

How sounds and soundscapes can help to maintain situational awareness

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ABSTRACT

Introduction: Main research questions of this doctoral paper are how sound perceptions are connected to the understanding of emergent situations and how often they are in an important role in sense-making during critical and crisis situations. **Method:** All completed maritime investigation reports (N=99) made by the Safety Investigation Authority in Finland during the last ten years were analysed. **Results and discussion:** Sound perceptions or the lack of them were mentioned in 35 reports (35%) and in eleven reports, which is 11 % of all reports, the correct understanding of emergent situations was mainly based on the observations of natural sounds.

KEYWORDS

Sound; soundscape; situational awareness.

INTRODUCTION

This doctoral paper is a part of the author's dissertation in the field of psychology of music with the title of "Sounds of fear and hope: How to enhance mental performance during emergency situations" for University of Jyväskylä, Finland. The dissertation is multidisciplinary because of the tight connection to the human factors science. The first supervisor is Ph.D. Suvi Saarikallio, Academy of Finland Research Fellow, while another supervisor is adjunct professor Ph.D. Veli-Pekka Nurmi, executive director of Safety Investigation Authority, Finland.

The original idea in the dissertation is to find out what the role and significance of sounds, soundscapes (including silence) and music is during demanding situations in sociotechnical systems. The first research question is what kind of information sounds can carry, i.e. how soundscapes can maintain situational awareness. The second research question will be how soundscapes affect feelings, i.e. whether sounds can awake or startle feelings or even cause fear. The third research question will be how sounds and music can serve to enhance human performance in addition to physical and psychological methods such as relaxation and mental images. This doctoral paper is meant to answer to the first question with the following sub-questions:

1. how sound perceptions are connected to the understanding of emergent situations, and
2. how often they are in an important role in sense-making during critical and crisis situations

Scientific background

Younger generations listen to music mainly to regulate their emotions and mood (Saarikallio, 2007) and to create their own sonic environments, also when walking in the heavy city traffic. The absence of sound signals has been proved to increase risks in this kind of environments. (Lichtenstein et.al., 2012) Other findings also indicate that both the frequency and severity of driving violations are higher when drivers listen to aggressive music than during trips when no music is played. (Brodsky & Slor, 2012)

When sounds in scuba-diving were studied by the author, it was found that sounds are very significant signals for divers. Divers use sounds as an information source and many kinds of underwater sounds and also the silence cause strong emotions. The underwater silence was merely considered as positive and nice, and the technogenic noise as noxious and frightful. (Seppänen & Nieminen, 2004)

The term soundscape is the designation of any human-audible sounding environment. Soundscapes are usually divided into three basic elements: *keynote sounds* outline the character of the acoustic environment, *sound signals* are consciously listened foreground sounds and *soundmarks* are sounds which are unique to a particular environment. (Schafer, 1994) The airborne soundscape in natural environment at sea is dominated by keynote sounds of the wind and sea. (Lee & Lu, 2009) There are also sound signals, i.e. sounds by, for example, other vessels, sea birds, fog signal devices and occasionally some specific sound marks, e.g. sounds of the packing ice, sounds of jumping humpback whales.



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When examining the acoustic environment onboard from the OOW's⁸ point of view, monotonous keynote sounds including the tiring isothermal air conditioning and some sound signals (e.g. alarms, radio calls) are typical of a modern closed bridge. However, a proper look-out by sight and hearing shall be maintained at all times. (COLREG, 5§) If a sound signal from the operational environment, e.g. from another vessel's foghorn, is not observed, or if there are disturbances (e.g. wrong filtering, unsuccessful interpretation, long reaction time) it results in a shortage of situation awareness which may be critical regarding the required decision-making. (Factors contributing to fatigue)

According to Endsley (1995), situational awareness is based on the perceptions in the current situation, the comprehension of the current situation and the projection of the future status. As a part of situational awareness, auditory inputs allow to assess and monitor the socio-technical environment of the craft. It has been stated, for example, that all crew members know the sounds of a normal-functioning craft, while on the other hand, unexpected sounds or the lack of sounds may alert them to possible malfunctions, failures, or hazards. (Hearing and noise)

METHODS

Soundscape is also a method and an idea to study the interrelation among sound, environment and human. It is the human that feels, thinks and remembers the sound and environment and then response to the sound and environment. (Lee & Lu, 2009). The priority in this article is "to employ natural sounds" (Schafer, 1994) i.e. to find primary sounds as naturalistic elements to maintain situational awareness; neither sound alarms nor voices of the communication inside the bridge or via radio are taken into account.

To find out what has been the importance of sounds in noticing emergencies, all maritime accident and incident investigation reports made by the Safety Investigation Authority in Finland (SIAF) during the last ten years, 2003-2012, with the total number of 99 completed (by 18 March 2013) reports have been analysed.

