The Institute of Aerospace Medicine at the German Aerospace Center (DLR) comprises departments in Cologne and in Hamburg with an internationally unique research infrastructure. At DLR, the Institute serves as the interface between sophisticated technology and life sciences research comprising biology, medicine, and psychology. The research is conducted in close collaboration with leading national and international research institutions. The long-standing experience of the Institute in selecting and caring for pilots, air traffic controllers, and astronauts in particular directly after return to Earth provides a solid foundation guiding our research efforts. Mechanism-oriented human research, which is a particular strength of our Institute, is fostered by the state-of-the-art research infrastructure at the :envihab facility. Systematic ground-based studies in radiation, astro- and gravitational biology are conducted in dedicated simulation facilities and are complemented by successful investigations in space. Our overarching goal is to conduct research that improves the lives of human beings in space and on Earth.

Influences of environmental factors, such as atmosphere conditions, radiation, gravity, and noise, on human health and performance are in the focus of our research. We translate mechanistic understanding to targeted preventive measures for aerospace and terrestrial medicine. Human-human and Human-machine interactions are another important research focus. The issue is increasingly relevant given the demographic change and digitalization thrust in years to come. The present report provides an exemplary overview of our research activities in 2018 illustrating our interdisciplinary and translational research approach.
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Cardiovascular Aerospace Medicine

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Pharmacological baroreflex testing with fMRI reveals baroreflex mediated brainstem nuclei

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Background

Brainstem nuclei mediate baroreflex adjustments in efferent sympathetic and parasympathetic traffic. Yet, human brainstem physiology is poorly understood given the lack of suitable methodology. We developed a novel approach combining pharmacological testing, beat-by-beat cardiovascular monitoring, and high-resolution functional magnetic resonance imaging (fMRI) to assess human baroreflex regulation at the level of the brainstem.

Method and materials: In 11 healthy men (30.7 ± 6.6 years; 24.1 ± 1.9 kg/m²), we monitored continuous finger arterial blood pressure and ECG using customized hardware during multiband fMRI brain acquisitions. We applied repeated intravenous phenylephrine (PHE, 25 and 75 µg, n=8) and nitroprusside (NTP 25 and 75 µg, n=8) boluses using a remote controlled injector. Brainstem and hypothalamus fMRI images were analyzed to identify brainstem nuclei involved in baroreflex-mediated blood pressure control using a masked general linear model (GLM). Blood pressure (BP) changes were correlated with the time-courses of blood-oxygen-level dependent (BOLD) signals by mixed-effects general linear model [1].

Results

Pharmacological baroreflex testing yielded baroreflex sensitivity measurements with typical blood pressure and inter-beat interval (RR) patterns. Correlation of the baroreflex-mediated changes in systolic blood pressure with BOLD signals clearly revealed brainstem nuclei. The solitary tract (NTP: 7.3; PHE: 6.0 t-value), the caudal ventrolateral me-
dulla (PHE: 5.8 t-value), the rostral ventrolateral medulla (NTP: 5.6; PHE: 7.1 t-value), the nucleus ambiguus (PHE: 5.8 t-value), the paraventricular nucleus (NTP:7.1; PHE: 4.5 t-value), and raphe nuclei (NTP: 5.7; PHE: 6.0 t-value) were identified with high sensitivity and corrected for multiple comparisons (p < 0.01).

Conclusion
We developed a novel approach testing baroreflex regulation at the level of the brainstem in humans. The methodology identified baroreflex-mediated activation and deactivation patterns consistent with previous investigations in animal models. The methodology can be applied to elucidate human physiology and mechanisms of autonomic cardiovascular disease.

References

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Evolution of human pulmonary hemodynamics during severe sustained hypoxia

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Background

Susceptible individuals experience hypoxia-induced pulmonary hypertension when ascending to high altitude [1]. Descent is considered the primary intervention to treat this condition. A human feasibility study testing influences of severe sustained normobaric hypoxia corresponding to >7,000 m altitude on the heart allowed us to follow the evolution of pulmonary hypertension using state-of-the-art cardiovascular imaging.

Material & Methods

Two healthy, professional mountaineers (subject A, male 57 years, subject B, female 50 years) pre-acclimatized for one week in the field at 4559 m altitude. Then, they stayed at the envihab facility of our Institute where normobaric hypoxia was achieved by nitrogen dilution starting at 13.5% O2 to a minimum of 8% O2 over three weeks. Afterwards, 8.5% O2 during the daytime and 8.8% O2 at night was kept for another 14 days. Velocity

Fig. 1: Echocardiographic exam in one subject in the chamber with hypoxic conditions
encoded single plane phase contrast MRI of the pulmonary artery (PA) and echocardiography were performed one month before, during and one and three months after hypoxia for assessment of right ventricular (RV) function, and end systolic pressure (RV\textsubscript{sP}), PA- area, flow and distensibility.

Results
Right ventricular end systolic pressure (RV\textsubscript{sP}) was related to the decrease in oxygen during acclimatization. In subject B RV\textsubscript{sP} peaked at 67 mmHg, 48 mmHg higher than baseline. RV\textsubscript{sP} decreased steadily to a minimum of 44 mmHg after two weeks while still at 8.5% oxygen (Fig. 2). Peak values occurred with clinical symptoms of acute mountain sickness and a drop in exercise capacity but without signs of cerebral or pulmonary edema. In subject A peak RV\textsubscript{sP} was 44 mmHg and remained stable over the entire hypoxia exposure. Table 1 shows the results for RV-function and pulmonary artery hemodynamics.

Conclusion
In healthy humans, severe normobaric hypoxia induces pulmonary hypertension with paradoxically preserved right ventricular function. Pulmonary hypertension may improve over time in some individuals, even in the face of sustained hypoxia. This is even more remarkable as it contradicts current clinical consens [2]. The findings attest to the remarkable physiological reserve of healthy human beings allowing for adaptation to massively increased pulmonary pressure.
Preserved cardiac and cerebral function during 14 days of severe normobaric hypoxia (8.5%)
Despite the severe hypoxia the participants maintained a normal daily life during the study including high cognitive tasks and regular exercise (image). Left ventricular (-46ml, -50ml) and right ventricular (-44ml, -77ml) end-diastolic volumes decreased during hypoxia compared to baseline in both subjects (Fig. 2). End-systolic volumes remained stable in the left ventricle (+5ml, -7ml) while decreasing in the right ventricle (-15ml, -50ml). During hypoxia, a 20 bpm increase in heart rate in both individuals did not compensate for the loss in stroke volume resulting in a small decrease in cardiac output. Left ventricular mass index was lower after hypoxia (-8g/m², -3g/m²). We observed markedly dilated cerebral veins in both subjects (Fig. 3) and scattered cerebral white matter lesions. Yet, cognitive function testing remained stable in severe hypoxia. Both cerebral findings, fully recovered within a few weeks in normoxia.

We conclude that 14 days of severe normobaric hypoxia between 8 and 9% O2 is feasible in healthy humans following an individualized acclimatization profile; however, larger studies in healthy individuals are required. Our ultimate goal is to test whether the approach can induce cardiac regeneration in patients after a myocardial infarction.

Acknowledgements: We are grateful to Nancy Hansen and Ralf Dujmovits for their keen participation in this pilot study.

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References

Fig. 2: Magnetic resonance imaging of the heart of the female subject before and during hypoxia. Marked contractions of the end-diastolic volumes during severe hypoxia (8% O2) are visible, which can be attributed to several adaptive mechanisms of the human body to hypoxia.

Fig. 3: Magnetic resonance imaging of the brain of the male subject before and during hypoxia. A marked dilation of the veins of his brain is visible in hypoxia (8% O2), which indicates that the brain responds with an increase in blood volume to hypoxia.

Fig. 4: The female subject is exercising on a rotating climbing wall under hypoxic atmospheric conditions while two scientists breathing normoxic air via facemasks are monitoring her.
Muscle and Bone Metabolism

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Virtual reality and eyetracking during docking training

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The ability to manually dock a spacecraft on a space station can be crucial for mission safety. The computer-based learning program “6df” is an abstract docking simulation that teaches and refreshes the needed skill of controlling six degrees of freedom. During the AGBRESA bed rest study additional technologies can be tested that might improve this learning process. Common two-dimensional (2D) presentation of the learning program “6df” for docking is compared to a stereoscopic three-dimensional (3D) presentation. Since the beginning of docking simulation at the end of the last century, it has been of interest to analyze the operator’s eye movements. Several eye tracking systems have been prepared for use in space but did not reach practicality. With proceeding commercialization, for example in the gaming industry, plug-and-play systems emerged that suggest an easy and robust applicability of eye tracking.

With this study we would like to investigate if there is a faster learning progress with 3D presentation compared to standard 2D presentation. Moreover, eye tracking is used to answer the question whether there is a relationship between docking quality and extent or timing of visual information processing regarding speed and distance of the spacecraft.

Until now twelve subjects (33.33% female) participated in the ongoing study. Each of them completed 20 training sessions which lasted approximately 45 minutes and were conducted twice a week. The learning program is self-sufficient and adapts itself to the individual learning speed. Half of the participants were presented with a UNITY-based stereoscopic visualization of docking, whereas the other half used the standard version of the learning program “6df”. Learning progress was measured as the number of tasks needed to reach a target task in the middle of the learning range. In the 2D group an eye tracking device (Tobii C4) could be used to assess eye movements as well as pupil dilation. This only required an additional short calibration phase.

Results showed no significantly faster learning progress while using 3D technology. Looking at the eye movements, there was a continuous decrease in pupil dilation while approaching the docking point. Various task types produced specific eye patterns and subjects differed in eye transition frequency. Furthermore there was a signifi-
cant positive relationship between visual control of speed and distance to the docking point and the quality of the docking maneuver. Preliminary results suggest that the learning process does not benefit above average from stereoscopic presentation during early training stages. As the real maneuver has to be flown with a two dimensional view, one may favor common 2D training in comparison to the (yet) costlier 3D system. The analysis of eye movements during docking training proved itself to be feasible and an opportunity to gain more insight into the learning process. There are first hints at the possible suitability of eye tracking to give learners crucial feedback about productive information processing strategies. Further conclusions are expected by the end of the second AGBRESA campaign.

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Fig. 2: Exemplary eye movement protocol of one subject “flying” a low level docking task. Marked areas of interest are: task overview from above (left corner), visor (in the middle) and two displays for speed and distance information (right corner).

Fig. 3: Decreasing dilation of the left pupil during approach to the docking point. Each time interval comprises approximately ten seconds, “1” being the last time interval before docking contact. Error bars depict a 95% confidence interval.

Fig. 4: Correlation between docking accuracy and visual control of the area of interest comprising information about speed and distance to the docking point.
Introduction
In skeletal muscle the lymphatic system is involved in the homeostasis and drain of extracellular fluid. Moreover the lymphatic system returns proteins and other macromolecules from the interstitial tissue to the blood vessel system. A disability of the lymphatic efflux can induce grave consequences like local edema or even a systemic deficiency of blood proteins.

The study “Exercise-Induced Decline in the Density of LYVE-1-Positive Lymphatic Vessels in Human Skeletal Muscle” from the Institute of Cardiology and Sports Medicine, German Sport University Cologne, shows that the density of lymphatic capillaries within the extracted biopsy of M. vastus lateralis decreased significantly after a cycling training intervention. [3]

After it has been asserted that raised endurance training leads to decreased density of lymphatic capillaries in human skeletal muscle, a change could also be assumed during atrophy in skeletal muscle. We hypothesize an increased density of lymphatic capillaries during atrophy in human skeletal muscle and use the Hephaistos Orthosis as atrophy model and analyzed biopsies from the M. soleus to investigate this hypothesis.

Material
The extracted biopsies are results of the “NutriHep” study. In the course of which 12 subjects were wearing the “Hephaistos Orthosis” for sixty days. 7 of them were treated by Lupin-substitution and daily electrostimulations while wearing the Hephaistos Orthosis. 5 subjects of the control group used Hephaistos Orthosis without any treatments. The NutriHep study shows a muscular atrophy after load reduction while wearing the Hephaistos Orthosis for sixty days. The subjects of the control group show an increased loss of muscle volume [2].

Methods
Biopsies were extracted pre and post induced atrophy. Lymphatic capillaries were stained by immunohistochemistry using Anti-LYVE-1 and Podoplanin antibodies for lymph specific staining and Anti-Caveolin-1 for detecting endothelial cells of lymphatic and blood vessels.

Results
The fragile construction of lymph capillaries leads to spread fragments of lymphatic endothelial cells. In this case counting single lymph vessels is impeded. Additionally the muscle fibres should be cut in...
cross-sections to improve identifying single lymph vessels. Our preliminary results of 4 NutriHep-subjects (1 pre and 1 post slices) show the following percentages: lymphatic vessels in non-atrophic muscle 0.24 +/- 0.038%, in atrophic muscle 0.35 +/- 0.114%. For the ratio of lymphatic to blood vessels we found 3.6 +/- 1.612% in non-atrophic muscle, while in atrophy it was 5.59 +/- 1.84%.

