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TECHNICAL NOTE

AIR FORCE EXPERIENCE INFLUENCES A PILOT'S VISUAL PERCEPTION: PRELIMINARY RESULTS

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Abstract: The objective was to characterize visual scanning of a jet fighter cockpit by pilots with different air force experiences using the eye movement monitoring method and flight simulator under G-Force.

Total, 36 pilots with various experiences in piloting MIG-29 participated in the study. Pilots performed basic manoeuvres required for patrolling the air space, including taking off, turning, landing. Experiments were conducted using an human carrying centrifuge with the MIG-29 flight simulator mode. The visual scene was divided into 22 ROI affiliated to cockpit's instrument and out of widow area. Eye-tracking was performed with The GLASSES portable google sensor manufactured by Sensomotoric Instruments GmbH (SMI, Tetlow, Germany). ANOVA of total dwell time and average fixation duration recorded in each flight phase were run to evaluate statistical significance between the expertise at 95% confidence ($p<0.05$).

Significant differences in total dwell time and fixation duration on selected ROI were revealed between pilots various experiences, i.e. while patrolling air space regarding attitude director indicator (ADI) and exhaust gas temperature (EGT). The median duration of fixation was also significantly different on altimeter while turning. Fixation duration on airspeed indicator, EGT, IPV were unique for each group during approach landing. Also, the total duration time on the altimeter and ADI were significantly different.

Keywords: eye-tracking, visual perception, jet-fighter pilot training, aviation experience

Figures: 8 • **References:** 5 • **Full-text PDF:** http://www.pjambp.com • **Copyright** © 2020 Polish Aviation Medicine Society, ul. Krasińskiego 54/56, 01-755 Warsaw, license WIML • **Indexation:** Index Copernicus, Polish Ministry of Science and Higher Education

INTRODUCTION

Expert pilots' gaze behaviour differs from fewer experience counterparts [1]. Although it could be generalised that experienced expert pilots made more fixations with shorter dwell time than the cadets, it is essential to carefully interpret perception studies in aviation. For example, a different study [3] showed that expert pilots had longer dwell times to relevant ROIs than the novice, related to better decision-making.

Svensson et al. showed the importance of the balanced visual scanning of fighter pilots, who made shorter fixations to the head-down tactical display and alternated more frequently between the tactical display and the outside world, maintaining the best flight performance [4].

It is essential to underline that expert pilots do not always rely on shorter fixations while sampling aviation relevant information in a cockpit [3]. Experts' longer duration of the expert pilots was associated with more accurate decision-making than fewer experienced pilots.

Interestingly, experience development at the early stages of training might strongly impact the visual perception of airman cadets [2]. Private pilot's license and over 50 hours of flight time made more fixations to a navigation map and kept altitude better than cadets with experience between five and 15 hours of flight time.

This study aims to evaluate visual scanning metrics of pilots with different Air Force experiences while flying MIG-29 under G-force. The primary metrics evaluated were total dwell time and median fixation duration at a particular cockpit instrument and display area.

METHODS

Total, 36 pilots with various experiences in piloting MIG-29 participated in the study. The fewer experience subjects of 12 have on average 40h of air force training on the jet fighter, whereas the other 11 who spent over 860h in MIG-29 were considered experts. The intermit 13 pilots have a mean of 515h flighting MIG-29. All participants gave written informed consent to all procedures prior to the study. All procedures had been approved by the Institutional Review Board of the Military Institute of Aviation Medicine, Warsaw, Poland and have been performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

The pilots performed basic manoeuvres required for patrolling the air space, including taking off, turning (Fig. 2), and landing (Fig. 2). Experiments were conducted using an human carrying centrifuge with MIG-29 flight simulator mode. The vision system of the simulator provides a wide field of view (120x70°) and high-resolution images required to visualise the terrain and aerial situation in all lighting and weather conditions.