RESULTS

Number of observations

Altogether 47 separate sound observations or instances of lack of observation have been mentioned in 35 different safety investigation reports (35 % of all reports), and altogether 39 different words were found to be used describing the nature of the sounds or noise. Words used more than once were collision (in Appendix numbers 3, 4, 27, 28, 30), loud (9, 36, 37, 42), cry (32, 33, 35), vibration (1, 26, 31), slam (7, 8, 10), crash (2, 6), short (11, 17) and start (21, 47). Allegories have been used in two cases (1, 20).

Sources of the sounds mentioned in the reports and descriptions of the nature of the sounds are collected in Appendix. Descriptions are taken literally from the reports by the SIAF and their English translations. When necessary, Finnish descriptions have been translated by the author.

Roles of the sounds

The role of the sounds is estimated based on the actions taken after them. In eleven reports, sounds heard by operators have been in a major role i.e. the correct understanding of emergent situations was based on the sound observations, and due to them at least someone has taken some immediate steps to control the emergency. Actions are listed below, starting from very severe cases:

- they heard a rattling noise and the sound of objects sliding on the deck above => they rushed up and out from the superstructure (44)
- when heard five short blasts given by Silja Serenade => he realized the situation and started the turn immediately (17)
- he heard the other seaman's cry => when he turned his head towards the sound he saw the seaman's legs disappear over the rail (33)
- a deck hand called out, "stop, stop, help" => the skipper switched off the engine and turned to look towards the aft (34)
- he heard an unfamiliar sound coming from the water => immediately he caught hold of a torchlight and detected a seaman in the water (38)
- after hearing a noise => the AB rushed to the site and saw that part of the crane had been derailed and collapsed (42)
- after stopping their own craft, the patrol boat crew heard crying for help => they moved ahead towards the sounds and saved lives of both men (35)
- the trainee heard a sound of something falling => a moment later he noticed that the Electrician had fallen about three meters (40)
- he heard an exceptionally sudden and strong raise in the engine noise => the first engineer narrowly escaped from the danger zone before the engine raced and broke down (20)

⁸ Officer on watch

- on hearing the noise of the collision => she immediately ran down to see what had happened (4)
- he heard the crash => and returned to the bridge (6)

In all other 24 reports sound observations have been in a minor role, i.e. also some other information sources were mentioned or the sounds were considered to have no significant role.

Conclusions

From the perspective of the soundscapes studies, only some keynote sounds are mentioned: a sound of the storm, a rumble noise of the tugboat (both in 46) and a loud hit of the wave (9). Also normal vibrations as such are characteristic to the ship environment. Blasts given or not given by vessels (11-18) are signal sounds and other sounds mentioned refer to temporary soundmarks, very unique to the particular ongoing situation onboard.

Based on the findings and previous studies, the role of sounds and their connections to the understanding of emergent situations is described in figure 1. As the figure shows, sounds carry information about onboard environments of different kinds (natural, operational, socio-technical) and are essential tools in individual and social processes.

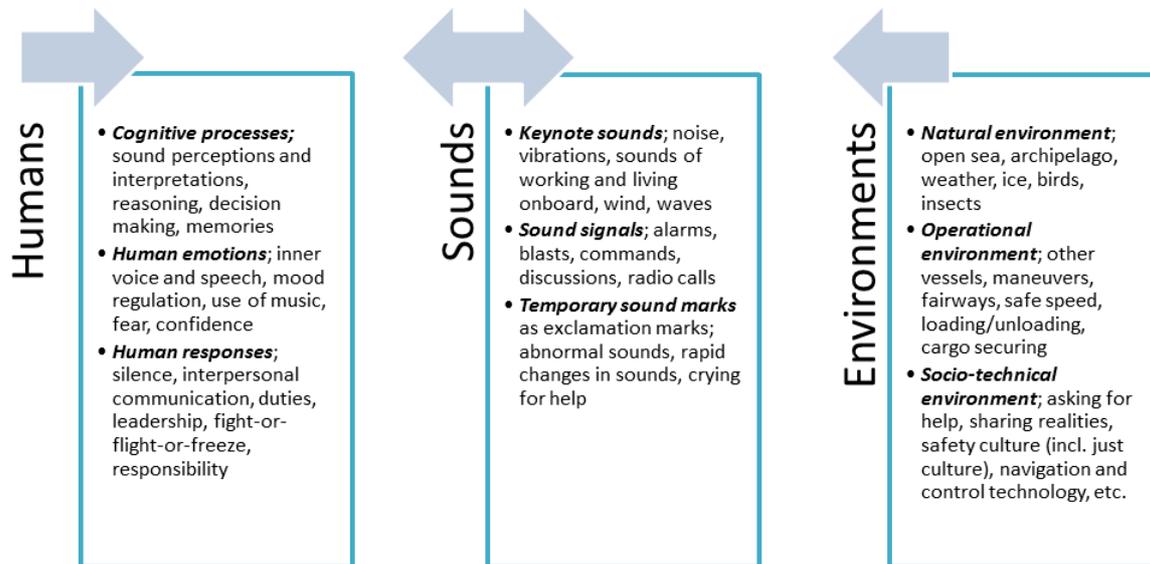


Figure 1. The role of soundscapes in maritime. After semicolons, there are only some examples. (Modified from Truax, 1984 and Wrightson, 2000).

