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## EMPIRICAL INVESTIGATION OF POSSIBLE CONCERNS REGARDING THE USE OF MAGNETIC LEVITATION ELEVATORS

**Aim:** This study focused on an issue regarding an innovation of magnetic levitation elevators which was by different media coverage indicated as being unresolved: Are potential users of magnetic levitation elevators concerned about the safe use of these elevators and, if so, what kind of concerns exist?

**Methods:** To contribute a first scientifically sound assessment to this, a three-day face-to-face survey at the elevator test tower in Rottweil (Baden-Wuerttemberg), where aforesaid elevator technology is tested, has been conducted. (Touristic) visitors of the tower and the observation platform on it have been surveyed a standardized questionnaire.

**Results:** The results have shown that the average tendency of prospective conceivable users tends to be free of concerns. In addition, a share of about one-sixth has both expressed and concretized concerns. Those relate mainly to new characteristics of this elevator technology – absence of ropes, magnetic levitation, magnetic field presence – partially associated with known aspects such as power loss.

**Conclusion:** The study provides an explorative contribution to the topic described. Thusly it seems to be particularly interesting for both researchers willing to look further at this or similar areas and manufacturers or future clients of the technology in the context of, for instance, communicating its prospective implementations.

**Keywords:** Maglev Elevators, Concerns of Use, Multi, Prospective Use, Safety

## INTRODUCTION

A levitation system based on magnetic levitation technology, which is intended to enable vertical as well as horizontal movement of cable-free elevator cars, has lately been attracting attention in industry, mobility sector and public. Based on the principle of the paternoster, the elevator system should allow several cabins to circulate independently of each other in a shaft circuit. According to its German developer the innovation can be an important factor influencing future mobility in cities in the context of advancing urbanization and rising skyscraper construction [1].

At the time of this study (November/December 2017) tests were carried out in a company-owned elevator test tower in Rottweil (Baden-Wuerttemberg) [2]. Yet,

no persons were allowed to ride in tested prototypes, since qualifying certifications were still outstanding [3, 4].

Safety aspects are generally considered to be one of the main challenges in the realization of the technology as new systems and interaction “beyond known concepts [5]” are necessary. Accordingly, when promoting the magnetic levitation elevator phrases like „Fokus auf Sicherheit“ [6] („focus on safety”) or safety as „Schlüsselbegriff [7]“ („key term”) are used.

While the general public was dominated by enthusiasm for the progress made possible through this elevator innovation, aspects of safety regarding the potential use occasionally sparked concerns in editorial reports. Accordingly, the following question appeared to be in need of an answer:

**Are potential users of magnetic levitation elevators concerned about the safe use of these elevators and, if so, what kind of concerns exist?**

In a scarcely considered scientific field this work – hereafter presented in highly compressed shape – should enable to formulate a first objective assessment regarding the existence of concerns and their possible manifestations.

## METHODOLOGY & THEORETICAL APPROACH

In order to handle the topic adequately, the survey was chosen as the central methodology. More specifically, a three-day quantitative empirical investigation – realized by a standardized face-to-face questionnaire – was carried out to visitors of above-mentioned elevator tower in Rottweil.

Basically – not excluding own researching resources as a cause – no scientifically founded state of research on explicitly considered subject matter seemed to exist. Hence, it was necessary to both gain orientation on the basis of helpful theoretical topics and, in particular, develop guidelines as well as circumstances for the survey itself. In Figure 1 presented key content for the questionnaire arose based on findings from known concerns regarding elevator use, of the value of safety in the exercise of mobility, of technology acceptance tendencies and of individual risk assessment for the use of (new) mobility technologies – combined with an analytical consideration of the central issue.

Results of the subconscious and intuitive assessment of the use by a semantic polarity profile as well as of the open and concrete questioning of possible concerns should enable an answering of the central issue.

