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Safety in passenger ships: The influence of environmental design characteristics on people's perception of safety

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ABSTRACT

Although objective safety is a widely studied topic in ergonomics, subjective safety has received far less research attention. Nevertheless, most of human decision-making and behavior depends on how we perceive our environment. This study investigates the effects of various environmental design characteristics on people's safety perception in a passenger ship context. Five different environmental design characteristics were manipulated to increase the openness of the space or to create more clear navigation, resulting in 20 different cabin corridors for a passenger ship. Ninety-seven respondents were asked to rate these corridors on the perceived safety in an experiment. The results showed that people feel more safe when the corridors have a curved ceiling, when the walls do not have a split-level design, and when there is a view to the outside. Designers can use these insights when designing future environments.

1. Introduction

Safety is a critical determinant for people's quality of life (Cummins, 1996; Stamps, 2010; Van Rijswijk et al., 2016), and much research has been devoted to create safer products (e.g., Benedyk and Minister, 1998; Min et al., 2012; Wilson, 1984) and environments (e.g., Duarte et al., 2011; Hsiao et al., 2013; Stamps, 2005a,b; Vilar et al., 2013), such as cruise ships (Papanikolau, 2009). However, when experiencing environments in daily life, people are generally hardly able to effectively evaluate the objective safety level of their environment (Ahola et al., 2014; Campbell et al., 1976). Instead, people often rely on their perceptions to ascertain an environment's safety. Consequently, it is important to go beyond objective safety ('being safe') by uncovering the factors that influence whether people will 'feel safe' (Van Rijswijk et al., 2016).

People need to feel safe before they can feel comfortable and experience other positive emotions, such as enjoyment (Epstein, 1990; Sheldon et al., 2001). As a consequence, positively influencing people's safety perceptions is especially critical for environments with entertaining purposes, such as cruise ships. Cruise ship operators transport passengers by sea for pleasure, and passengers' comfort is one of their main priorities (Yarnal and Kerstetter, 2005). Thus, it is important to understand how safety perceptions are evoked to minimize uncomfortable feelings in order to guarantee passengers' enjoyment of the cruise experience (Baker, 2013).

One way to evoke more positive safety perceptions is through a successful environmental design. In this respect, various scholars have proposed that designers[1] need to consider safety perceptions in the design process (Ahola et al., 2014, Kim et al., 2004; Vilar et al., 2013; Williamson et al., 1997). However, evidence exists that it can be challenging to design cruise ships that 'feel safe'. First of all, prior research has demonstrated that significant differences exist between users and designers with respect to their perceptions of design objects, which makes the transfer of consumer needs into technical and design specifications challenging (Blijlevens et al., 2009; Hsu et al., 2000). Second, designing passenger ships is a complex design process with many conflicting requirements (e.g., technical demands caused by moving on water, berth capacity, safety regulations, comfort). Third, in the study of Ahola et al. (2014), it was identified that shallow and narrow cabin corridors of the passenger ship have a negative influence on passengers'

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[1] With the term designer, we mean different experts that are involved in the interior design of a ship, such as industrial designers, architects, and ship engineers.

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safety perception and because of this passengers also feel more uncomfortable in these environments. Taking into account the fact that these spaces cover a significant area of passenger ships and that designing passenger ship is a complex endeavor, ship 'safety' designers' would benefit from more knowledge on the specific environmental design characteristics (e.g., design of ceiling, walls, and doors) that they should consider during the design process in order to evoke more positive safety perceptions.

To provide these insights, research has started to investigate the effects of certain environmental design characteristics on safety perceptions. However, this stream of research remains relatively scarce and only limited insights are offered to designers to use as a starting point in their design process. The majority of studies have focused on the importance of lighting (Haans and de Kort, 2012; Vilar et al., 2012, 2013) and colors (Dalke et al., 2006; Duarte et al., 2011) for improving people's safety perception. Moreover, research has started to uncover the effects of physical environmental design characteristics, such as the design of the ceiling, walls, and doors. For example, Stamps (2005a,b, 2010, 2013) has investigated the influence of physical environmental design characteristics on people's perceptions in urban settings. These findings showed that physical design characteristics in an environment influence the degree of enclosure (open vs. enclosed) and thereby the ability to perceive and move, which are the most important influencing factors for people's safety impressions in urban settings. Although these studies provided important insights, more research is needed to comprehend people's safety perception in specific indoor settings for which safety is essential in order to experience other positive emotions, such as passenger ships.

In a qualitative study, Ahola et al. (2014) provided some first exploratory insights on the architectural elements that can affect people's safety perceptions in a passenger ship. Their findings suggested that openness and guidance are preferred characteristics for a safe ship environment. We propose that by purposefully designing and arranging specific environmental design characteristics (e.g., design of the ceiling, walls, and doors) in passenger ships, it is possible to trigger greater openness or a better feeling of guidance in order to make people feel safer and increase their comfort. However, to effectively design for safety a more detailed understanding is needed on how specific environmental design characteristics will influence safety perceptions.

The present research contributes to the literature by investigating the effects of five environmental design characteristics that were shown to influence environment-human interaction (Sagun et al., 2014) on openness and a feeling of guidance, and consequently, on people's safety perceptions for a passenger ship context. Specifically, we focus on people's first impressions of safety that influence these impressions when encountering a new environment. As discussed, these first impressions are important for people to feel comfortable and enjoy the cruise experience. Providing an understanding on this matter is important for two reasons. First, it contributes to our understanding on which environmental design characteristics contribute to people's safety perceptions in indoor settings. Second, more knowledge on the relationship between environmental design characteristics and safety perceptions is relevant for designers when designing environments in which people will feel comfortable.