First Conclusions
We could demonstrate that muscle atrophy increases the total fraction as well as the ratio in respect to blood vessels of lymphatic vessels in muscle biopsies. However not all data was taken into account and further analyses are required. Especially the Lupin- and electrostimulation may have significant influence on these preliminary results.

Outlook
Investigating the numeric change of lymph vessels after induced muscle atrophy is the first step to comprehend the actual meaning of skeletal muscle contractions in relation to lymph drain. Afterwards we will determine the relevance of immobilization caused atrophy. Comparing atrophied muscle tissue of immobilized subjects to astronauts after their stay aboard the ISS may appoint the effect of hydrostatic pressure – especially on calf muscles.

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References
Assessment of vertical treadmill running under different levels of simulated gravity

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Prolonged exposure to microgravity during space-flights leads to severe deconditioning in the physical performance of astronauts which affects crew health and safety during mission critical maneuvers dangerously. To understand the effectiveness of the existing inflight daily countermeasures, treadmill running in simulated microgravity under different levels of adjusted g-load is compared to usual treadmill running on Earth.

For purposes of exercise planning onboard the ISS, the objective of this study was to assess the oxygen uptake using spiroergometric assessment of men and women (n=26, 8 female and 6 male 20-30 years; 6 male and 6 female 50-60 years) during running on a horizontal treadmill and on a vertical treadmill under different levels of simulated gravity with the Vertical Treadmill Facility (VTF) and Subject loading system (SLS) from the European Space Agency (ESA). This study was carried out in the Physiology Laboratory of the Institute of Aerospace Medicine at the Department of Muscle and Bone Metabolism at the German Aerospace Center (DLR) in Cologne, Germany.

After assessing the maximum oxygen uptake using the Bruce-protocol on the horizontal treadmill, an incremental running protocol on both the vertical and horizontal treadmill was performed in randomized order, starting at a speed of 4 kph and increasing every 4 min by 2.5 kph to a maximum of 19 kph. The runs on the vertical treadmill were performed under 0.3g, 0.6g and 1 g of body weight. 26 subjects were included with a total of 90 runs. 14 of 104 runs were excluded.
The maximum speed for 0.3g and 0.6g on the vertical treadmill was higher than on the horizontal treadmill (P <0.001). By contrast, peak oxygen uptake was greater for the horizontal treadmill than for all conditions on the vertical treadmill (P <0.001), and so was maximal heart rate (P <0.05). The reduction in peak oxygen uptake on the vertical treadmill was strikingly similar across the three simulated gravity conditions and cannot be explained by inability to run faster. Rather, gravity-related impediment of gas exchange-, or impediment of perfusion in horizontal position can be suspected. If this should be the case, this would constitute a substantial limitation to exercise in space.

Table 1: Maximum speed in [km/h], Maximum oxygen uptake ("VO2 peak") in [ml/min*kg]) and maximum heart rate in [beats/min] that are measured on the horizontal ("horizontal") treadmill and vertical treadmill under a load of 1g of body weight("vert_1g"), 0.6g of body weight ("vert_0.6g") and 0.3g of body weight ("vert_0.3g").

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<th>vert_1g</th>
<th>vert_0.6g</th>
<th>vert_0.3g</th>
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<td>Maximum Speed***</td>
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<td>11.5</td>
<td>15.9***</td>
<td>18.5***</td>
</tr>
<tr>
<td>[km/hr]</td>
<td>(2.4)</td>
<td>(2.6)</td>
<td>(3.1)</td>
<td>(1.1)</td>
</tr>
<tr>
<td>VO2 peak***</td>
<td>41.7***</td>
<td>30.5</td>
<td>32.9</td>
<td>30.9</td>
</tr>
<tr>
<td>[ml/(min*kg)]</td>
<td>(7.2)</td>
<td>(6.6)</td>
<td>(7.0)</td>
<td>(5.2)</td>
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<tr>
<td>Maximum Heart Rate**</td>
<td>170.8aa</td>
<td>152.2</td>
<td>154.9</td>
<td>151.5</td>
</tr>
<tr>
<td>[beats/min]</td>
<td>(14.4)</td>
<td>(23.5)</td>
<td>(20.2)</td>
<td>(18.0)</td>
</tr>
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No significant condition*group interaction terms were found (all P ≥ 0.20).

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Fig 2: Maximum reached oxygen uptake in [ml/(kg*min)] in relation to runninspeed in [kilometer/h] on the horizontal ("hor") treadmill (colour = red) and vertical treadmill under a load of 1g of body weight ("1.0g") (colour = blue), 0.6g of body weight ("0.6 → g") (colour = orange) and 0.3g of body weight ("0.3g") (colour=green).

Fig 3: left: Maximum reached heartrate in [beats/min] in relation to the four different running conditions. right: Maximum reached oxygen uptake in [ml/(kg*min)] in relation to the four different running conditions."horizontal"= Horizontal treadmill , “v 1g”= vertical treadmill under a load of 1g of body weight, “v03g”= vertical treadmill under a load of 0.3g of body weight 0.6g of body weight, “v 0.6g”= vertical treadmill under a load of 0.6g of body weight ("0.6g"). Red filled points= women between 20-30 years, red empty points= women between 50-60 years, blue filled points= men between 20-30 years, blue empty points= men between 50-60 years.
Acceptance of 3D accelerometer technology for real world gait speed in paediatrics

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Fig. 1: Acceptance measured via wearing time and questionnaire concerning the restriction of activity of daily living and wearing comfort.

Background

In paediatric rehabilitation the most important aim is to enable the patient to manage the daily living by himself. For the clinical setting a large number of assessments is available \cite{1}, which do represent e.g. the ability to walk but not predominantly assess the challenges the patient has to face at home.

Wearables are widespread and have been proven very useful as an assessment for physical activity to close the gap \cite{2} between laboratory conditions and real life. These devices are well established in various fields for adult population \cite{3}. Therefore, the question arises if they can also be used in children.
Objectives
Assessment of the children’s acceptance to wear a 3D-accelerometer which is attached to the waist under real-world conditions, and also to compare gait speed during supervised testing with the non-supervised gait speed in every-day life.

Methods
In several recruitment waves two groups of children, 30 subjects with cerebral palsy (personal recruitment), classified with the Gross Motor Function Classification System Level I&II and 30 healthy children as control (personal recruitment or e-mail recruitment), aged 3-12, had been asked to wear an accelerometric device for 7 days at home. Initially they had to perform a 1-minute-walking test under laboratory conditions. Acceptance has been measured via wearing time and questionnaire. Subjects could rate restriction of daily living and wearing comfort with a score between 1 and 5. Under laboratory conditions a mobile perambulator has been used as “gold standard” to evaluate the validity of the accelerometric device for children.

Results
Generally, acceptance was good in terms of wearing time and reported comfort (Fig. 1). There was a difference of approximately one hour in the daily wearing time between groups (p=0.3), but no significant group differences in reported restriction of activity of daily living and comfort of wearing (p_{restriction}=0.9; p_{comfort}=0.7). In general, it has been more difficult to attract subjects for study participation than to make them wearing the accelerometric device. Bland-Altman analysis showed moderate, systematic variation between gold standard and 3D-accelerometry (Fig. 2).

Conclusion
3D-accelerometry is well accepted in paediatric rehabilitation patients.

Fig. 2: Validity of gait speed measured by the accelerometric device compared with the gold standard.

References
Assessment of vibration-induced stretch-shortening cycles by B-mode ultrasound

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It has been demonstrated in the past that stretch-shortening is occurring during vibration exercise [1]. However, because of technical limitations the investigated vibration frequency was substantially lower than frequencies used in clinical applications. Now we not only assess elongations of the contractile elements, we also infer upon force modulation by vibration-induced stretch-shortening. This enables us to estimate to which extent vibration exercise increases muscular tissue stresses above stresses during conventional resistive exercise.

The study is performed on the muscle atrophy research and exercise system (MARES). This facility was used on the International Space Station to investigate the multifold aspects of muscle function, with astronauts’ self-testing via crew-guided procedures. The aim of the present study is to assess the modulation of vibration-induced stretch-shortening cycles on alterations in pennation angle and fascicle length, and to compare fascicle dynamics during vibration and during voluntary contractions with varying force contractions. It is anticipated that through addition of high-speed B-mode ultrasound (which was not available on ISS), we can deepen our understanding of muscle mechanics and thus better interpret results from our ISS experiment ‘Sarcolab3’.

Of the available MARES routines, we are here using the ‘angle-torque relationship’ (ATR) and the ‘sinusoidal Perturbation’ (SP) profiles. During the ATR the subjects perform their maximum voluntary contraction (MVC) in plantar flexion in different ankle angles. The SP protocol includes 100 periods of each vibration, applied via a foot plate against which the subject performs plantar flexion contractions at 25%, 50%, 0% and 75% of the MVC. Vibrations are applied at 4, 5, 6, 7, 8, 9, 10, 12, 14, and 16 Hz.

We are examining the pennation angle and the fascicle length of the medial gastrocnemius muscle, using B-mode ultrasound. The ultrasound videos are evaluated using a semi-automatic tracking algorithm, which calculates the fascicular length and the pennation angle. For this purpose, it is assumed that a fascicle is the straight-line connection between the upper and the lower aponeurosis, in the arrangement of the intramuscular connective tissue. The algorithm implements an affine extension of the optical flow model based on the Lucas-Kanade method. With the data recorded before the vibration, the calibration curves of the
The calibration curve applies the fascicle length or pennation angle to the force level. Using fast Fourier transformation, the amplitude spectra are calculated for each condition, in order to isolate the changes in the musculature associated with the vibration. The difference of the sum in the end and in the beginning yield in the change in the muscle associated with the oscillation frequency. The changes in the amplitude spectrum applied to the calibration curve reveal how far the force changes due to the induced vibration.

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Children are thought to be more at risk to negative consequences of transportation noise, since, amongst other factors, undisturbed sleep is vital for their physiological and cognitive development [1]. However, little is known about childhood sleep exposed to aircraft noise and associated short-term annoyance response. An investigation seemed particularly necessary given the differences of sleep architecture between children and adults.

We investigated the acute effects of nocturnal aircraft noise on sleep and resulting short-term annoyance response in a field study conducted around Cologne/Bonn Airport. Sleep of 51 children aged 8 to 10 years was measured polysomnographically (via EEG, EMG, EOG, ECG, and pulse oximetry) during four consecutive nights at home. During each night, aircraft noise exposure was recorded inside the children’s bedrooms and noise metrics were calculated.

Children evaluated their aircraft noise-induced short-term annoyance on a five-point scale (“1 = not” to “5 = very” disturbed or annoyed) in the morning. Further information on potential mod-
erating factors of annoyance response (e.g., noise sensitivity, attitudes towards air traffic) was obtained in personal interviews.

For the prediction of objective sleep quality from aircraft noise exposure, we applied mixed models with random intercept and the number of aircraft noise events as dichotomous factor (median split at 37.5 events). The following variables were analyzed: a) proportion of slow wave sleep (S3 and S4) per total sleep time (in %), b) proportion of waking during sleep period time (in %), c) sleep efficiency (proportion of total sleep time during time in bed, in %), d) proportion of REM sleep per total sleep time (in %), e) number of noise-associated awakenings, f) self-rated sleep quality (“1 = very good” to “5 = very bad”).

Subjective sleep quality did not differ between the two exposure groups (p = .694). Likewise, aircraft noise-induced annoyance was not significantly increased in higher exposed nights (p = .369). Additional mixed logistic regression analyses revealed that annoyance ratings were not influenced by established noise metrics such as number of aircraft noise events or equivalent sound pressure levels. Instead, the self-reported noise sensitivity, the attitude that aircraft are dangerous, and the use of coping strategies in the presence of aircraft noise at home had a significant impact.

From the results, it is concluded that nighttime aircraft noise exposure can objectively impair childhood sleep, but these deteriorations are not reflected in higher short-term annoyance and lower subjective sleep quality. These findings underline the importance of objective measures for identifying noise-induced changes in children’s sleep. The magnitude of slow wave sleep reduction due to higher exposure was similar to the findings in a study comparing sleep parameters in healthy children vs. children with obstructive sleep apnea syndrome [2]. The potential health impact of the small but recurrent loss of slow wave sleep due to aircraft noise is currently unknown, and should be the focus of future research.

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Traffic noise is a growing and serious environmental problem due to its association with health risk, sleep disturbances and annoyance of which the latter is particularly pervasive. Since many traffic noise studies are based on laboratory surveys or exhibit shortcomings in noise measurement, there is a lack of valid exposure-response relationships between traffic noise and annoyance. To fill this gap for road traffic, precise measurements of noise parameters (e.g., A-weighted energy equivalent sound pressure level \([L_{Aeq}]\)) are needed. Furthermore we intended to explore the effect of different noise sources on annoyance by comparing data from a new study on road traffic with those from previous studies on air and railway traffic.

Forty healthy participants (mean age = 29.1; SD = 11.7; 26 females) were studied at their homes in areas with moderate nighttime road traffic in the vicinity of Cologne and Bonn. On four consecutive mornings the participants completed a questionnaire that asked for their annoyance due to road traffic noise in the previous night (1 = “not at all” to 5 = “extremely annoyed”) as well as for
non-acoustical mediators of annoyance (e.g., subjective sleep quality, perceived noise load, perceived degree of having adapted to road traffic noise). Measurements of acoustic parameters were undertaken inside the participants’ bedroom.

