologe, 89,* 162-165

Gloor, B., Schmied, U., & Fässler, A. (1981). Changes of glaucomatous field defects. *Docum Ophthal Proc Series, 26,* 11-15

Haffmans, J. H. A. (1862). Beiträge zur Kenntnis des Glaucoma [Contribitions to the Knowledge of Glaucoma]. *Arch.Ophth., 8,* 124-178

Harrington, D. O. (1981). Instruments of perimetry and their use. The visual fields - a textbook and atlas of clinical perimetry. In: St. Louis: Mosby.

Heijl, A., Lindgren, G., & Olsson, J. (1989). The effect of perimetric experience in normal subjects. *Archives of Ophthalmology, 107,* 81-86

Lindenmuth, K. A., Skuta, G. L., Rabbani, R., & Musch, D. C. (1989). Effects of pupillary constriction on automated perimetry in normal eyes. *Ophthalmology, 96,* 1298-1301

Lindenmuth, K. A., Skuta, G. L., Rabbani, R., Musch, D. C., & Bergstrom, T. J. (1990). Effects of pupillary dilation on automated perimetry in normal patients. *Ophthalmology, 97,* 367-370

Lüdtke, H., Wilhelm, B., Adler, M., Schaeffel, F., & Wilhelm, H. (1998). Mathematical procedures in data recording and processing of pupillary fatigue waves. *Vision Research, 38,* 2889-2896

Lutz, S., Dietrich, T. J., Benda, N., Selig, B., Strasburger, H., & Schiefer, U. (2001). An explicit *no* response instead of *time-out* in automated visual field testing. *Graefes Archive for Clinical and Experimental Ophthalmology, 239,* 173-181

McCluskey, D. J., Douglas, J. P., O'Connor, P. S., Story, K., Ivy, L. M., & Harvey, J. S. (1986). The effect of pilocarpine on the visual field in normals. Ophthalmology 93:843-846. *Ophthalmology,* 843-846

Mikelberg, F. S., Drance, S. M., Schulzer, M., & Wijsman, K. (1996). The effect of miosis on visual field indices. *Doc Ophthal Proc Ser, 49,* 645-649

Mordi, J. A., Lyle, W. M., & Mousa, G. Y. (1986). Effect of phenylephrine on accommodation. *Am.J Optom.Physiol Opt., 63,* 294-297

Mutlukan, E. (1993). Computerised campimetry with static dark-on-bright stimuli. *Doc.Ophthalmol., 84,* 335-350

Mutlukan, E. (1994). A comparison of automated static dark stimuli with the Humphrey STATPAC program in glaucomatous visual field loss. *British Journal of Ophthalmology, 78,* 175-184

Pinkerton, R. M., & Reifel, C. (1971). The effect of phenylephrine 10 per cent on quantitative perimetry. *Can.J Ophthalmol., 6,* 104-108

Rebolleda, G., Munoz, F. J., Fernandez Victorio, J. M., Pellicer, T., & del Castillo, J. M. (1992). Effects of pupillary dilation on automated perimetry in glaucoma patients receiving pilocarpine. *Ophthalmology, 99,* 418-423

Rosenbach, O. (1903). Über monoculare Vorherrschaft beim binocularen Sehen [On monocular prevalence in binocular vision]. *Med Wochenschrift, 50,* 1290-1292

Schmitz, S., Krummenauer, F., Henn, S., & Dick, H. B. (2003). Comparison of three different technologies for pupil diameter measurement. *Graefes Arch Clin Exp Ophthalmol, 241,* 472-477

Searle, A. E., Wild, J. M., Shaw, D. E., & O'Neill, E. C. (1991). Time-related variation in normal automated static perimetry. *Ophthalmology, 98,* 701-707

Wabbels, B., Schiefer, U., Treutwein, B., Benda, N., & Stercken-Sorrenti, G. (1995). Automated perimetry with bright and dark stimuli. *German Journal Ophthalmology, 4,* 217-221

Wilcox, C. S., Heiser, J. F., Crowder, A. M., Wassom, N. J., Katz, B. B., & Dale, J. L. (1995). Comparison of the effects on pupil size and accommodation of three regimens of topical dapiprazole. *Br J Ophthalmol, 79,* 544-548

Wilensky, J. T., & Joondeph, B. C. (1984). Variation in visual field measurements with an automated perimeter. *Am J Ophthalmol, 97,* 328-331

Wilhelm, B., Wilhelm, H., Lüdtke, H., Streicher, P., & Adler, M. (1998). Pupillographic assessment of sleepiness in sleep-deprived healthy subjects. *Sleep, 21,* 258-265

Williams (1983). Aging and the central visual field area. *Am.J Optom.Physiol Opt., 60,* 888-891

Wood, J. M., Wild, J. M., Bullimore, M. A., & Gilmartin, B. (1988). Factors affecting the normal perimetric profile derived by automated static threshold LED perimetry. I. Pupil size. *Ophthalmic Physiol Opt, 8,* 26-31

Figures and Table

Legends

Figure 1: Examination grid with the nine tested locations

Table : Examination procedure

Figure 2: The stabilizing effect of perimetric examination on Pupil Fluctuation: Pupil Fluctuation was reduced in the sessions with perimetry (E2 and E3) as compared to the merely pupillographic sessions without perimetry (E1 and E4). The horizontal line represents the geometric mean of all 144 examinations. The dots represent average pupil size fluctuation per subject and per session. The diamonds portray the mean (middle horizontal line), 95%-CI (vertical diamond span), and 90%-CI (height between small horizontal lines) per examination type.

Figure 3: Pupil Fluctuation by medication: the mean of each session has a different sign depending on the stimulus (× without perimetry , ○ bright, ● dark,). A horizontal bar marks the stimulus-specific grand mean for each medication type. Fluctuations were highest without perimetry and lowest with dark stimuli.

Figure 4: Matched pairs Bland/Altman plot of the difference between pupil size fluctuations during recordings while a subject is undergoing perimetry (With Peri) and merely gazing at the screen center (Without Peri), plotted against the mean Pupil Fluctuation for both situations, using the measurement data *from placebo days only* (see also figure 2).

}*: 95% confidence interval; }†: reference interval, the twelve pairs of signs represent the twelve subjects.

Figure 5: Differential luminance sensitivity (DLS) threshold plotted by mean pupil diameter for each stimulus location (ID 1-9; the graphics are arranged according to the stimulus localization – see Figure 1), for bright stimuli (a) and for dark stimuli (b). Each subject is marked by a different symbol (the same as in Figure 3) and was measured three times (phenylephrine, placebo, dapiprazole) at each location.

Figure 1

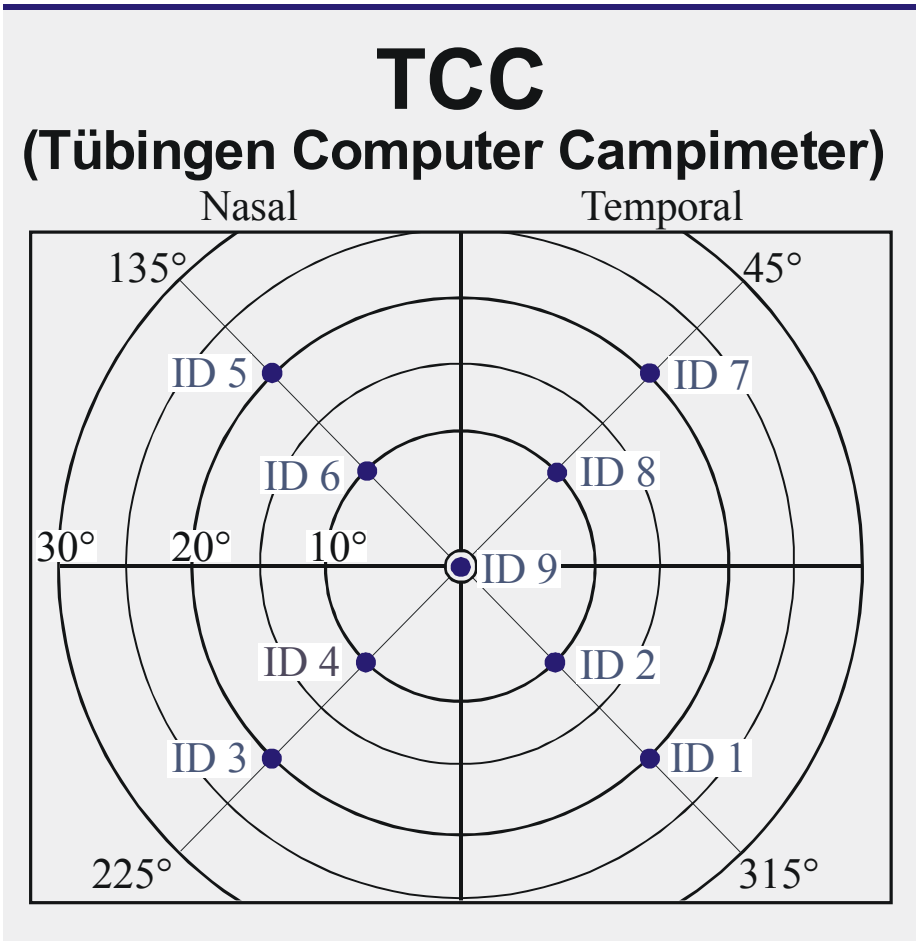

TCC
(Tübingen Computer Campimeter)
Nasal
Temporal
135°
45°
ID 5
ID 7
ID 6
ID 8
30°
20°
10°
ID 9
ID 4
ID 2
ID 3
ID 1
225°
315°