2. Design for subjective safety

In the literature, openness is recognized as one of the most desirable characteristics to create a safe environment (e.g. Fisher and Nasar, 1992; Stamps, 2005a,b, 2010; 2013). More openness in an environment results in a greater ability to move (Nasar et al., 1993; Stamps, 2013) and a greater ability to perceive (Appleton, 1975/1996; Stamps, 2005b, 2013), which are both directly linked to the objective safety of an environment. For example, it is demonstrated that people tend to prefer wider corridors when navigating in an emergency situation (Vilar et al., 2012, 2013). If movement is restricted, a potential escape is prevented, and blocked visibility prevents people or animals to see potential enemies or other sources of danger, which both will decrease their survival chances (Gibson, 1979; Stamps, 2005a). In addition to these effects of openness on objective safety, prior research has demonstrated that people's perceptions of safety in urban environments, such as areas with buildings and parks, are also influenced by openness (Mambretti, 2011; Stamps, 2005a, 2013). Stamps (2005a) concluded that for urban environments enclosure and openness are reflected by five physical variables: 1) percentage of view covered by obstacles (limiting the motion and vision); 2) percentage of regions permitting both vision and motion; 3) lightness; 4) distance of the visibility, and 5) number of sides open at the scene. These variables are rather general and to a certain extent determined by the space/environment in which people are moving. Nevertheless, designers could also use other more specific environmental design characteristics (e.g., design of the ceiling, walls, and doors, and views to the outside) to create more (impressions of) openness in an indoor setting.

In addition to openness, an environment that offers people the feeling of a clear guidance can positively influence people's safety perceptions. If people have difficulty finding their way, this may result in stress, anxiety, and confusion (Dogu and Erkip, 2000). As a consequence of this uncertainty and stress, people may feel less safe in such an environment (Ahola et al., 2014). When navigating, people rely heavily on the spatial properties of the setting (Arthur and Passini, 1992). For example, people use distinguishable features of the environment as landmarks to help them find their way (Emo et al. 2012). From a safety perspective, the guiding characteristics of the environment should be easily recognizable, because this enables people to effectively create or reconstruct cognitive maps of the environment (Zeisel, 2006). While navigating, these cognitive maps help people remember how to find their way, which is essential for daily life and even for their survival.

Based on the former, we conclude that openness and a feeling of guidance are important criteria for evoking a positive safety perception. By designing specific environmental design characteristics, such as ceilings, walls and doors, designers can trigger openness in a space or enhance people's feeling of guidance. The present study focuses on investigating the effects of such environmental design characteristics on people's safety perceptions in passenger ships.

3. Methodology

To test the effects of various environmental design characteristics that are likely to trigger openness and a feeling of guidance on people's safety perceptions, we performed an experimental study, in which 97 participants rated variations of cabin corridors of a passenger ship in which the environmental design characteristics of circulation, dimensioning, shape and geometry, finishing materials and accessories were manipulated. As we aimed to understand people's first impressions of safety when encountering a new environment, we used pictorial representations of the environment. Pictorial representations can provide a good indication of how people will perceive a particular environment when seeing it for the first time. Accordingly, pictures have been frequently used in other recent work on people's preferences and safety perceptions in environments (e.g., Stamps, 2007, 2012, 2013; Van Oel & Van den Berkhof, 2013). Furthermore, a study on the visualization of urban spaces suggested that static color images are at least as effective as any other mediums for evaluating the visual appeal of environments (Stamps, 2012).

3.1. Stimuli

In passenger ships, narrow and shallow spaces are perceived unsafe because they provide limited visibility to other spaces or the outside, and because people are unable to gather enough information to comprehend where the space leads them (Ahola et al., 2014). Cabin corridors in passenger ships are normally narrow and shallow and cover a significant area of the ship. In a typical passenger ship, such as the Freedom of the Seas, cabin corridors (9,900M2) alone cover approx. 24% of the overall passenger accommodation area of 41,500m2 (Royal Caribbean International, 2014). Additionally, cabin areas are optimized for accommodation capacity, which results in long and similar-looking corridors. Because cabin corridors look alike between different decks and in different walking directions, people find it difficult to navigate, which negatively affects their safety perceptions (Ahola et al., 2014). Because cabin corridors form a crucial environment in passenger ships, where safety and comfort are highlighted in the design process, cabin corridors were chosen as a suitable environment to investigate how different environmental design characteristics affect people's safety perceptions.

To select the environmental design characteristics that will encourage more openness in a passenger ship or that create more guidance, we built on Sagun et al. (2014), who have classified characteristics involved in the interaction process between people and the environment into: 1) circulation; 2) dimensioning; 3) shape & geometry; 4) finishing materials; and 5) accessories. In their classification, certain other characteristics, such as communication, temperature, and sounds, were also distinguished. However, in line with prior research on the effects of environmental design characteristics (Van Oel & Van den Berkhof, 2013), we decided to focus only on physical design characteristics of the environment because the designer can directly control these. Within these characteristics, we aimed to select and manipulate those environmental design characteristics that provided the best opportunities to influence people's safety perceptions based on prior research and consultations with design experts from the maritime industry. Because of the specific nature of a passenger ship environment in terms of structural and safety design, we also consulted three ship design experts in the stimuli design process and they confirmed in individual interviews the plausibility and feasibility of all introduced manipulations for contemporary passenger ship design. Specifically, we asked experts whether there are structural limitations or safety regulations that would prevent designers from implementing the different manipulations of the design characteristics in future ships and whether the effects on ship systems (i.e. heating, ventilating, and air conditioning systems) and berth capacity are minimal. Even though certain manipulations are not implemented in passenger ships at the moment (e.g., curved ceilings), the experts concluded that these could all be implemented in future ships.