We applied logistic regression using Generalized Estimating Equations (GEE) models to derive the probability to be annoyed (categories ≥ 2) by road traffic noise as a function of the L_{Aeq} and non-acoustical mediators (Fig. 1). In a further analysis the road traffic data were combined with those from two earlier field studies in which the effect of nocturnal railway noise (1) and aircraft noise (2) on residents’ annoyance in the vicinity of Cologne and Bonn were investigated. The pooled data sets were used to derive comparative exposure-response curves for noise-induced annoyance by road, railway and air traffic (Fig. 2).

The analysis of the road traffic data revealed a statistically significant rise in the annoyance with increasing L_{Aeq} (p = .023, OR = 1.159). The extent of the perceived noise load had a reinforcing effect (p < .001, OR = 44.606), whereas a high subjective sleep quality had a reducing effect (p = .007, OR = .924) on annoyance. In the pooled data set annoyance increased again with increasing L_{Aeq} (p = .001, OR = 1.043). In contrast, the perceived degree of an individual’s adaptation to traffic noise reduced annoyance (p < .001, OR = .528). The probability to be annoyed turned out to be higher for road traffic noise than for aircraft noise (p = .001, OR = 3.026), whereas railway noise did not differ from aircraft noise (reference) in its impact on annoyance (p = .079, OR = 1.812).

The current field-study on road traffic noise emphasizes the importance of subjective sleep quality for annoyance responses and delivers a prediction model for road traffic noise-induced nocturnal short-term annoyance in areas with moderate traffic. The analysis of the pooled data set revealed the L_{Aeq} to be a significant acoustical predictor for annoyance even when taking noise from different traffic sources into consideration. Additionally, we found an important influence of the perceived degree of an individual’s adaptation and showed that the extent of annoyance tends to vary depending on the respective noise source. The significant differences in annoyance reactions between aircraft and road traffic might be explained by the different temporal patterns of noise distribution throughout the night.

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Epidemiological studies consistently indicate that chronic sleep restriction is associated with increased all-cause mortality [1] and prevalence of cardiovascular diseases [2, 3], type 2 diabetes [4] and trait-like impairments in cognitive functions [5-7]. We examined whether this trait vulnerability of cognitive performance to sleep loss extends also to glucose tolerance and insulin sensitivity.

Thirty-six healthy volunteers underwent a 12-day sleep lab study. In a sequential design, they completed one adaptation night and two baseline nights with 8 h time in bed (TIB) each, 5 nights with 5 h TIB (sleep restriction group: N=21, 9 female, mean age 26 ± 4 years SD, mean BMI 23.1 ± 1.9 kg/cm² SD) or 5 nights with 8 h TIB (control group: N=15, 5 female, mean age 28 ± 6 years SD, mean BMI 23.6 ± 2.9 kg/cm² SD), followed by one night with 8 h TIB, one 38-h period of acute sleep deprivation, and a final night with 10 h TIB. Oral glucose tolerance was tested in the morning immediately after lights on (>10 h fasting) on the second baseline day, after 5 nights with 5 h or 8 h TIB.
TIB, after the recovery night, and after 24 h of sustained wakefulness. Fasting serum glucose and insulin levels, as well as those 30, 60, 90, and 120 min after glucose intake were analyzed in blood samples. Additionally, areas under the curve (AUC) for glucose, insulin, and HOMA were calculated. Averaged daytime results of a 3-hourly performed psychomotor vigilance task (10-min PVT) were considered. Effects on the dependent variables were analyzed with mixed ANOVAs in SAS with ‘sleep condition’ (4x) and ‘sex’ (2x) as factors (post-hoc Bonferroni-Holm adjustment) for each of the two groups. Pearson correlations between impairments (differences to baseline) in glucose metabolism and performance were calculated.

In comparison to baseline AUC of glucose (Δ 32.5 ± 7.0 mg*h/dl), insulin (Δ 44.9 ± 9.2 mU*h/dl), and the homeostasis model assessment (HOMA; Δ 20.7 ± 3.9) were increased after sleep restriction (all p<0.0003), stayed elevated after one night of recovery sleep (glucose Δ 17.3 ± 6.8 mg*h/dl; insulin Δ 24.7 ± 9.2 mU*h/dl; HOMA Δ 11.3 ± 3.8; all p<0.02), but returned to baseline levels after 24 h of sleep deprivation (all p>0.6). The control group did not show significant changes in glucose tolerance and insulin sensitivity.

Impairments after 5 nights of sleep restriction showed significant correlations between mean speed / 10th percentile of speed and glucose at 90 min (r=-0.51/r=-0.52), insulin at 30 min (r=-0.55/ r=-0.59), 90 min (r=-0.61/-0.61), and at 120 min (r=-0.51/trend r=-0.49) after exposure. Sleep restriction, but not acute sleep deprivation, impaired glucose tolerance and insulin sensitivity. Impairments due to sleep restriction outlasted a single night of recovery sleep, but did not show cumulative effects with acute sleep deprivation. Chronic sleep restriction and acute sleep deprivation appear to activate different regulatory responses in glucose metabolism. Individuals under sleep restriction appeared to be likewise either vulnerable or resilient regarding both glucose metabolism and cognitive performance.

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Fig. 2: Correlation between impairments in the 10th percentile (10P) of psychomotor vigilance performance (PVT) speed and glucose levels 90 min after glucose ingestion indicating a trait resilience / vulnerability to sleep restriction (5 nights with 5 h TIB).
Transient pressure changes in high speed trains do not interfere with speech intelligibility

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High speed trains are becoming a backbone of the transportation infrastructure in many countries. To facilitate safe operation in increasingly complex railway networks a multitude of driver assistance systems are under development. The auditory channel can be used to provide information without disrupting visual attention, but it must be interruption-free. Disequilibrium of tympanic air pressure promotes conductive hearing loss and it is not known whether the transient pressure changes experienced in high speed trains when passing through tunnels may interfere with speech intelligibility.

Our primary objective was to assess whether transient pressure changes of 25 hPa in two seconds affect speech intelligibility in persons with normal hearing ability and our secondary question was whether the direction of the pressure change makes a difference.

Since statistical tests only control for false positives it was crucial to study a sufficiently sized sample to restrict false negative outcomes as well. Data for a reliable power calculation was nonexistent and we conducted a pilot study with 20 participants (10 female, mean age 27 years ± 6 SD) to estimate variability. The upper 80% confidence limit guided sample size of the main campaign with 72 participants (35 female, 25 years ± 5 SD), enabling us to identify a 10% difference in speech intelligibility while limiting the chance of alpha and beta error to 5% and 10% respectively.

Speech intelligibility was measured using the monosyllable word test by Wallenberg and Kollmeier [1]. Subsequent to each audibly presented test word participants were asked to identify the word from five written alternatives, each differing in one of three phonemes.

We used a cross-over design in which each participant was studied in a single one hour session. Participants were presented with two test blocks of 50 words each. In one block each test word was played immediately after a pressure change, while the other block was performed at steady pressure.
ambient pressure of 950 hPa. To account for potential order effects, we permutated the pressure condition. A speech simulating background noise of 67 dB(A) was constantly played throughout the experiment, masking the operating sounds of the chamber. The signal to noise ratio of the presented test words was adjusted to yield 50% speech intelligibility without pressure changes.

To maintain an overall family-wise error rate of 5% we devised hierarchical testing using complete alpha spending from the primary to the secondary hypothesis.

On average participants understood 0.7 more words when listening in steady ambient pressure, compared to experiencing a pressure change before announcement of the test word. This would equate to an effect size of 0.1, however, a two-sided Wilcoxon signed rank test \( Z=-1.29; p=0.20 \) did not detect this to be distinguishable from chance. When comparing increasing and decreasing pressure the average understanding differed by 0.2 words, which was not formally tested since the primary hypothesis lacked statistical significance.

High speed train drivers are not only operating their vehicles in ever more complex railway infrastructures, but they are also subject to a multitude of factors, such as monotonous operating cycles and shift work, known to increase the likelihood of fatigue and human error, consequences of which may be catastrophic. Advanced assistance systems are a necessity to ensure safe rail operation in this ever more demanding environment. Such systems can safely make use of speech to communicate relevant information to train drivers. The pressure changes occurring during the passage of tunnels, a peculiarity of the train environment, do not interfere with speech intelligibility and are consequently not a risk factor when using the verbal auditory channel.
Clinical Aerospace Medicine

Stern, C.; Trammer, M.: Another “Direct Return” of an European astronaut

Stern, C. et al.: Optic disc edema in test subjects during 30 days of 6° head down tilt bed rest
Another “Direct Return” of an European astronaut

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Until 2014 European astronauts used to stay in Star City or were brought to the NASA Johnson Space Center after their Soyuz landing in Kazakhstan. Alexander Gerst was the first European astronaut to profit from the so called “Direct Return”. European astronauts are flown directly after their landing back to the European Astronaut Center and DLR in Cologne where the needs of postflight science examinations, clinical data collection and rehabilitation are covered.

In December 2018 Alexander Gerst returned after a 197 day stay on board of the International Space Station to the Institute of Aerospace Medicine’s research facility :envihab. He was the second European astronaut who served as a commander of the ISS. In addition to this, he is the European astronaut who spent the most time in space. He returned already for the second time to the :envihab after his time in space and is now the fourth European astronaut who was brought to our Institute directly after his landing in Kazakhstan.

Fig. 1: Nocturnal arrival of Alexander Gerst at the :envihab after his landing in Kazakhstan.
Following the agreed postflight examination protocol of the participating space agencies we performed immediately after his arrival in the :envihab a blood draw and an electrocardiogram. During the first three postflight weeks the following examinations among others were performed:

- Several blood draws
- Exercise Stress Tests (cycle and treadmill)
- Eye examinations (including visual acuity, contrast sensitivity, slit lamp examination, intraocular pressure, OCT, visual field and ultrasound)
- Audiogram
- Dual-energy X-ray absorptiometry (DXA)
- Brain MRI
- Dermatological assessment
- Fitness assessment

The astronaut received also two hours of reconditioning every day at the European Astronaut Center.

A main focus lays on the examinations of the eye as more than 60% of long-term mission astronauts show changes in the anatomical structure of the eye. These changes may include globe flattening with hyperopic shift, optic disc edema, cotton wool spots and chooroideal folds.

We perform the medical examinations in the scope of medical monitoring to get more knowledge about the influence on the health status of astronauts by their stay on the International Space Station. But we also conduct medical examinations for scientific studies which address special fields of interest to research the long-term effect of microgravity on the human body for more knowledge and experience to prepare the astronauts better for Moon and Mars missions. When astronauts land in Kazakhstan, there is an armada of specialists helping the astronauts out of the Soyuz capsule and to recover their legs – in the true sense of the word. This support will not be available on Moon and Mars and therefore the crew must stay in proper body condition during their long missions, reducing muscle and bone loss, as well as other microgravity side effects as much as possible.

With these examinations we contribute to the fast recovery of the astronauts as well as for science.

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Optic disc edema in test subjects during 30 days of 6° head down tilt bed rest

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In 2008 the first cases of eye changes in astronauts were published [1]. When NASA detected these changes in astronauts, it started a survey of all astronauts concerning observed vision changes during and after their missions. 29% of short-term mission and 60% of long-term mission astronauts reported a degradation in distant and near visual acuity. About 60% of long-term space mission astronauts showed ophthalmological changes like posterior globe flattening and a resulting hyperopic shift, an increased optic sheath diameter, optic disc edema, choroidal folds and cotton wool spots. These changes were in the beginning called “Visual impairment and intracranial syndrome” (VIIP) and now are summarized under the acronym SANS (Space Associated Neuro-ocular Syndrome). The pathologies can be transient or can stay for years. Fluid shift, a different pressure gradient between intracranial pressure and intraocular pressure, increased CO² and high sodium intake are discussed as possible causes [2].

Because the causes of SANS are still unknown research needs to be executed for safe future missions especially in the scope of Moon and Mars. In 2018 NASA performed a 30 days head down tilt bed rest study together with and at the Institute of Aerospace Medicine with the main focus on possible eye changes. The VaPER study (VIIP and Psy-
chological :envihab Research) took place under the conditions of the International Space Station with a strict bed rest in head down tilt and additional increased CO₂. For the first time the test subjects were not allowed to use a pillow and were observed 24/7 to make sure that the very strict head down tilt position was complied with. The eyes of the 11 test subjects were examined in a similar way as the astronauts are examined before, during and after the mission. The Ocular Coherence Tomography enables us to measure the retina and optic disc correct to 5 µm and changes can be demonstrated in a quantitative matter. Out of the 11 test subjects, 5 persons showed optic disc edema in different degrees [3]. As two variables were changed at the same time (CO² and strict head down tilt) it is not clear which one was the crucial one to create for the very first time optic disc edema in bed rest studies. Therefore the following NASA study takes place without the increased CO² condition.

Fig. 2: Optic disc edema in one of the test subjects.