When sounds have been mentioned, in almost every third cases they have been in a very significant role. Of the 99 analysed reports, in eleven reports, which is 11 % of all reports, the correct understanding and sense-making of emergent situations was mainly based on the sound observations. Further studies are needed to determine the role of sounds as tools in individual processes: how and how often sounds, e.g. music, musical memories or inner voices are used to regulate mood and enhance mental performance.

DISCUSSION

In the generalisation used in soundscape studies, post-industrial soundscapes are defined as "lo-fi" soundscapes: meaningful sounds can be masked due to the fact that ambient noise and sonic information can mutate easily into anti-information. Pre-industrial soundscapes are considered to form exactly opposite environments: in "hi-fi" soundscapes all sounds can be heard clearly, and the so called acoustic horizon may reach several miles. (Wrightson, 2000)

The findings of this study – e.g. in three cases blasts given by a nearby vessel were not heard (11, 15, 16) and in two cases blasts were not even given (14, 18) – indicate that acoustic environments inside modern ships correspond unquestionably to the "lo-fi" soundscapes. Particular sounds are not always heard and individual's aural space (see Wrightson, 2000) is sometimes so reduced that sounds are underrated. On the other hand, when the look-out by hearing or other kind of proper alertness has been maintained, people have been able to hear blasts and cries for help (especially 17 and 35, also 33, 34, 38).

The listening of sounds in onboard environments is not a historical relic from the times of "hi-fi" soundscapes in tall ships and steamers: sounds and soundscapes will always be very essential factors in maintaining situational awareness in maritime operations and in demanding situations.

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APPENDIX

The source and the nature of the sounds mentioned in safety investigation reports. All reports can be found at <http://www.turvallisuustutkinta.fi/en/Etusivu> using the report number mentioned.

Hull or similar

1. vibrations and metallic sound, like pushing trolley along rugged surface, D3/2011M
2. sound of the crash, C4/2010M
3. grinding sound, collision was smooth and sounds were faint, C3/2010M
4. noise of the collision, C3/2009M
5. scraping sounds from the bottom, C3/2008M
6. crash, C4+C5/2006M
7. slam was heard, everyone was silent for a while, C2/2005M
8. slamming sounds, C4/2003M
9. loud hit of the wave under the stern, B1/2003M
10. slam in the bow when hitting ice, C1/2003M

Fog signal device

11. short blast given, not heard, D2/2011M
12. NoD. (= no description), blasts were given as long as there were electricity onboard, D18/2009M, 1/2010M
13. NoD., blasts given by ships in the area, used to help in search, D11/2009M, 1/2010M
14. NoD., no sound or light signals were made by either vessel, C5/2008M
15. NoD., fog signal device was at use, but there was no audio lookout onboard another vessel, C1/2007M
16. long blasts were given, not heard, C7/2005M
17. five short blasts were given, C4/2005M
18. NoD., no sound signals were made by either vessel, C3/2004M

Engine

19. engine pounding forcefully, N5/2012M
20. exceptionally sudden and strong raise, like a whining chainsaw, C1/2009M
21. start of the emergency generator, C7/2006M
22. rumble noise, C9/2004M
23. chinking sound from the valve, B1/2003M
24. abnormal sound from the bearing area, B1/2003M
25. strange engine sound, C5/2003M osa II

VDR⁹

26. sounds of the vibration, C4/2009M
27. sound of the collision, MS BIRKA EXPRESS & HANSE VISION, BSU Ref.: 20/09
28. collision noise, items dropping from tables, C5/2008M
29. impact to the pier, MS FINNLADY, BSU Ref.: 211/08
30. collision sounds, C6/2006M
31. vibrations, B1/2004M

Crying for help

32. men cried help but it was not heard, D17/2009M, 1/2010M
33. seaman's cry, B1/2009M
34. deck man called out stop stop help, B2/2008M
35. patrol boat crew heard crying for help, C5/2003M osa I

Underwater sound

36. loud commotion, C3/2009M
37. loud and dull sound, B2/2004M

Other

38. unfamiliar sound from the water, MV CARISMA DMAIB 201204183
39. attention drawing sound from tracks of the (floatable) digger, D4/2011M
40. sound of the falling, D10/2010M
41. sound "tscha" and a sound of water in pipes, MV SEA WIND SHK Rapport RS 2011:01 Dnr S-211/08
42. AB heard huge noise, master heard loud noise, B1/2006M
43. hissing noise of escaping compressed air, C7/2006M
44. rattling noise and objects sliding on the deck above, sliding and rattling sounds, C7/2006M
45. cracking sounds were heard before, while heavy sea, B2/2004M
46. sounds of the storm, C9/2004M
47. sound of the automatically starting bilge pump could help to notice leak, C5/2003M osa I

⁹ VDR (Voyage data recorder) is a data recording system designed for all vessels, sometimes also called Black box for ship, which inter alia include audio information from the bridge and bridge wings. VDR data is usually utilized e.g. in accident and incident investigation.