Below, we will discuss how we have manipulated each of these environmental design characteristics.

3.1.1. Circulation

'Circulation' is one of the basic concepts of architectural design and suggests the system of prescribed routes (including stairs, corridors etc.) that are frequently used (Davies and Jokiniemi, 2008). The environment needs to have a fluent circulation to facilitate people's orientation. According to Dogu and Erkip (2000), difficult orientation causes decreased feelings of safety and being able to see outside is a good means to encourage more fluent circulation and orientation within the location. At present, cabin corridors in passenger ships generally do not provide views to the outside. Consequently, we manipulated circulation in our study by having a view to the outside either present or absent at the end of the corridor.

Having a view to the outside at the end of the corridor helps people to see that the corridor leads outside and because the outside view attracts their attention, reaching the 'destination' may feel more fluent and prompt (Dogu and Erkip, 2000). Having a view to the outside is also the first means of interaction between people and the outside, which has a positive effect on safety perceptions in terms of providing a direct way to the outside and thus a better feeling of guidance (Sagun et al., 2014). Furthermore, it can reflect the favorable direction for survival (Appleton, 1975/1996; Stamps, 2005a). In addition, it provides visibility to the outside, which extends the space and provides the desired openness (Ahola et al., 2014).

3.1.2. Dimensioning

'Dimensioning' is defined as the spatial dimensions (e.g., width, height, and length) of an environment. Obviously, dimensioning has a strong effect on openness: high spaces are naturally more open than low spaces, and wide spaces are more open than narrow ones (Hayward and Franklin, 1974). In this respect, Vilar et al. (2013) demonstrated that people prefer to take wider corridors when evacuating in an emergency situation. It is likely that such corridors are perceived as more safe. Clearly, dimensioning is not optimized for openness in the case of cabin corridors of passenger ships. Cabin corridors are generally perceived as enclosed due to the narrowness and shallowness of their width and height. Limited corridor dimensions result from optimized berth capacity, and therefore, widening the dimensions is not considered a realistic option. Due to the limited possibilities to increase dimensions horizontally, we decided to manipulate the ceiling with the intention to increase vertical openness. Because room for piping et cetera needs to be reserved, it is to some extent possible to change the traditionally flat ceiling design, while minimizing detrimental effects on berth capacity. Therefore, the environmental design characteristic 'Dimensioning' was manipulated by including two different ceiling designs in addition to the traditionally flat ceiling design (see Fig. 1A), that nevertheless have a minimal effect on the ship's structure.

The first option to create more vertical openness is by using a curved ceiling design (see Fig. 1B). Prior research has demonstrated that curvilinear architecture can increase human well-being and has a positive effect on emotions, because curvature is the most dominant form in nature (Madani Nejad, 2003; Pearce and Turner, 1990; Van Oel & Van den Berkhof, 2013) and people prefer living spaces that share essential qualities to natural forms (Salingaros, 1998). Correspondingly, Bar and Neta (2006) demonstrated that people prefer curved shapes over sharp and 'controlled' shapes, because the latter convey a sense of threat. We expect that this preference for curvature will positively influence people's safety perceptions, because people prefer to have consistent judgments about objects (Dion et al., 1972). Consequently, a curved ceiling design may have a positive effect on safety perceptions.

The second ceiling design that we included to increase the vertical openness in the corridor is a coffered ceiling design. A coffered ceiling is a type of ceiling in which the ceiling comprises of two different levels. For example, in comparison to the rest of the ceiling, a rectangular contour in the middle may be positioned slightly higher (see Fig. 1C). By applying two different heights in the ceiling, people may perceive the corridor as more open.

Fig. 1. Examples of the corridor visualizations used in the experiment. Visualization A (Profile 13) presents the corridor with a flat ceiling, split-level walls, matt doors, and without a view to the outside. B (Profile 7) presents the corridor with a view to the outside, curved ceiling, straight walls, and reflective doors. C (Profile 11) presents the corridor with a coffered ceiling, straight walls, reflective doors, a clock as landmark, and without a view to the outside. D. (Profile 6) presents the corridor with a coffered ceiling, curved walls, matt doors, and a view to the outside.

3.1.3. Shape and geometry

The environmental design characteristic 'Shape and Geometry' defines the way the three-dimensionality of the space is formed and thus is a significant determinant of the environment that distinguishes the setting from others (Arthur and Passini, 1992). By manipulating the 'Shape and Geometry', designers give borders to a space that can help in perceiving the distances and edges of the overall space. Ahola et al. (2014) reported that such borders were linked to the clearness of the space, and therefore, positively affect safety perceptions. In cabin corridors of passenger ships, the walls play a prominent role for the three-dimensionality of the space in addition to the ceiling (which was manipulated as part of 'Dimensioning'). Nowadays, the cabin corridors make use of either a straight or split-level wall design. A straight wall design can be considered as open, clear, and easy to perceive, which is expected to have a positive effect on safety perceptions. Split-level wall design stands for wall design in which the wall is structured into two different levels that alternate each other. For example, in comparison to the rest of the corridor walls, the doors to the rooms can be positioned either more to the front or to the back, thereby creating a recurring pattern (see Fig. 1A). Prior research proposed that people may use certain patterns (e.g., in the carpet) for perceiving distances and the rhythm of the space (Ahola et al., 2014). Correspondingly, it may be that the pattern created by the split-level wall design can enhance people's spatial perceptions and thus contribute to their feeling of guidance. On the other hand, the split-level wall design may also increase the complexity of the space. According to many environmental researchers (e.g. Bentley et al., 1985; Rapoport and Hawkes, 1970; Stamps, 1999, 2005a), people prefer moderate levels of complexity in their environment. Excessively simple stimuli are disliked because these are considered boring, whereas too complex stimuli lead to confusion and avoidance. Based on the latter, the complexity of a split-level wall design may also have a detrimental effect on people's safety perceptions.