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[3] Laurie et al., Ophthalmology 126, 2019
Study Team

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Orthostatic dysfunction is observed in astronauts after a prolonged stay in weightlessness or in subjects after mid- or long-term bed rest studies. Development of countermeasures to avoid orthostatic dysfunction after space flight is mandatory. Artificial Gravity generated by centrifugation is a promising multi-system countermeasure which could help to maintain physical fitness of crew members even on long term missions.

In a previous study using the Short Arm Human Centrifuge (SAHC) at DLR Cologne, it was demonstrated via measurements of skin perfusion that the resistance vessels on the lower leg are capable of active constriction despite drastically increased local arterial pressure. This could also be maintained in hypergravity conditions of +2Gz. On the other hand, skin perfusion increased significantly in an area with paralyzed vessels. In addition, near-infrared spectroscopy (NIRS) revealed microvascular blood pooling in the lower leg muscles and a progressive hemococoncentration [1]. Previous experiments showed that the control of peripheral body temperature due to thermoregulation processes plays an important role in cardiovascular regulation [1,2]. Venous pooling is a factor here, but also the microvascular component [1]. Based on these findings we conducted a randomized trial in crossover design to test the hypothesis that external peripheral cooling can improve orthostatic tolerance in hypergravity. Study aims were as follows:

1. Differentiation of the contribution of the systemic sympathetic response and the local myo-genic response of resistance vessels to the vasoconstriction of the dermal vessels under different gravitational loads.
2. Determination of the max. acceleration (and thus of the local arterial pressure) up to which the tone of the resistance vessels can withstand these pressures.
3. Determination of the compliance of the various compartments of blood-fluid displacement in the lower leg, namely the large veins, the muscular resistance vessels and the transvascular fluid filtration.
4. The influence of thermoregulation on orthostatic responses and g-Force induced Loss of Consciousness (GLOC).

Different methods of microcirculation were combined: laser Doppler flux for measuring skin perfusion, iontophoresis for topical application of Na-nitroprusside (complete vascular paralysis) and Phentolamin (non-selective α-receptor blocker) into the skin and NIRS for measurement of hemoglobin concentration in muscle.

In addition, the usability and efficiency of the peripheral cooling before and during G+ load was tested. A statement on the efficiency and benefits in terms of protection against orthostatic events and the probability of occurrence of a presyncope on the one hand, and also with regard to post-expositional physical and cognitive performance on the other hand can be made.
18 healthy male participants were involved in the study which was conducted in the *envihab* facility on the SAHC of our Institute.

Pre and post centrifugation several tests were performed (table 1).

Subjects were divided randomly into 2 groups. Group A was cooled on the 1st day and performed their centrifuge run on their 2nd study day without cooling. Group B was handled vice versa. There was a wash out phase of at least 3 days between both study days.

Cooling was achieved by using an ArcticSun5000 medical cooling system, and adhere the cooling pads to the thighs of the subjects (Fig. 1).

An experienced physician monitored the centrifugation and terminated the protocol when the subject showed presyncopal signs (dizziness, blurry vision, nausea, sweating, heart palpitations, sudden drop in blood pressure) according the general termination criteria for SAHC runs.

18 participants performed two study days each with all tests incl. final VO2max-Test. Analysis of all data is still work in progress.

This study was performed in cooperation with the Charité, Berlin, as a project in the frame of the 2nd National Centrifuge Program (NZP2), announced by the DLR Space Administration.

**Table 1: COOLSPIN Study protocol**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
<th>Duration [min]</th>
<th>g-force (Gz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrival/Anamnesis</td>
<td>- Brief medical examination - Venipuncture</td>
<td>~20min</td>
<td>-</td>
</tr>
<tr>
<td>Preparation Supine on SAHC</td>
<td>- BIA pre - ECG - SpO2 - Blood pressure cuff and Finometer - NIRS - Double sensor - Electrodes for microcirculation - Cooling pads (thighs) - Blood draw pre - Response test pre</td>
<td>~60 min</td>
<td>-</td>
</tr>
<tr>
<td>Centrifugation</td>
<td>- Break and cooling/no cooling</td>
<td>10 min</td>
<td>1g</td>
</tr>
<tr>
<td>Supine on SAHC</td>
<td>- Rotation</td>
<td>10 min</td>
<td>-</td>
</tr>
<tr>
<td>Centrifugation</td>
<td>- Preparation Supine on SAHC - BIA pre - ECG - SpO2 - Break and cooling/no cooling - Energy test post</td>
<td>3 min</td>
<td>1g</td>
</tr>
<tr>
<td>Out of Centrifuge</td>
<td>- VO2max (Cycling) post</td>
<td>40 min</td>
<td>-</td>
</tr>
<tr>
<td>End of protocol</td>
<td>- Medical release</td>
<td>5 min</td>
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</table>

**Fig. 2: g-profile of the centrifuge protocol.**


The DLR Institute of Aerospace Medicine has longtime experience in supporting human spaceflights. Ever since contributing to the Spacelab Program, the Institute has supported the psychological and medical astronaut selection, training and mission operations. The program is flanked by state-of-the-art ground based biological, medical and psychological research.

Initiated by ESA, we started in 2014 hosting most of the ESA-Astronauts after their ISS missions in :envihab for their first 21 days back on Earth - the so-called “Direct Return”.

The :envihab, derived from the words environment and habitat, is fully operational since 2013. Only with this unique medical research facility of our Institute the Direct Return at DLR could be realized. Within its eight modules, :envihab houses multi-purpose laboratories and specialized equipment for life science research. Together with the advantages of the Cologne campus which means only a few meter distance to the EAC as well as to the Flight Medicine Clinic the Institute now supports a large number of the postflight activities of ESA astronauts.

Astronauts, crew surgeon and operational staff can be easily accommodated in :envihab. All of them find a comfortable, noise-reduced and quiet place with a small kitchen and a large living area. The crew quarters are access-controlled avoiding infection and providing astronaut privacy. A large control room located directly next to the crew quarter allows ESA and DLR perfect supervision of all scheduled activities during the first busy weeks after returning to Earth.

All medical post-flight examinations required according to the Medical Standards for crew mem-

Fig. 1: Entrance hall of :envihab.
bers can be performed at the adjacent DLR Flight Medicine Clinic. As a great advantage pre- and post-flight examinations and measurements can be performed at the same site with the same equipment and the same staff, thus limiting variability. Similarly, post-flight experiments are conducted by DLR scientists within :envihab. In November 2014, Alexander Gerst was the first astronaut to directly return to Cologne, followed by Andreas Mogensen (Sept. 2015), Timothy Peake (June 2016) and Thomas Pesquet (June 2017). ISS commander Alexander Gerst was hosted a second time in December 2018. As the next astronaut we expect Luca Parmitano in :envihab in February 2020.

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Fig. 2: Crew quarter – view insight.

Fig. 3: Alexander Gerst entering Module 5 of :envihab functioning as crew quarter.
Aviation and Space Psychology

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Ability requirements of unmanned aerial systems operators

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In military contexts, unmanned aerial systems (UAS) offer two major advantages over manned aviation: They can be deployed during dangerous missions too risky for crewed aircraft or personnel on the ground, and they have been argued to be more cost effective in procurement and operation than manned aviation [1]. Since the introduction of UAS in the German Bundeswehr, their usage as well as the demand for qualified operating personnel have increased. The aim of the study, conducted in cooperation with the German Air Force Center of Aerospace Medicine is to develop specific requirement profiles for UAS operating personnel, and to identify potential differences in the requirements between unmanned and manned military aviation personnel.

During an initial job analysis phase, operators were observed on-the-job, allowing to determine the different operating positions of each UAS system and the associated tasks. Subsequently, more than 300 experienced UAS operators and pilots of manned aircraft completed an extended German version of the Fleishman Job Analysis Survey (F-JAS) [2]. The F-JAS consists of 73 scales for assessing individuals’ abilities and skills from cognitive, psychomotor, physical, sensory, and interactive/social domains. Two additional scales on operational monitoring and vigilance from previous DLR research projects on future requirements in aviation jobs were used [3, 4].

The domain means for each system and operating position are shown in Fig. 2. Requirements for UAS operators were high, particularly in the cognitive and the interactive/social domains, where-
as physical abilities were generally low for both UAS operators and sensor operators. Individual scales reveal overall high requirements for all UAS operators irrespective of operating position or system in selective attention, vigilance, dependability, and perseverance. Moreover, some requirements were rather specific for a particular position: For UAS operators (irrespective of the operated system), problem sensitivity, time sharing, operational monitoring, and self-control were critical abilities. For sensor or payload operators, demands were highest for the abilities flexibility of closure, spatial orientation, visualization, perceptual speed, near vision, achievement striving, and self-sufficiency. We also found differences in requirements between the systems. Operating the Aladin system posed lower demands on their operators when compared to other UAS. For the remaining three systems (Luna, KZO, and Heron), largely similar abilities were required: No differences were found in the interpersonal/social skill domain only (KZO operators reported higher demands than Heron operators). Differences between manned and unmanned aviation were expected in psychomotor and physical abilities due to the high level of automation in UAS and will be addressed in future analyses. Additional future steps will include collecting and including additional data from incident reports and expert workshops. Together with the present data, the results will also assist determining the possible impact of HMI concepts and different levels of automation on operator demands. The outcomes will contribute valuable information about which human factors are relevant to be considered in personnel selection, training, and stress management of future military UAS operators.

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Ability tests are core elements in performance research as well as in applied contexts and are increasingly carried out using computer-based versions. The Department of Aviation and Space Psychology at DLR, Hamburg, has employed computer-based ability tests for several years to select cockpit personnel and air traffic controllers for several major European airlines, air traffic control organizations and the European Space Agency (Fig. 1).

In the last few decades a private commercial training and coaching industry has developed to prepare individuals for these computer-based assessments. Evidence suggests that such commercial training programs can result in score gains in ability tests, thereby creating an advantage for those who can afford it and challenging the fairness of ability assessment. As a consequence, several authors recommended freely offering training software to all participants to increase measurement fairness. However, it is still an unanswered question whether the unsupervised use of training software could have a negative impact on the measurement properties of ability tests. The goal of the present study was to answer this question by examining the subjects’ ability test scores for measurement and structural invariance across different amounts of comput-
er-based training. Structural equation modeling was employed in a sample of 15,752 applicants who participated in high-stakes assessments with computer-based ability tests.

A descriptive analysis showed that there were training effects consistent with previously published research (Fig. 2).

But most importantly, the invariance analysis demonstrated that the structure of the tests was not altered by offering free training to all applicants: across different training amounts, our analyses supported measurement and structural invariance of ability scores.

Particularly in times of internet testing and the growing (online) availability of information about tests, to be reliable and fair, psychological diagnostics have to react. Our results suggest that free computer-based training is an appropriate way to react to today’s challenges without affecting the measurement quality in diagnostic decision making, and tests for measurement invariance are an efficient way to screen for such potential biases.

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Fig. 2: Relation between the mean number of computer-based training runs and mean test performance. Due to small sample sizes with more than 40 training runs and increasingly larger confidence intervals, applicants with on average more than 40 training runs have been aggregated (only for display purposes; n = 262, M = 53 training runs). N = 15,752; the data point with the smallest sample size is at 39 training runs with n = 28.
Human performance assessments in remotely piloted aircraft system (RPAS) implementations

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Introduction
Remotely piloted aircraft systems (RPAS) receive more and more attention in the aviation sector. The role of humans in RPAS differs from crewed aviation due to technological advancements and increased automation. Therefore, it is important that the human factor (HF) is considered sufficiently in concept designs. Here, we assessed if and how human performance (HP) issues have been considered in RPAS concept designs developed in the DLR-project “Unmanned Freight Operations” (UFO).

Method
A multi-method approach (Fig. 1) was used to assess how HP has been considered in the concept designs [1]. Firstly, the Fleishman Job Analysis Survey (F-JAS [2]), consisting of 73 behavior-anchored scales covering cognitive, psychomotor, sensory, social and interpersonal abilities was used to assess RPAS job requirements. Eighty-two RPAS-operators (data from ongoing data collection; [3]) rated job tasks on a 1 to 7 scale in relation to the ability required, irrespective of the time spent on the task, its difficulty, or the importance of the ability. Secondly, two aviation psychologists from DLR Hamburg organized a workshop with nine end-users (air traffic controllers and safety personnel from various backgrounds: tower, approach and center) from the German Air Navigation Service Provider (ANSP) DFS in 2016. The first aim was to evaluate ANSP-based RPAS cargo operations from an end-users perspective. The second aim was to determine ANSP-personnel’s prognosis for the earliest possible implementation of such a concept. Finally, the Human Performance Assessment Process (HPAP), a standardized methodology to assess HP considerations in concept designs (developed in a SESAR project [4]) was used to systematically identify HP aspects in the UFO concept designs. An adapted version of the HPAP was used: Issues related to the HP arguments were specified and recommendations expressed accordingly (Table 1).