Figure 2

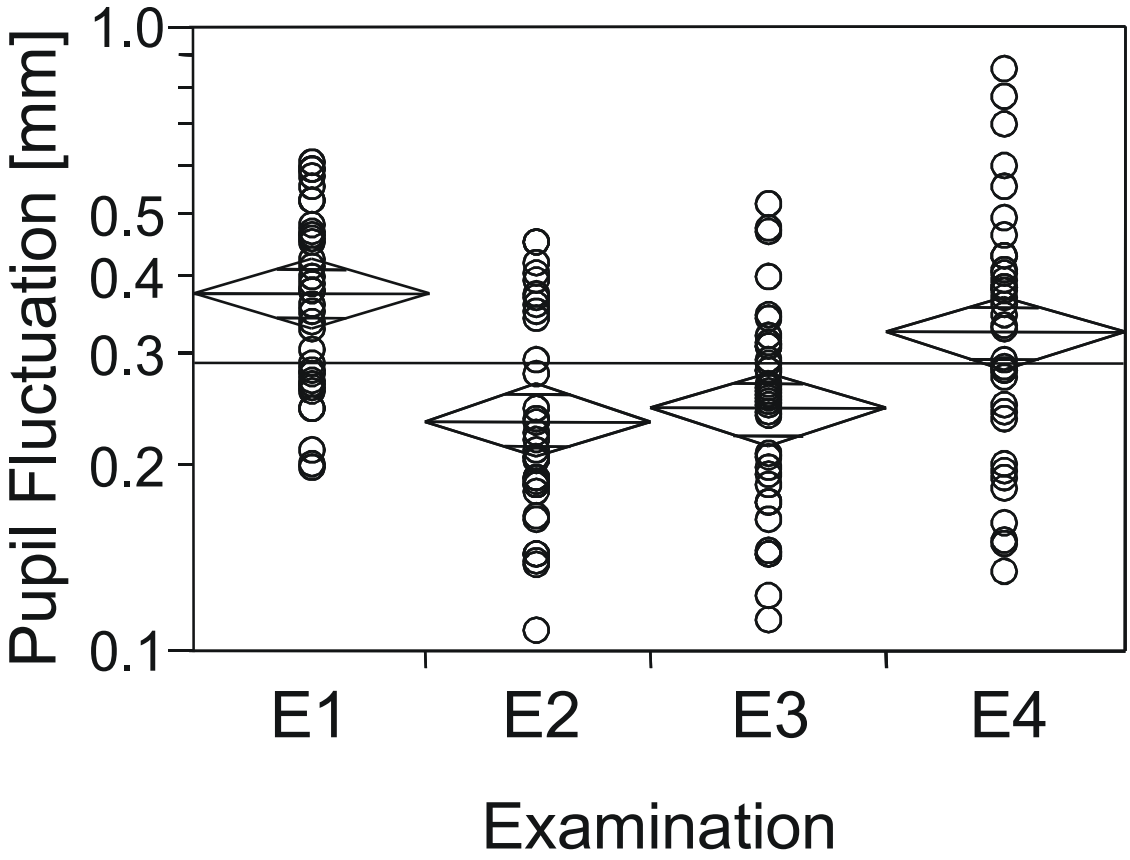


Figure 3

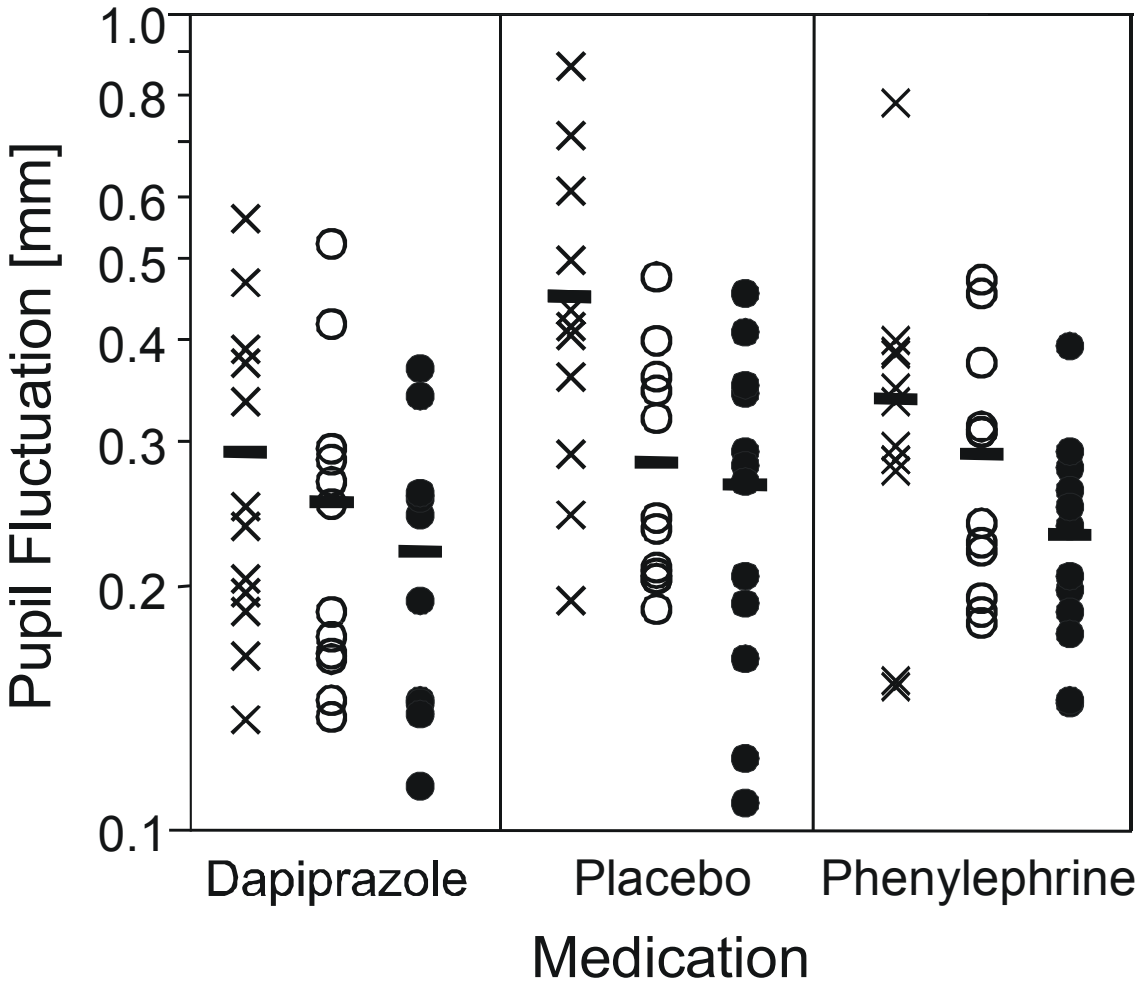
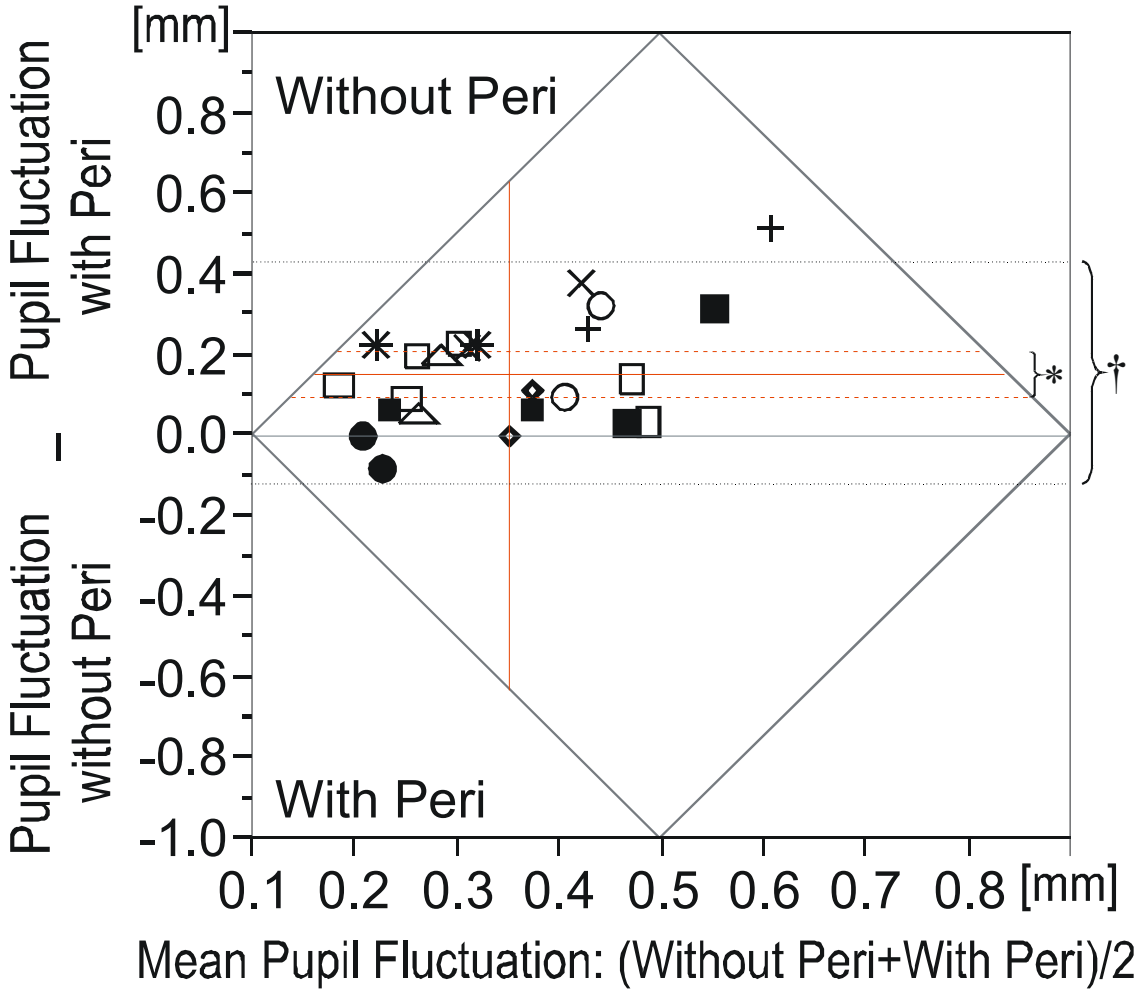

1.0
0.8
0.6
0.5
0.4
0.3
0.2
0.1
Pupil Fluctuation [mm]
Dapiprazole
Placebo
Phenylephrine
Medication

Figure 4



*: 95% confidence interval; †: reference interval

The twelve pairs of signs represent the twelve subjects, each measured *twice* with and *twice* without perimetry.

Figure 5a

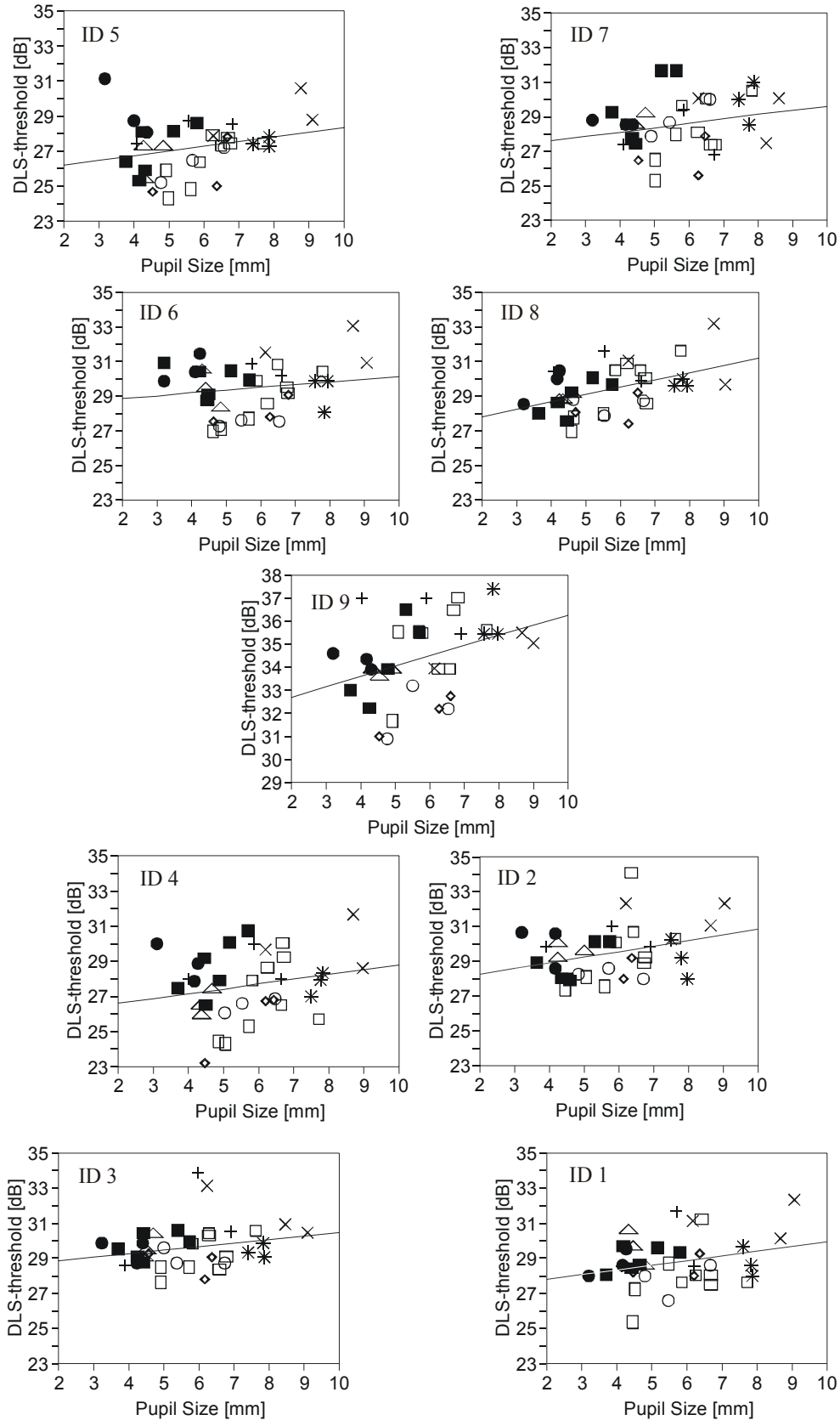
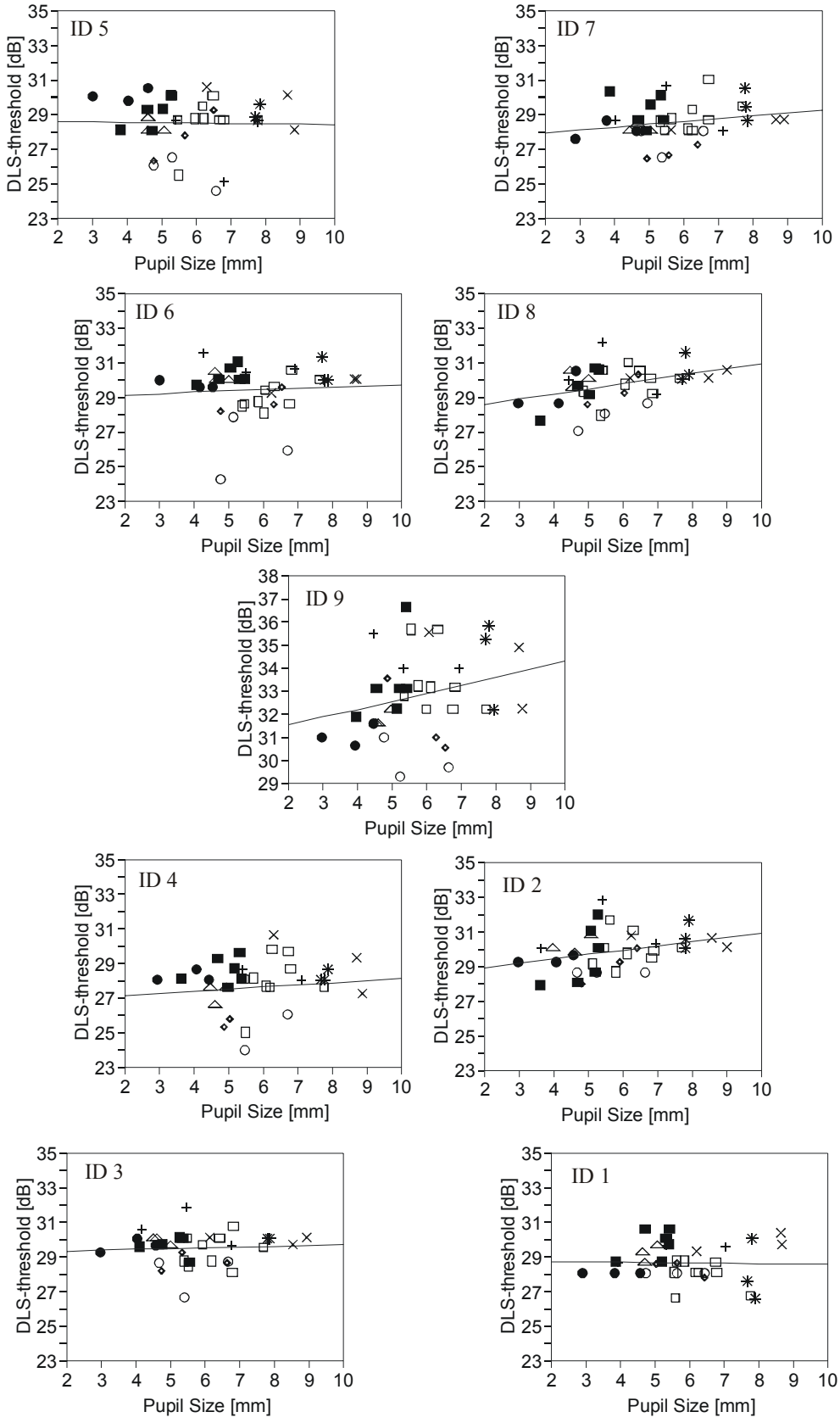

ID 5
ID 7
ID 6
ID 8
ID 9
ID 4
ID 2
ID 3
ID 1
DLS-threshold [dB]
Pupil Size [mm]

Figure 5b


ID 5
ID 7
ID 6
ID 8
ID 9
ID 4
ID 2
ID 3
ID 1
DLS-threshold [dB]
Pupil Size [mm]

Table

Timepoint	Examination
-15 min	Refraction and visual acuity tests
-10 min	Adaptation to background illumination (5min)
-5 min	E1: Pupillography (5min)
0 min	Drops application (miotic/placebo/mydriatic)
20 min	Refraction and visual acuity tests
25 min	E2: Pupillography + perimetry (in- or decrement; 5 min)
32 min	E3: Pupillography + perimetry (de- or increment ;5 min)
45 min	E4: Pupillography (5min)
50 min	Refraction and visual acuity tests

Deutschsprachige Zusammenfassung

Ziel dieser Studie war es, natürlich vorkommenden Pupillenschwankungen während perimetrischen Untersuchungen zu erfassen, und die Wechselwirkungen zwischen Pupillenweite und der Lokalen Lichtunterschiedsempfindlichkeit (LUE) für helle (inkrement) und dunkle (dekrement) Stimuli zu evaluieren.