In addition to these two wall designs, we explored the effect of a curved wall design on safety perceptions. Curved walls were chosen for similar reasons as mentioned for the ceiling design above: people tend to prefer curvature, which can trigger a positive bias. In support of this argument, Van Oel & Van den Berkhof (2013) found that curved wall design is one of the most preferred characteristics in airport design. On the other hand, curved wall design also increases the spatial complexity, which may have a negative effect (Berlyne, 1971; Barrow and Tenenbaum, 1981).

3.1.4. Finishing materials

'Finishing materials' give the final touch to the environment (Sagun et al., 2014) and by selecting particular surface materials for the doors, walls, and floors, the appearance of a space can be manipulated. Traditionally, cabin corridors in passenger ships make use of matt materials. However, it is well known that glossy and reflective surfaces can optically extend space dimensions, thereby creating more visual openness in a horizontal direction. Consequently, we expected that having mirroring door panels in the corridors of a passenger ship may positively influence safety perceptions, and therefore, this environmental design characteristic was included in our study.

3.1.5. Accessories

With 'Accessories', we understand the 'scattered' objects of the environment that can be placed in different environments without architectural constraints, such as art pieces, plants, and furniture. Accessories are part of the architectural information of the environment that helps people to understand what the setting contains and how it is organized (Dogu and Erkip, 2000). For example, exit signs provide clear information about where the nearest exit is and can thus help people to navigate (Vilar et al., 2013). Logically, seeing safety-related accessories, such as exist signs and life-saving appliances (e.g., fire-extinguishers) would result in a feeling of greater safety because this is true from a conscious consideration of the environment. However, our research aim was to uncover first impressions by exploring the environmental design characteristics that influence people's perceptions of safety. Prior research has proposed that people navigate according to attention-attracting environmental accessories, also known as landmarks, and thus may use other types of accessories to get a feeling of guidance (Ahola et al., 2014). As we wanted to uncover the more irrational effects of environmental characteristics on people's safety perceptions, we purposefully focused on accessories without an obvious relationship to safety.

Cabin corridors in a passenger ship contain many spatial settings that look very much alike, and therefore, it is desirable if the environmental information has an identity that distinguishes a particular corridor from surrounding spaces (Arthur and Passini, 1992). We expect that placing a unique environmental accessory as a landmark in the corridor could enhance the recognition of the space, and therefore, positively affect safety perceptions. When people recognize a unique landmark, they know where they are (Meilinger, 2008).

Within this study, we test the effects of a landmark by adding a hanging wall clock to the environment. We chose the wall clock, because in comparison to standing art pieces, wall clocks will minimize potential negative effects on visibility, motion possibilities, and openness.

The five environmental design characteristics and the specific manipulations for each characteristic are summarized in Table 1.

3.2. Experimental design

An experimental study was conducted to test how the manipulation of the environmental design characteristics for the cabin corridors of a passenger ship affect people's safety perceptions. Specifically, we manipulated five environmental design characteristics ($3 \times 3 \times 2 \times 2 \times 2$ design) that were expected to result in more openness and a better feeling of guidance (see Table 1). Because including the effects of all five environmental design characteristics in a full-factorial experimental design would require too many stimuli (i.e., 72 stimuli) to be tested, we used a conjoint analysis approach with a fractional factorial design. Conjoint analysis is generally used to analyze people's evaluations and perceptions of products based on the different functions and aesthetics (Hair et al., 2006; Mambretti, 2011). Accordingly, the approach is appropriate to uncover which environmental design characteristics are most influential for people's safety perceptions. To reduce the number of profile presentations, a fractional factorial design of twenty hypothetical environments was constructed based on combinations of the different levels of the five environmental design characteristics (see Table 2). In contrast to a full-factorial experimental design, only a relatively small set of stimuli profiles needs to be included in a fractional factorial design, whereas it remains possible to reliably test the main effects of the five independent variables. These profiles were created with an orthogonal array design using the statistical software program SPSS 22.0. The authors verified the suitability of the proposed profiles. The reduced number of stimuli that was used in the conjoint analyses imposes restrictions on the statistical analysis, and thus only one interaction effect was analyzed in addition to the main effects. After consideration of the five environmental design characteristics that were manipulated, we expected the strongest interaction between the wall and ceiling designs. Consequently, we included the interaction effect between dimensioning and shape & geometry. The levels of these two environmental design characteristics have a certain degree of correspondence due to which the combined effect of these two factors may have particular consequences for people's perceptions. Prior research has demonstrated that people's attitude towards objects may be more positive when there is congruity between the different elements (Van Rompay and Pruyn, 2011). Correspondingly, the congruity between a curved (flat) ceiling and curved (straight) walls may influence people's safety perceptions, and therefore, this interaction effect was included in our data analysis.

Fig. 1 presents four examples of the visualizations that were used in the experiment. Google SketchUp, Maxwell Render and Photoshop software programs were used to make the visualizations. All visualizations were standardized as much as possible, for example, with respect to lighting, colors, handrails, and perspective. Furthermore, the visualizations were pretested ($N = 6$) to ensure that the manipulations of the environmental design characteristics (i.e., walls, ceilings, window, material of the door, and the added accessory) were perceived as intended. Similar to the main study, participants conducted the pretest individually. In the pretest, participants were asked to express how they interpreted the different environments, if they identified the manipulation of the different characteristics between visualizations and they scored the profile pictures according to given instructions. Specifically, they were asked how they interpreted the ceilings, walls, doors, added accessory, and the end of the hallway. All pretest participants were unaware of the specific study purpose. Pretest participants recognized all manipulations in the visualizations, which provided us with evidence that we were successfully investigating the effects of these environmental design characteristics on people's safety perceptions.