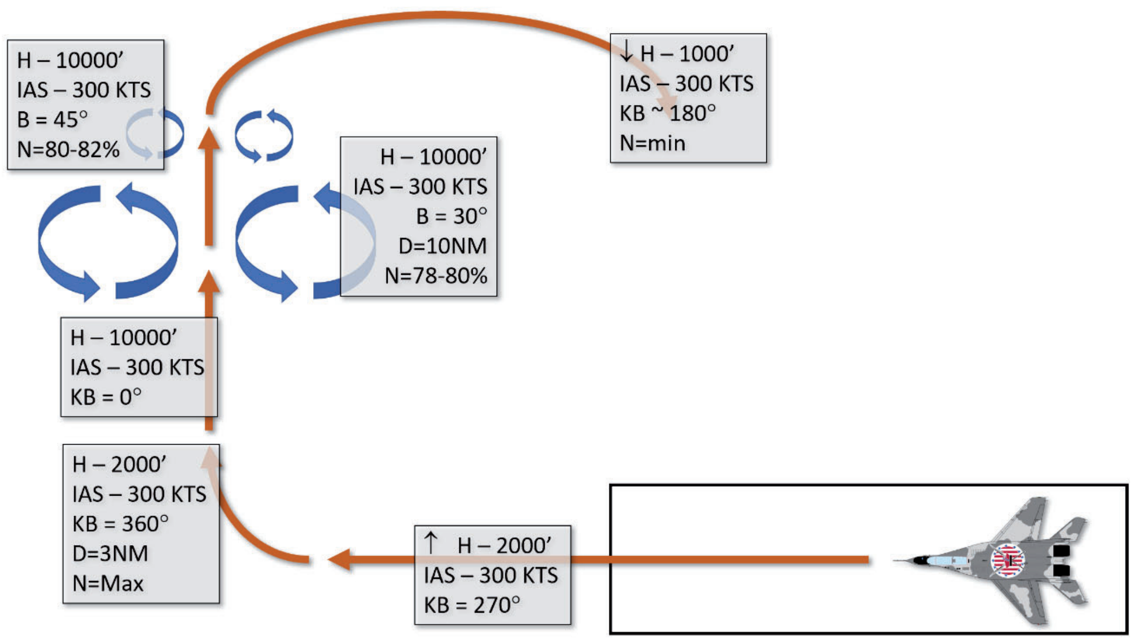

Fig. 1. Patrolling air space task profile starts on the ground and requires taking-off and ascending 2000m before the initial turn, after which additional climb to 10000m with 300 knots. Pilots circled over the designated area four times performing 360 degrees left, and right turns with different radius.

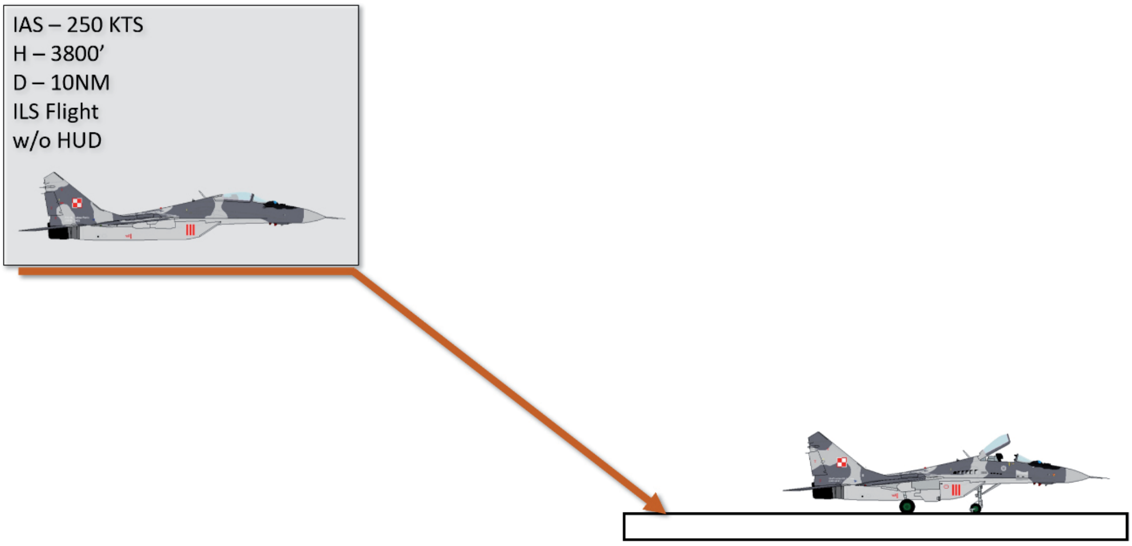

Fig. 2. Approaching the landing task profile starts with the initially indicated airspeed (IAS) of 250 knots at 3800m altitude h. Pilots used the instrument landing system (ILS) flights without HUD.