Probanden und Methoden: 12 gesunde Probanden (Alter 20-30 Jahre) wurden an drei verschiedenen Tagen unter dem Einfluss von jeweils Phenylephrin 2%, Dapiprazol 0.5% und Placebo untersucht. Die Pupillenweite wurde mit einer Infrarot-Videokamera vor Medikamentenapplikation, während der 25 Minuten nach Medikamentenapplikation beginnenden campimetrischen Untersuchungen am Tübingen Computer Campimeter (TCC) und 45 Minuten nach Medikation digital registriert. Die lokale LUE wurde an 9 Testorten innerhalb der zentralen 20° mit Hilfe des TCC in zwei getrennten Sitzungen mittels heller (inkrement) und dunkler (dekrement) Stimuli ermittelt (10 cd/m^2 Hintergrundleuchtdichte, 4-2-1-dB-Schwellenstrategie, 4 Schwellenüberschreitungen, Stimulus-„Durchmesser“ 26-Bogenminuten).

Ergebnisse: Es zeigten sich erhebliche interindividuelle Unterschiede in der Pupillenweite und deren Standardabweichungen. Hingegen waren die intraindividuellen Unterschiede gering. Im Durchschnitt betrug der Einfluss der Pupillenweite auf die LUE 0.21 dB/mm (95%-Confidenzintervall: 0.09 bis 0.33 dB/mm). Dieser Einfluss war abhängig von der Stimuluslokalisation, und geringer, wenn dunkle Stimuli verwendet wurden (Steigungsunterschied zwischen dunklen und hellen Stimuli: 0.13 dB/mm; 95%-CI: 0.00 bis 0.26 dB/mm). Trotz der erheblichen interindividuellen Unterschiede in der Pupillenweite war der Einfluss der Pupillenweite auf die LUE fast ausschließlich auf intraindividuelle Unterschiede zurückzuführen.

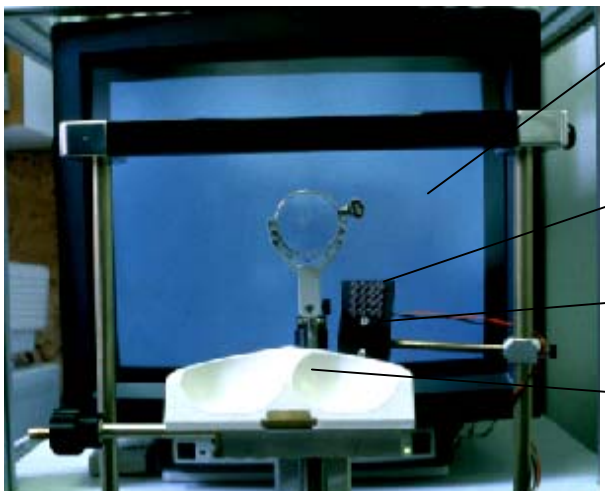
Schlussfolgerung: Perimetrische Untersuchungen haben einen stabilisierenden Einfluss auf Pupillenschwankungen. Die Pupillenweite beeinflusst die Ergebnisse der Inkrement Perimetrie mehr als die der Dekrement Perimetrie. Bei gesunden jungen Probanden ist dieser Effekt in der Größenordnung natürlich schwankender Fluktuationen der Pupillenweite nicht relevant für klinische Studien oder Normwert- Studien.

Anhang: Nicht zur Publikation eingereichte Abbildungen

Figure A1. Photographs of the examination unit

a) Tübinger Computer Campimeter with infra-red video camera

b) Pupil monitoring unit


High-resolution stimulus-presentation monitor (BARCO Kalibrator)
Infra-red LED panel
Infra-red video camera
Chin-forhead support

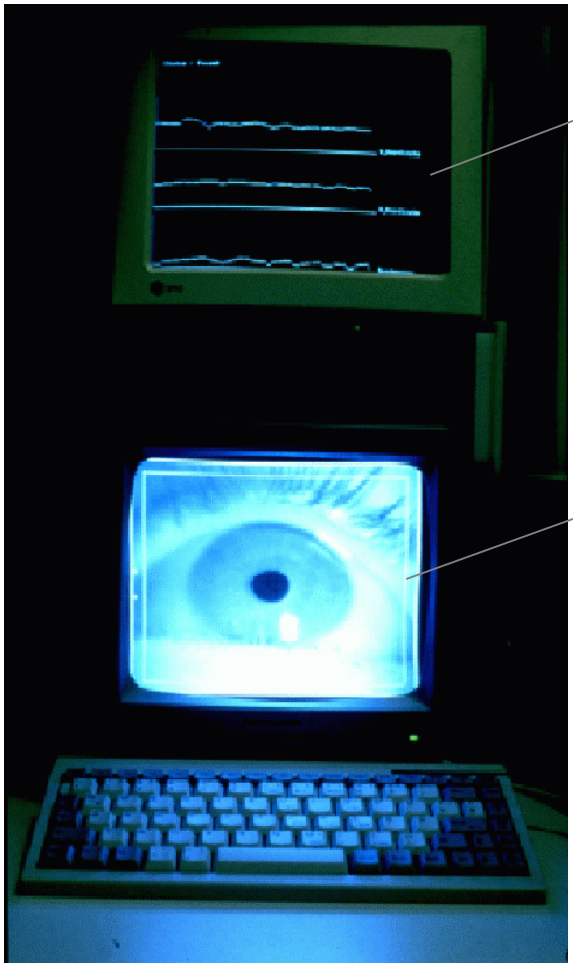

Real-time graphical recording of pupil diameter and position
Real-time movie of the subject's eye

Table A1. Improvement or worsening of refraction after medication. No systematic change was found.

Medication	Better (+) or worse (-), in diopters	Number of sessions
Dapiprazole	-0.5	1
Dapiprazole	-0.25	2
Dapiprazole	0	2
Dapiprazole	0.25	1
Dapiprazole	0.5	1
Placebo	-0.5	1
Placebo	-0.25	1
Placebo	0	2
Placebo	0.25	4
Phenylephrine	-0.25	3
Phenylephrine	0	2
Phenylephrine	0.25	2

Figure A2: Example of how pupil size fluctuations are reduced in the campimetric examinations (E2 and E3) as compared to the merely pupillographic sessions without perimetry (E1 and E4), on a *placebo-day*. Pupil diameter is plotted by time. The straight lines portray a linear fit.

Figure A2

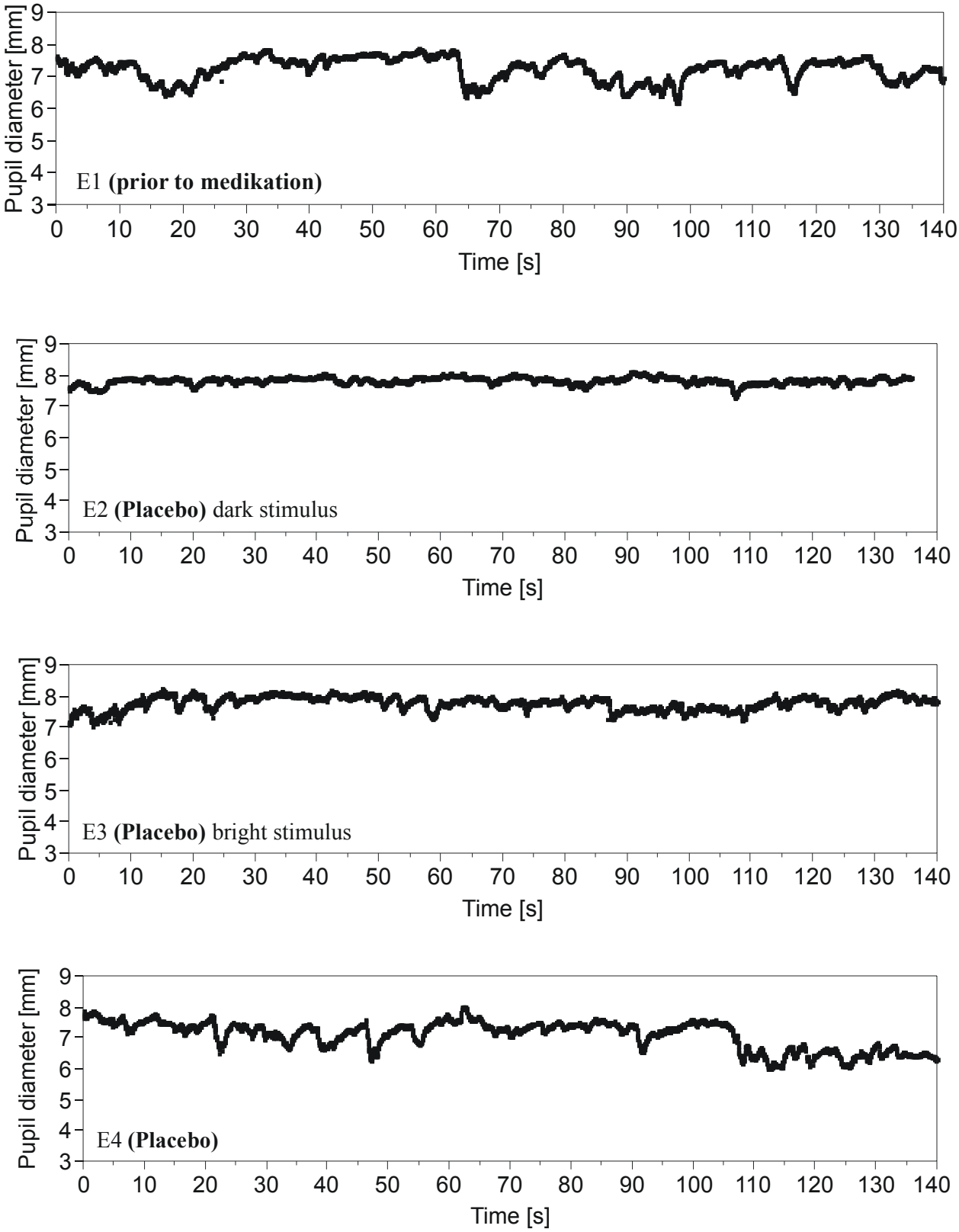

Pupil diameter [mm]
E1 (prior to medikation)
E2 (Placebo) dark stimulus
E3 (Placebo) bright stimulus
E4 (Placebo)
Time [s]

Figure A3. The stabilizing effect of perimetric examination on pupil fluctuations: the fluctuations in Pupil size (SD ø [mm]) were reduced in the sessions *with* perimetry (E2 and E3) as compared to the merely pupillographic sessions *without* perimetry (E1 and E4). The dots represent average pupil size fluctuation per subject and per session. The diamonds portray the mean (diamond middle line) and 95% confidence interval (vertical diamond height) per examination type.