3.3. Procedure and participants

A letter was sent to all participants, in which participants were explained the general research objective, the general procedure, and in which they were asked to volunteer in the study by completing the research in their own house on their own pace. Furthermore, it was explained that all responses will be analyzed anonymously and will be treated confidentially. If participants chose to participate, they could continue by reading the detailed instructions, the questionnaire, and by examining the 20 pictures of hypothetical cabin corridors printed in color on A5 paper (see Fig. 1), and an A3 scoring form with a three-point scale (1 = low, 2 = medium, 3 = high). The order in which the profile pictures were offered to participants was randomized. In the instructions, participants were asked to imagine that they were traveling in a passenger ship. Next, we asked participants to look at the different profile pictures and to determine whether they perceive the cabin corridor as safe or not by following several steps. As a first step, we asked participants to complete the first grouping by asking participants to organize all 20 profile pictures on the A3 scoring form

Table 1
Conjoint factors and information about their levels.

Environmental design characteristics	Design aim	Level 1	Level 2	Level 3
1 Circulation	Guidance/Openness	No view to the outside	View to the outside	
2 Dimensioning	Openness	Flat ceiling	Curved ceiling	Coffered ceiling
3 Shape & Geometry	Guidance/Openness	Straight walls	Curved walls	Split-level walls
4 Finishing materials	Openness	Matt doors	Reflective doors	
5 Accessories	Guidance	No landmark	Landmark in the shape of a wall clock	

Table 2
Hypothetical cabin corridor profiles obtained by means of the orthogonal array design.

Profile	Environmental design characteristics & levels				
	Circulation	Dimensioning	Shape & geometry	Finishing material	Accessory
1.	No view to the outside	Curved	Curved	Matt	Landmark
2.	View to the outside	Flat	Straight	Matt	Landmark
3.	No view to the outside	Flat	Straight	Matt	No landmark
4.	No view to the outside	Coffered	Straight	Matt	Landmark
5.	No view to the outside	Flat	Straight	Reflective	No landmark
6.	View to the outside	Coffered	Curved	Matt	No landmark
7.	View to the outside	Curved	Straight	Reflective	No landmark
8.	View to the outside	Flat	Split-level	Matt	Landmark
9.	View to the outside	Flat	Straight	Reflective	Landmark
10.	No view to the outside	Curved	Split-level	Reflective	Landmark
11.	No view to the outside	Coffered	Straight	Reflective	Landmark
12.	No view to the outside	Flat	Curved	Reflective	No landmark
13.	No view to the outside	Flat	Split-level	Matt	No landmark
14.	View to the outside	Curved	Straight	Matt	No landmark
15.	View to the outside	Flat	Curved	Reflective	Landmark
16.	View to the outside	Coffered	Split-level	Reflective	No landmark
17.	View to the outside	Flat	Split-level	Reflective	No landmark
18.	View to the outside	Coffered	Straight	Matt	No landmark
19.	No view to the outside	Curved	Curved	Reflective	No landmark
20.	No view to the outside	Curved	Split-level	Matt	No landmark

into three groups (1 = low, 2 = medium, 3 = high) based on their expectations regarding the safety of the environment. When they were satisfied with organizing the pictures, they were asked to record this first score on the top of each picture and to make three piles, one for each of the three scores (i.e., pile 1, pile 2, and pile 3). Next, it was explained that even though some environments received the same score in the first grouping, more subtle differences in safety perceptions may exist. Accordingly, participants were asked to do a second grouping by taking the pictures of pile 1, and re-organize these on the A3 scoring form into three groups (1 = low, 2 = medium, 3 = high), again based on their expectations regarding the environment's safety. Participants noted this second score on the bottom of each picture. This procedure was repeated for the pictures belonging to piles 2 and 3. We performed multiple pilots to ensure that the procedure was clear to respondents.

The former procedure resulted in two three-point scores given to each profile picture. We recoded these scores into a nine-point safety perception score by taking the first score as the primary indicator (1 = 1–3; 2 = 4–6; 3 = 7–9) and the second score as the secondary indicator. For example, a picture that received the score 1 in the first grouping and the score 3 in the second grouping, obtained a final safety perception score of 3. Similarly, a picture that received the score 3 in the first grouping and the score 1 in the second grouping, obtained a final safety perception score of 7. Higher scores thus suggested that the environment was perceived to be safer.

After scoring all profiles, participants were asked to fill in a questionnaire. This questionnaire included several individual differences scales that were expected to influence people's ratings and thus served as covariates in the data analysis. Specifically, expertise with passenger ships was measured with the item: How much experience do you have with passenger ships? (1 = not at all; 7 = a lot). Involvement with safety in passenger ships was measured with three items on seven-point scales (unimportant vs. important; irrelevant vs. relevant; does not matter vs. does matter; Cronbach's $\alpha = 0.88$). Furthermore, we included four items (Cronbach's $\alpha = 0.68$) to measure people's ability to visually process information: 1) I generally prefer to use a diagram than a written set of instructions; 2) I like to "doodle"; 3) When I'm trying to learn something new, I'd rather watch a video (e.g., Youtube) than read instructions; and 4) My thinking often consists of mental "pictures" or images, which were based on Childers et al. (1985). These items were measured using seven-point Likert scales ranging from strongly disagree (1) to strongly agree (7). Finally, participants were asked to return both the filled-in questionnaire and the 20 profile pictures by making use of the return envelope. After two weeks, all participants received a debrief in which they were thanked for participation and were given some additional insights in the research goal. All participants received a small financial compensation (€3.45) for their participation.