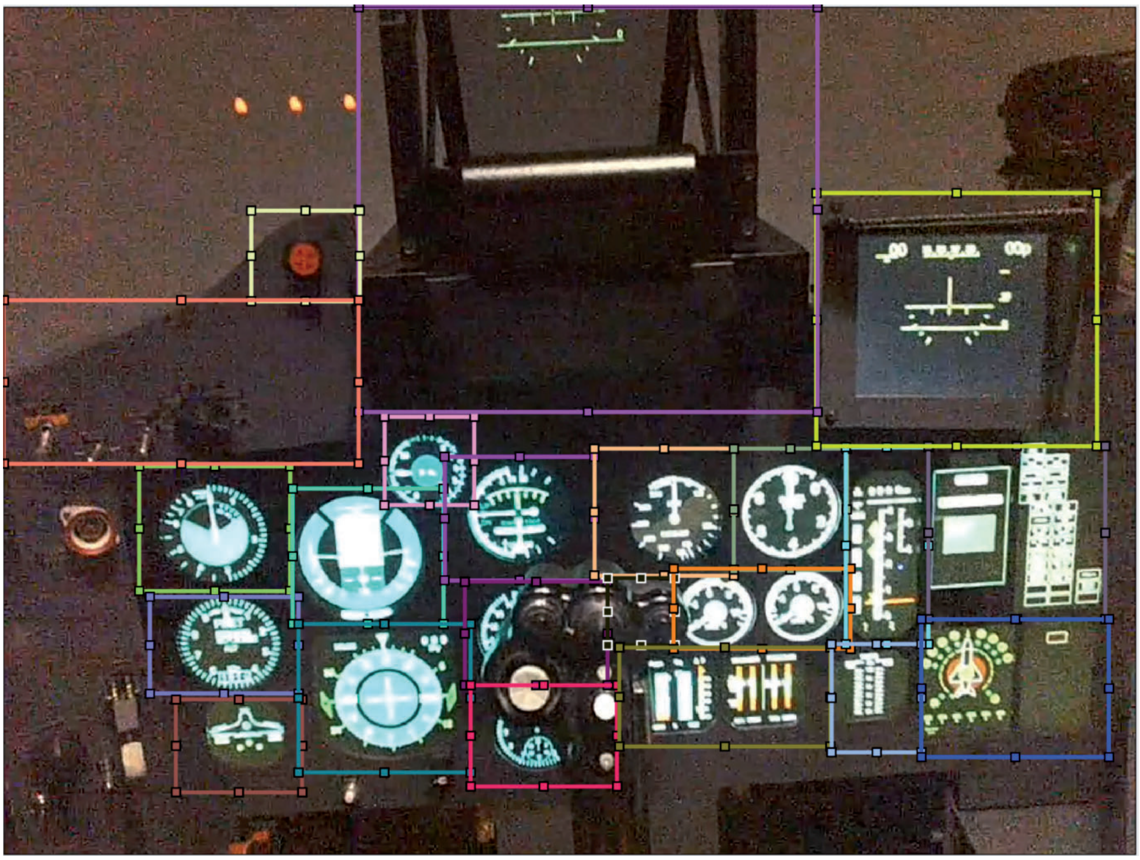

Fig. 3. A total of 22 ROIs covers the most relevant cockpit instruments and out of the window area of MIG-29, i.e. Airspeed, Altimeter, Pilot approach display, Attitude Director Ind, Navigation Instr, G-force Ind, Vertical Velocity Ind, Mach speed Ind, Clock, Radio Altimeter Ind, Flares amount, Engine tachometer, Exhaust Gas Temp Left-Right Engine, Oxygen & Hydraulics, Fuel, Ramp pos, Ekran03BITE/CAS display, Radar warning, IPV1, ILS31HUD, Air to Ground, and Aiming & navigation.

The visual scene was divided into 22 ROI affiliated to the cockpit's instrument and out of widow area (Fig. 3). Eye-tracking was facilitated with The GLASSES portable google sensor manufactured by Sensomotoric Instruments GmBH (SMI, Tetlow, Germany).