Figure A3

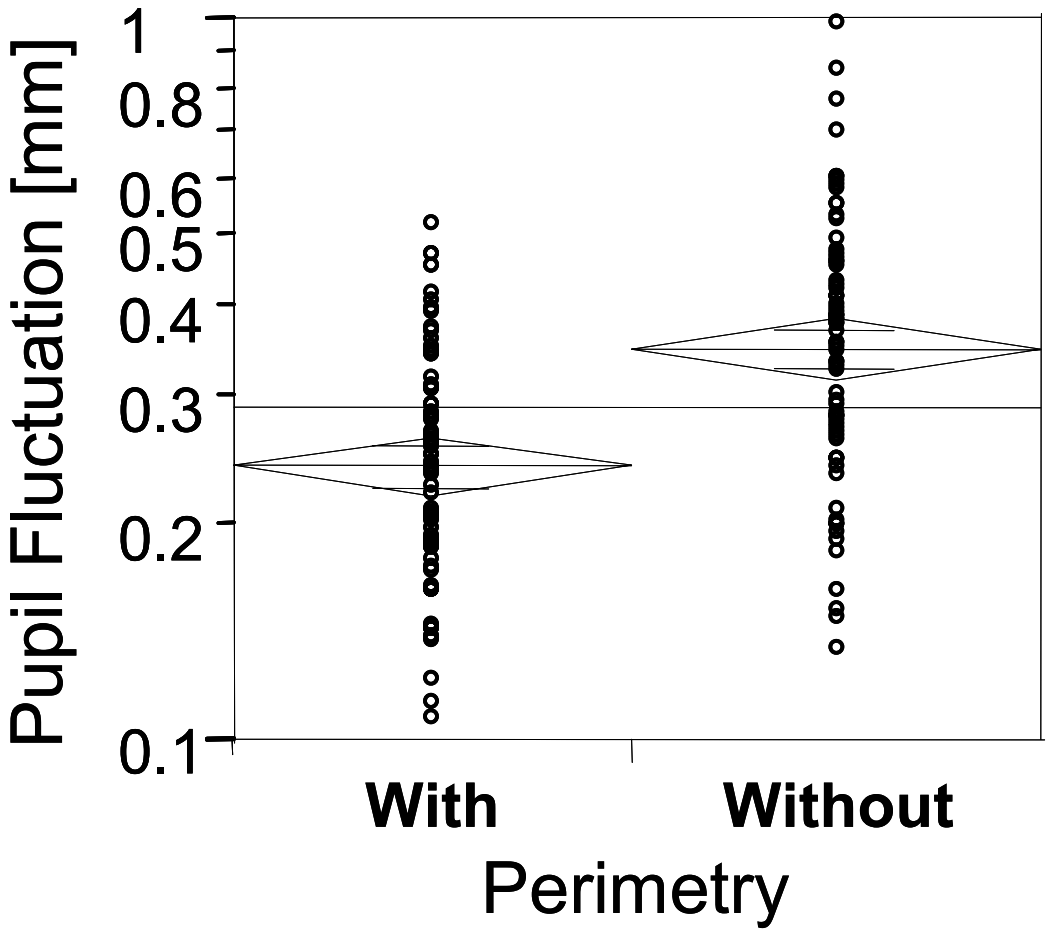

Pupil Fluctuation [mm]
1
0.8
0.6
0.5
0.4
0.3
0.2
0.1
With
Without
Perimetry

Table A2. Summary of the DLS and pupil diameter values per subject (Subj), day, examination (E), medication (Med: 1 dapiprazole, 2 placebo, 3 phenylephrine), stimulus type (Stim: 1 increment, 2 decrement) and (ID). Typ: the subject's answers to stimulus presentation either overlapped the respective DLS threshold (Ÿberschn.; in 183 cases) or there was a clear-cut threshold (getrennt; in 464 cases); in one case, DLS threshold could not be estimated as the subject answered positively to all stimulus intensities (nur Ja). The subject-centered values of pupil diameter and LUE are also shown.

Subj	Day	E	Med	Stim	ID	Typ	DLS [dB]	Pupil Size [mm]	Pupil Fluct [mm]	Pupil Size [mm] centered by subject	LUE [dB] centered by subject
1	1	2	1	1	1	getrennt	28.00	3.67	0.17	-1.12	-2.06
1	1	2	1	1	2	getrennt	28.90	3.62	0.28	-1.17	-1.16
1	1	2	1	1	3	getrennt	29.50	3.68	0.29	-1.12	-0.56
1	1	2	1	1	4	getrennt	27.40	3.69	0.20	-1.11	-2.66
1	1	2	1	1	5	getrennt	26.35	3.74	0.24	-1.06	-3.71
1	1	2	1	1	6	getrennt	30.90	3.17	1.22	-1.62	0.84
1	1	2	1	1	7	Ÿberschn.	29.20	3.76	0.21	-1.03	-0.86
1	1	2	1	1	8	getrennt	27.95	3.60	0.19	-1.19	-2.11
1	1	2	1	1	9	Ÿberschn.	32.99	3.67	0.30	-1.12	2.94
1	1	3	1	2	1	getrennt	28.70	3.85	0.34	-0.95	-1.36
1	1	3	1	2	2	Ÿberschn.	27.87	3.60	0.31	-1.20	-2.18
1	1	3	1	2	3	Ÿberschn.	29.58	4.09	0.13	-0.71	-0.48
1	1	3	1	2	4	getrennt	28.10	3.61	0.31	-1.18	-1.96
1	1	3	1	2	5	getrennt	28.10	3.79	0.22	-1.00	-1.96
1	1	3	1	2	6	Ÿberschn.	29.73	4.07	0.22	-0.73	-0.33
1	1	3	1	2	7	Ÿberschn.	30.32	3.86	0.38	-0.94	0.27
1	1	3	1	2	8	getrennt	27.60	3.60	0.27	-1.20	-2.46
1	1	3	1	2	9	Ÿberschn.	31.86	3.95	0.29	-0.84	1.81
1	2	2	2	1	1	getrennt	29.30	5.78	0.17	0.98	-0.76
1	2	2	2	1	2	getrennt	30.10	5.72	0.13	0.92	0.04
1	2	2	2	1	3	getrennt	29.90	5.72	0.17	0.93	-0.16
1	2	2	2	1	4	Ÿberschn.	30.69	5.67	0.23	0.87	0.63
1	2	2	2	1	5	Ÿberschn.	28.58	5.79	0.11	0.99	-1.47
1	2	2	2	1	6	getrennt	29.90	5.65	0.20	0.85	-0.16
1	2	2	2	1	7	getrennt	31.60	5.63	0.28	0.83	1.54
1	2	2	2	1	8	getrennt	29.60	5.75	0.18	0.96	-0.46
1	2	2	2	1	9	getrennt	35.45	5.67	0.18	0.88	5.39
1	2	3	2	2	1	getrennt	28.70	5.18	0.35	0.38	-1.36
1	2	3	2	2	2	Ÿberschn.	31.06	5.05	0.31	0.25	1.00
1	2	3	2	2	3	getrennt	29.70	4.77	0.30	-0.03	-0.36
1	2	3	2	2	4	getrennt	28.70	5.15	0.27	0.36	-1.36
1	2	3	2	2	5	getrennt	29.30	5.03	0.32	0.23	-0.76
1	2	3	2	2	6	getrennt	31.00	5.23	0.29	0.44	0.94
1	2	3	2	2	7	Ÿberschn.	29.58	5.00	0.47	0.21	-0.48
1	2	3	2	2	8	Ÿberschn.	30.55	5.29	0.30	0.49	0.50
1	2	3	2	2	9	getrennt	32.20	5.13	0.36	0.34	2.14

Table A2 continued

Subj	Day	E	Med	Stim	ID	Typ	DLS [dB]	Pupil Size [mm]	Pupil Fluct [mm]	Pupil Size [mm] centered by subject	LUE [dB] centered by subject
1	3	2	3	1	1	Ÿberschn.	29.59	5.15	0.20	0.36	-0.47
1	3	2	3	1	2	getrennt	30.10	5.28	0.26	0.48	0.04
1	3	2	3	1	3	Ÿberschn.	30.55	5.37	0.17	0.58	0.50
1	3	2	3	1	4	getrennt	30.00	5.14	0.16	0.34	-0.06
1	3	2	3	1	5	getrennt	28.10	5.10	0.20	0.31	-1.96
1	3	2	3	1	6	getrennt	30.40	5.13	0.20	0.34	0.34
1	3	2	3	1	7	getrennt	31.60	5.18	0.29	0.38	1.54
1	3	2	3	1	8	getrennt	30.00	5.17	0.23	0.38	-0.06
1	3	2	3	1	9	Ÿberschn.	36.45	5.29	0.29	0.49	6.39
1	3	3	3	2	1	getrennt	29.70	5.39	0.09	0.60	-0.36
1	3	3	3	2	2	Ÿberschn.	31.95	5.26	0.20	0.47	1.89
1	3	3	3	2	3	getrennt	30.10	5.25	0.18	0.45	0.04
1	3	3	3	2	4	getrennt	28.10	5.35	0.16	0.56	-1.96
1	3	3	3	2	5	getrennt	30.10	5.25	0.14	0.45	0.04
1	3	3	3	2	6	getrennt	30.00	5.44	0.21	0.65	-0.06
1	3	3	3	2	7	getrennt	30.10	5.32	0.19	0.52	0.04
1	3	3	3	2	8	getrennt	30.55	5.28	0.13	0.49	0.49
1	3	3	3	2	9	Ÿberschn.	36.65	5.37	0.27	0.58	6.59
2	1	2	3	2	1	getrennt	29.70	5.32	0.28	-0.17	-0.63
2	1	2	3	2	2	Ÿberschn.	32.92	5.38	0.20	-0.11	2.60
2	1	2	3	2	3	Ÿberschn.	31.92	5.45	0.32	-0.04	1.60
2	1	2	3	2	4	getrennt	28.70	5.37	0.59	-0.12	-1.63
2	1	2	3	2	5	getrennt	28.70	5.38	0.27	-0.11	-1.63
2	1	2	3	2	6	getrennt	30.50	5.48	0.20	-0.01	0.17
2	1	2	3	2	7	Ÿberschn.	30.72	5.48	0.30	-0.01	0.40
2	1	2	3	2	8	getrennt	32.20	5.40	0.16	-0.09	1.87
2	1	2	3	2	9	getrennt	34.00	5.33	0.20	-0.16	3.67
2	1	3	3	1	1	getrennt	31.70	5.70	0.40	0.21	1.37
2	1	3	3	1	2	getrennt	31.00	5.78	0.24	0.29	0.67
2	1	3	3	1	3	getrennt	33.90	5.94	0.22	0.45	3.57
2	1	3	3	1	4	getrennt	30.00	5.85	0.34	0.36	-0.33
2	1	3	3	1	5	getrennt	28.75	5.57	0.24	0.08	-1.58
2	1	3	3	1	6	getrennt	30.90	5.71	0.20	0.22	0.57
2	1	3	3	1	7	Ÿberschn.	29.42	5.82	0.37	0.33	-0.90
2	1	3	3	1	8	getrennt	31.60	5.53	0.29	0.04	1.27
2	1	3	3	1	9	getrennt	37.00	5.87	0.51	0.38	6.67
2	2	2	2	2	1	Ÿberschn.	29.60	7.01	0.28	1.52	-0.72
2	2	2	2	2	2	Ÿberschn.	30.36	6.92	0.31	1.43	0.04
2	2	2	2	2	3	getrennt	29.70	6.75	0.21	1.26	-0.63
2	2	2	2	2	4	getrennt	28.10	7.09	0.26	1.60	-2.23
2	2	2	2	2	5	Ÿberschn.	25.14	6.79	0.33	1.30	-5.18
2	2	2	2	2	6	Ÿberschn.	30.71	6.89	0.27	1.40	0.39
2	2	2	2	2	7	getrennt	28.10	7.10	0.15	1.62	-2.23
2	2	2	2	2	8	getrennt	29.20	6.95	0.31	1.46	-1.13

Table A2 continued

Subj	Day	E	Med	Stim	ID	Typ	DLS [dB]	Pupil Size [mm]	Pupil Fluct [mm]	Pupil Size [mm] centered by subject	LUE [dB] centered by subject
2	2	2	2	2	9	getrennt	34.00	6.92	0.49	1.43	3.67
2	2	3	2	1	1	getrennt	28.55	6.19	0.30	0.71	-1.78
2	2	3	2	1	2	getrennt	29.90	6.87	0.27	1.38	-0.43
2	2	3	2	1	3	getrennt	30.55	6.90	0.17	1.41	0.22
2	2	3	2	1	4	getrennt	28.00	6.61	0.26	1.12	-2.33
2	2	3	2	1	5	getrennt	28.55	6.78	0.19	1.29	-1.78
2	2	3	2	1	6	Ÿberschn.	30.26	6.60	0.29	1.11	-0.07
2	2	3	2	1	7	getrennt	26.80	6.70	0.29	1.21	-3.53
2	2	3	2	1	8	getrennt	29.90	6.59	0.37	1.10	-0.43
2	2	3	2	1	9	getrennt	35.45	6.87	0.12	1.38	5.12
2	3	2	1	2	1	getrennt	28.70	3.91	0.79	-1.58	-1.63
2	3	2	1	2	2	getrennt	30.10	3.61	1.63	-1.88	-0.23
2	3	2	1	2	3	Ÿberschn.	30.62	4.14	0.85	-1.35	0.29
2	3	2	1	2	4	getrennt	28.70	4.04	0.85	-1.45	-1.63
2	3	2	1	2	5	getrennt	29.30	4.56	0.42	-0.93	-1.03
2	3	2	1	2	6	getrennt	31.60	4.26	1.06	-1.23	1.27
2	3	2	1	2	7	getrennt	28.70	4.03	1.31	-1.46	-1.63
2	3	2	1	2	8	getrennt	30.00	4.41	0.41	-1.08	-0.33
2	3	2	1	2	9	getrennt	35.50	4.45	0.69	-1.04	5.17
2	3	3	1	1	1	getrennt	28.55	4.10	0.25	-1.39	-1.78
2	3	3	1	1	2	getrennt	29.90	3.88	0.04	-1.61	-0.43
2	3	3	1	1	3	getrennt	28.60	3.87	0.11	-1.62	-1.73
2	3	3	1	1	4	getrennt	28.00	3.98	0.29	-1.51	-2.33
2	3	3	1	1	5	getrennt	27.40	4.04	0.37	-1.45	-2.93
2	3	3	1	1	6	getrennt	30.50	4.12	0.27	-1.37	0.17
2	3	3	1	1	7	Ÿberschn.	27.45	4.09	0.18	-1.40	-2.87
2	3	3	1	1	8	Ÿberschn.	30.41	4.05	0.15	-1.44	0.09
2	3	3	1	1	9	getrennt	37.00	4.00	0.20	-1.49	6.67
3	1	2	3	1	1	getrennt	32.30	9.06	0.17	1.17	1.63
3	1	2	3	1	2	getrennt	32.30	9.01	0.27	1.12	1.63
3	1	2	3	1	3	getrennt	30.40	9.08	0.17	1.19	-0.27
3	1	2	3	1	4	getrennt	28.55	8.94	0.38	1.05	-2.12
3	1	2	3	1	5	Ÿberschn.	28.74	9.07	0.18	1.18	-1.92
3	1	2	3	1	6	getrennt	30.90	9.04	0.19	1.15	0.23
3	1	2	3	1	7	getrennt	27.40	8.22	1.35	0.34	-3.27
3	1	2	3	1	8	getrennt	29.60	9.03	0.20	1.14	-1.07
3	1	2	3	1	9	Ÿberschn.	35.04	9.00	0.17	1.11	4.38
3	1	3	3	2	1	getrennt	29.70	8.64	0.74	0.76	-0.97
3	1	3	3	2	2	getrennt	30.10	8.99	0.13	1.10	-0.57
3	1	3	3	2	3	getrennt	30.10	8.92	0.21	1.04	-0.57
3	1	3	3	2	4	getrennt	27.20	8.86	0.32	0.97	-3.47
3	1	3	3	2	5	getrennt	28.10	8.80	0.36	0.91	-2.57
3	1	3	3	2	6	getrennt	30.00	8.68	0.34	0.79	-0.67
3	1	3	3	2	7	getrennt	28.70	8.89	0.20	1.01	-1.97

