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Vision Research xxx (2006) xxx–xxx

Vision Research

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Motion perception deficits in albino ferrets (*Mustela putorius furo*)

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Received 21 October 2005; received in revised form 20 February 2006

Abstract

Albino ferrets contrary to their pigmented conspecifics show no optokinetic nystagmus. Therefore, in this study motion perception was compared between pigmented and albino ferrets (*Mustela putorius furo*) trained to discriminate between coherently moving random dot patterns and dynamic noise stimuli in a two-alternative forced choice task. Fully coherently versus incoherently moving patterns could be distinguished by ferrets of both phenotypes. Motion coherence thresholds, however, were significantly higher in albinos. These results indicate that albino ferrets are not motion blind as could be expected from their total lack of optokinetic reactions. However, they are severely impaired in global motion perception.

Keywords: Albinism; Motion coherence; Visual acuity; Contrast sensitivity; Carnivore

1. Introduction

Perception of visual motion is crucial for normal orientation and interaction with the environment, and patients lacking motion perception (akinetopsia) are severely impaired in everyday life (e.g., Zeki, 1991). In many instances, albinos are unable to stabilize their visual environment properly (e.g., Abadi & Pascal, 1994a, 1994b). In addition, the optokinetic reaction, a reflex to stabilize the image of the world on the retina, is highly variable at best and quite often severely disturbed (Collewijn, Winterson, & Dubois, 1978; Collewijn, Apkarian, & Spekreijse, 1985; Demer & Zee, 1984; Hahnenberger, 1977; St. John, Fisk, Timney, & Goodale, 1984).

Probably due to the lack of DOPA in the retina and subsequent disturbance of spatio-temporal maturation of the retina, the visual system of tyrosinase-negative albinos is altered (for review Jeffery, 1997). The anatomical changes lead to physiological deficits in subcortical and cortical centres (Akerman, Tolhurst, Morgan, Baker, & Thompson, 2003; Chino, Shansky, & Jankowski, 1984; Hoffmann, Garipis, & Distler, 2004; Philipp, Distler, & Hoffmann, 2005; Shatz, 1977; Simoni & Sprague, 1976). Behaviourally, albinotic subjects suffer from reduced visual acuity, reduced visual field dimensions and reduced stereopsis (e.g., Abadi & Pascal, 1991; Elekessy, Campion, & Henry, 1973; Garipis & Hoffmann, 2003; Lee, King, & Summers, 2001; Wilson, Mets, Nagy, & Kressel, 1988; for review see e.g., Creel, Summers, & King, 1990; Lyle, Sangster, & Williams, 1997; Perez-Carpinell, Capilla, Illueca, & Morales, 1992).

The ferret's visual system closely resembles that of the cat, a particularly well-studied carnivore. In contrast to cat, albino ferret strains are easily available. Albino ferrets are severely impaired in that a regular optokinetic reaction cannot be elicited (Hoffmann et al., 2004). Therefore, we set out to investigate if this deficit is restricted to the optokinetic system or if these animals cannot perceive visual motion at all.

2. Materials and methods

2.1. Animals

A total of 17 ferrets, 10 albino (6 male, 4 female), and 7 wildtype pigmented (4 male, 3 female), participated in the present experiments. Males and females were tested in separate groups. Female ferrets were castrated

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doi:10.1016/j.visres.2006.02.020

and 18 months old, males were fertile and between 6 and 30 months old at the beginning of the tests. All but two males that were purchased from Marshall Farms, North Rose NY, USA, were bred and raised in the animal facility of the Department of General Zoology and Neurobiology, Ruhr-University Bochum. Ferrets were marked by a subcutaneous passive transponder chip. All wildtype males and two albino male ferrets had previous experience in behavioural experiments (Garipis & Hoffmann, 2003).

Ferrets were grouphoused in an enriched environment with access to an outdoor enclosure. They could avoid exposure to light by visiting their home boxes at any time. During the test period, animals were food deprived to improve their motivation to participate in the experiments. They received their daily ration as reward during the experiments. Body weight was controlled daily before the test session to avoid undue weight loss.

The experiments were performed in accordance with the European Communities Council Directive of 24 November, 1986 (S6 609 EEC), as well as the National Institutes of Health guidelines for the care and use of animals for experimental procedures. Experiments were approved by the local authorities (Regierungspräsidium Arnsberg) and were carried out in accordance with the Deutsche Tierschutzgesetz of 12 April, 2001.