Results
Firstly, the F-JAS revealed that cognitive, and social and interpersonal abilities were considered most important (Table 2). Secondly, the workshop with end-users showed that the general concept of ANSP-based RPAS was seen as feasible and realistic to implement within the next 10 years. The end-users expressed skepticism towards the possible increase in responsibilities and the new tasks were not necessarily perceived as job enrichment. Therefore, a clear definition of roles and responsibilities was considered important. Finally, the core implications derived from the HPAP include the following aspects: Task
distributions need to be clear and well defined. A high level of automation is needed, but operators must be kept in the control loop in order to maintain situational awareness. To minimize workload and confusion, the different types of RPAS controlled by a remote pilot need to be limited. Risks of automation have to be further examined, and equipment must be reliable for operators to be able to develop trust in the automated system. Questions related to team structures cannot be answered as yet, but currently established roles are going to change. Fast and stable communication between all relevant actors must be established. Proposed changes in roles and responsibilities must be acceptable to the affected human actors, and the impacts on job satisfaction have to be considered.

Conclusion & Outlook
Both cognitive and interactive abilities proved to be equally important. End-users considered the ANSP-based RPAS concept feasible, but also expressed scepticism towards the potential increase in responsibilities. Further investigations on HF, based on the resulting activity list from the HPAP analysis, need to be conducted (e.g., via simulations, workshops or interviews). By applying the HPAP, DLR researchers gained valuable expertise that will be useful for future concept developments.

Table 1: Selected example of the revised HPAP argument structure.

<table>
<thead>
<tr>
<th>Transition Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argument 4.1.1.</td>
</tr>
<tr>
<td>Changes in roles and responsibilities are acceptable to the affected human actors.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>HP Issues and Aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workshop participants: reluctant towards the potential increase in responsibility (controlling RPAS)</td>
</tr>
<tr>
<td>Pilots: might find it difficult to give up working in the cockpit</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Potential Mitigation/ Recommendations</th>
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</thead>
<tbody>
<tr>
<td>Integrate all end-user parties in the development of the descriptions of roles and responsibilities</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proposed HP Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discuss roles/responsibilities with all end-users</td>
</tr>
<tr>
<td>Real-time simulation (observation and questionnaires)</td>
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</tbody>
</table>

Table 2: Rank order of top ten RPAS operator requirements. Mean ratings (1 = low to minimum level, 7 = highest level of the ability required for the job) are given.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Ability</th>
<th>M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Perseverance¹</td>
<td>5.82 (1.03)</td>
</tr>
<tr>
<td>2</td>
<td>Dependability¹</td>
<td>5.77 (1.15)</td>
</tr>
<tr>
<td>3</td>
<td>Vigilance²</td>
<td>5.72 (1.06)</td>
</tr>
<tr>
<td>4</td>
<td>Selective Attention²</td>
<td>5.37 (1.06)</td>
</tr>
<tr>
<td>5</td>
<td>Self Sufficiency¹</td>
<td>5.18 (1.12)</td>
</tr>
<tr>
<td>6</td>
<td>Memorization²</td>
<td>5.17 (1.02)</td>
</tr>
<tr>
<td>7</td>
<td>Self-Control¹</td>
<td>5.15 (1.31)</td>
</tr>
<tr>
<td>8</td>
<td>Spatial Orientation²</td>
<td>5.11 (1.34)</td>
</tr>
<tr>
<td>9</td>
<td>Resistance to Premature Judgement¹</td>
<td>5.10 (1.12)</td>
</tr>
<tr>
<td>10</td>
<td>Speed of Closure²</td>
<td>5.06 (0.97)</td>
</tr>
</tbody>
</table>

¹ social/interpersonal skill, ² cognitive skill

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[1] Pecena et al., Proc. 33rd EAAP, 2018
GAP – A new approach in measuring behavior in groups for Aviation and Space personnel

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Civil aviation and spaceflight are teamwork environments, and teamwork and leadership skills are of the utmost significance, as recent job requirement analyses for pilots reveal [1] (Fig. 1). Over 70% of flight accidents involve pilot factors as most studies report [2], and the most common factors relate to insufficient team skills (including poor communication, decision making, and adherence to procedures). The rare accidents in human spaceflight show similar contributing factors (e.g. Columbia space shuttle accident [3]); probably a higher degree of team skills is needed due to long confinement conditions.

Computer based group tasks
Evaluating team skills in the pilot selection process is ambitious due to methodological constraints and designing useful group tasks is a demanding assignment [4]. Socially desired behavior for example has to be focused and it decreases with the cognitive challenge in a given situation. Common assessment center group tasks suffer from their required simplicity (in order to be observable) and therefore show only medium validities [5]. The DLR project GAP (Group Assessment of Performance and Behavior) [6] started to improve the quality of group tasks by developing a fully digital system on the candidates’ and on the observers’ side [4]. All tasks are presented on individual touchscreens provoking a face-to-face discussion. These computer based group tasks allow a more realistic simulation of individual and team workload, and therefore add relevant information to draw selective decisions in selection procedures. An additional individual is integrated in order to increase mental load, again to reduce socially desired behavior.

Computer based behavior observation
In traditional AC’s the group of observers write down what they see. A real-time registration of mental performance is not very likely. Additionally, a distraction from observing process while writing as well as an interference of observation & judgement (“good/bad behavior”) is highly probable. In GAP, all observation is organized by using a set of behavioral anchors (buttons on the touch screen), as a job-significance-analysis and an Act-Frequency-Analysis [7]. The objectivity of behavioral observation increases. On the ob-

Fig. 1: Mean score Pilot requirements with N=230 pilots from various fleets (F33 Airbus A380).

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Fig. 2: GAP setup at DLR Hamburg.
server’s touch screen task-relevant information (e.g., state of candidate’s moves, objective errors) is displayed to assist the observer with the intention to allow a higher degree of complexity of group tasks (Fig. 2).

Results
The analysis of Intraclass correlations (ICC) as a measure of Interrater Reliability was conducted by comparing the ratings of 4 observers (two aviation psychologists and two training pilots) indebted in pilot selection at DLR Hamburg, rating a group of four flight school applicants. Figure 3 shows the ICC scores for the GAP areas of competence (Fig. 3).

As can be seen in Figure 4 the correlations between the (independent) individual performance in a sample of $N=131$ flight school applicants vary with the complexity of the group task (Fig. 4).

But GAP serves not only as a method for personnel selection on high risk occupations, e.g., pilots or astronauts. GAP is used as a research environment for small groups, e.g., in confinement studies. GAP offers a platform to conduct systematic research on safety issues in small groups under hazardous conditions.

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[4] Zinn et al., in Bor et al. (eds), Pilot Selection: Psychological Principles and Practice. Taylor & Francis, Milton Park, in press
Radiation Biology

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Solar ultraviolet radiation (UVR) is significantly higher at aviation altitudes with respect to sea level due to weaker attenuation by the atmosphere [1]. At higher flight levels clear sky conditions cause permanent direct sunlight during daytime hours. Cockpit windshields protect pilots from UV-B radiation but studies have shown that this is not necessarily the case for UV-A radiation [2].

The Radiation Protection in Aviation Group of the DLR Radiation Biology Department performed spectral measurements of UV irradiance with an array spectroradiometer on several short-haul and long-haul commercial flights in cooperation with Lufthansa German Airlines. The measurements at the surface of cockpit windshields revealed specimens with good and poor attenuation of UV-A which highly depends on the manufacturer of the windshield. All of the measurements discussed in this report refer to windshields with poor UV-A attenuation. During an approach for landing the altitude dependence of UV-A irradiance was measured behind a windshield with high spatial resolution (Fig. 1). A nearly linear trend for higher flight levels was observed which corresponds to a relative rate of change of 6.5% per km.

Measurements of the maximal UVR irradiance were compared to recommended exposure limits by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP recommends limits for the weighted UVR exposure and for the unweighted UV-A exposure. Measurements at the pilot’s position were performed with direct sunlight under blinding conditions with low solar elevation angles. In this case the recommended unweighted UV-A exposure limit would be exceeded, if no sunglasses or visors were used. The use of the visor for filtering direct sunlight reduced the UV-A irradiance by a factor of about 30. The recommended weighted UVR exposure limit was not exceeded, neither with the use of the visor at the pilot’s position nor without it.

In the case of high solar elevation angles the pilot is not exposed to direct sunlight. Therefore, measurements at the surface of the windshields with a large field of view and permanent direct sunlight during high solar elevation angles do not represent the exposure conditions at the pilot’s position. These measurements at the surface of the windshield exceed the recommended unweighted UV-A exposure limit and in some scenarios also the recommended weighted UVR exposure limit.

An efficient and comparatively economic solution for reducing the UV-A transmittance could be the use of transparency films which block UV-A at the surface of the windshields. We recommend the use of sunglasses that block UV-A.

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Fig. 1: Altitude dependence of UV-A (315nm-400nm) irradiance during the approach to Frankfurt Airport.
Astronauts in space are constantly exposed to an elevated level of cosmic radiation compared to the general public on ground. The intensity of the omnipresent galactic cosmic radiation (GCR) follows the solar activity cycle and sporadic solar particle events (SPEs) can further increase this exposure. SPEs which are caused by energetic particles accelerated at or close to the sun are more likely to occur during times of enhanced solar activity and can sometimes be recorded at the Earth’s surface by ground-based Neutron Monitors (NMs); these events are then called ground level enhancements (GLE). The most recent GLE occurred in September 2017 during a period of enhanced solar activity comprising two of the largest solar X-ray flares of the past decades. Images of NASA’s Solar Dynamic Observatory (SDO) of the second of these flares (Fig. 1, left) impressively illustrate its intensity. This flare occurred on 10 September and was followed by a sharp increase in proton intensity in space and count rates increase of NMs on Earth (Fig. 1, right). The event was also recorded by several instruments on-board the International Space Station (ISS), among which was the DOSTEL instrument of the Radiation Biology department led DOSIS-3D project [1,2], and by the MSL-RAD instrument on the surface of Mars [3,4,5] for which our Radiation Biology Department is co-investigator. Additionally, numerical simulations of the event were performed at the Department with GEANT4, a Monte-Carlo toolkit calculating the transport of particles through matter and complementing the measurements of the radiation exposure [6]. Such calculations facilitate the further investigation of...
potential impacts of the event on the radiation exposure of humans in space in hypothetical future scenarios, for instance exploration missions to Moon and Mars.

The comparison of the data measured in geostationary orbit, on-board the ISS and on the Martian surface showed that the impact of the event on the dose rates and the particle intensity varied significantly depending on the measurement location. While the proton intensity measured in geostationary orbit increased shortly after the X-ray flare, corresponding increases in the dose rates were recorded about 7 hours later on the surface of Mars and more than 12 hours later on-board the ISS. The underlying reason for the different responses to the event are the magnetic shielding in low Earth orbit (LEO) which varies over the ISS trajectory and the large distance between Earth and Mars in the ecliptic plane at the time of the event. Fig. 2 illustrates how the magnetic shielding effect modulates the dose rates along the ISS trajectory. The energetic particles affect the dose rates only when the lowest magnetic shielding is reached (lowest cut-off rigidity $R_C$).

While the measured and calculated dose on the ISS during the event [1,2] corresponded to the equivalent of about half a day of typical exposure on the space station, the calculations showed that the exposure in a lightly shielded environment in interplanetary space could have been considerable, reaching values which could have led to immediate radiation effects [6]. The investigation of the event which was observed with an unprecedented set of detectors at different locations in space and the comparison of measurements and calculations significantly improved the understanding of how such an event can impact human radiation exposures in different scenarios in space.

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Fig. 2: Dose rate in silicon measured by the DOSIS 3D-DOSTEL and ISS-RAD on-board the ISS (a) and calculated (b). The cut-off rigidity $R_C$ (c) quantifies the magnetic shielding along the ISS trajectory; adapted from [1].

[1] Berger et al., Space Weather 16, 2018
Refutation of a long-existing hypothesis: No correlation between desiccation and radiation tolerance

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Anaerobic microorganisms are widely distributed in Earth’s extreme environments, yet we still know little about their physiology and their capacity to adapt to extreme conditions. In particular, there is a paucity of studies whereby different anaerobic microorganisms from extreme environments are investigated to understand their diverse physiological and metabolic capabilities. In this study, the two stressors of interest were the tolerance to periods of water loss and the exposure to ionizing radiation. These stressors also occur in other extreme environments, but their combination is rare. Microorganisms frequently experience periodic desiccation in subaerial environments or during dispersal. Although most natural environments do not experience ionizing radiation beyond the level of naturally occurring background radiation [1], this stress can be explored as a proxy for an organism’s ability to repair general cell damage. Furthermore, there has often been claimed a correlation between desiccation and ionizing radiation resistance, which is of interest to explore further. It is suggested that the physiological basis and repair mechanisms to counteract the stress-induced damage by radiation or desiccation might be linked or might even be the same [2].