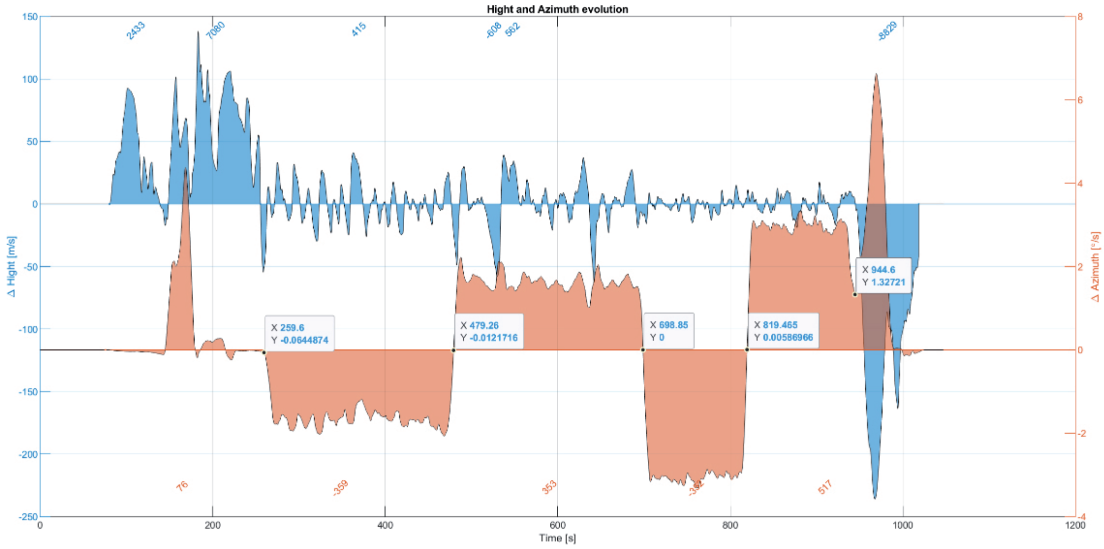

Fig. 4. An example of processed and analysed flight parameters while a pilot patrolled air space according to the task profile.

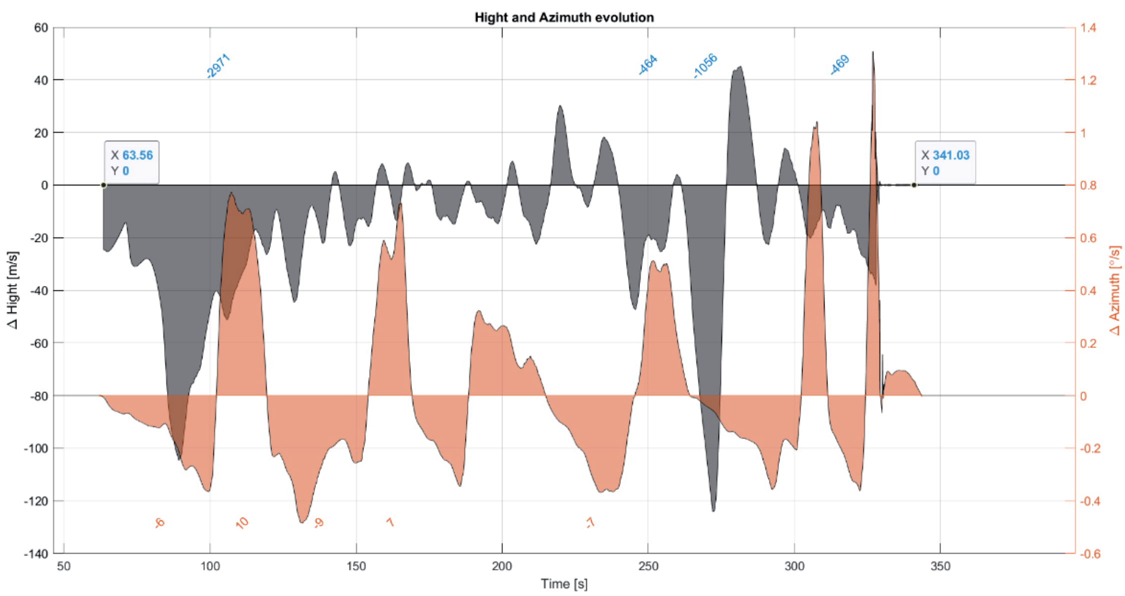

Fig. 5. An example of processed and analysed flight parameters during approaching landing to the instructed task profile.

Flight parameters of altitude, longitude and latitude were recorded during the flight simulation. Postprocessing analysis enables calculating the height and flight direction changes during patrolling (Fig. 4) and landing (Fig. 5).