2.2. Setup and procedures

A two-alternative forced choice (2AFC) paradigm in a modified discrimination box adapted to species specific preferences (Fig. 1A) was used. Both stimuli were presented on one monitor next to each other, creating a “left” versus “right” choice situation. Ferrets indicated their choice by passing one of two (left or right) horizontal tubes in front of the stimuli (see Fig. 1A). Movable slides were used to guide the ferret’s tour through the setup for each trial, i.e., they were lifted in front of the ferret and lowered behind them immediately after the passage of the animal. The operant behaviour consisted of passing a choice tube and thus entering a target box. Then the ferret had to go back to the central box to start the next trial.

The stimulus presentation was started by the experimenter who also lifted the first opaque slide in front of the choice tubes to enable the ferret to watch the stimuli. After approximately 1 s the transparent slide was lifted so that the animal could choose between the two stimuli by entering one of the tubes. In case of a correct choice the ferret received a food pellet at the end of the target box. The stimulus was blanked approximately 3 s after the animal entered the choice tube. After a correct choice the ferret was allowed to take the direct way back through a straight tube to reach the central box and start a new trial. In case of a false choice it was forced to take a longer way through a three-dimensionally bent tube without a previous reward. Thus, the costs in terms of time and energy were higher after a false than after a correct choice.

To accustom the ferrets to this procedure a handshaping was performed in about four to eight (daily) sessions. The handshaping was followed by a visual discrimination training using a white versus black training stimulus. First, an alternating presentation of the visual target was used until the ferret made 80% correct choices over 20 trials, then a pseudorandomised target presentation (Gellermann, 1933) was introduced and maintained for all further training and test sessions. To reduce the influence of the experimenter the setup was covered by dark materials. All manipulations within and between trials (lifting and lowering slides) were done without direct contact to the animal. After each session the ferret received the remainder of its daily ration not consumed during the session in a separate box, water was available ad libitum in their homeranges.

2.3. Stimuli

Stimuli were limited lifetime moving random dot patterns with adjustable coherence, and were created and presented with the software “randomdots” developed by B. Krekelberg. The patterns consisted of white dots (squares) on a black background. Apparent motion of the dots was created by shifting their position between single frames. Each dot vanished after 1 s and was replaced at a new random position. The proportion of dots moving in the same direction is referred to as the percentage of motion coherence, in this study a coherent movement was always to the right. Equal proportions of dots moving in different directions create an incoherent motion (dynamic noise).

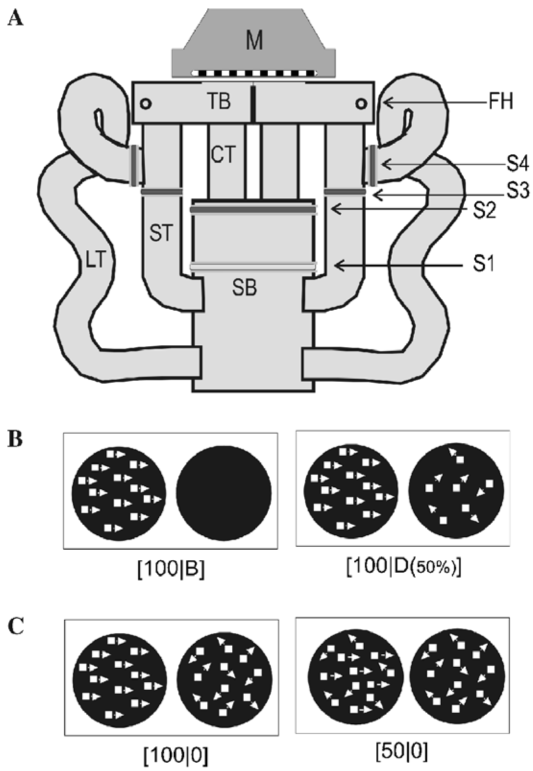

Fig. 1. Setup and stimulus illustrations. (A) Scheme of experimental setup as seen from above. CT: choice tube; FH: food hole; LT: long tube; M: monitor; S1: transparent slide; S2: opaque slide; S3: slide 3, regulating access to ST; S4: slide 4, regulating access to LT; SB: start box; ST: short tube; TB: target box. A ferret in SB can see the stimuli on the monitor if S2 is lifted. Lifting S1 allows access to both choice tubes CT. A choice is indicated by entering the left or right CT. Food reward is given via food holes FH in the top of the target boxes TB. For detailed procedures see Section 2. (B) Illustration of training stimuli as seen through choice tubes CT. Level [100|B], 100% coherence versus a black screen, is shown in the left panel with the S+ illustrated in the left circular window. The panel on the right shows an exemplary training stimulus with varying dot densities in S−, here with 50% of the final dot density [100|$D_{(50\%)}$]. (C) Illustration of test stimuli. Left panel shows level [100|0] with 100% coherent motion to the right as rewarded, 0% coherence as non-rewarded stimulus. The right panel shows level [50|0] as an example for the stimuli of the coherence threshold task, with a pattern of 50% coherence as rewarded stimulus in the left circle versus dynamic noise as reference stimulus.