Four facultative anaerobic and two obligate anaerobic bacteria were isolated from extreme Mars analogue environments (deep subsurface, halite mine, sulfitic anoxic spring, mineral-rich river) in the frame of the EU-funded MASE project (Mars Analogues for Space Exploration, grant agreement n° 607297) [3]. The isolates were investigated under anoxic conditions for their survivability after desiccation for up to 6 months and their tolerance to ionizing radiation up to 3000 Gy. The results indicated that tolerances to both stresses are highly strain-specific features. Yersinia intermedia MASE-LG-1 showed a high desiccation tolerance but its radiation tolerance was very low. The most radiation-tolerant strains were Buttiauxella sp. MASE-IM-9 and Halanaerobium sp. MASE-BB-1. In both cases, cultivable cells were detectable after an exposure to 3 kGy of ionizing radiation, but cells only survived desiccation for 90 and 30 days, respectively. The other investigated strains exhibited a desiccation and radiation tolerance between that of Buttiauxella sp. MASE-IM-9 and Yersinia intermedia MASE-LG-1 (Fig. 1). These results indicated that facultative and obligate anaerobic organisms living in extreme environments possess varied species-specific tolerances to extremes [4, 5].
These species-specific adaptation strategies could be a general adaptation to a (dry) habitat and the formation of cell aggregates and biofilms. Additionally, there are some intracellular factors which play a role inside the cells like specific (reactive oxygen species scavenging) enzymes and compatible solutes. Although a correlation between desiccation and ionizing radiation resistance has been hypothesized for some aerobic microorganisms (like Deinococcus radiodurans [2], Chroococcidiopsis [6] and some haloarchaea [7]) our data from the MASE project, as well from earlier studies with other extremophilic (hyper-)thermophilic bacterial and archaean strains showed that there is no overall correlation between tolerance to desiccation and ionizing radiation, suggesting that the physiological basis of both forms of tolerances is not necessarily linked [8].

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[3] Cockell et al., Int. J. Astrobiol. 17, 2017
Intercellular communication in response to ionizing radiation

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One of the major limiting factors in human spaceflight is cosmic radiation. Exposure to space-relevant radiation qualities (such as accelerated heavy ion nuclei) can have detrimental effects on human health. Irradiated cells communicate with neighboring cells via secretion of signaling factors which can initiate radiation responses in non-irradiated cells [1]. Molecular understanding of these intercellular communications helps to assess radiation risks and offers new opportunities for pharmacological mitigation of harmful radiation effects.

Fig. 1: The surviving fraction of MEFs was assessed after direct exposure with increasing X-ray doses (purple) and after treatment with conditioned medium (blue).
In order to analyze the intercellular communication, mouse embryonic fibroblasts (MEFs) were directly X-irradiated or treated with conditioned medium which contains signaling factors secreted by irradiated MEFs. The treatment modalities were compared for cellular survival and induction of permanent cell cycle arrest (senescence). As seen in Figure 1, while directly irradiated cells show a steep decrease in survival with decrease in survival with increasing dose, cells treated with conditioned medium suffer a threshold-dependent drop to a lower survival level at conditioning doses higher than 2 Gy.

Cells can respond to genotoxic stresses with a permanent proliferation stop – the stress-induced senescence – in order to protect the organism from neoplastic transformation. MEFs become senescent after treatment with the anti-cancer drug etoposide and after exposure to high X-ray doses (8 Gy). Intercellular communication with irradiated cells can also induce senescence, as shown in Figure 2 by treatment of MEF cells with medium conditioned by cells exposed to moderate (4 Gy) and high (8 Gy) X-ray doses (Fig. 2).

In conclusion, secreted factors from high-dose irradiated cells can have detrimental effects on neighboring, non-irradiated cells. The relevance for space mission-relevant doses will be analyzed in future studies.

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Effect of space radiation and microgravity on the fungus *Aspergillus niger*

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Fungi are able to colonize indoor-closed habitats such as space stations, growing in a variety of solid and liquid substrates – e.g., walls, windows, life-support systems, etc.. Their growth is usually associated with material degradation and spore formation, which can pose a threat to both astronauts’ health and spacecraft safety, in particular when in long-duration missions [1-4]. The outer space environment is known to be challenging to life mainly due to microgravity and space radiation [5-6]. As human space missions grow longer in duration and complexity, being able to understand the growth of fungi aboard spacecraft is crucial for a successful future of space exploration. It will be important not only in the fungal maintenance of similar indoor environments here on Earth, such as hospitals, but also in the fungal-based production of pharmaceuticals, food and other compounds of interest, and assessing future opportunities for biotechnology in space [7]. *Aspergillus niger* is one of the predominant fungi detected aboard the Russian Space Station (Mir) as well as the International Space Station (ISS) [4]. Despite its spaceflight relevance, *A. niger*

![Fig. 1: LD₉₀ – radiation dose at which there is only 10% survival, of Aspergillus niger spores of different strains after exposure to A) heavy ions (Fe and He ions) and X-rays (200 keV); and B) UV-C radiation at 254 nm. Energy and LET of the ions: He ions 150 MeV/n (2.2 keV/µm), Fe ions 500 MeV/n (200 keV/µm).](image-url)
spore resistance to space radiation as well as its growth under spaceflight microgravity environment is not well characterized. Therefore, to understand how space radiation affects A. niger spores, spores of different strains having different levels of pigmentation and DNA repair capabilities were subjected to UV (254 nm) as well as to sparsely (X-rays) and densely (accelerated heavy ion) ionizing radiation. With regard to space radiation resistance, spores of A. niger were able to withstand high doses of ionizing radiation: X-rays (lethal dose for 90% of the initial population LD$_{90}$ ~ 350 Gy), helium and iron ion irradiation (LD$_{90}$ ~ 500 Gy and ~ 100 Gy, respectively). Interestingly, drying the spores before irradiation resulted in an increased sensitivity towards ionizing radiation (Fig. 1). Survivability after exposure to UV-C radiation indicated high resistance of A. niger spores (LD$_{90}$ ~ 1000 J/m$^2$) (Fig. 1) which is significantly higher than the LD$_{90}$ of other microorganisms such as Deinococcus radiodurans. Moreover, exposure to high fluences of UV decreased A. niger biofilm formation. To study how microgravity affects the growth of A. niger, scanning electron microscopy (SEM) methodology [8] was used to study morphological and structural changes induced by simulated microgravity (SMG) using clinorotation, and under terrestrial gravity (1xg). The data obtained suggest that simulated microgravity induces changes in colony thickness, and imply that melanin plays a role in adapting to the low gravity environment (Fig. 2). It is important to note that the doses used in this study are multiple times higher than doses expected from traveling in space. For instance, a 180 day trip to Mars is calculated to yield a dose of 0.66 ± 0.12 Gy. Therefore, it is not expected for A. niger spores to be easily inactivated due to space radiation [9], suggesting that current planetary protection guidelines may need revising to include the high resistance of fungal spores. Further studies should address fungal spore resistance to combined environmental factors of the space environment such as vacuum, air pressure, temperature fluctuations and mixed types of radiation. In particular testing to what extent vacuum dried A. niger spores are vulnerable to space radiation, since this condition was previously shown to increase radiation resistance of A. niger spores [10].

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[8] Fuchs et al., J. Microbiol. Meth. 152, 2018
Biofilms are accumulations of microorganisms that adhere to surfaces and produce dense matrices of extracellular polymeric substances (EPS), which mainly include polysaccharides, proteins, nucleic acids and lipids [1]. Long-term human missions to space require methods for sustaining the health and safety of the crew. Therefore, microbiological monitoring and reduction of contamination are important. Microbial biofilms are of special interest here because they can jeopardize astronauts’ health, can cause damage to spaceflight equipment and are difficult to eliminate due to their increased resistance to antibiotics and disinfectants [2]. However, the introduction of antimicrobial surfaces for medical, pharmaceutical and industrial purposes has shown a unique potential for reducing and preventing biofilm formation.

ESA supports the International Space Station (ISS) experiment BIOFILMS “Biofilm inhibition on flight equipment and on board the ISS using microbiologically lethal metal surfaces”. The main goal of the project is to evaluate the effect of microgravity on biofilm formation on non-inhibitory surfaces such as steel and on antimicrobial metal surfaces. These surfaces are going to be composed of different metals with and without nanostructures, which are generated by direct laser interference patterning (DLIP).

For the project, human-relevant bacterial strains were selected. One of the selected strains is *Staphylococcus capitis* subsp. *capitis* K1-2-2-23, which was isolated on the ISS from steel and is forming strong biofilms. To evaluate the antimicrobial efficacy of the surfaces against biofilm formation, the adhesion of cells to the surfaces was tested. For this, *S. capitis* subsp. *capitis* K1-2-2-23 was incubated in direct contact with the surfaces for 24 h at 37 °C in liquid growth medium. A smooth steel plate and a smooth copper plate were analyzed via scanning electron microscopy (SEM) after incubation (Fig. 1). On steel surface a dense, flat layer of bacteria was attached. These bacteria were cocci shaped and embedded into a netlike biofilm matrix. In the matrix, intact cells with smooth cell walls were apparent and some of the embedded cells were lysed, which is common in aged biofilms. Occasionally, bacteria were arranged in piles and some cells showed cleavage furrows in different stages, which indicates that bacteria were actively reproducing within the biofilm.

Compared to steel, fewer cells adhered to the copper surface. The cells were not producing EPS since no biofilm matrix is apparent in the SEM images. The cell wall was often coated with small particles, which are most likely corrosion particles...
from the copper surface. Some cells were covered completely with these particles. The reduction of adherent cells to copper and the reduced EPS production might be caused by the release of copper ions from the surface into the medium, which damages and ultimately kills the cell [3]. Also, the direct contact of bacteria with the copper surface makes the cells more susceptible to damage by copper ions [4]. In further experiments (data not shown) it was observed that all copper containing surfaces reduced biofilm formation. Especially pure copper surfaces, which were structured with DLIP, were very efficient in reducing growth and biofilm formation of \textit{S. capitis} subsp. \textit{capitis} K1-2-2-23. The obtained results lay the foundation for the BIOFILMS spaceflight project that will be conducted aboard the ISS and may provide suitable antimicrobial surfaces for spaceflight purposes.

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Gravitational Biology

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Life support systems are mandatory for long duration space missions and closed habitats like space stations or planetary outposts, because it is impossible to carry along sufficient supplies of water, food and oxygen. All kinds of life support systems have to withstand altered gravity and an enhanced radiation environment during human space exploration.

The DLR compact satellite mission Eu:CROPIS (Euglena gracilis: Combined Regenerative Organic-food Production In Space) serves for the first time as a test bed for investigating the behavior of biological life support systems under lunar and Martian gravity, which is achieved by rotation of the satellite [1]. In parallel, the radiation environment is measured for one year at 600km altitude and thus under the conditions humans will experience during interplanetary missions. The NASA experiment PowerCells deals with synthetic biology and in situ resource utilization (ISRU).

The satellite is a cylindrical container (1m diameter x 1m height), with four solar panels (1m x 1m). In orbit, the top side will face the sun, and it will rotate to achieve altered gravity levels within the payload: after a spin-up phase of several weeks, it will reach about 20.5 rpm and generate an acceleration force of 0.16 x g on the reference radius, which equals the acceleration on the surface of the Moon. After 6 months of lunar gravity, the experiment will be terminated. The satellite will ramp up its rotation rate to achieve 31.6 rpm, generating 0.38 x g on the reference radius, which is the acceleration on Mars and the second set of experiments will start. A challenge in human space flight is the processing of urine. Presently, water is the only component recovered from it, while all dissolved substances such as urea and salts are extracted and then discarded. In our approach, we follow the concept to use these valuable commodities and include them in a closed system to grow fresh fruits and vegetables after proper conversion. Waste management means biodegradation of waste into food production, closing of element cycles, as well as optimization of plant growing in space, which bears also new technologies for agriculture on Earth in extreme environments [2,3].

Core element of the life support system is the DLR C.R.O.P.® (Combined Regenerative Organic-food Production) system, a microbiological trickle filter made from lava rock, providing a large number of different bacteria (Nitrosomonas, Nitrobacter, etc.)
with suitable habitats on and inside the porous surface of the substrate [2,3]. Urea is decomposed to ammonia and CO2 and converted via nitrite to nitrate. The oxygen necessary for this reaction is initially provided by *Euglena gracilis*, a photosynthetic flagellate [4] and later on by tomato plants. All components of the biological experiment were designed and manufactured by DLR and the University of Erlangen.

The RAMIS (RAdiation Measurement In Space) detector developed at our Institute measures the radiation environment during the mission by means of two RAMIS detectors. The first one is mounted at the top surface of the satellite under very low shielding (which is only provided by the aluminum casing of the detector itself). The second one is positioned as a sensor for the primary Eu:CROPIS payload and will provide radiation quantities and dosimetry for the biological samples. RAMIS uses an arrangement of two silicon detectors in telescope geometry, and enables to investigate the following scientific objectives: the first aim is the exact determination of the fluxes of protons and electrons in the Earth’s radiation belts. These data will serve as input for the validation and benchmarking of current radiation field models and in addition for further model developments. As a second aim the experiment will determine the variation of the galactic cosmic ray contribution to the radiation field by measuring the relevant parameters in dependence of the orbit of the satellite. In a next step, analyzing the data gathered for the radiation field parameters, the experiment will also provide the relevant quantities for radiation dosimetry as the absorbed dose, the energy deposition spectra and the relevant dose equivalent.