A consumer panel of Dutch households was used for the research. All panel members have volunteered to become a member of the panel and agreed to be approached for participation in scientific research. From the available 1700 households, we selected a subset of 220 panel members based on age and gender to warrant a satisfactory distribution in our sample. The questionnaire and pictures were sent by regular post to these 220 panel members. Of the addressed 220 panel members, 97 participants (response rate = 44%) returned their questionnaire. Participants did not report any difficulties in following the instructions or conducting the survey.

3.4. Data analysis

To analyze the effects of the five different environmental design characteristics on safety perceptions, the conjoint rating data of people's safety perceptions was analyzed with a linear mixed model ANOVA (ANalysis Of VAriance) in SPSS 22.0. Linear mixed model ANOVA is typically used for the analysis of population effects in conjoint experiments based on rating scales (Næs et al., 2010). Our model included circulation, dimensioning, shape & geometry, finishing materials, and accessories as main effects, and the two-way interaction effect between dimensioning and shape & geometry as fixed factors. The respondent number was included as a random factor. Additionally, interaction effects between respondent number and the five factors were included as random factors to account for individual preferences. As including these interaction effects did not change the effects of the environmental design characteristics on safety perceptions, these interaction effects were removed from the final analysis. Expertise with passenger ships, involvement with safety, visual processing style, and age were included as possible covariates in the linear mixed model ANOVA.

4. Results

The 97 participants who returned the questionnaire consisted of 49% males and were on average 48.8 years old (SD = 14.1). Most participants had relatively little experience with passenger ships intended for cruising (M = 2.91, SD = 1.79), and 30% indicated that they did not have any experience at all. A feeling of safety was considered very important by the majority of participants (M = 6.11, SD = 1.07). There was diversity in participants' visual/verbal processing style (M = 4.28, SD = 1.19) suggesting that both people with a visual and verbal processing style participated in the study.

The included covariates expertise with passenger ships, involvement with safety, visual processing style, and age did not significantly influence the results, and were excluded from the analysis. The mixed model ANOVA results are presented in Table 3. Significant effects were found for circulation (no view to the outside vs. view to the outside; $p < 0.001$), dimensioning (ceiling design, $p < 0.01$), and shape & geometry (wall design, $p < 0.001$) on people's safety perceptions. No effects were found for finishing materials (matt vs. reflective doors), accessories (landmark) and the interaction between dimensioning and shape & geometry (all p's > 0.05).

More specifically, with respect to circulation participants expected the passenger ship environment to be safer when there was a view to the outside at the end of the cabin corridor ($M_{\text{view to the outside}} = 5.71$ vs. $M_{\text{no view to the outside}} = 3.78$; see Fig. 2). Post-hoc pairwise comparisons with Bonferonni adjustment on the three levels of the environmental design characteristic dimensioning revealed that participants' safety perceptions were more positive when the ceiling is curved than when it is flat ($M_{\text{curved}} = 5.07$ vs. $M_{\text{flat}} = 4.74$, $p < 0.05$) and coffered ($M_{\text{curved}} = 5.07$ vs. $M_{\text{coffered}} = 4.44$, $p < 0.01$; see Fig. 3). No significant difference in safety perceptions was found between flat and coffered ceilings ($p = 0.20$). With respect to shape & geometry, post-hoc pairwise comparisons showed that participants' safety perceptions were more positive when the walls are straight or curved than when the walls follow a split-level design ($M_{\text{straight}} = 5.30$ vs. $M_{\text{split-level}} = 3.63$, $p < 0.001$; $M_{\text{curved}} = 5.32$ vs. $M_{\text{split-level}} = 3.63$, $p < 0.001$; see Fig. 4). No significant difference in safety perceptions was found between straight and curved walls ($p > 0.20$).

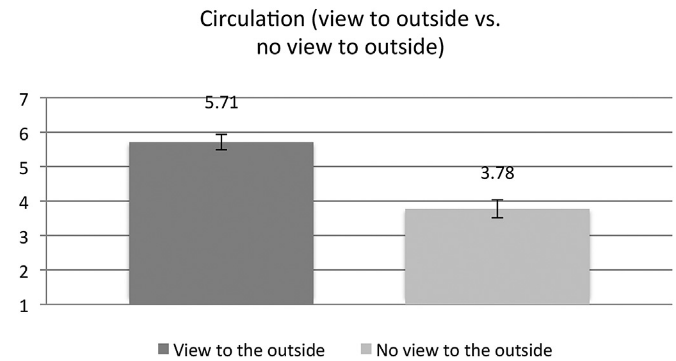

Fig. 2. Mean safety perception for different circulation conditions. Error bars represent the 95% confidence interval.

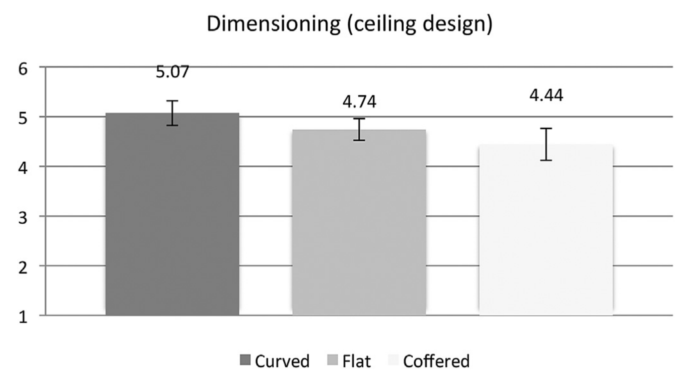

Fig. 3. Mean safety perception for different dimensioning conditions. Error bars represent the 95% confidence interval.