From the entrance to each of the choice tubes a stimulus area 12° of visual angle in diameter was visible. Dot size was 1° × 1° of visual angle, dots moved at a velocity of 10°/s, mean dot density was 0.5/deg^2 unless otherwise mentioned.

In the initial stimulus detection task a fully coherent moving RDP was presented as rewarded (S+) versus a black screen as non-rewarded (S−) stimulus. This level will be referred to as [100|B], where “100” represents the percentage of coherence of the S+ and “B” indicates the type of S−, in this case a black screen. At this level discrimination is possible simply based on luminance, it creates a white versus black choice. The coherently moving random dot pattern was the rewarded stimulus for all further stimuli. Criterion was set at 80% correct choices over 20 trials for two consecutive sessions, but at least 80 trials had to be done on this level. Once stable performance on level [100|B] was reached a number of dots were added to the S− (black screen), moving incoherently. The dot density (D) of the S− was increased stepwise (20%, 33%, 47%, 67%, and 87 % of final dot density), making the non-rewarded stimulus more and more prominent. At these intermediate levels, referred to as [100|*D*], the two stimulus alternatives could be discriminated by multiple features (dot number and density, overall luminance), finally only coherence served as reliable feature. The next level of these training stimuli was introduced when the actual stimulus was detected with 80% correct choices over at least 20 trials and two consecutive sessions. To test motion coherence detection the level [100|0] was used, where a completely coherent movement to the right (100% coherence) had to be discriminated from dynamic noise (0% coherence). Criterion was set at 70% correct choices over 80 trials, for evaluation of mean performance on level [100|0] at least 200 trials had to be performed by each animal. For evaluation of coherence thresholds the method of constant stimuli was used. The proportion of coherently moving dots in the rewarded pattern was reduced by steps of 10%, values from 100% to 10% coherence for S+ were used. As male ferrets performed high on 10% motion coherence they were additionally tested on stimulus coherence of 0% ("catch trials") to obtain chance performance data. Four different coherence values were presented randomised within one session, different combinations were used to finally test all coherence levels. Two stimuli with high coherence were combined with stimuli with low coherence to ensure that at least two of the stimuli used in each session could be readily discriminated by the animal. If discrimination performance did not exceed chance level for two consecutive coherence values, stimuli with even less coherence were not tested in this individual. During training and testing positional choice strategies (e.g., alternating choices) were observed occasionally. In this case, a counterbalanced target presentation was applied, and, if necessary, combined with a retraining on an easier stimulus to reestablish stimulus related choices. Usually choice behaviour was again under stimulus control at the end of such a "re-training" session.

2.4. Visual acuity and contrast sensitivity

Using the same setup and procedure the visual spatial resolution limit was assessed as grating acuity in a subpopulation of three albino and three wildtype male ferrets.

Vertical sinewave gratings were created with Matlab and presented as jpeg-files using MS Powerpoint. Gratings had a mean luminance of 30 cd/m^2 and were presented versus gray patches of three different luminance values (20, 30, and 40 cd/m^2, randomised) to ensure that luminance could not be used as a cue for a correct choice. Choice of the grating was rewarded by food, false choices were punished as described above. For spatial resolution tests full contrast gratings (0.95 Michelson contrast) of different spatial frequencies ranging from 0.5 to 8 cpd were presented in randomised order within one session. Contrast thresholds were additionally tested in two wildtype and two albino males. For contrast sensitivity assessment gratings of the same spatial frequency but of different contrast (between 0.04 and 0.95) were presented in randomised order within one session. Spatial frequencies were randomly changed between sessions to obtain contrast thresholds for four spatial frequencies.