After the successful launch on 3rd of December 2018, the satellite has reached its orbit and achieved the desired rotation speed (Fig. 1).

**Fig. 1: Successful launch of Eu:CROPIS on December 3, 2018.**

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[3] Bornemann et al., Life Sci. Space Res. 18, 2018
Spin Your Thesis: Exercise in artificial gravity as a countermeasure for long-term human spaceflight

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Real and simulated weightlessness cause multiple physiological changes in the human organism. For instance, the absence of gravity results in a loss of mechanical loading upon the muscles and bones and in a redistribution of fluids in the body. Microgravity has also been associated with changes in the acid-base balance (mostly for dietary reasons), which may contribute to progressive reduction of bone, cartilage and muscle mass, particularly in the lower extremities. Deconditioning is also observed in the cardiovascular system contributing to post-flight orthostatic intolerance. Cognitive performance is critical for space missions and has been suggested to be negatively affected by the space environment and thus strategies to optimize psychological wellbeing are required [1].

Combination of artificial gravity (AG) provided by a human centrifuge (Short Arm Human Centrifuge, SAHC) and exercise has been proposed as a way to mitigate the physiological deconditioning associated with microgravity and thereby support human health during long-term space missions. However, research is needed to define which AG dose and mode of exercise should be part of a new training protocol during centrifugation [2].

Hence, the Spin your Thesis! – Human Edition programme from ESA in cooperation with the German Aerospace Center (DLR) provides the opportunity to university students to perform experimental research on the SAHC as part of this process.

For the first campaign, the objectives of the three selected experiments were to

- compare the effects of AG on skeletal muscle pump-mediated blood pressure modulation during a stand test before and after centrifugation,
- investigate the effect of the g-force with exercise upon the height of the lumbar and cervical intervertebral discs (IVD), and
- determine psychological and physiological effects of music on stress reactions caused by changed gravity conditions.

The study has been conducted using the SAHC in the :envihab building at DLR, Institute of Aerospace Medicine, at Cologne. Ten healthy male participants had been recruited.
Gravitational Biology

Fig. 2: Ultrasound examinations of the intervertebral discs were one part of the experiments to investigate the effects of centrifugation on the disc height.

Fig. 3: All participants were familiarized with the experiment protocol. Safety checks and a continuous monitoring of vital parameters by a physician are mandatory for each centrifuge experiment.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Duration [min]</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>5</td>
<td>Passive baseline on the SAHC without rotation</td>
</tr>
<tr>
<td>Ramp up</td>
<td>30-40 seconds</td>
<td>Ramping up to +1Gz</td>
</tr>
<tr>
<td>Baseline at +1Gz</td>
<td>5</td>
<td>Passive baseline on the SAHC with +1Gz rotation</td>
</tr>
<tr>
<td>Exercise phase#1 at +1Gz CoM</td>
<td>5</td>
<td>5 min exercise (6 squats/min)</td>
</tr>
<tr>
<td>Ramp down</td>
<td>30-40 seconds</td>
<td>Ramping down to full stop</td>
</tr>
<tr>
<td>Break</td>
<td>10-15</td>
<td>In-between measurements</td>
</tr>
<tr>
<td>Ramp up</td>
<td>30-40 seconds</td>
<td>Ramping up to +1.5Gz</td>
</tr>
<tr>
<td>Baseline at 1.5 Gz</td>
<td>5</td>
<td>Passive baseline on the SAHC with +1.5 Gz rotation</td>
</tr>
<tr>
<td>Exercise phase#2 at +1.5 Gz CoM</td>
<td>5</td>
<td>5 min exercise (6 squats/min)</td>
</tr>
<tr>
<td>Ramp down</td>
<td>few seconds</td>
<td>Ramping down to full stop</td>
</tr>
</tbody>
</table>

Each participant was selected by a medical screening done at DLR’s Aeromedical Center (AMC). The medical examination consisted of a clinical-chemical analysis (glucose, creatinine, urea, uric acid, SGOT, SGPT, yGT, total cholesterol, HDL and LDL), hematology (blood count), urine analysis (glucose, protein, urobilinogen), resting ECG, exercise test to verify endurance capacity and a medical history. All volunteers underwent a comprehensive clinical assessment and gave a written informed consent prior to the study. Each of them had been centrifuged at +1g and +1.5g at center of mass (CoM) in the supine position on the SAHC and performed four periods of leg press exercises during rotation. A linear sledge system was used to support the performance of leg presses. All participants completed the protocol. No drop-outs occurred due to cardiovascular or sensori-motor problems. The data were shared with ESA and the participating teams after completion of the SAHC runs. The students’ groups analysed the complete data, publications of the results are currently in the review process at different journals.

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NeuroSpace: Changes in neuronal development indicated by live-cell imaging in hypergravity

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The perception and neural integration of gravitational input is an appropriate example to investigate multisensory integration. Recent studies have shown that altered gravity significantly affects excitability of neuronal cells [1]. Altered gravity can lead to an incorrect multisensory integration and in turn to a significant reduction in human performance. Conclusively, neuronal cells and their signaling are sensitive to changes in gravity conditions. Neuronal cells and especially their synaptic activity are therefore valuable targets in research applications.

In order to investigate the role of altered gravity on cellular behavior, we used primary murine hippocampal neurons as a cellular in vitro model for neuronal cells of the human brain as well as co-cultured astrocytes, the major type of glial cells, which are important for neuronal injury repair, but also to provide nutrients and growth factors to the neurons [2, 3, 4]. Live-cell imaging under hypergravity conditions was carried out by installing a live-cell imaging system (Zeiss Axio-Observer Z1) on the short-arm human centrifuge of the DLR :envihab facility (Fig. 1) [5].

Astrocytic migratory characteristics are important for future ex vivo or even in vivo studies, in which astrocytes will be migrating towards a nervous tissue injury site in order to form a glial scar to

Fig. 1: Live-Cell Imaging Microscope on the Short-Arm Human Centrifuge at :envihab, DLR Cologne
The “HyperScope” live cell imaging microscope, was installed on the short-arm human centrifuge within the DLR :envihab. A swing-out platform enabled minimization of shear forces on the hardware. During extensive test scenarios, several modifications have been implemented optimizing the environment for the cells as well as the microscopic imaging routines.

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In order to investigate the role of altered gravity on cellular behavior, we used primary murine hippocampal neurons as a cellular in vitro model for neuronal cells of the human brain as well as co-cultured astrocytes, the major type of glial cells, which are important for neuronal injury repair, but also to provide nutrients and growth factors to the neurons [2, 3, 4]. Live-cell imaging under hypergravity conditions was carried out by installing a live-cell imaging system (Zeiss Axio-Observer Z1) on the short-arm human centrifuge of the DLR :envihab facility (Fig. 1) [5].

Astrocytic migratory characteristics are important for future ex vivo or even in vivo studies, in which astrocytes will be migrating towards a nervous tissue injury site in order to form a glial scar to
Fig. 2: Live Measurement of Astrocyte Migration under 2g Hypergravity

Primary murine cortical astrocytes were exposed to 2xg hypergravity conditions for 9h or kept at 1xg normal gravity as a control.

(A) A confluent monolayer of primary astrocytes was subjected to the wound-healing assay. Time-lapse images were selected from a defined region for time points 0h to 9h. (B) The individual samples derived from n=3 independent cultures were analyzed with regard to their migration rate in µm each for 1µm of total scratch length for every time point during the 9h exposure time. The inter-individual variation is within expected margins for each 1xg and 2xg sample. (C) Comparing the mean migration rate of astrocytes exposed to 1xg (circles) or 2xg hypergravity (squares) indicates a significant (p=0.0014) decrease in migration velocity of approx. 20% due to the impact of hypergravity.

counteract neuronal regeneration processes. Thus, primary astrocytes were exposed to 2xg hypergravity and their migratory behavior was analyzed. The cells were inhibited to start migrating compared to normal gravity conditions (Fig. 2). The mean migration rate revealed an approx. 20% decrease of migration velocity of astrocytes at 2xg hypergravity than control cells derived from the same culture at 1xg.

For future studies, a longer exposure and imaging time of approx. 24h instead of 9h will yield insight into the adaptation rate of the cells to altered gravity conditions. Importantly, neuronal activity measured by calcium-dependent imaging is a next aim.

Further, the stimulation of the cells with pharmacological substances will identify underlying mechanisms of cytoskeletal rearrangements, which are thought to be responsible for the occurring changes, such as the migratory deficit of astrocytes under enhanced gravity conditions.

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Validation of ground-based facilities by means of a mechanosensitive biosensor

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Limited access to space flight opportunities motivated developments to achieve microgravity conditions - to at least some extent - in the Earth laboratory in order to prepare space experiments and obtain indications upon gravity-related signaling pathways. Though gravity has been the only constant environmental factor during evolution, experimenters try to create a condition in which a biological system abandons its orientation with respect to gravity, and, under optimal conditions, even does no longer perceive gravity and experiences conditions similar to weightlessness.

The principle of a two-dimensional (2D) clinostat, which we apply in our experiments, works as follows: samples in cuvettes are rotated around one axis which is oriented perpendicular to the direction of the Earthly gravity vector. In order to keep accelerations as minimal as possible, the diameter of the sample cuvettes is kept small (in the range of below 4mm) and placed in the center of rotation. Our 2D clinostats are constantly rotating in one direction, thereby inducing a static change of the gravity vector in relation to the sample. In turn, sedimentation is prevented, which is the basic mechanism of gravisensing. Heavy masses with a higher density than the surrounding medium have to sediment, thereby activating a physiological signal transduction chain which results in a graviresponse. Random Positioning Machines (RPMs), another type of ground-based experimental platforms, are characterized by two rotation axes, gimbal-mounted and rotated with randomly changing the speed as well as the direction of rotation. It is assumed that over time the gravity level approaches zero (for review see [1]).

Fig. 1: Ground-based facilities for the simulation of microgravity for small biological systems. Fast-rotating clinostats (DLR) are characterized by one rotation axis and have been designed for on-line microscopy (a), cultivation of cells in suspension (b) or adherent cell cultures (c). Random Positioning Machine (Airbus Defense and Space Netherlands) (d).
In order to demonstrate potential impacts of these two kinds of simulation approaches – clinorotation versus random positioning - we applied a fast reacting biosensor, the dinoflagellate *Pyrocystis noctiluca* [2]. Deformation of the cell membrane of *P. noctiluca* due to shear stress results in a detectable bioluminescence emission, which can be measured by photomultipliers. We exposed *P. noctiluca* to different microgravity simulation methods. Cells in an RPM operated with random velocities and directions showed significantly greater mechanical stress as indicated by the bioluminescence signal compared to clinostat experiments and thus constant rotation around one axis. We conclude that, in contrast to an RPM, one axis clinorotation induces a substantially less non-gravitational stimulation through shear forces. Therefore, we apply clinostats as our preferred means to simulate microgravity in ongoing cell biological experiments. In some cases, a direct comparison with results obtained in real microgravity was already possible and validated 2D clinorotation as an appropriate method to simulate microgravity for some questions in gravitational biology [1]. In order to guarantee a high quality of simulation, a small sample volume and consequently a restricted experimental time have to be taken into account.

Ground-based facilities provide the opportunity to prepare space experiments and learn about the sensitivity and behavior of the biological system of interest. However, operation modes should be carefully considered in order to avoid a misinterpretation of results impacted by external forces resulting in stress responses.

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**Fig. 2**: Bioluminescence of *P. noctiluca*, seen in nature as ocean lighting and used as biosensor for mechanical stress (top). Bottom: After a relaxation time of 3600s and thus achievement of a stable level of emitted photons, the platform was started first in the clinostat mode and thereafter in the RPM mode. The differences in photons produced by the dinoflagellates clearly demonstrate the mechanical stimulation, which is negligible in the clinostat, but significant in the RPM mode [2].

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Publications

Journal articles (peer-reviewed)


DOI: 10.3390/life8020023. ISSN 2075-1729.

DOI: 10.1038/nrdp.2018.14. ISSN 2056-676X.

DOI: 10.1089/ast.2016.1631. ISSN 1531-1074.

DOI: 10.3389/fphys.2018.01759. ISSN 1664-042X.

DOI: 10.3389/fnhum.2018.00440. ISSN 1662-5161.

DOI: 10.1038/s41526-018-0052-1. ISSN 2373-8065.

DOI: 10.1007/s11914-018-0497-x. ISSN 1544-1873.

DOI: 10.1113/jp275605. ISSN 0022-3751.

DOI: 10.3389/fphys.2018.00810 . ISSN 1664-042X.

DOI: 10.3389/fmicb.2018.00335. ISSN 1664-302X.

DOI: 10.1093/gerona/gly069. ISSN 1079-5006.


Young adults are more vulnerable to chronic sleep deficit and recurrent circadian disruption than older adults. 
Scientific Reports, 8, 11052. Nature Publishing Group. DOI: 10.1038/s41598-018-29358-x. ISSN 2045-2322.