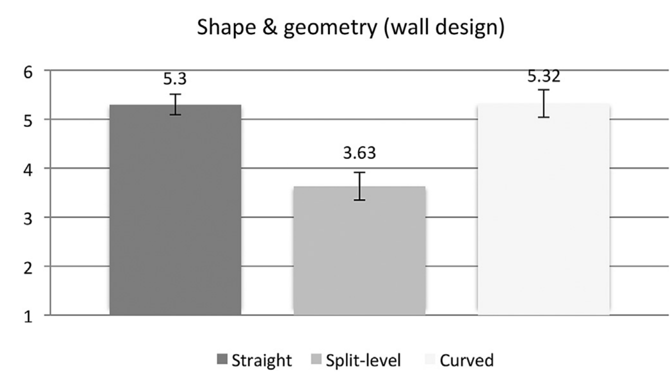

Fig. 4. Mean safety perception for different shape & geometry conditions. Error bars represent the 95% confidence interval.

5. Discussions

This study aimed to explore the effect of environmental design characteristics on people's preliminary safety perceptions in a passenger ship context. The very first perceptions of safety strongly affect human information processing, decision-making, and are key in order for people to feel comfortable and enjoy the cruise experience (e.g., Mischel, 1973; Vallacher, 1993). Based on the classification of Sagun et al. (2014), we modified specific characteristics in the design of cabin corridors that were intended to make a space more open or give a better feeling of guidance, and thereby positively affect people's safety perceptions. Our findings show that designers can indeed influence people's safety perceptions through

Table 3
Results of the Linear mixed model ANOVA testing the effects of the environmental design characteristics on people's safety perceptions.

Environmental design characteristics	Numerator *df*	Denominator *df*	*F*-value	*p*-value
Circulation (view to the outside vs. no view to the outside)	1	582,476	173,086	0.000
Dimensioning (ceiling design)	2	596,033	6694	0.001
Shape & geometry (wall design)	2	543,943	77,674	0.000
Finishing materials (matt vs. reflective doors)	1	1189,379	2188	0.139
Accessories (landmark vs. no landmark)	1	758,688	0,972	0.325
Dimensioning * Shape & geometry	4	476,066	0,748	0.560

purposefully changing the environmental design.

Specifically, we found significant effects for the ceiling and wall design. These results support Stamps' (2005a) conclusion that people's perceptions of safety are influenced first and foremost by their overall view. By using more realistic stimuli, we demonstrate that the dimensions and shapes of the walls and ceilings are also important for safety perceptions in ship environments. The split-level wall design and to some extent the coffered ceiling were perceived as less safe. Based on prior research (Ahola et al., 2014), we expected that split-level walls would give a better feeling of guidance. Furthermore, coffered ceilings were expected to give more openness to the corridor space. However, our findings demonstrated that both environmental design characteristics had a detrimental effect on people's safety perceptions. A potential explanation for this effect is that split-level walls and coffered ceilings are visually complex. Prior research has demonstrated that complexity influences people's perceptions of products (Creusen et al., 2010) and environments (Bentley et al., 1985; Rapoport and Hawkes, 1970; Stamps, 1999, 2005a). People generally prefer moderate levels of complexity from an aesthetic perspective (Berlyne, 1971; Rapoport and Hawkes, 1970). Thus far, complexity has not yet been considered as an influencing factor for safety perceptions. Nevertheless, our findings provide some preliminary evidence for the value of low complexity in order to enhance people's safety perceptions when designing ship environments. Due to the complexity of split-level walls and coffered ceilings, the continuation of the horizontal and perspective lines is disturbed. As these horizontal and perspective lines can improve people's orientation within the space, people's feeling of guidance may be weakened for split-level walls and coffered ceilings, resulting in lower safety perceptions. This is in line with the notion that especially in complex situations even relatively simple architectural design characteristics can become difficult to interpret, which can set limitations for people's information processing and decision-making (Kinateder et al., 2014). Although a degree of complexity may be desired to create aesthetically pleasant and interesting environments (Rapoport and Hawkes, 1970), from a safety perspective a more simple environmental design with clear and continuous lines is preferred for the corridors in passenger ships. Nevertheless, more research is needed to completely understand the effect of visual complexity in environments on people's safety perceptions. For example, it could be interesting to study the effects of complexity for various environments. It may be that even though the effect is negative for narrow and long environments, such as corridors, complexity can have a positive effect in more spacious environments, such as restaurant areas in passenger ships. Furthermore, future research could investigate whether greater levels of complexity would negatively affect people's safety perceptions if the complexity does not disturb the continuation of the horizontal and perspective lines, for example, by changing the carpet design or wall paper.

Having a view to the outside in a corridor also had a positive impact on people's safety perceptions. A view to the outside extends the space and makes the corridor visually more open. Furthermore, the clear destination triggered by the outside view can make people feel more safe as it helps in their orientation (Dogu and Erkip, 2000). A view to the outside can be implemented by having a window at the end of the corridor. Although experts confirmed the technical feasibility of such a window in a passenger ship, it may not be the most optimal solution from an economic perspective. Currently, outside views are occupied for the economically more profitable spaces, such as cabins and restaurants. Another possibility to create a view to the outside is by adding an artificial view to the outside (e.g., virtual window), which broadcasts the outside scenery of the ship. However, it is uncertain whether such an artificial view to the outside would have a similar effect on people's safety perceptions. Further research is needed to test this effect.