2.5. Analysis

2.5.1. Motion coherence

Sessions were protocolled by hand. Data included the number of trials as well as target and choice positions for each trial. The outcome of a training session was given as percentage of correct choices over all trials, mean performance of each individual was calculated over sessions. For evaluation of motion coherence perception the mean percentage of correct choices was calculated over at least 200 trials for level [100|0]. To calculate coherence thresholds for each animal the mean performance (percentage of correct choices) per level was calculated based on at least 80 trials for each animal. One coherence-threshold session produced up to four results in terms of four performance values, one for each coherence level. If less than 10 trials of one level were obtained within a session data were pooled for this and the following session for this level. Re-training sessions were not included in the final analysis of discrimination performance but contributed to the number of trials to criterion. Coherence threshold was calculated as the percentage of coherence at criterion performance level. Threshold criterion was calculated individually, as the mean between lapse rate (best performance) and guess rate (50% correct choices). For male ferrets criterion levels were about 70% correct choices. As for female ferrets performance was generally lower, criterion levels were thus close to 67% correct choices. Results are shown as means with standard deviation (mean ± SD) or median values with lower and upper quartiles (med; Q_{25}, Q_{75}).

Statistical analysis consisted of comparing performance between albino and wildtype and/or male versus female ferrets. The null hypothesis for the Mann–Whitney rank sum test was that medians of both groups were based on the same population. If the probability for an error in rejecting this hypothesis was below 5% the hypothesis was rejected and the difference between mean values was regarded as significant ($p < 0.05$).

2.5.2. Control experiments

Mean performance for different stimulus levels was calculated and thresholds were obtained from the resulting psychometric function as stimulus intensity at criterion performance. For spatial resolution threshold criterion was 75% correct choices, the spatial frequency at criterion performance was taken as resolution limit. For evaluation of contrast threshold criterion was set at 70% correct choices, contrast value at criterion performance was taken as threshold. Contrast sensitivity is given as (1/contrast threshold). No further statistical analysis was performed.

3. Results

3.1. Motion coherence

Throughout the training and testing period the number of trials per session was about 20 (Q_{25}: 20; Q_{75}: 22) in females and 33 (Q_{25}: 28; Q_{75}: 36) in male ferrets.

Discrimination training on the first level [100|B], when a coherently moving random dot pattern (100% coherence) had to be discriminated from a black screen, usually lasted for 3–6 sessions. Wildtype males needed the least trials (153 ± 60), whereas for wildtype females the highest average number of trials to criterion was observed (355 ± 42). Albino ferrets showed a large interindividual variability and no difference between males and females (males: 267 ± 240; females: 252 ± 117). No significant differences were found between ferrets of different phenotype or sex (i.e., $p > 0.05$, rank sum tests). Discrimination performance in terms of percentage of correct choices, which is shown in Fig. 2A, did not differ significantly between ferrets of both phenotypes or between male and female ferrets ($p > 0.05$, rank sum test) for this first visual discrimination task. Relation of discrimination performance and number of trials to criterion for this level is shown in Fig. 3A.

In a second step ferrets were trained to discriminate 100% coherently moving random dot patterns from non-coherent (0% coherence) stimuli of increasing dot density, referred to as [100|*D*]. Performance for these [100|*D*] training stimuli was also not different between phenotypes ($p > 0.05$, rank sum test). Females performed less well than male ferrets (compare Fig. 2B), which was only significant for albino ferrets (female versus male: $p < 0.05$, rank sum test). Wildtype males reached criterion for the discrimination of 100% versus 0% coherence with about a third the number of trials of wildtype females (males: 401 ± 155; females: 1195 ± 361) or albino ferrets (males: 1195 ± 937; females: 1277 ± 277), however, this difference was not significant ($p > 0.05$, rank sum tests). The relation of discrimi-