Publications in scientific books


*Life Detection Group of BIOMEX/BIOSIGN: Mickaël Baqué, Daniela Billi, Ute Böttger, Charles S. Cockell, Rosa de la Torre, Bernard H Foing, Franziska Hanke, Stefan Leuko, Jesús Martineez Frías, Ralf Moeller, Karen Olsson-Francis, Silvano Onofri, Petra Rettberg, Susanne Schröder, Dirk Schulze-Makuch, Laura Selbmann, Dirk Wagner, Laura Zucconi
Reports (without peer-review)


Events, Presentations and Talks

Institute Lectures

16.01.2018  
Prof. Dr.-Ing. Martin Reuber, Rheinische Fachhochschule Köln, Institut für Werkzeug- und Fertigungstechnik, “Verfahren, Anwendungen und Potenziale additiver Fertigungstechnologien”

06.02.2018  
Dr. Christian von Dewitz, Schwielowsee, Germany: “Ethische Maßstäbe und rechtliche Grundlagen klinischer Studien am Menschen, die nicht dem Arzneimittel-, Medizinprodukte- oder Strahlenschutzrecht unterfallen”

20.02.2018  
Prof. Ulrich Kintscher, M.D., Charité - Universitätsmedizin Berlin, Director, Institute of Pharmacology, Center for Cardiovascular Research, CCR, Berlin, Germany: “Adipose Tissue Lipolysis and Chronic Heart Failure”

13.03.2018  
Prof. Dr. Jörn Rittweger, German Aerospace Center (DLR), Cologne, Germany/Department of Pediatrics and Adolescent Medicine, University of Cologne, Germany: “SARCOLAB3: Pilot-study and preliminary results from 4 crew members”

15.03.2018  
Dr. Mirko Moroni, Laboratory Head, Disease Genomics, Bayer AG, Drug Discovery, Pharmaceuticals - MDC – Max Delbrück Center for Molecular Medicine, Berlin, Germany: “Role of PIEZO channels in mechanotransduction”

10.04.2018  
Prof. Dr. Justin Lawley, Institut für Sportmedizin, Universität Innsbruck, Innsbruck, Österreich: “Protecting the human brain in space: The choice of impedance, occlusion or vacuum”

17.04.2018  
Prof. Dr. A.H. Jan Danser, Division of Pharmacology and Vascular Medicine, Department of Internal Medicine, Erasmus MC, Rotterdam, The Netherlands: “Endothelin-1: a central factor in both preeclampsia and VEGF inhibition-induced hypertension”

24.04.2018  
Prof. Dr. Michael Schloter, Research Unit for Comparative Microbiome Analysis, Helmholtz Zentrum München, Oberschleißheim, Germany: “The role of exercise as a driver for the structure and function of the human gut microbiome”

15.05.2018  
Prof. Dr. Anders Eklund, Professor in Biomedical Engineering at Umeå University, Umeå, Sweden: “The astronaut syndrome Visual Impairment/Intracranial Pressure – Aspects on assessment and modeling of CSF and venous system?”

29.05.2018  
Prof. Dr. med. Friedrich C. Luft, MD, Experimental and Clinical Research Center and Max-Delbrück Center for Molecular Medicine, Berlin, Germany, “Genes that ‘really’ cause hypertension”

13.06.2018  
Nikea J. Ulrich, German Aerospace Center (DLR e.V.), Institute of Aerospace Medicine, Radiation Biology, Space Microbiology Research Group, Cologne, Germany: “Enduring the Antarctic Extremes: from humans inside Concordia Station to the microbes outside”

26.06.2018  
Prof. Carsten Lundby, Clinical Professor, University of Copenhagen, Department of Clinical Medicine, Copenhagen, Denmark: “Determination, regulation and importance of blood volume adaptations to exercise training”

28.06.2018  
Dr. Ganesan Sathiyanarayanan, CEA Enhanced Eurotalent, Laboratory of Microbial Ecology of the Rhizosphere and Extreme Environments (LEMIRE), Biosciences and Biotechnology Institute of Aix-Marseille (BIAM), CEA Cadarache, St-Paul-lez-Durance, France: “Arctic extremophiles from thawing permafrost and their biotechnological and ecological implications”

10.07.2018  
Prof. Alexandros Georgakilas, DNA Damage Laboratory, Physics Department, National Technical University of Athens (NTUA), Greece: “Complex DNA damage as the triggering mechanism for radiation systemic effects”

30.08.2018  
Philip D. Chilibeck, Ph.D., Professor, College of Kinesiology, University of Saskatchewan, Saskatoon, Canada: “Novel exercise and nutritional interventions for preserving vascular health during space flight”
04.09.2018
Univ.-Prof. Dr. Dr. med. Wolfram Döhner, Interdisziplinäre Schlaganfallforschung, BCRT - Berlin-Brandenburg Centrum für regenerative Therapien, Charité, Universitätmedizin Berlin, Berlin, Germany: “Obesity and mortality in health and disease - Paradox or paradigm? About old guidelines and new data”

25.09.2018
Univ.-Prof. Dr. Stefan Gründer, Direktor, Institut für Physiologie, Medizinische Fakultät der RWTH Aachen, Aachen, Germany: “A small peptide from cone snail venom enhances muscle pain by slowing desensitization of Acid-Sensing Ion Channel 3 (ASIC3)”

09.10.2018
Dr. Harald Huber, Institute for Microbiology and Archaeal Center, University of Regensburg, Germany: “Photodynamic inactivation of Microorganisms by Reactive Oxygen Species”

30.10.2018
Francesco P. Cappuccio, MD, DSc, FRCP, FFPH, FBIHS, FESC, FAHA, Cephalon Chair of Cardiovascular Medicine & Epidemiology, University of Warwick, Warwick Medical School, Division of Health Sciences, Coventry, UK: “Sleep deprivation and cardio-metabolic disease”

13.11.2018
PD Dr. Gregor Grass, Bundeswehr Institute of Microbiology, Munich, Germany: “Anthrax – detection, diagnosis and bioforensics”

15.11.2018
Prof. Betty Nusgens, Laboratory of Connective Tissues Biology, University of Liege, Belgium: “The Biolab Experiment Cytoskeleton - why and how”

27.11.2018
Cédric Moro, Ph.D., Research Director, Obesity Research Laboratory, Inserm UMR1048, Institute of Metabolic and Cardiovascular Diseases, Toulouse, France: “Natriuretic peptides: a potential target for metabolic diseases?”

18.12.2018
Kemal S. Türker, BDS, PhD, Professor of Physiology, Koc University School of Medicine, Istanbul, Turkey: “A new method to study functional neuronal networks in human neuromuscular system”

Workshops, Events, Seminars at the Institute

17.1.2018
Visit: Scientific Committee EASA

17.1.2018
Visit: Research Track, Cologne University

17.1.2018
Visit: Students TU Braunschweig

23.1.2018
Visit: Students RWTH Aachen

24.01.18
Visit: Federal Association Unternehmer mittelständische Wirtschaft

25.1.2018
Visit: Director JAXA Paris Office

31.1.2018-1.2.2018
Workshops: Space Health Week/EAC

20.2.2018
Visit: DLR Graduate Program

22.-23.2.2018
Scientific Advisory Board Institute of Aerospace Medicine

1.-2.3.2018
Workshops: Spin your Thesis/EAC
8.3.2018
Visit: Member of the Bundestag Reinhard Houben

12.3.2018
Visit: Student initiative Euroavia, Stuttgart University

14.3.2018
Visit: Bayer AG

3.-6.4.2018
Workshops: Students Cologne University: Space Medicine

11.4.2018
Visit: FDP Parliamentary Group Cologne

19.04.2018
Visit: Freundeskreis German Air Force

26.4.2018
Girls Day

2.5.2018
Visit: Minister of Economic Affairs, Innovation, Digitalization and Energy Northrine Westphalia Prof. Dr. Andreas Pinkwart

5.7.2018
Visit: Prorector for Science Univ.-Prof.'in Dr. Bettina Rockenbach Cologne University

18.7.2018
Visit: Prof. Dr. Nina Kloster, TH Cologne

14.8.2018
Visit: Delegation Bonn University

30.8.2018
Visit: ADAC

5.9.2018
Visit: gewi-Institut für Gesundheitswirtschaft e.V.

10.9.2018
Visit: Representatives Ministry of Economic Affairs, Innovation, Digitalization and Energy Northrine Westphalia

15.9.2018
Workshop: Science meets Clinic

17.9.2018
Visit: Foundation der Deutschen Wirtschaft

18.9.2018
Visit: DLR Graduate Program

20.9.18
Visit: NASA delegation project E-MIST

25.9.2018
Visit: Prime Minister Armin Laschet

5.10.2018
Visit: Jim Bridenstine, NASA

16.10.2018
Visit and Workshop: International SANS Working Group

30.10.2018
Visit: Deutsche Physikalische Gesellschaft

15.11.2018
Visit: United Nations / Germany High Level Forum

16.1.2018
Visit: Students Munich University

28.11.2018
Visit: GIZ/DLR Workshop
05.12.18
Visit: Workshop Participants Medical Association of North Rhine-Westphalia

6.12.2018
Visit: DAF

8.12.2018
Workshop: Human Physiology Workshop

11.12.2018
Visit: Students Bonn University

13.12.2018
Visit: Research Track, Cologne University

18.12.2018
Visit: Institute of Human Genetics, Cologne University

20.12.2018
Visit: Member of the Bundestag Thomas Jarzombek

Teaching Activities

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<tr>
<th>Name</th>
<th>University</th>
<th>Subject</th>
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<td>Aeschbach, Daniel</td>
<td>Havard Medical School</td>
<td>Sleep Medicine</td>
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<td>Anken, Ralf</td>
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<td>Zoologie</td>
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<td>Berger, Thomas/Hellweg, Christine</td>
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<td>Master of Space Studie (MSS)</td>
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<td>Frings-Meuthen, Petra</td>
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<td>Psychologische Diagnostik: Psychologische Gutachten</td>
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<td>Psychologische Diagnostik: Praktische Übungen zu diagnostischen Verfahren</td>
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## Supervised Doctoral Students

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## Doctorates

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## Bachelor Degrees

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## Supervised Doctoral Students

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<td>Uni Regensburg</td>
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Awards

Marta Cortesão
Grant – PhD, grant for the Biofilms 8 Conference in Aarhus, Denmark, from May 27-29, 2018

Marta Cortesão
Travel Grant, DAAD, für Feldforschung am Jet Propulsion Laboratory, Pasadena, USA, July 02-31, 2018

Marta Cortesão
2nd prize – Student contest “Space Factor”, EANA 2018, Berlin, Germany, September 24-28, 2018

Marta Cortesão
Women in Aerospace-Europe grant – WIA-E 2018

Marta Cortesão
DGE Messreiseförderung, Messreise: Robert Koch-Institut, Berlin, Topic: „How does simulated microgravity affect the micro morphology and colony structure of the fungus Aspergillus niger?“, April 1st – Mai 24, 2019

Timo Frett
1. Posterpreis "Verträglichkeit von reaktiven Sprüngen auf einer Kurzarmhumanzentrifuge", 56. Wissenschaftliche Jahrestagung der DGLRM

Felix Fuchs
FEMS YSMG grant – registration fees for the 8th European Spores Conference in Royal Holloway, University of London

Felix Fuchs
Grant – PhD, grant for the Biofilms 8 Conference in Aarhus, Denmark, from May 27-29, 2018

Darius Gerlach
Travel grant, 29th International Symposium On The Autonomic Nervous System, Arbeitsgemeinschaft Autonomes Nervensystem

Darius Gerlach
FMS/Penaz Wesseling travel Fellowship Award for “Functional brainstem imaging reveals brainstem nuclei governing human baroreflex function” at the 29th International Symposium On The Autonomic Nervous System

Darius Gerlach
Deutsche Hochdruckliga e.V. DHL®: Reisestipendium und Einladung zu den „Best of …“ Sessions

Hendrik Kronsbein

Markus Rohde
Förderpreis Elektrotechnik H-BRS 2018, Bachelorarbeit: „Ab Schätzung der Gefährdung durch terrestrische Gammastrahlenblitze auf kommerziellen Flugreisen“

Katharina Siems
Early career award (young microbiologist), EANA 2018, Berlin, Germany, September 24-28, 2018
Patents

Department Gravitational Biology

Department Radiation Biology

Department Cardiovascular Aerospace Medicine
Deutsches Patent- und Markenamt, 02.10.2018: Keilförmiges Lagerkissen (Gebrauchsmuster No. 202017003430.1)
DLR at a glance

The German Aerospace Center (DLR) is the national aeronautics and space research centre of the Federal Republic of Germany. Its extensive research and development work in aeronautics, space, energy, transport, security and digitalisation is integrated into national and international cooperative ventures. In addition to its own research, as Germany’s space agency, DLR has been given responsibility by the federal government for the planning and implementation of the German space programme. DLR is also the umbrella organisation for the nation’s largest project management agency.

DLR has approximately 8000 employees at 20 locations in Germany: Cologne (headquarters), Augsburg, Berlin, Bonn, Braunschweig, Bremen, Bremerhaven, Dresden, Goettingen, Hamburg, Jena, Juelich, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Oldenburg, Stade, Stuttgart, Trauen, and Weilheim. DLR also has offices in Brussels, Paris, Tokyo and Washington D.C.

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