Table A2 continued

Subj	Day	E	Med	Stim	ID	Typ	DLS [dB]	Pupil Size [mm]	Pupil Fluct [mm]	Pupil Size [mm] centered by subject	LUE [dB] centered by subject
3	1	3	3	2	8	getrennt	30.55	8.97	0.14	1.08	-0.12
3	1	3	3	2	9	getrennt	32.20	8.76	0.14	0.87	1.53
3	2	2	1	1	1	getrennt	31.10	6.16	0.14	-1.72	0.43
3	2	2	1	1	2	getrennt	32.30	6.19	0.16	-1.70	1.63
3	2	2	1	1	3	Ÿberschn.	33.09	6.21	0.17	-1.68	2.43
3	2	2	1	1	4	getrennt	29.60	6.17	0.09	-1.71	-1.07
3	2	2	1	1	5	getrennt	27.80	6.25	0.19	-1.63	-2.87
3	2	2	1	1	6	getrennt	31.50	6.11	0.13	-1.78	0.83
3	2	2	1	1	7	getrennt	30.00	6.23	0.19	-1.65	-0.67
3	2	2	1	1	8	getrennt	31.00	6.21	0.17	-1.68	0.33
3	2	2	1	1	9	getrennt	33.90	6.12	0.24	-1.77	3.23
3	2	3	1	2	1	getrennt	29.30	6.19	0.42	-1.70	-1.37
3	2	3	1	2	2	Ÿberschn.	30.76	6.23	0.20	-1.66	0.09
3	2	3	1	2	3	getrennt	30.10	6.12	0.40	-1.77	-0.57
3	2	3	1	2	4	getrennt	30.60	6.29	0.18	-1.60	-0.07
3	2	3	1	2	5	Ÿberschn.	30.56	6.29	0.22	-1.59	-0.10
3	2	3	1	2	6	getrennt	29.20	6.21	0.46	-1.68	-1.47
3	2	3	1	2	7	getrennt	28.10	5.63	1.70	-2.26	-2.57
3	2	3	1	2	8	getrennt	30.10	6.19	0.26	-1.69	-0.57
3	2	3	1	2	9	getrennt	35.50	6.04	0.27	-1.85	4.83
3	3	2	2	1	1	getrennt	30.10	8.65	0.25	0.76	-0.57
3	3	2	2	1	2	getrennt	31.00	8.63	0.17	0.74	0.33
3	3	2	2	1	3	getrennt	30.90	8.45	0.33	0.56	0.23
3	3	2	2	1	4	getrennt	31.60	8.67	0.22	0.78	0.93
3	3	2	2	1	5	Ÿberschn.	30.55	8.77	0.13	0.88	-0.11
3	3	2	2	1	6	Ÿberschn.	33.05	8.64	0.19	0.75	2.38
3	3	2	2	1	7	getrennt	30.00	8.58	0.20	0.70	-0.67
3	3	2	2	1	8	Ÿberschn.	33.15	8.69	0.22	0.80	2.48
3	3	2	2	1	9	getrennt	35.45	8.66	0.22	0.78	4.78
3	3	3	2	2	1	Ÿberschn.	30.36	8.61	0.21	0.73	-0.31
3	3	3	2	2	2	getrennt	30.60	8.54	0.14	0.65	-0.07
3	3	3	2	2	3	getrennt	29.70	8.53	0.21	0.64	-0.97
3	3	3	2	2	4	Ÿberschn.	29.32	8.69	0.23	0.80	-1.34
3	3	3	2	2	5	getrennt	30.10	8.61	0.12	0.72	-0.57
3	3	3	2	2	6	getrennt	30.00	8.63	0.20	0.74	-0.67
3	3	3	2	2	7	getrennt	28.70	8.67	0.15	0.78	-1.97
3	3	3	2	2	8	getrennt	30.10	8.46	0.13	0.57	-0.57
3	3	3	2	2	9	Ÿberschn.	34.85	8.65	0.22	0.76	4.19
4	1	2	3	1	1	Ÿberschn.	27.65	7.72	0.17	1.18	-2.01
4	1	2	3	1	2	Ÿberschn.	30.31	7.61	0.20	1.07	0.64
4	1	2	3	1	3	Ÿberschn.	30.55	7.63	0.15	1.09	0.89
4	1	2	3	1	4	getrennt	25.70	7.72	0.14	1.19	-3.97
4	1	2	3	1	5	Ÿberschn.	27.45	7.69	0.14	1.16	-2.21
4	1	2	3	1	6	getrennt	30.40	7.80	0.11	1.26	0.73

Table A2 continued

Subj	Day	E	Med	Stim	ID	Typ	DLS [dB]	Pupil Size [mm]	Pupil Fluct [mm]	Pupil Size [mm] centered by subject	LUE [dB] centered by subject
4	1	2	3	1	7	getrennt	30.50	7.81	0.13	1.27	0.83
4	1	2	3	1	8	getrennt	31.60	7.77	0.10	1.23	1.93
4	1	2	3	1	9	Ÿberschn.	35.63	7.63	0.20	1.10	5.96
4	1	3	3	2	1	Ÿberschn.	26.75	7.74	0.12	1.21	-2.91
4	1	3	3	2	2	getrennt	30.10	7.67	0.13	1.13	0.43
4	1	3	3	2	3	Ÿberschn.	29.54	7.67	0.18	1.13	-0.12
4	1	3	3	2	4	getrennt	27.65	7.74	0.11	1.21	-2.02
4	1	3	3	2	5	getrennt	28.70	7.77	0.13	1.23	-0.97
4	1	3	3	2	6	getrennt	30.00	7.62	0.13	1.09	0.33
4	1	3	3	2	7	Ÿberschn.	29.48	7.67	0.14	1.13	-0.19
4	1	3	3	2	8	getrennt	30.10	7.61	0.10	1.07	0.43
4	1	3	3	2	9	getrennt	32.20	7.72	0.14	1.18	2.53
4	2	2	2	1	1	getrennt	28.00	6.24	0.52	-0.30	-1.67
4	2	2	2	1	2	Ÿberschn.	30.72	6.42	0.15	-0.11	1.06
4	2	2	2	1	3	getrennt	30.40	6.28	0.23	-0.25	0.73
4	2	2	2	1	4	getrennt	26.50	6.64	0.20	0.10	-3.17
4	2	2	2	1	5	getrennt	27.30	6.48	0.10	-0.05	-2.37
4	2	2	2	1	6	Ÿberschn.	30.82	6.47	0.11	-0.07	1.15
4	2	2	2	1	7	getrennt	30.00	6.49	0.19	-0.05	0.33
4	2	2	2	1	8	getrennt	30.50	6.57	0.14	0.03	0.83
4	2	2	2	1	9	getrennt	33.90	6.58	0.16	0.04	4.23
4	2	3	2	2	1	getrennt	28.10	6.25	0.11	-0.29	-1.57
4	2	3	2	2	2	getrennt	31.70	5.62	1.78	-0.92	2.03
4	2	3	2	2	3	getrennt	29.70	5.91	0.75	-0.62	0.03
4	2	3	2	2	4	getrennt	27.65	6.17	0.14	-0.36	-2.02
4	2	3	2	2	5	Ÿberschn.	29.48	6.18	0.08	-0.35	-0.19
4	2	3	2	2	6	Ÿberschn.	29.45	6.05	0.61	-0.49	-0.22
4	2	3	2	2	7	getrennt	29.30	6.25	0.16	-0.28	-0.37
4	2	3	2	2	8	getrennt	31.00	6.14	0.19	-0.40	1.33
4	2	3	2	2	9	getrennt	32.20	5.98	0.71	-0.55	2.53
4	3	2	1	1	1	Ÿberschn.	27.62	5.84	0.15	-0.70	-2.04
4	3	2	1	1	2	getrennt	30.10	5.92	0.10	-0.61	0.43
4	3	2	1	1	3	Ÿberschn.	29.81	5.83	0.19	-0.71	0.15
4	3	2	1	1	4	getrennt	27.90	5.83	0.13	-0.71	-1.77
4	3	2	1	1	5	getrennt	26.35	5.89	0.18	-0.64	-3.32
4	3	2	1	1	6	getrennt	29.90	5.88	0.15	-0.65	0.23
4	3	2	1	1	7	getrennt	29.60	5.77	0.18	-0.76	-0.07
4	3	2	1	1	8	getrennt	30.50	5.85	0.16	-0.69	0.83
4	3	2	1	1	9	getrennt	35.45	5.79	0.11	-0.75	5.78
4	3	3	1	2	1	getrennt	26.65	5.57	0.07	-0.97	-3.02
4	3	3	1	2	2	getrennt	30.10	5.44	0.13	-1.10	0.43
4	3	3	1	2	3	getrennt	30.10	5.48	0.14	-1.06	0.43
4	3	3	1	2	4	getrennt	28.10	5.44	0.10	-1.10	-1.57
4	3	3	1	2	5	getrennt	28.70	5.46	0.10	-1.08	-0.97

Table A2 continued

Subj	Day	E	Med	Stim	ID	Typ	DLS [dB]	Pupil Size [mm]	Pupil Fluct [mm]	Pupil Size [mm] centered by subject	LUE [dB] centered by subject
4	3	3	1	2	6	getrennt	28.60	5.44	0.10	-1.09	-1.07
4	3	3	1	2	7	getrennt	28.10	5.46	0.18	-1.07	-1.57
4	3	3	1	2	8	Ÿberschn.	30.59	5.42	0.11	-1.12	0.93
4	3	3	1	2	9	Ÿberschn.	32.76	5.34	0.14	-1.19	3.09
5	1	2	3	2	1	Ÿberschn.	27.81	6.46	0.15	0.72	-0.40
5	1	2	3	2	2	getrennt	30.10	6.42	0.26	0.67	1.89
5	1	2	3	2	3	getrennt	28.70	6.66	0.08	0.91	0.49
5	1	2	3	2	4	Ÿberschn.	22.71	6.52	0.25	0.77	-5.50
5	1	2	3	2	5	getrennt	29.30	6.50	0.15	0.76	1.09
5	1	2	3	2	6	getrennt	29.60	6.54	0.21	0.79	1.39
5	1	2	3	2	7	Ÿberschn.	27.30	6.42	0.22	0.67	-0.91
5	1	2	3	2	8	Ÿberschn.	30.39	6.47	0.14	0.72	2.18
5	1	2	3	2	9	getrennt	30.55	6.56	0.27	0.81	2.34
5	1	3	3	1	1	getrennt	29.30	6.38	0.98	0.63	1.09
5	1	3	3	1	2	getrennt	29.20	6.39	0.33	0.64	0.99
5	1	3	3	1	3	getrennt	29.10	6.39	0.32	0.64	0.89
5	1	3	3	1	4	Ÿberschn.	26.86	6.44	0.27	0.69	-1.35
5	1	3	3	1	5	getrennt	27.80	6.69	0.19	0.94	-0.41
5	1	3	3	1	6	getrennt	29.10	6.83	0.12	1.08	0.89
5	1	3	3	1	7	getrennt	27.90	6.48	0.36	0.73	-0.31
5	1	3	3	1	8	getrennt	29.20	6.53	0.33	0.78	0.99
5	1	3	3	1	9	Ÿberschn.	32.76	6.62	0.20	0.87	4.55
5	2	2	1	2	1	getrennt	28.65	5.05	0.15	-0.70	0.44
5	2	2	1	2	2	getrennt	28.00	4.82	0.20	-0.93	-0.21
5	2	2	1	2	3	Ÿberschn.	28.26	4.74	0.21	-1.01	0.05
5	2	2	1	2	4	Ÿberschn.	25.36	4.87	0.28	-0.87	-2.85
5	2	2	1	2	5	getrennt	26.35	4.80	0.38	-0.95	-1.86
5	2	2	1	2	6	Ÿberschn.	28.26	4.78	0.25	-0.97	0.05
5	2	2	1	2	7	getrennt	26.50	4.95	0.27	-0.80	-1.71
5	2	2	1	2	8	Ÿberschn.	28.63	4.99	0.37	-0.76	0.42
5	2	2	1	2	9	Ÿberschn.	33.56	4.87	0.16	-0.87	5.35
5	2	3	1	1	1	Ÿberschn.	28.25	4.47	0.20	-1.28	0.04
5	2	3	1	1	2	getrennt	28.10	4.64	0.27	-1.11	-0.11
5	2	3	1	1	3	getrennt	29.30	4.58	0.24	-1.17	1.09
5	2	3	1	1	4	getrennt	23.25	4.49	0.38	-1.26	-4.96
5	2	3	1	1	5	Ÿberschn.	24.70	4.56	0.28	-1.19	-3.51
5	2	3	1	1	6	getrennt	27.55	4.64	0.25	-1.11	-0.66
5	2	3	1	1	7	Ÿberschn.	26.49	4.54	0.24	-1.21	-1.72
5	2	3	1	1	8	getrennt	28.10	4.73	0.22	-1.02	-0.11
5	2	3	1	1	9	getrennt	31.00	4.55	0.17	-1.20	2.79
5	3	2	2	2	1	getrennt	28.70	5.65	1.34	-0.10	0.49
5	3	2	2	2	2	getrennt	29.30	5.91	0.47	0.16	1.09
5	3	2	2	2	3	getrennt	29.30	5.36	1.50	-0.39	1.09
5	3	2	2	2	4	getrennt	25.80	5.04	1.69	-0.71	-2.41