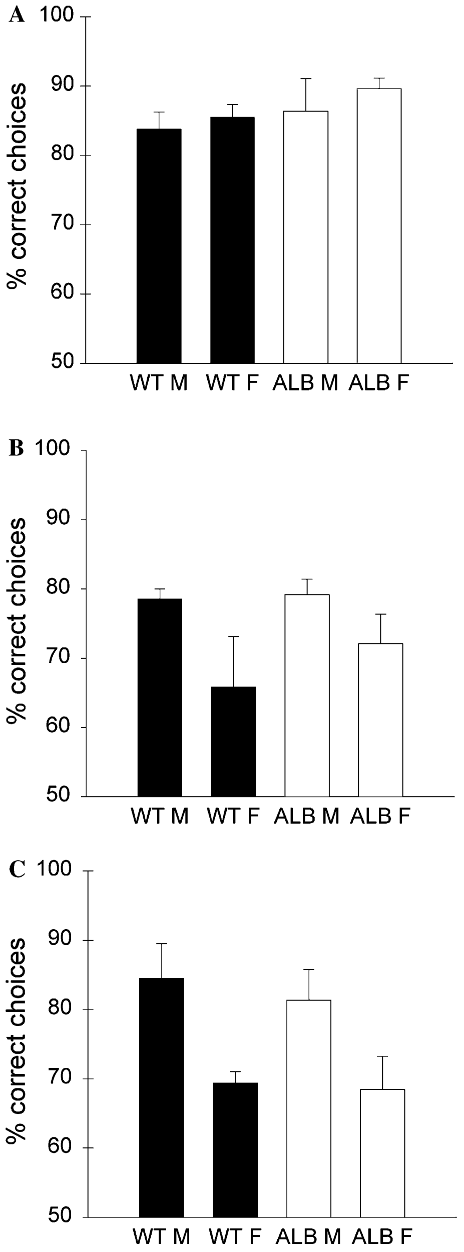

Fig. 2. Discrimination performance on training and coherence detection stimuli. (A) Ordinate shows performance (mean ± SD) for the discrimination of level [100|B], a moving random dot pattern (100% coherence, S+) versus a black screen, based on at least 80 trials per individual. There is no significant difference between groups. (B) Performance (mean ± SD) over five training levels (at least 40 trials each) of the type [100|*D*], i.e., with increasing density of incoherently moving dots for S− is shown on the ordinate. (C) Ordinate shows the mean performance (±SD) on coherence detection level [100|0] based on at least 200 trials per individual. A fully coherent (100% coherence) random dot pattern had to be discriminated from dynamic noise (0% coherence). Female performance is below male level for both phenotypes, the difference between male and female albino ferrets is significant ($p < 0.05$, rank sum test). WT: wildtype; ALB: albino; M: male; F: female.

nation performance and number of trials to criterion for this level is shown in Fig. 3B.

Every ferret investigated reached criterion performance (70% correct choices over 80 trials) on level [100|0]. Thus, both albino and pigmented ferrets were able to discriminate between 100% coherently and completely incoherently moving random dot patterns (0% coherence). Performance over 200 trials on this level [100|0] (Fig. 2C) did not differ between wildtype and albino ferrets ($p > 0.05$, rank sum test). Performance of females was again worse than that of males, this difference was significant for albino female versus male ferrets ($p < 0.05$, rank sum test).

The relation between the discrimination performance and the number of trials to criterion on level [100|B] is shown for each individual in Fig. 3A. There is no clear correlation between amount of trials and performance because performance was comparably high for all ferrets. Only within the group of albino males a trend to higher performance for more trials to criterion can be observed. For level [100|0] data were highly variable, but there was an overall tendency that individuals which reached criterion with fewer trials also performed better in terms of percentage of correct choices (Fig. 3B). However, this was not the case for the individual groups separated by sex and phenotype. Thus, performance in this task seems more dependent on sex than on number of trials to criterion.

Fig. 4A shows the motion discrimination performance for albino and wildtype ferrets at different percentages of coherence of S+. Performance of wildtype ferrets was always equal to or higher than performance of albinos, performance decreases with decreasing percentage of coherence. For 10% coherence, where only males were tested, performance was still high in wildtype but not albino ferrets. Many individuals, females and wildtype males, but not albino males, had highest performance not at 100% coherence but at moderate coherence values around 60–50% coherence. Motion coherence thresholds (Fig. 4B, i.e., the minimal proportion of dots moving in the same direction to be recognized as coherent pattern motion, varied considerably between individuals. There was no significant difference between males and females, neither for wildtype nor for albino ferrets ($p > 0.05$, rank sum test). Thus, male and female data were pooled to investigate the influence of the phenotype on motion coherence thresholds. With a median threshold of 20% coherence (Q_{25}: 11%; Q_{75}: 33%) wildtype ferrets had significantly ($p < 0.01$, rank sum test) lower thresholds than albino ferrets (med: 45%; Q_{25}: 35%; Q_{75}: 50%). Thus, albino ferrets needed more than twice the signal strength which was sufficient for wildtype ferrets.