One-way ANOVA of total dwell time and average fixation duration recorded in each flight phase were run to evaluate statistical significance between the expertise at 95% confidence ($p<0.05$). The normality of distributions were evaluated with Kolmogorov-Smirnov Test.

RESULTS

Pilots with various experiences spent significantly different amounts of total dwell time and made fixations on selected ROIs with different duration. Airspeed was dwelled relatively longer by the intermit group during take-off (Fig. 6). The percentage of dwell dedicated to the altimeter, attitude director indicator (ADI), engine tachometer, exhaust gas temperature (EGT), ILS31HUD and airspeed varied between pilots' groups during turns (Fig. 6).

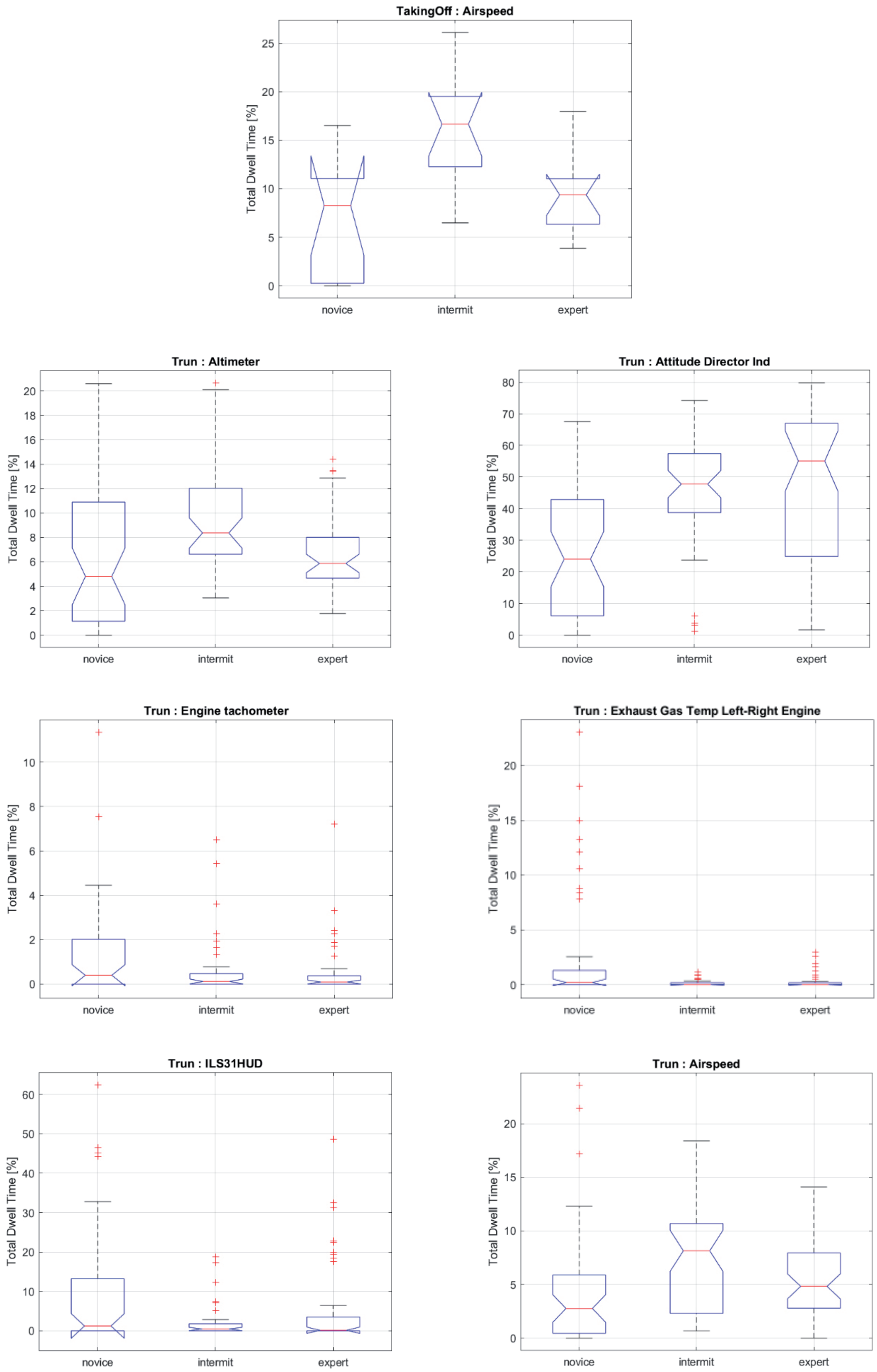

Fig. 6. Boxplots of total dwell time for selected ROIs during take-off and turning, when ANOVA revealed statistically significant difference at $p<0.05$.