Table A2 continued

Subj	Day	E	Med	Stim	ID	Typ	DLS [dB]	Pupil Size [mm]	Pupil Fluct [mm]	Pupil Size [mm] centered by subject	LUE [dB] centered by subject
5	3	2	2	2	5	Ÿberschn.	27.81	5.69	1.09	-0.06	-0.40
5	3	2	2	2	6	getrennt	28.60	6.31	0.23	0.56	0.39
5	3	2	2	2	7	Ÿberschn.	26.69	5.58	1.25	-0.17	-1.52
5	3	2	2	2	8	getrennt	29.30	6.05	0.58	0.30	1.09
5	3	2	2	2	9	getrennt	31.00	6.27	0.11	0.52	2.79
5	3	3	2	1	1	getrennt	28.00	6.20	0.31	0.45	-0.21
5	3	3	2	1	2	getrennt	28.00	6.15	0.27	0.40	-0.21
5	3	3	2	1	3	getrennt	27.85	6.17	0.48	0.42	-0.36
5	3	3	2	1	4	Ÿberschn.	26.79	6.22	0.42	0.47	-1.42
5	3	3	2	1	5	Ÿberschn.	25.05	6.38	0.09	0.63	-3.16
5	3	3	2	1	6	getrennt	27.85	6.28	0.27	0.53	-0.36
5	3	3	2	1	7	Ÿberschn.	25.62	6.29	0.36	0.55	-2.59
5	3	3	2	1	8	getrennt	27.40	6.24	0.39	0.49	-0.81
5	3	3	2	1	9	getrennt	32.20	6.30	0.29	0.55	3.99
6	1	2	2	2	1	getrennt	29.30	4.67	0.18	0.05	-0.07
6	1	2	2	2	2	getrennt	30.10	3.98	1.23	-0.64	0.73
6	1	2	2	2	3	getrennt	30.10	4.61	0.17	-0.01	0.73
6	1	2	2	2	4	getrennt	27.65	4.49	0.25	-0.13	-1.72
6	1	2	2	2	5	getrennt	28.10	4.63	0.10	0.01	-1.27
6	1	2	2	2	6	getrennt	30.00	4.66	0.20	0.04	0.63
6	1	2	2	2	7	getrennt	28.10	4.45	0.79	-0.17	-1.27
6	1	2	2	2	8	Ÿberschn.	29.58	4.55	0.13	-0.06	0.21
6	1	2	2	2	9	getrennt	31.60	4.54	0.06	-0.08	2.23
6	1	3	2	1	1	getrennt	30.60	4.36	0.19	-0.26	1.23
6	1	3	2	1	2	getrennt	29.20	4.24	0.34	-0.38	-0.17
6	1	3	2	1	3	getrennt	29.10	4.46	0.23	-0.16	-0.27
6	1	3	2	1	4	Ÿberschn.	25.95	4.39	0.28	-0.22	-3.42
6	1	3	2	1	5	Ÿberschn.	25.41	4.32	0.23	-0.29	-3.96
6	1	3	2	1	6	Ÿberschn.	30.56	4.31	0.33	-0.31	1.19
6	1	3	2	1	7	Ÿberschn.	28.59	4.44	0.22	-0.17	-0.78
6	1	3	2	1	8	getrennt	28.85	4.26	0.31	-0.36	-0.52
6	1	3	2	1	9	Ÿberschn.	33.62	4.54	0.22	-0.08	4.25
6	2	2	1	2	1	getrennt	28.70	4.72	0.26	0.11	-0.67
6	2	2	1	2	2	Ÿberschn.	29.82	4.63	0.13	0.01	0.45
6	2	2	1	2	3	getrennt	30.10	4.51	0.17	-0.10	0.73
6	2	2	1	2	4	getrennt	26.65	4.60	0.12	-0.02	-2.72
6	2	2	1	2	5	Ÿberschn.	28.86	4.62	0.13	0.00	-0.51
6	2	2	1	2	6	getrennt	30.50	4.61	0.21	0.00	1.13
6	2	2	1	2	7	Ÿberschn.	28.47	4.68	0.20	0.06	-0.90
6	2	2	1	2	8	getrennt	30.55	4.47	0.10	-0.15	1.18
6	2	2	1	2	9	getrennt	31.60	4.61	0.13	0.00	2.23
6	2	3	1	1	1	getrennt	29.70	4.50	0.21	-0.12	0.33
6	2	3	1	1	2	getrennt	30.10	4.24	0.37	-0.38	0.73
6	2	3	1	1	3	getrennt	29.50	4.50	0.33	-0.11	0.13

Table A2 continued

Subj	Day	E	Med	Stim	ID	Typ	DLS [dB]	Pupil Size [mm]	Pupil Fluct [mm]	Pupil Size [mm] centered by subject	LUE [dB] centered by subject
6	2	3	1	1	4	Ÿberschn.	26.48	4.35	0.27	-0.26	-2.89
6	2	3	1	1	5	getrennt	27.30	4.29	0.34	-0.32	-2.07
6	2	3	1	1	6	getrennt	29.50	4.42	0.24	-0.20	0.13
6	2	3	1	1	7	getrennt	28.55	4.45	0.21	-0.17	-0.82
6	2	3	1	1	8	getrennt	28.85	4.35	0.24	-0.27	-0.52
6	2	3	1	1	9	getrennt	33.90	4.35	0.26	-0.27	4.53
6	3	2	3	2	1	getrennt	29.70	5.07	0.15	0.45	0.33
6	3	2	3	2	2	Ÿberschn.	30.82	5.10	0.15	0.48	1.45
6	3	2	3	2	3	getrennt	29.70	5.03	0.29	0.41	0.33
6	3	2	3	2	4	getrennt	27.65	4.96	0.18	0.34	-1.72
6	3	2	3	2	5	getrennt	28.10	5.08	0.10	0.47	-1.27
6	3	2	3	2	6	getrennt	30.00	5.02	0.22	0.41	0.63
6	3	2	3	2	7	getrennt	28.10	5.04	0.24	0.42	-1.27
6	3	2	3	2	8	getrennt	30.10	5.01	0.27	0.39	0.73
6	3	2	3	2	9	getrennt	32.20	4.98	0.22	0.37	2.83
6	3	3	3	1	1	getrennt	28.65	4.81	0.07	0.19	-0.72
6	3	3	3	1	2	getrennt	29.65	5.03	0.24	0.41	0.28
6	3	3	3	1	3	getrennt	30.40	4.73	0.21	0.11	1.03
6	3	3	3	1	4	getrennt	27.40	4.67	0.28	0.05	-1.97
6	3	3	3	1	5	getrennt	27.30	4.85	0.12	0.24	-2.07
6	3	3	3	1	6	Ÿberschn.	28.37	4.84	0.23	0.23	-1.00
6	3	3	3	1	7	getrennt	29.20	4.74	0.30	0.12	-0.17
6	3	3	3	1	8	Ÿberschn.	29.20	4.63	0.20	0.01	-0.17
6	3	3	3	1	9	getrennt	33.90	4.93	0.15	0.31	4.53
7	1	2	1	2	1	getrennt	30.60	4.68	0.26	0.00	1.33
7	1	2	1	2	2	getrennt	28.10	4.64	0.15	-0.05	-1.17
7	1	2	1	2	3	getrennt	29.70	4.62	0.19	-0.06	0.43
7	1	2	1	2	4	getrennt	29.30	4.66	0.14	-0.02	0.03
7	1	2	1	2	5	getrennt	29.30	4.55	0.12	-0.14	0.03
7	1	2	1	2	6	getrennt	30.00	4.70	0.19	0.01	0.73
7	1	2	1	2	7	getrennt	28.70	4.66	0.11	-0.03	-0.57
7	1	2	1	2	8	Ÿberschn.	29.70	4.65	0.22	-0.04	0.43
7	1	2	1	2	9	getrennt	33.10	4.53	0.15	-0.16	3.83
7	1	3	1	1	1	getrennt	29.70	4.15	0.15	-0.53	0.43
7	1	3	1	1	2	getrennt	28.00	4.32	0.13	-0.37	-1.27
7	1	3	1	1	3	getrennt	29.10	4.21	0.10	-0.47	-0.17
7	1	3	1	1	4	getrennt	26.50	4.46	0.35	-0.22	-2.77
7	1	3	1	1	5	getrennt	28.10	4.22	0.12	-0.47	-1.17
7	1	3	1	1	6	getrennt	30.40	4.17	0.31	-0.52	1.13
7	1	3	1	1	7	getrennt	28.55	4.18	0.18	-0.51	-0.72
7	1	3	1	1	8	Ÿberschn.	28.63	4.16	0.15	-0.53	-0.64
7	1	3	1	1	9	nurJa	.	4.26	0.14	-0.43	.
7	2	2	2	2	1	getrennt	30.60	5.40	0.26	0.71	1.33
7	2	2	2	2	2	getrennt	28.70	5.16	0.59	0.47	-0.57

Table A2 continued

Subj	Day	E	Med	Stim	ID	Typ	DLS [dB]	Pupil Size [mm]	Pupil Fluct [mm]	Pupil Size [mm] centered by subject	LUE [dB] centered by subject
7	2	2	2	2	3	getrennt	30.10	5.32	0.37	0.63	0.83
7	2	2	2	2	4	getrennt	27.65	4.94	0.51	0.25	-1.62
7	2	2	2	2	5	getrennt	28.10	4.70	0.42	0.01	-1.17
7	2	2	2	2	6	Ÿberschn.	30.69	5.02	0.58	0.34	1.42
7	2	2	2	2	7	getrennt	28.10	4.87	0.36	0.18	-1.17
7	2	2	2	2	8	Ÿberschn.	29.18	4.98	0.47	0.29	-0.08
7	2	2	2	2	9	getrennt	33.10	5.19	0.55	0.51	3.83
7	2	3	2	1	1	Ÿberschn.	28.45	4.37	0.49	-0.31	-0.81
7	2	3	2	1	2	Ÿberschn.	27.91	4.55	0.42	-0.14	-1.36
7	2	3	2	1	3	getrennt	28.75	4.39	0.32	-0.30	-0.52
7	2	3	2	1	4	Ÿberschn.	29.18	4.40	0.35	-0.28	-0.08
7	2	3	2	1	5	getrennt	25.90	4.28	0.30	-0.41	-3.37
7	2	3	2	1	6	getrennt	29.10	4.43	0.45	-0.25	-0.17
7	2	3	2	1	7	getrennt	27.40	4.42	0.39	-0.26	-1.87
7	2	3	2	1	8	getrennt	29.20	4.55	0.29	-0.14	-0.07
7	2	3	2	1	9	getrennt	32.20	4.20	0.18	-0.48	2.93
7	3	2	3	2	1	getrennt	30.10	5.27	0.34	0.59	0.83
7	3	2	3	2	2	getrennt	30.10	5.24	0.26	0.55	0.83
7	3	2	3	2	3	getrennt	28.70	5.52	0.18	0.84	-0.57
7	3	2	3	2	4	Ÿberschn.	29.66	5.28	0.21	0.60	0.39
7	3	2	3	2	5	getrennt	30.10	5.24	0.24	0.55	0.83
7	3	2	3	2	6	getrennt	30.00	5.27	0.16	0.59	0.73
7	3	2	3	2	7	getrennt	28.70	5.38	0.10	0.69	-0.57
7	3	2	3	2	8	Ÿberschn.	30.68	5.16	0.38	0.47	1.41
7	3	2	3	2	9	getrennt	33.10	5.38	0.15	0.70	3.83
7	3	3	3	1	1	getrennt	28.65	4.60	0.16	-0.08	-0.62
7	3	3	3	1	2	getrennt	28.00	4.45	0.35	-0.24	-1.27
7	3	3	3	1	3	getrennt	30.40	4.37	0.32	-0.31	1.13
7	3	3	3	1	4	getrennt	27.90	4.85	0.15	0.16	-1.37
7	3	3	3	1	5	Ÿberschn.	25.30	4.12	0.44	-0.57	-3.96
7	3	3	3	1	6	getrennt	28.75	4.43	0.53	-0.25	-0.52
7	3	3	3	1	7	Ÿberschn.	27.79	4.33	0.46	-0.36	-1.48
7	3	3	3	1	8	Ÿberschn.	27.59	4.42	0.39	-0.27	-1.68
7	3	3	3	1	9	getrennt	33.90	4.75	0.36	0.06	4.63
8	1	2	1	2	1	getrennt	28.70	5.62	0.25	0.22	0.47
8	1	2	1	2	2	Ÿberschn.	28.61	5.78	0.27	0.38	0.38
8	1	2	1	2	3	getrennt	28.70	5.40	0.56	0.00	0.47
8	1	2	1	2	4	getrennt	28.10	5.72	0.23	0.33	-0.13
8	1	2	1	2	5	getrennt	28.70	5.96	0.11	0.57	0.47
8	1	2	1	2	6	Ÿberschn.	28.70	5.85	0.21	0.45	0.47
8	1	2	1	2	7	getrennt	28.70	5.66	0.27	0.27	0.47
8	1	2	1	2	8	getrennt	29.30	4.84	2.15	-0.56	1.07
8	1	2	1	2	9	Ÿberschn.	33.16	5.74	0.34	0.34	4.93
8	1	3	1	1	1	Ÿberschn.	27.14	4.51	0.49	-0.88	-1.09