Finally, a curved ceiling design was perceived as more safe than flat and coffered ceilings. This result corroborates and extends the conclusions of prior studies that people prefer curvilinear architectural designs over rectangular or flat designs (see e.g., Madani Nejad, 2003; Van Oel & Van den Berkhof, 2013). Curved shapes in architecture can increase people's subjective well-being and trigger positive emotions. We extend these findings by demonstrating that curvature in the ceiling design of a passenger ship is also desired from a safety perspective. Nevertheless, a curved wall design did not result in greater safety perceptions than the straight wall design in our study. We believe that this is the result of the fact that only moderate curvature could be implemented in the wall design, whereas high levels of curvature were possible for the ceiling design. Due to the limited design latitude in the corridor's width of passenger ships, the achievable curvature was limited because this would otherwise negatively affect berth capacity. As a consequence, a curved ceiling was more important for positively influencing people's safety perceptions.

Designers can use these guidelines to design passenger ships that will be perceived as safe as expected or even safer. Although our research focused on corridors in passenger ships, we expect that the provided guidelines may also be applicable to other environments that have long corridors, such as hospitals and hotels, and thus designers involved in the design of these environments can benefit from our findings as well.

It was assumed that placing a wall clock as a landmark in the environment would positively influence safety perceptions because landmarks are significant elements for fluent navigation (e.g. Ahola et al., 2014; Arthur and Passini, 1992; Dogu and Erkip, 2000). However, we did not find support for such an effect. We believe that this may be because landmarks are typically used when people orientate themselves (Meilinger, 2008) and distinguish an environment from the surrounding environments (Arthur and Passini, 1992). In the experiment, we wanted to test people's first impressions of an environment's safety. Pictures are considered an adequate means to investigate such perceptions (Stamps, 2007, 2012; Van Oel & Van den Berkhof, 2013). Although visualizations are frequently employed and can provide important insights considering people's evaluations of environments (Van Oel & Van den Berkhof, 2013), they also have some shortcomings. For example, people were not able to move around in the environments, which might reduce the effects of landmarks, as participants were not able to compare different corridors with different landmarks or move along the corridor where a landmark could help them to estimate the distance. This may also explain why we did not find an effect for the reflective door panels on people's safety perceptions in our study. More research is thus needed to test the effects of accessories and finishing. A promising approach would be to study these effects using virtual reality (VR) techniques (Duarte et al., 2011; Vilar et al., 2013). This would enable people to move in the corridor, see multiple perspectives, and to investigate actual navigation behavior, which could help to provide a more comprehensive understanding of the effects of different environmental design characteristics on people's safety perceptions. It would also be interesting to replicate our effects concerning the value of low complexity for people's safety perceptions using such VR techniques. In addition, future research could study the effects of other types of accessories on people's perceptions of safety in passenger ships. For example, a more robust-looking design of the handrail may also trigger more positive safety perceptions.

Our study was limited to the investigation of five environmental design characteristics that were based on the classification of Sagun et al. (2014). We selected these design characteristics because they were expected to strongly contribute to people's safety perceptions. Specifically, we were able to extend the work of Sagun et al. (2014) by putting their classification into practice and showing that three of the identified characteristics indeed significantly influence people's perceptions of safety. Nevertheless, we realize that other environmental design characteristics than the ones included in our research may also have an effect. Future research could extend our findings by investigating the effects of other manipulations of either the overall view or the details (e.g., hand rail design) on people's safety perceptions. In addition, our fractional factorial design allowed us to test only one interaction effect. It would be interesting for future research to explore other possible interactions between environmental design characteristics.

Another limitation of our study is that we could only test the direct effects of the environmental design characteristics on people's safety perceptions. Although we theorized based on prior research (e.g. Ahola et al., 2014; Dogu and Erkip, 2000; Madani Nejad, 2003; Stamps, 1999, 2005a; Van Oel & Van den Berkhof, 2013) that openness and guidance are the anticipated underlying processes for how the different environmental design characteristics influence people's perceptions of safety, we were not able to verify this in our study. More research is needed to confirm this for these and other environmental design characteristics.

Our findings did not reveal significant effects of the participants' age, expertise with passenger ships, involvement with safety, and their visual/verbal processing style when including these as covariates. This provides preliminary support that many people will be influenced by these environmental design characteristics. Nevertheless, we acknowledge that our sample was relatively inexperienced with respect to passenger ships. It would be worthwhile for future research to replicate our findings for people who have had more experience.

Finally, it would be interesting to explore to what degree the provided guidelines are applicable to other, especially larger spaces, such as promenades and lobbies.

6. Conclusions

It is important for designers to consider the safety perceptions in passenger ships in order to develop environments in which people will feel comfortable. Summarizing, our findings demonstrate that if designers want to increase people's safety perceptions, they could use a curved ceiling design and a view to the outside at the end of the corridor. Furthermore, they should make use of clear and continuous architectural lines and thus avoid complicated ones, such as split-level wall designs. Employing these guidelines will create more openness and will give a more clear guidance to people. Based on these findings, it can be concluded that the current design of the cabin corridors in passenger ships is far from optimal from a safety perception perspective. At present, these environments often contain split-level characteristics, for example to cover heating, ventilation, and air conditioning systems, and curvilinear design or views to outside are a rare sight. Although we realize that changing the architectural design in passenger ships is a challenging task because there are many contradicting requirements to consider, we do feel that professionals involved in the passenger ship design can greatly benefit from our guidelines for the design of future ships. For example, ship classification societies that develop references for ship comfort design, could make use of the provided understanding in order to design passenger ships that are not only safe from an objective perspective, but also feel safe. Only if people feel safe, they can truly enjoy the travel, and thus there is much to gain by increasing people's safety perceptions.

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