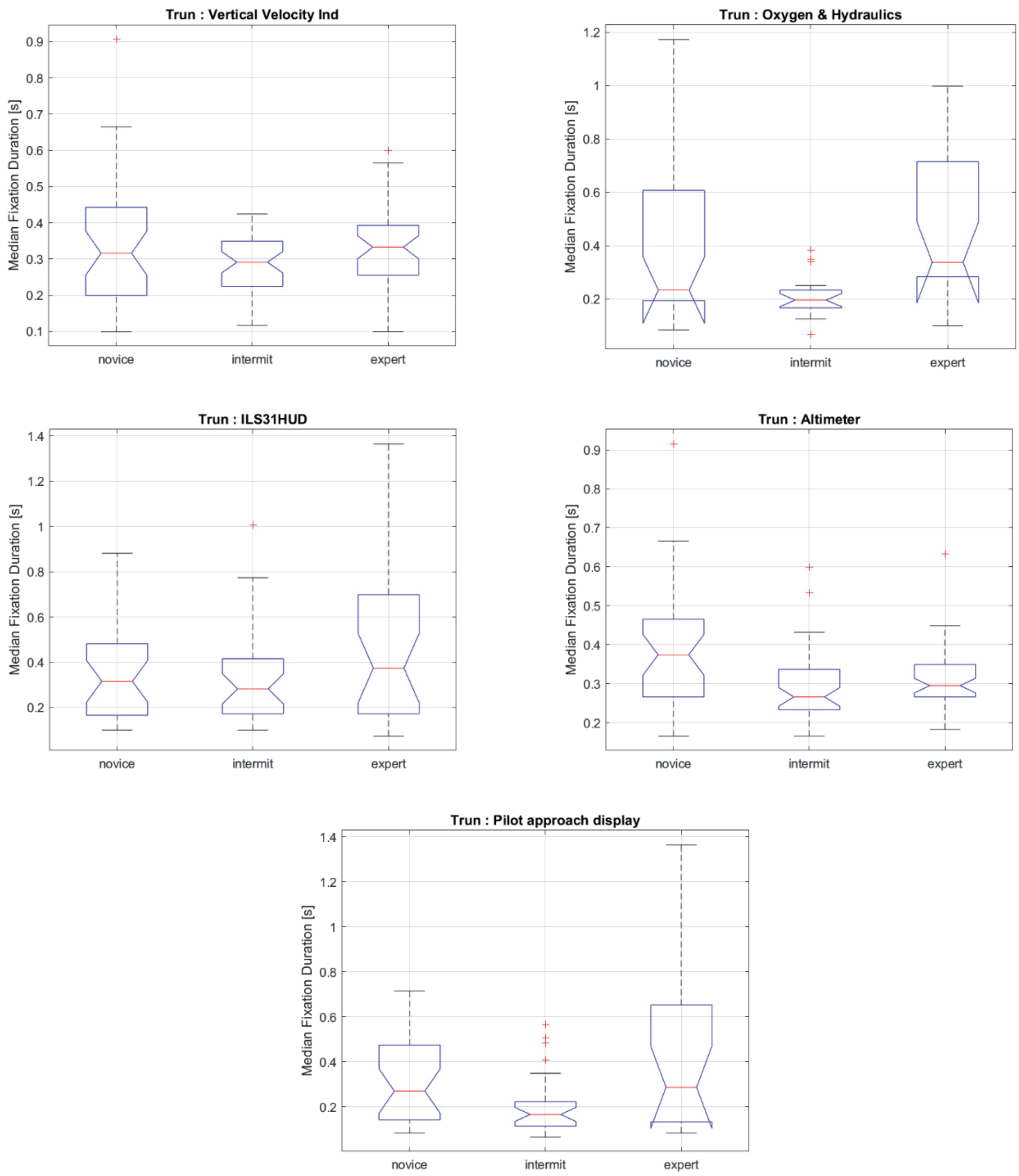

Fig. 7. Boxplots of median fixation duration [s] for selected ROIs while turning, when ANOVA revealed statistically significant difference at $p<0.05$.

