SENSORISCH

Passenger comfort goes beyond anthropometrics

How environmental factors in the aircraft cabin interior influence comfort experience

Besides anthropometrics, there are many other, environmental, factors that have a direct effect on sitting comfort, wherein smell is probably the predominant factor influencing (dis)comfort, followed by light, vibrations, noise, and climate. Anthropometrics seems to be the least influential factor. This literature review investigates the individual effect of these ambient conditions on comfort perception of airplane passengers.

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Airlines are often eager to offer passengers a comfortable journey, since this likely results in returning customers (Vink & Brauer, 2011). The airplane cabin interior is the environment where people spend most of their time in when travelling by airplane. Research shows that during the cruise flight, passengers experience the lowest comfort levels of their entire journey (Bouwens et al., in press). Therefore, it is important to focus on the aircraft interior relevant for this phase of the flight.

Krist (1993) indicated four factors (anthropometry, climate, noise and vibrations) that have a direct effect on sitting comfort, and weighed them in order to suggest a hierarchy between these factors. Bubb et al. (2015) complemented this comfort pyramid by adding light and smell (see figure 1). Smell is the predominant factor influencing physical comfort, followed by light, vibrations, noise, climate and anthropometry. The five most important factors seem to be ambient conditions, while many studies focus on designing for variation in anthropometrics and optimal pressure distribution (Hiemstra-van Mastrigt et al., 2017). Therefore, the aim of this literature study was to investigate the effect of ambient conditions in the aircraft cabin interior on the comfort experience of the passenger.

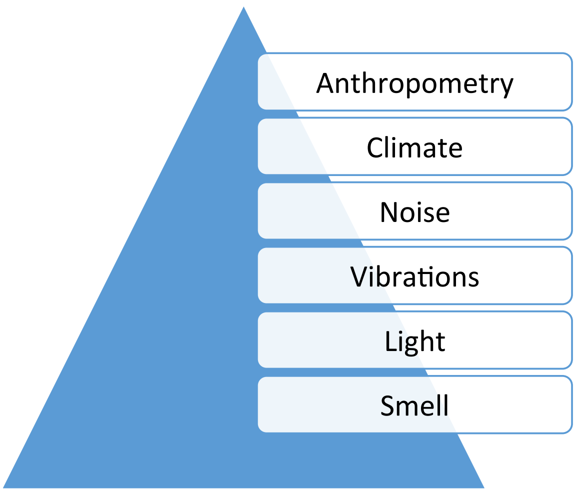

Figure 1. Comfort pyramid (Bubb, Bengler, Grünen et al., 2015)

Method

The studies for the literature review were retrieved through a search in Scopus. The following combination of terms was searched for: ambient comfort (climate, noise, vibrations, light, smell) and context (airplane cabin) characteristics on comfort experience. In the results section of this paper, the highlights of these findings are mentioned, and the discussion suggests design implications for future aircraft cabin design.

Results

Smell in the airplane cabin

The olfactory system, which is responsible for the sense of smell, can distinguish 20.000 different odours and has direct connections to the amygdala and the hippocampus (two brain areas that are implicated in emotions and memories) (Abrahams, 2007). Perception of different odours can vary from person to person, based on age, gender and cultural background (Cardello & Wise, 2008) resulting in affected mood, physiology and behaviour (Herz, 2009), cooperation and interaction (Cardello & Wise, 2008).

Figure 2. Sunset and sunrise (Pixabay)

Nevertheless, general perceptions of smell were found in literature as well. Curtis and Biran (2001) described 'disgust' as a primal mechanism and, therefore, the odour of faeces is universally loathed. Jellinek (1998) suggested that the smell of eucalyptus improves the memory, jasmine and orange cause activation and stress reduction, rose and rosemary activate, lavender and sandalwood deactivates and peppermint improves concentration (Jellinek, 1998).

Although the environmental conditions (mild hypoxia, dry air, low pressure) in the airplane cabin may cause an impaired sensitivity of smell (Burdack-Freitag et al., 2011; Kühn et al., 2009), passengers still report complaints regarding the odours that come with being in close quarters while aboard an airplane (Vredenburgh et al., 2015). And although each passenger reacts differently on odours, a bad odour in an airplane will have a significant influence on the comfort perception of the majority of the people (Vink & Brauer, 2011).

Light in the airplane cabin

The retina, located at the back of the eye, contains photoreceptors that are sensitive to light of different colours. The brain utilizes and interprets the signals from both eyes to construct a three dimensional image of the environment (Abrahams, 2007; Clarkson, 2008).

Light is defined by its colour(temperature) and intensity. Its effect on the human-being has been studied extensively. For example, the sleep-wake cycle is synchronized by outdoor light from the sun (Abrahams, 2007). The sunset has a red glow, which activates the production of melatonin that leads to sleepiness. The sunrise on the other hand, consist of bright blue light that supports the production of cortisol in the brain and makes people alert (see figure 2).

Psychological effects of light colour and intensity have also been studied. For example, Schauss (1979) indicated that pink light has a sedative effect on people and should be used in any situation where sudden aggression is likely. However, Bakker (2014) mentioned that the effect of colour on people is highly dependent on its context.