3.2. Control experiments

Discrimination performance on stationary gratings versus gray fields was high, e.g., for a full contrast grating of 0.5 cpd ferrets had mean performance values between 79 ± 7% and 95 ± 8% correct choices. Spatial resolution limits were 3.35, 3.6, and 4.0 cpd for wildtype and 3.1, 3.1, and 3.7 cpd for albino ferrets. Thus, there was no difference in visual acuity between pigmented and albino ferrets.

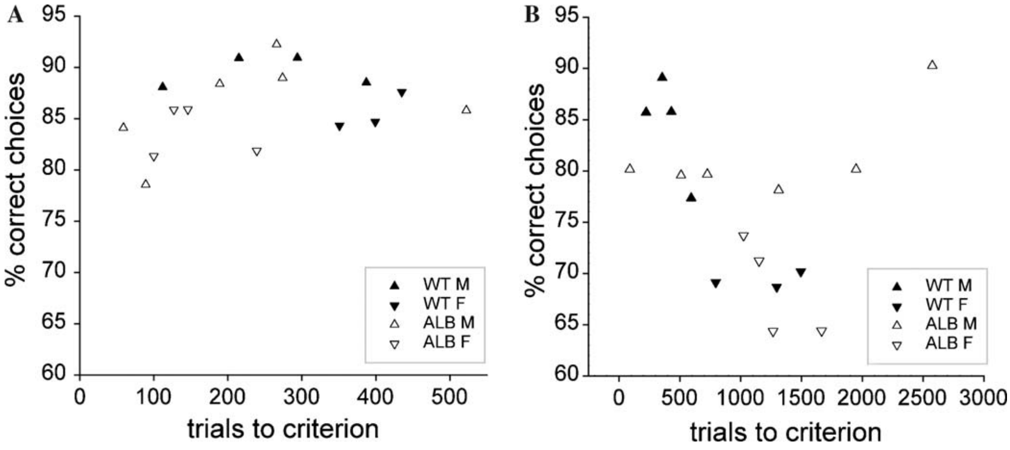

Fig. 3. Relation of performance to number of trials. (A) Performance (mean % correct choices over at least 80 trials on [100|B]) is shown on the ordinate versus the individual number of trials to reach criterion performance (at least 80% correct choices over 20 trials on two consecutive sessions) on the abscissa. (B) Performance (mean % correct choices over 200 trials on [100|0]) is shown on the ordinate versus the individual number of trials to reach criterion performance (at least 70% correct choices over 80 trials) on the abscissa. WT: wildtype; ALB: albino; M: male; F: female.

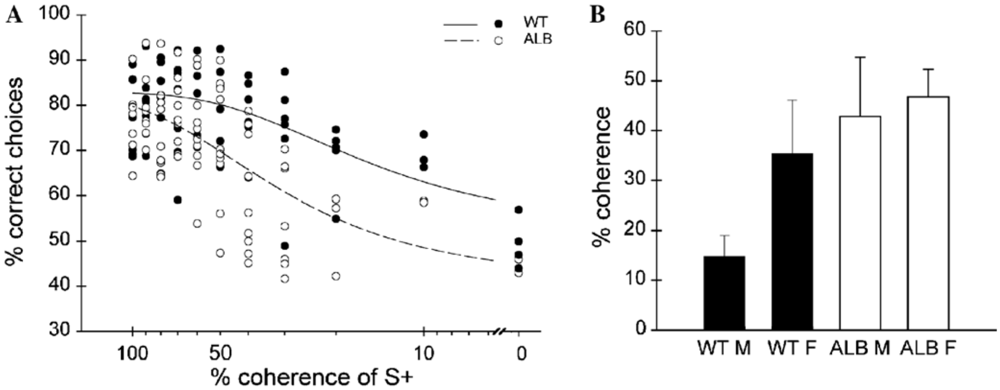

Fig. 4. Discrimination performance for coherence threshold assessment. (A) Discrimination performance (ordinate: mean percentage of correct choices) of individual animals at various levels of coherence of S+ (abscissa). Data of wildtype ferrets are plotted as black circles, albino data are shown as open circles. Sigmoid curves are fitted to the data sets of wildtype (black line) and albino (dashed line) ferrets. (B) The mean (±SD) motion coherence threshold (percentage of coherence) is shown on the ordinate for four groups of ferrets. Females of both phenotypes show higher, but not significantly, motion coherence thresholds than male ferrets. The difference between coherence thresholds for wildtype versus albino ferrets is significant ($p < 0.01$, rank sum test). WT: wildtype; ALB: albino; M: male; F: female.