Table A2 continued

Subj	Day	E	Med	Stim	ID	Typ	DLS [dB]	Pupil Size [mm]	Pupil Fluct [mm]	Pupil Size [mm] centered by subject	LUE [dB] centered by subject
8	1	3	1	1	2	getrennt	28.00	5.06	0.50	-0.33	-0.23
8	1	3	1	1	3	getrennt	28.40	4.91	0.54	-0.49	0.17
8	1	3	1	1	4	getrennt	24.25	5.07	0.42	-0.33	-3.98
8	1	3	1	1	5	Ÿberschn.	24.20	4.97	0.36	-0.43	-4.03
8	1	3	1	1	6	Ÿberschn.	27.04	4.86	0.44	-0.54	-1.19
8	1	3	1	1	7	Ÿberschn.	26.40	5.01	0.36	-0.39	-1.83
8	1	3	1	1	8	getrennt	26.90	4.57	0.81	-0.83	-1.33
8	1	3	1	1	9	getrennt	35.45	5.07	0.55	-0.33	7.22
8	2	2	3	2	1	getrennt	28.00	5.56	0.50	0.16	-0.23
8	2	2	3	2	2	Ÿberschn.	29.10	5.11	0.72	-0.29	0.87
8	2	2	3	2	3	getrennt	28.40	5.53	0.40	0.13	0.17
8	2	2	3	2	4	Ÿberschn.	24.94	5.47	0.39	0.08	-3.29
8	2	2	3	2	5	getrennt	25.40	5.47	0.30	0.08	-2.83
8	2	2	3	2	6	getrennt	28.40	5.39	0.64	-0.01	0.17
8	2	2	3	2	7	getrennt	28.55	5.31	0.32	-0.09	0.32
8	2	2	3	2	8	getrennt	27.90	5.34	0.55	-0.06	-0.33
8	2	2	3	2	9	Ÿberschn.	35.63	5.55	0.41	0.15	7.40
8	2	3	3	1	1	getrennt	25.30	4.46	0.68	-0.94	-2.93
8	2	3	3	1	2	Ÿberschn.	27.33	4.46	0.75	-0.93	-0.90
8	2	3	3	1	3	Ÿberschn.	27.55	4.90	0.77	-0.49	-0.68
8	2	3	3	1	4	getrennt	24.35	4.84	0.57	-0.56	-3.88
8	2	3	3	1	5	Ÿberschn.	25.85	4.92	0.57	-0.48	-2.38
8	2	3	3	1	6	getrennt	26.90	4.60	0.55	-0.79	-1.33
8	2	3	3	1	7	getrennt	25.20	5.01	0.26	-0.39	-3.03
8	2	3	3	1	8	Ÿberschn.	27.73	4.66	0.56	-0.74	-0.50
8	2	3	3	1	9	getrennt	31.60	4.92	0.51	-0.48	3.37
8	3	2	2	2	1	getrennt	28.70	5.86	0.52	0.47	0.47
8	3	2	2	2	2	getrennt	29.70	6.13	0.18	0.73	1.47
8	3	2	2	2	3	getrennt	28.70	6.18	0.19	0.78	0.47
8	3	2	2	2	4	getrennt	27.65	6.07	0.26	0.67	-0.58
8	3	2	2	2	5	getrennt	28.70	6.21	0.29	0.82	0.47
8	3	2	2	2	6	getrennt	28.00	6.00	0.35	0.60	-0.23
8	3	2	2	2	7	getrennt	28.10	6.12	0.27	0.73	-0.13
8	3	2	2	2	8	getrennt	29.70	6.06	0.30	0.66	1.47
8	3	2	2	2	9	getrennt	33.10	6.11	0.19	0.72	4.87
8	3	3	2	1	1	getrennt	28.65	5.48	0.46	0.08	0.42
8	3	3	2	1	2	getrennt	27.50	5.59	0.32	0.19	-0.73
8	3	3	2	1	3	getrennt	28.40	5.73	0.35	0.33	0.17
8	3	3	2	1	4	getrennt	25.25	5.70	0.24	0.30	-2.98
8	3	3	2	1	5	Ÿberschn.	24.79	5.63	0.28	0.23	-3.44
8	3	3	2	1	6	Ÿberschn.	27.62	5.65	0.44	0.26	-0.61
8	3	3	2	1	7	getrennt	27.90	5.62	0.40	0.23	-0.33
8	3	3	2	1	8	getrennt	27.90	5.50	0.24	0.10	-0.33
8	3	3	2	1	9	getrennt	35.45	5.67	0.41	0.28	7.22

Table A2 continued

Subj	Day	E	Med	Stim	ID	Typ	DLS [dB]	Pupil Size [mm]	Pupil Fluct [mm]	Pupil Size [mm] centered by subject	LUE [dB] centered by subject
9	1	2	1	1	1	getrennt	28.00	4.82	0.37	-0.81	0.14
9	1	2	1	1	2	Ÿberschn.	28.27	4.83	0.21	-0.80	0.41
9	1	2	1	1	3	Ÿberschn.	29.60	5.02	0.26	-0.61	1.74
9	1	2	1	1	4	getrennt	26.10	5.04	0.29	-0.59	-1.76
9	1	2	1	1	5	Ÿberschn.	25.21	4.80	0.29	-0.83	-2.65
9	1	2	1	1	6	getrennt	27.30	4.82	0.46	-0.81	-0.56
9	1	2	1	1	7	getrennt	27.90	4.92	0.35	-0.71	0.04
9	1	2	1	1	8	getrennt	28.85	4.65	0.38	-0.98	0.99
9	1	2	1	1	9	getrennt	30.90	4.78	0.33	-0.85	3.04
9	1	3	1	2	1	getrennt	28.10	4.75	0.14	-0.88	0.24
9	1	3	1	2	2	getrennt	28.70	4.68	0.27	-0.95	0.84
9	1	3	1	2	3	getrennt	28.70	4.69	0.25	-0.94	0.84
9	1	3	1	2	4	Ÿberschn.	22.93	4.88	0.27	-0.75	-4.93
9	1	3	1	2	5	getrennt	26.10	4.78	0.30	-0.85	-1.76
9	1	3	1	2	6	getrennt	24.30	4.79	0.26	-0.84	-3.56
9	1	3	1	2	7	getrennt	28.10	4.80	0.18	-0.84	0.24
9	1	3	1	2	8	Ÿberschn.	27.10	4.71	0.21	-0.92	-0.76
9	1	3	1	2	9	getrennt	31.00	4.77	0.26	-0.86	3.14
9	2	2	3	1	1	getrennt	28.65	6.68	0.37	1.04	0.79
9	2	2	3	1	2	getrennt	28.00	6.72	0.23	1.09	0.14
9	2	2	3	1	3	getrennt	28.75	6.74	0.27	1.11	0.89
9	2	2	3	1	4	getrennt	26.90	6.47	0.36	0.84	-0.96
9	2	2	3	1	5	Ÿberschn.	27.23	6.59	0.43	0.96	-0.63
9	2	2	3	1	6	Ÿberschn.	27.59	6.57	0.30	0.93	-0.27
9	2	2	3	1	7	Ÿberschn.	30.05	6.62	0.40	0.99	2.19
9	2	2	3	1	8	Ÿberschn.	28.77	6.69	0.17	1.05	0.91
9	2	2	3	1	9	getrennt	32.20	6.56	0.36	0.93	4.34
9	2	3	3	2	1	getrennt	28.10	6.45	0.24	0.82	0.24
9	2	3	3	2	2	getrennt	28.70	6.65	0.24	1.01	0.84
9	2	3	3	2	3	Ÿberschn.	28.79	6.69	0.32	1.06	0.93
9	2	3	3	2	4	getrennt	26.10	6.73	0.18	1.10	-1.76
9	2	3	3	2	5	getrennt	24.60	6.60	0.28	0.97	-3.26
9	2	3	3	2	6	Ÿberschn.	25.94	6.71	0.18	1.07	-1.92
9	2	3	3	2	7	getrennt	28.10	6.58	0.20	0.95	0.24
9	2	3	3	2	8	getrennt	28.70	6.71	0.23	1.08	0.84
9	2	3	3	2	9	Ÿberschn.	29.70	6.65	0.34	1.02	1.84
9	3	2	2	1	1	getrennt	26.60	5.47	0.06	-0.16	-1.26
9	3	2	2	1	2	getrennt	28.60	5.72	0.17	0.09	0.74
9	3	2	2	1	3	getrennt	28.75	5.37	0.19	-0.26	0.89
9	3	2	2	1	4	Ÿberschn.	26.63	5.53	0.38	-0.10	-1.23
9	3	2	2	1	5	Ÿberschn.	26.47	5.70	0.26	0.06	-1.39
9	3	2	2	1	6	Ÿberschn.	27.62	5.45	0.43	-0.18	-0.24
9	3	2	2	1	7	Ÿberschn.	28.67	5.46	0.39	-0.18	0.81
9	3	2	2	1	8	getrennt	27.90	5.55	0.15	-0.08	0.04

Table A2 continued

Subj	Day	E	Med	Stim	ID	Typ	DLS [dB]	Pupil Size [mm]	Pupil Fluct [mm]	Pupil Size [mm] centered by subject	LUE [dB] centered by subject
9	3	2	2	1	9	Ÿberschn.	33.23	5.53	0.29	-0.10	5.37
9	3	3	2	2	1	getrennt	28.10	5.65	0.22	0.02	0.24
9	3	3	2	2	2	getrennt	28.70	5.26	0.31	-0.38	0.84
9	3	3	2	2	3	Ÿberschn.	26.68	5.42	0.29	-0.21	-1.18
9	3	3	2	2	4	getrennt	24.00	5.47	0.19	-0.16	-3.86
9	3	3	2	2	5	Ÿberschn.	26.60	5.32	0.19	-0.31	-1.26
9	3	3	2	2	6	Ÿberschn.	27.89	5.16	0.29	-0.47	0.03
9	3	3	2	2	7	getrennt	26.55	5.37	0.24	-0.26	-1.31
9	3	3	2	2	8	getrennt	28.10	5.49	0.20	-0.15	0.24
9	3	3	2	2	9	getrennt	29.30	5.26	0.26	-0.38	1.44
10	1	2	2	1	1	getrennt	28.65	4.19	0.16	0.31	-1.00
10	1	2	2	1	2	getrennt	28.60	4.20	0.13	0.32	-1.05
10	1	2	2	1	3	getrennt	28.75	4.26	0.09	0.39	-0.90
10	1	2	2	1	4	getrennt	27.90	4.20	0.16	0.33	-1.75
10	1	2	2	1	5	getrennt	28.75	4.03	0.20	0.15	-0.90
10	1	2	2	1	6	getrennt	30.40	4.12	0.20	0.25	0.75
10	1	2	2	1	7	getrennt	28.55	4.17	0.08	0.30	-1.10
10	1	2	2	1	8	getrennt	30.00	4.18	0.17	0.31	0.35
10	1	2	2	1	9	Ÿberschn.	34.39	4.19	0.24	0.32	4.74
10	1	3	2	2	1	getrennt	28.10	3.87	0.24	-0.01	-1.55
10	1	3	2	2	2	Ÿberschn.	29.32	4.08	0.28	0.21	-0.33
10	1	3	2	2	3	getrennt	30.10	4.07	0.30	0.19	0.45
10	1	3	2	2	4	getrennt	28.70	4.07	0.35	0.20	-0.95
10	1	3	2	2	5	Ÿberschn.	29.83	4.06	0.17	0.19	0.18
10	1	3	2	2	6	getrennt	29.60	4.17	0.21	0.30	-0.05
10	1	3	2	2	7	getrennt	28.70	3.80	0.12	-0.08	-0.95
10	1	3	2	2	8	getrennt	28.70	4.14	0.30	0.27	-0.95
10	1	3	2	2	9	Ÿberschn.	30.65	3.97	0.18	0.09	1.00
10	2	2	1	1	1	getrennt	28.00	3.21	0.17	-0.66	-1.65
10	2	2	1	1	2	Ÿberschn.	30.69	3.23	0.14	-0.65	1.04
10	2	2	1	1	3	getrennt	29.90	3.26	0.10	-0.61	0.25
10	2	2	1	1	4	getrennt	30.00	3.13	0.15	-0.74	0.35
10	2	2	1	1	5	Ÿberschn.	31.18	3.17	0.11	-0.70	1.53
10	2	2	1	1	6	getrennt	29.90	3.20	0.13	-0.67	0.25
10	2	2	1	1	7	Ÿberschn.	28.81	3.20	0.14	-0.67	-0.85
10	2	2	1	1	8	getrennt	28.55	3.20	0.11	-0.67	-1.10
10	2	2	1	1	9	Ÿberschn.	34.63	3.22	0.14	-0.65	4.98
10	2	3	1	2	1	getrennt	28.10	2.91	0.09	-0.96	-1.55
10	2	3	1	2	2	getrennt	29.30	2.97	0.12	-0.90	-0.35
10	2	3	1	2	3	getrennt	29.30	2.98	0.10	-0.89	-0.35
10	2	3	1	2	4	getrennt	28.10	2.94	0.11	-0.94	-1.55
10	2	3	1	2	5	getrennt	30.10	3.02	0.11	-0.86	0.45
10	2	3	1	2	6	getrennt	30.00	3.01	0.06	-0.86	0.35
10	2	3	1	2	7	getrennt	27.60	2.90	0.06	-0.98	-2.05