Similarly, median fixation duration was different while changing aircraft direction on vertical velocity indicator, oxygen and hydraulics, ILS31HUD, and altimeter (Fig. 7).

Approaching landing conducted by pilots with different aviation experiences were characterised by a significant difference in total dwell time dedicated navigation instrument and median fixation duration on exhaust gas temperature, airspeed, andIPV1 (Fig. 8).

DISCUSSION

Pilots sampled aviation relevant information distinguished to their experience range. It confirms that visual perception evolved in training. However, there is no simple paradigm applied to it, i.e. experts made shorter fixations etc. In contrast, novices, intermit, and experts implemented different visual scanning strategies at taking-off, patrolling, and approaching landing.

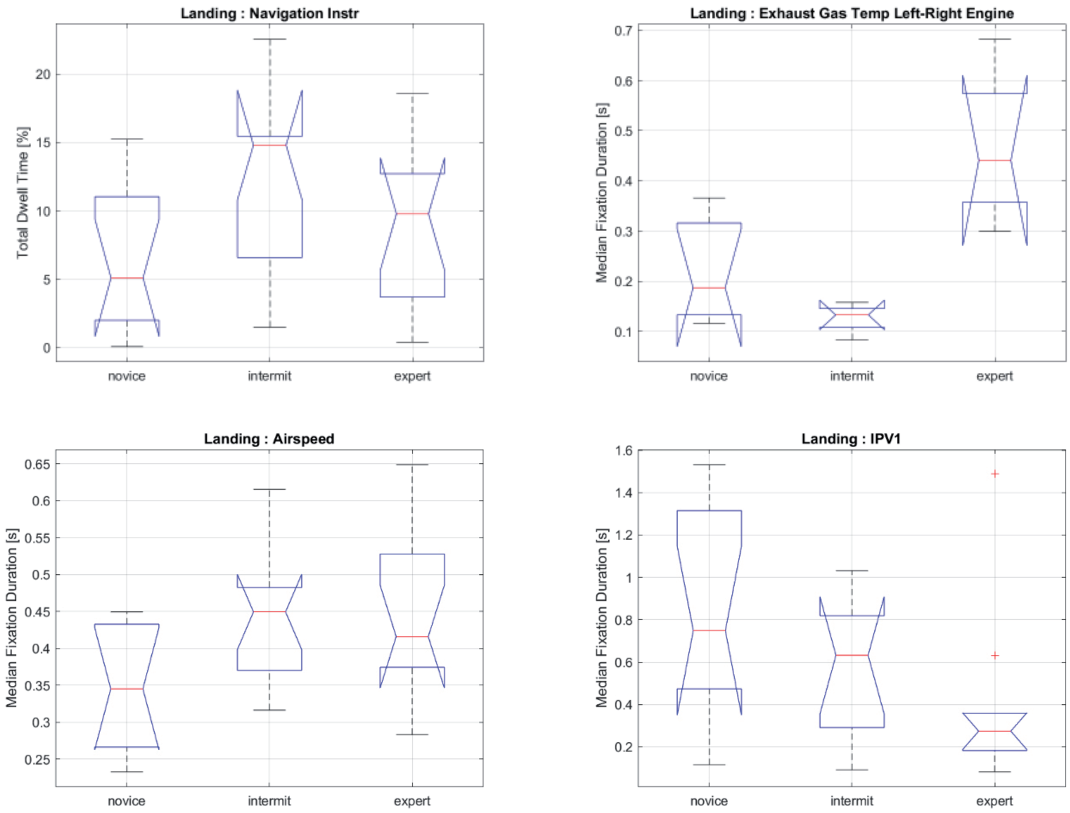

Fig. 8. Boxplots of total dwell time [%] and median fixation duration [s] for selected ROIs during take-off and turning, when ANOVA revealed statistically significant difference at $p<0.05$.

AUTHORS' DECLARATION:

Study Design: Mariusz Pietrzyk, Krzysztof Kowalczuk, Michał Janewicz, Ewelina Zawadzka-Bartczak, Lech Kopka; **Data Collection:** Mariusz Pietrzyk, Krzysztof Kowalczuk, Michał Janewicz, Ewelina Zawadzka-Bartczak, Lech Kopka; **Manuscript Preparation:** Mariusz Pietrzyk, Krzysztof Kowalczuk, Michał Janewicz, Ewelina Zawadzka-Bartczak, Lech Kopka. The Authors declare that there is no conflict of interest.

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