Light in the airplane cabin is mostly functional; the lights are turned on during boarding and when a meal is served and dimmed on a night flight when passengers tend to sleep. The cabin crew considers this lighting as adequate (Lee et al., 2000). Blue light improves the behavioural alertness of flight and cabin crew members (Brown et al., 2014) and improves the perceived air quality of the passengers, while yellow light makes the temperature of the environment feel warmer (Winzen et al., 2013).

Vibrations in the airplane cabin

Vibrations are the movement of the body about its mean position and can occur in all directions. In vehicles, for example, vibrations can be caused by engines and weather conditions (turbulence).

Vibrations that are perceived by the body are a source of discomfort and physical stress of which passengers should be protected from (DeHart, 2003; Oborne, 1977; Vink & Brauer, 2011).

Passengers in the airplane cabin will be exposed to vibrations during their flight. These vibrations will have peaks during take-off, landing and turbulence, and will cause discomfort for the airplane passengers. The more vibrations, the more discomfort; therefore, aircraft manufacturers should attempt to minimize vibrations.

Noise in the airplane cabin
Sound is defined by volume (dB) and tone (frequency in Hz). The human hearing range lies between 20 and 20.000 Hz, wherein people are most sensitive for frequencies between 2 and 5kHz (Slater, 1985). A volume of 0 dB is the hearing threshold for a child, and 150 dB corresponds with the volume of a rock concert when standing in front of the sound box. The brain is responsible for the perception of sound waves, which effect human behaviour and performance. Noise is a kind of sound that is characterized by its annoying nature.

Airplane passengers are exposed to a wide range of noises during the flight, originating from the aircraft engines to conversations of fellow passengers and crying babies (Lewis et al., 2016). The level of noise awareness also depends on the flight experience of the passenger; novice flyers may become more alarmed by and attentive to sudden changes in the aircraft acoustical environment than experienced flyers do (Västfjäll et al., 2003).

Cabin noise can cause increased awareness of symptoms as tiredness, concentration problems, swollen feet and headache (Mellert et al., 2008), but can also cause differences in comfort experience and mood (Pennig et al., 2012). Low frequency noise (80-135 Hz) with a volume above 82 dB can result in annoyance among airplane passengers (Mixson & Powell, 1985); however, the level of annoyance may vary per passenger (Quehl, 2001). Despite the reported effects, passengers are not always aware of the effects of noise; when recalling flight experiences, only 0.9% of the airplane passengers mentioned noise, whereas 79% mentioned comfort and service (Vink et al., 2012).

Climate in the airplane cabin
Climate exists of environmental temperature, humidity and atmospheric pressure. Thermoreceptors in the skin provide feedback on external temperatures. When the environmental temperature rises or falls, the body uses various mechanisms to ensure it maintains a comfortable equilibrium. Humidity is the amount of water vapour present in the air. High humidity leads to reduced ability of the body to cool down through perspiration and it can also lead to difficulty in breathing, while low humidity levels can lead to dry skin, cracked lips and excessive thirst. Atmospheric pressure determines how dense the air is, and indicates the amount of available oxygen. The body can adapt to changes in the concentration of oxygen when pressure is raised or lowered.

The climate in the airplane cabin is configured centrally. Airplanes are pressurized to counteract low atmospheric pressure at high altitude (Abrahams, 2007). The temperature in airplane cabin varies from 20-31.7 degrees Celsius (Pang et al., 2014), the relative humidity in the aircraft cabin is 15% and the atmospheric pressure is approximately 760 hPa (Burdack-Freitag et al., 2011).

Discussion: implications for cabin design

The results suggest that ambient conditions do influence comfort. In this section, the implications for cabin design in relation to each factor is discussed.

Smell
The effects of smell on human beings are numerous and highly individual. Applying scents in the aircraft cabin, for other purposes than masking very bad smells, should be done very carefully.

Light
Airplane cabin light should support passengers' activities. Since different in-flight activities require different lighting conditions, and passengers desire to do different activities, it is important to facilitate them on an individual level (Clarkson, 2008). It may even be possible to use light to treat jetlags (Zee & Goldstein, 2010).

Vibrations
Airplane cabin interiors should be designed to minimize resonance and maximize absorption of external vibrations.

Noise
The sound pressure levels in the airplane cabin should be reduced and high frequency components (sounds described as 'shrill' and 'bright') should be filtered in order to optimize comfort experience of the passengers (Pennig et al., 2012). Aircraft interior manufacturers should not aim for absolute silence, since the presence of a background noise also masks other (more annoying) sounds (Khan, 2003; Pierrette et al., 2015).

Climate
Indoor climate conditions can only work when occupants are offered sufficient means for creating their own comfort (De Korte et al., 2015; Kuijer & De Jong, 2012). Designers that aim for a comfortable

airplane cabin interior should therefore enable passengers to control their own temperature (Pasut et al., 2013) and air supply (Jacobs & De Gids, 2006).

Conclusion

Traveling by airplane is an immersive experience where every sense is strained. Therefore, aircraft interior designers should think beyond anthropometrics and consider all environmental factors when designing for comfort. However, more research is needed to investigate the relationships between the senses, as well as validating the suggested hierarchy.

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