The contrast sensitivity (1/contrast threshold) for four spatial frequencies is shown for two albino and two wildtype ferrets in Fig. 5. Contrast sensitivity was highest for medium spatial frequencies, whereas highest and lowest spatial frequencies tested could only be detected at high contrast (low sensitivity). While this relationship between contrast sensitivity and spatial frequency was observed for albino and wildtype ferrets the actual sensitivity values differed between phenotypes. Albino ferrets showed lower contrast sensitivity values than wildtype ferrets. Despite the small sample size the results show obvious differences between ferrets of both phenotypes.

4. Discussion

4.1. Visual discrimination in wildtype and albino ferrets

In the initial simple visual motion discrimination task ferrets of both phenotypes and of both sexes performed almost equally well, there was no general impairment in visual discrimination learning or performance of albino compared to wildtype ferrets. Ferrets of both phenotypes and sexes were able to discriminate coherent versus incoherent random dot patterns indicating that albino ferrets are not motion blind. The lower performance of female compared to male ferrets was observed for both phenotypes on all but the easiest visual discrimination stimulus and was accompanied by a lower number of trials performed per daily session and a delay in reaching criterion performance in females. The body weight dimorphism in this species, with females having nearly half the size and body weight of males, may have contributed to these differences in performance. The food reward for each trial and the food surplus for females was reduced accordingly (e.g., one pellet reward per trial for females, two for males) but may have still caused a different degree of motivation in males and females. We did not investigate this phenomenon in further detail, instead suggest to use male ferrets when

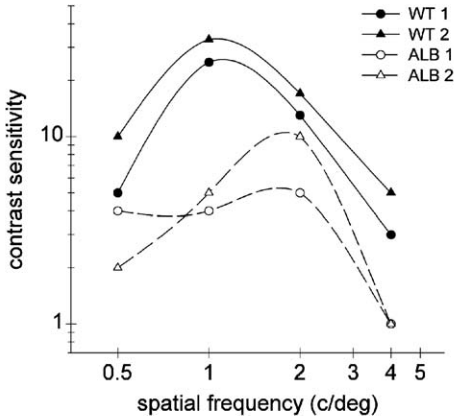

Fig. 5. Contrast sensitivity function for wildtype and albino ferrets. The ordinate shows the contrast sensitivity (1/contrast threshold) on a logarithmic scale, spatial frequency in cycles per degree is given on a logarithmic scale on the abscissa. Individual contrast sensitivity values for two wildtype and two albino ferrets are shown for four spatial frequencies. WT: wildtype; ALB: albino.

working with a food reward. Females were castrated to prevent hyperoestrogenism, which is common and potentially lethal in female ferrets, which may also have influenced motivation and thus contributed to the performance deficits. We conclude that it is a motivational rather than perceptional deficit causing the impairment in female performance on more demanding stimuli. Although, the difference in performance between male and female ferrets was not significant throughout all tasks, the present results stress the importance of considering the sex when selecting appropriate test and control groups for experimental designs.

4.2. Impaired motion perception in albinos

Evaluation of coherence thresholds revealed that albino ferrets had significantly higher thresholds than their pigmented counterparts, i.e., a higher percentage of dots had to move in the same direction to be recognized as coherent motion. Thus, motion perception is impaired but not absent in albino ferrets. This further indicates that the neuronal basis for the profound optokinetic deficits found in these animals are largely limited to the optokinetic system, i.e., the nucleus of the optic tract and the dorsal terminal nucleus of the accessory optic system (Hoffmann et al., 2004).

It is also unlikely that the deficits in motion perception described here may be due to differences in visual acuity, contrast sensitivity or general behavioural differences between wildtype and albino ferrets. Stimulus parameters like dot size and contrast were chosen based on available information on visual spatial resolution limits (about 3–3.5 cpd) for wildtype ferrets (Pontenagel & Schmidt, 1980; Price & Morgan, 1987). Unfortunately, there is only very limited information about albino ferrets' visual perception, i.e., spatial resolution and contrast sensitivity. Surprisingly, the resolution limit of one albino male ferret did not differ from that of wildtype ferrets (Pontenagel & Schmidt, 1980). In all other mammals investigated so far albinos have reduced spatial resolution and contrast sensitivity (e.g., rat: Birch & Jacobs, 1976; Keller, Strasburger, Cerutti, & Sabel, 2000; Prusky, West, & Douglas, 2000; cat: Blake & Antoinetti, 1976; Girelli, Campara, Tassinari, & Marzi, 1995; human: e.g., Abadi & Pascal, 1989; Summers, 1996). However, our own observations on visual spatial resolution also revealed only mild differences between albino and wildtype ferrets, thus supporting the previous finding of Pontenagel & Schmidt (1980). However, we did observe an impairment in contrast sensitivity in albino ferrets. The stimulus parameters (0.95 contrast and dot size of 1° v.a.) used for the motion perception task were readily perceivable for both albino and wildtype ferrets. Thus, the reduced motion coherence threshold of albino ferrets is unlikely to be caused by an impaired visibility of the random dot pattern.