Table A2 continued

Subj	Day	E	Med	Stim	ID	Typ	DLS [dB]	Pupil Size [mm]	Pupil Fluct [mm]	Pupil Size [mm] centered by subject	LUE [dB] centered by subject
10	2	3	1	2	8	getrennt	28.70	2.97	0.15	-0.90	-0.95
10	2	3	1	2	9	getrennt	31.00	2.99	0.11	-0.89	1.35
10	3	2	3	1	1	Ÿberschn.	29.59	4.27	0.18	0.40	-0.06
10	3	2	3	1	2	Ÿberschn.	30.65	4.20	0.16	0.32	1.00
10	3	2	3	1	3	getrennt	29.90	4.41	0.14	0.54	0.25
10	3	2	3	1	4	Ÿberschn.	28.92	4.28	0.12	0.41	-0.73
10	3	2	3	1	5	getrennt	28.10	4.38	0.08	0.51	-1.55
10	3	2	3	1	6	Ÿberschn.	31.52	4.24	0.14	0.37	1.87
10	3	2	3	1	7	getrennt	28.55	4.37	0.11	0.50	-1.10
10	3	2	3	1	8	Ÿberschn.	30.50	4.25	0.18	0.37	0.85
10	3	2	3	1	9	getrennt	33.90	4.33	0.10	0.46	4.25
10	3	3	3	2	1	getrennt	28.10	4.59	0.09	0.72	-1.55
10	3	3	3	2	2	getrennt	29.70	4.60	0.14	0.72	0.05
10	3	3	3	2	3	getrennt	29.70	4.59	0.18	0.72	0.05
10	3	3	3	2	4	getrennt	28.10	4.45	0.24	0.57	-1.55
10	3	3	3	2	5	getrennt	30.55	4.60	0.08	0.73	0.90
10	3	3	3	2	6	getrennt	29.60	4.54	0.08	0.67	-0.05
10	3	3	3	2	7	getrennt	28.10	4.64	0.10	0.77	-1.55
10	3	3	3	2	8	Ÿberschn.	30.55	4.64	0.11	0.76	0.90
10	3	3	3	2	9	getrennt	31.60	4.50	0.07	0.63	1.95
11	1	2	2	1	1	getrennt	27.50	6.66	0.10	0.09	-2.35
11	1	2	2	1	2	getrennt	28.90	6.68	0.09	0.11	-0.95
11	1	2	2	1	3	getrennt	29.10	6.76	0.11	0.20	-0.75
11	1	2	2	1	4	Ÿberschn.	29.20	6.69	0.08	0.12	-0.65
11	1	2	2	1	5	Ÿberschn.	27.77	6.66	0.11	0.09	-2.08
11	1	2	2	1	6	Ÿberschn.	29.17	6.75	0.13	0.19	-0.68
11	1	2	2	1	7	Ÿberschn.	27.34	6.72	0.13	0.15	-2.51
11	1	2	2	1	8	getrennt	30.00	6.67	0.07	0.10	0.15
11	1	2	2	1	9	getrennt	37.00	6.78	0.07	0.21	7.15
11	1	3	2	2	1	getrennt	28.70	6.73	0.12	0.16	-1.15
11	1	3	2	2	2	Ÿberschn.	29.49	6.78	0.13	0.21	-0.36
11	1	3	2	2	3	getrennt	28.10	6.77	0.13	0.20	-1.75
11	1	3	2	2	4	getrennt	28.70	6.76	0.16	0.19	-1.15
11	1	3	2	2	5	getrennt	28.70	6.75	0.10	0.18	-1.15
11	1	3	2	2	6	getrennt	28.60	6.71	0.17	0.15	-1.25
11	1	3	2	2	7	getrennt	28.70	6.68	0.04	0.11	-1.15
11	1	3	2	2	8	getrennt	30.10	6.73	0.15	0.17	0.25
11	1	3	2	2	9	getrennt	32.20	6.73	0.12	0.16	2.35
11	2	2	3	1	1	Ÿberschn.	31.22	6.39	0.20	-0.18	1.37
11	2	2	3	1	2	Ÿberschn.	34.07	6.31	0.25	-0.26	4.22
11	2	2	3	1	3	Ÿberschn.	30.31	6.23	0.23	-0.33	0.46
11	2	2	3	1	4	getrennt	28.65	6.23	0.17	-0.34	-1.20
11	2	2	3	1	5	getrennt	27.90	6.23	0.29	-0.34	-1.95
11	2	2	3	1	6	getrennt	28.55	6.15	0.18	-0.42	-1.30

Table A2 continued

Subj	Day	E	Med	Stim	ID	Typ	DLS [dB]	Pupil Size [mm]	Pupil Fluct [mm]	Pupil Size [mm] centered by subject	LUE [dB] centered by subject
11	2	2	3	1	7	getrennt	28.10	6.21	0.18	-0.36	-1.75
11	2	2	3	1	8	getrennt	30.90	6.15	0.20	-0.42	1.05
11	2	2	3	1	9	getrennt	33.90	6.22	0.24	-0.35	4.05
11	2	3	3	2	1	getrennt	28.10	6.74	0.18	0.18	-1.75
11	2	3	3	2	2	Ÿberschn.	29.88	6.85	0.10	0.28	0.03
11	2	3	3	2	3	Ÿberschn.	30.76	6.77	0.21	0.21	0.91
11	2	3	3	2	4	getrennt	29.70	6.69	0.23	0.12	-0.15
11	2	3	3	2	5	getrennt	28.70	6.66	0.18	0.09	-1.15
11	2	3	3	2	6	getrennt	30.55	6.80	0.18	0.23	0.70
11	2	3	3	2	7	getrennt	31.00	6.68	0.13	0.11	1.15
11	2	3	3	2	8	getrennt	29.20	6.81	0.12	0.25	-0.65
11	2	3	3	2	9	Ÿberschn.	33.18	6.77	0.22	0.20	3.33
11	3	2	1	1	1	getrennt	28.00	6.66	0.14	0.09	-1.85
11	3	2	1	1	2	getrennt	29.20	6.73	0.12	0.16	-0.65
11	3	2	1	1	3	Ÿberschn.	28.37	6.56	0.11	0.00	-1.48
11	3	2	1	1	4	getrennt	30.00	6.66	0.15	0.09	0.15
11	3	2	1	1	5	Ÿberschn.	27.45	6.73	0.07	0.16	-2.40
11	3	2	1	1	6	getrennt	29.50	6.73	0.12	0.16	-0.35
11	3	2	1	1	7	Ÿberschn.	27.35	6.59	0.13	0.03	-2.51
11	3	2	1	1	8	getrennt	28.55	6.71	0.09	0.14	-1.30
11	3	2	1	1	9	Ÿberschn.	36.45	6.65	0.11	0.08	6.60
11	3	3	1	2	1	getrennt	28.10	6.15	0.27	-0.42	-1.75
11	3	3	1	2	2	Ÿberschn.	31.09	6.25	0.39	-0.32	1.24
11	3	3	1	2	3	getrennt	30.10	6.39	0.13	-0.18	0.25
11	3	3	1	2	4	Ÿberschn.	29.82	6.21	0.34	-0.36	-0.03
11	3	3	1	2	5	getrennt	30.10	6.45	0.07	-0.11	0.25
11	3	3	1	2	6	getrennt	29.60	6.28	0.20	-0.28	-0.25
11	3	3	1	2	7	getrennt	28.10	6.22	0.40	-0.34	-1.75
11	3	3	1	2	8	getrennt	30.55	6.45	0.18	-0.12	0.70
11	3	3	1	2	9	Ÿberschn.	35.67	6.30	0.25	-0.27	5.82
12	1	2	2	2	1	getrennt	26.65	7.91	0.08	0.13	-3.31
12	1	2	2	2	2	getrennt	31.70	7.91	0.06	0.13	1.74
12	1	2	2	2	3	getrennt	30.10	7.90	0.13	0.11	0.14
12	1	2	2	2	4	getrennt	28.70	7.87	0.10	0.09	-1.26
12	1	2	2	2	5	Ÿberschn.	29.66	7.87	0.10	0.08	-0.30
12	1	2	2	2	6	getrennt	30.00	7.89	0.12	0.11	0.04
12	1	2	2	2	7	getrennt	28.70	7.87	0.13	0.08	-1.26
12	1	2	2	2	8	Ÿberschn.	30.34	7.93	0.11	0.15	0.38
12	1	2	2	2	9	getrennt	32.20	7.95	0.10	0.17	2.24
12	1	3	2	1	1	getrennt	28.00	7.88	0.14	0.10	-1.96
12	1	3	2	1	2	getrennt	29.20	7.83	0.23	0.04	-0.76
12	1	3	2	1	3	getrennt	29.10	7.87	0.19	0.09	-0.86
12	1	3	2	1	4	Ÿberschn.	28.35	7.84	0.15	0.05	-1.60
12	1	3	2	1	5	getrennt	27.80	7.89	0.13	0.11	-2.16

Table A2 continued

Subj	Day	E	Med	Stim	ID	Typ	DLS [dB]	Pupil Size [mm]	Pupil Fluct [mm]	Pupil Size [mm] centered by subject	LUE [dB] centered by subject
12	1	3	2	1	6	Ÿberschn.	28.11	7.84	0.22	0.05	-1.85
12	1	3	2	1	7	getrennt	31.00	7.90	0.12	0.11	1.04
12	1	3	2	1	8	getrennt	30.00	7.81	0.24	0.02	0.04
12	1	3	2	1	9	getrennt	35.45	7.97	0.18	0.19	5.49
12	2	2	1	2	1	getrennt	30.10	7.81	0.13	0.03	0.14
12	2	2	1	2	2	getrennt	30.60	7.81	0.18	0.03	0.64
12	2	2	1	2	3	getrennt	30.10	7.82	0.09	0.03	0.14
12	2	2	1	2	4	getrennt	28.10	7.69	0.22	-0.09	-1.86
12	2	2	1	2	5	getrennt	28.70	7.78	0.16	0.00	-1.26
12	2	2	1	2	6	getrennt	30.00	7.77	0.15	-0.01	0.04
12	2	2	1	2	7	getrennt	30.55	7.79	0.16	0.00	0.59
12	2	2	1	2	8	getrennt	30.10	7.73	0.23	-0.06	0.14
12	2	2	1	2	9	Ÿberschn.	35.85	7.82	0.14	0.04	5.90
12	2	3	1	1	1	getrennt	29.70	7.63	0.07	-0.16	-0.26
12	2	3	1	1	2	Ÿberschn.	30.31	7.51	0.17	-0.28	0.35
12	2	3	1	1	3	Ÿberschn.	29.34	7.42	0.14	-0.37	-0.62
12	2	3	1	1	4	Ÿberschn.	27.02	7.53	0.21	-0.26	-2.94
12	2	3	1	1	5	Ÿberschn.	27.45	7.40	0.25	-0.38	-2.50
12	2	3	1	1	6	getrennt	29.90	7.57	0.18	-0.21	-0.06
12	2	3	1	1	7	getrennt	30.00	7.46	0.19	-0.33	0.04
12	2	3	1	1	8	getrennt	29.60	7.60	0.17	-0.19	-0.36
12	2	3	1	1	9	getrennt	35.45	7.58	0.07	-0.21	5.49
12	3	2	3	2	1	getrennt	27.65	7.68	0.21	-0.10	-2.31
12	3	2	3	2	2	getrennt	30.10	7.81	0.13	0.03	0.14
12	3	2	3	2	3	getrennt	30.10	7.83	0.10	0.04	0.14
12	3	2	3	2	4	getrennt	28.10	7.79	0.07	0.00	-1.86
12	3	2	3	2	5	Ÿberschn.	28.88	7.72	0.17	-0.06	-1.08
12	3	2	3	2	6	Ÿberschn.	31.39	7.70	0.22	-0.08	1.43
12	3	2	3	2	7	Ÿberschn.	29.48	7.83	0.10	0.04	-0.48
12	3	2	3	2	8	getrennt	31.60	7.83	0.12	0.04	1.64
12	3	2	3	2	9	Ÿberschn.	35.26	7.71	0.17	-0.08	5.31
12	3	3	3	1	1	getrennt	28.65	7.85	0.25	0.06	-1.31
12	3	3	3	1	2	getrennt	28.00	7.97	0.15	0.18	-1.96
12	3	3	3	1	3	getrennt	29.90	7.84	0.14	0.06	-0.06
12	3	3	3	1	4	Ÿberschn.	27.94	7.80	0.21	0.01	-2.02
12	3	3	3	1	5	getrennt	27.30	7.88	0.32	0.09	-2.66
12	3	3	3	1	6	getrennt	29.90	7.94	0.16	0.16	-0.06
12	3	3	3	1	7	getrennt	28.55	7.75	0.21	-0.03	-1.41
12	3	3	3	1	8	getrennt	29.60	7.95	0.20	0.17	-0.36
12	3	3	3	1	9	Ÿberschn.	37.40	7.86	0.21	0.07	7.44

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