We can only speculate why spatial resolution in the albino ferret is not as severely affected as in other species. A spontaneous nystagmus, contributing to low resolution limits in human albinos, is not present in the ferret. The albino specific reduction of peak rod density and peak ganglion cell density can be found in albino ferrets (Jeffery & Kinsella, 1992; Jeffery, Darling, & Whitmore, 1994) and does not indicate any retinal "advantage" of albino ferrets compared to other species. Ferret domestication was based on hunting abilities, thus a selection in favour of albinos with good visual acuity could have occurred. Albino ferrets with better visual perception may also react less anxiously to handling procedures and may therefore have been preferred as they may have been less aggressive.

4.3. Comparison with other species

Coherence thresholds of cats were comparable to those obtained for wildtype ferrets in this study (25% coherence) and increased up to 75% after lesions of lateral suprasylvian areas (Huxlin & Pasternak, 2004). In primates coherence thresholds are generally lower, often reaching 5% coherence but values differ between studies (Bischof, Reid, Wylie, & Spetch, 1999; Newsome & Paré, 1988). A recent investigation in two seals revealed thresholds of around 10% coherence (M. Weiffen and G. Dehnhardt, personal communication). In comparable tests pigeons showed thresholds of 22–60% coherence (Bischof et al., 1999).

A comparison between albino and pigmented conspecifics is not available in the literature. Human albino vision has been studied in detail (e.g., Abadi & Pascal, 1991; Creel et al., 1990; Demer & Zee, 1984; St. John et al., 1984; Lee et al., 2001; Lyle et al., 1997; Perez-Carpinell et al., 1992; Summers, 1996; Wilson et al., 1988; Collewijn et al., 1985), however, to our knowledge there is no comparative study on motion coherence perception in albino and non-affected humans.

4.4. Neuronal substrate for motion perception

Extrastriate cortical areas of the dorsal stream of the visual system are crucial for global motion processing. The posteromedial lateral suprasylvian area (PMLS) of the cat, the posterior suprasylvian area (PSS) of the ferret, and the medial temporal and medial superior temporal area (MT, MST) of macaques are characterised by a high proportion of direction selective neurons (cat: e.g., Lomber, Payne, Cornwell, & Long, 1996; ferret: Philipp et al., 2005; monkey: Newsome & Paré, 1988; Pasternak & Merigan, 1994; Rudolph & Pasternak, 1999; human: Nakamura et al., 2003; Zeki, 1991). Lesions of these areas affect optokinetic performance (e.g., MT: Duersteler & Wurtz, 1988; Newsome, Wurtz, Dursteler, & Mikami, 1985; PMLS: Rudolph & Pasternak, 1996). Direction selectivity in area PSS of the ferret was compared in pigmented and albino animals (Philipp et al., 2005). Albino area PSS showed a significantly lower proportion of direction specific neurons and direction selectivity of these neurons was less pronounced than in pigmented ferrets. Thus, the threshold differences obtained in the present study on the behavioural level are paralleled by the physiological differences in area PSS. These physiological changes might be caused on the cellular level by an altered inhibitory mechanism, impairing e.g., the tuning of direction selective neurons. This hypothesis is supported by recent investigations in rat visual cortex, revealing a more positive chloride reversal potential leading to decreased IPSCs in pyramidal cells of albino compared to pigmented animals (Barmashenko, Schmidt, & Hoffmann, 2005).

5. Conclusion

The present study shows that albino ferrets can reliably discriminate moving random dot stimuli with different coherence, indicating that they can detect global direction vectors. Thus, albino ferrets are not “motion blind.” Coherence thresholds, however, are significantly higher in albino than in pigmented ferrets. Therefore, in addition to the lack of optokinetic reactions an impaired global motion perception seems to be another albino specific deficit.

Acknowledgments

We thank B. Krekelberg for creating the stimulus software “randomdots.” This study was supported by DFG grant Sonderforschungsbereich 509.

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