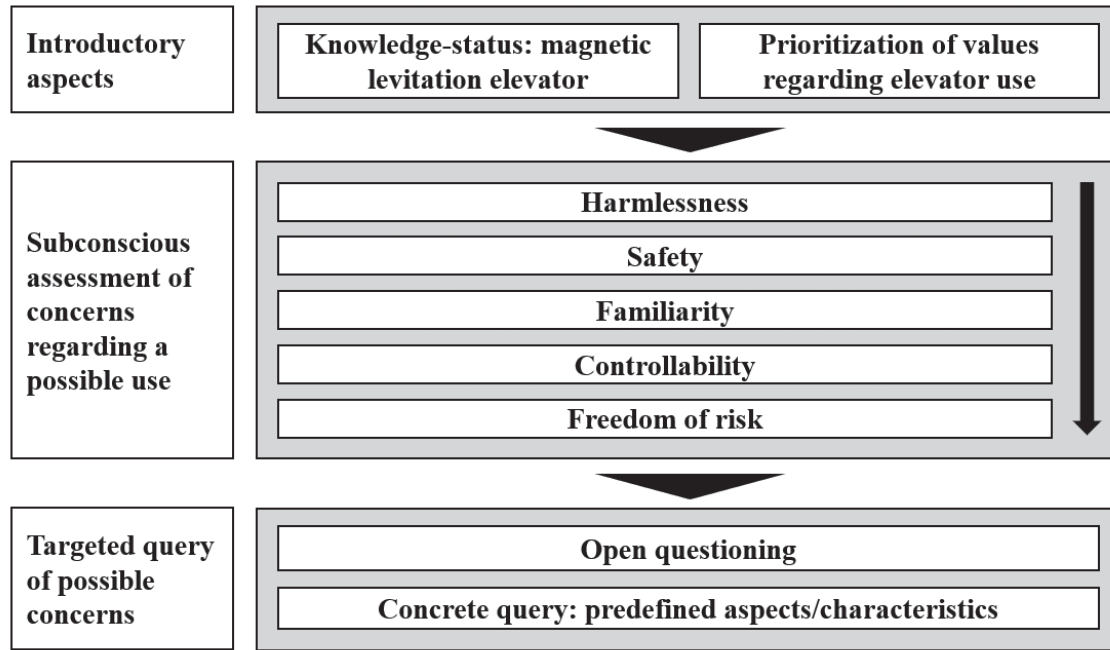


Fig. 1. Substantial-chronological structure of the questionnaire

## CONDENSED RESULTS

In total, 197 persons were questioned the complete questionnaire – almost two-thirds had already heard of the magnetic levitation elevator.

Central aspects of the survey revealed the following compressed discussion approaches and results, thematically depicted according to predefined guiding questions.

- How important is the personal value of safety regarding the use of elevators?

Among five predefined values, safety was rated as the most important value in elevator driving by 50.2 % of the sample size. Furthermore, for 24.4 % of the respondents it was the second most important value while another 25.4 % put at least two other values above safety.

Thusly, in the overall trend safety appeared to be the dominant feature by some margin followed by speed, availability, ride comfort and cabin design. The findings suggested that a large proportion of potential users of maglev elevators would prefer safety against effectiveness and/or efficiency. Above all, ‘being safe’ or ‘feeling safe’ combined with ‘moving quickly and ideally immediately’ seems to be important to many people in terms of elevator usage.

- How does the average potential user subconsciously assess a possible ride with the maglev elevator regarding personal concerns?
- Are there any differences regarding concerns among potential users and, if so, how do they share proportionally?
- Are there any connections between a subconscious assessment of concerns and their concrete questioning and, if so, which ones?

As Fig. 2 shows, respondents rated a potential ride with the magnetic levitation elevator as rather harmless with a slight tendency towards the middle. Furthermore, a possible trip was averagely considered fairly safe. Beyond that, interviewees estimated a potential usage between undecided and rather unfamiliar with a slight bias towards the former. Irresolution was dominating in terms of the ‘controllability’ while the sample average, slightly tending towards the middle, estimated a conceivable ride as rather risk-free.

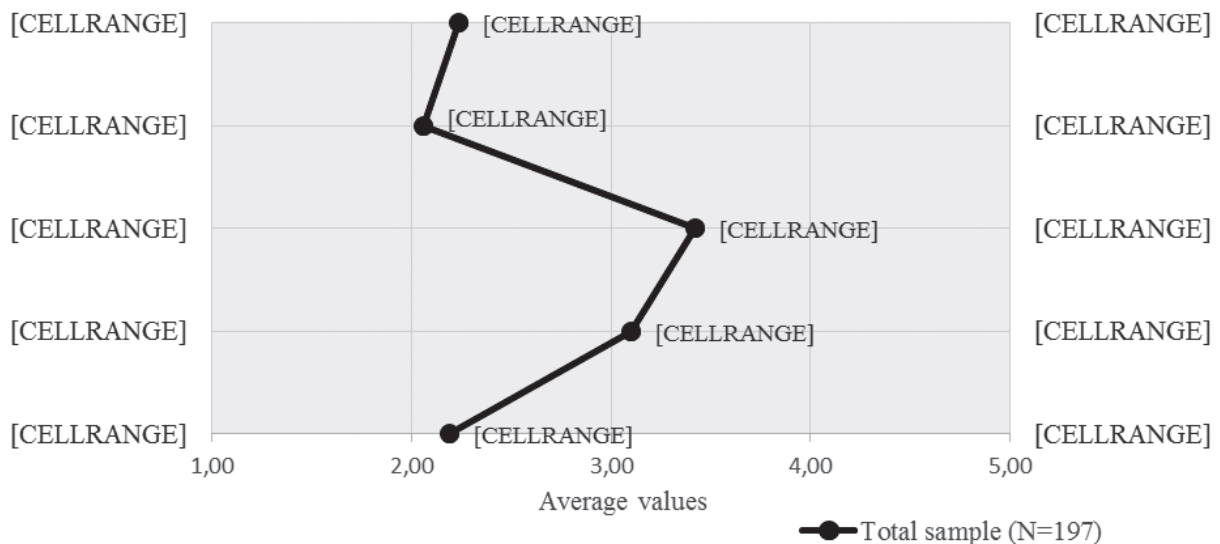


Fig. 2. Semantic profile of the total sample (N = 197)

Question: „Please assess from your perspective a possible ride with the magnetic levitation elevator by using the following contrastive pairs“

Further analysis showed that the personal assessment of the ‘harmlessness’, ‘safety’ and ‘freedom of risk’ are positively linked in terms of judging a potential trip with a magnetic levitation elevator. Therefore – with a moderately correlated interrelation ( $r = 0.586$ , significance level 0.01) – respondents appear to be more likely to assess a possible use as rather safe if they also consider it to be rather harmless (and contrariwise). Similar statements can be made regarding the other connections of this triumvirate of dimensions.

In addition to the consideration of these overall trends, possible categorical differences should be taken into account via an individual calculation methodology.

Relating to the polarity profile as in Table 1, the results of each questionnaire were determined using the following formula:

$$y_n = (x_{n1} + x_{n2}) * 1.0 + (x_{n3} + x_{n4} + x_{n5}) * 0.5$$

Table 1. Logic for the individual calculation methodology

	$x_n =$	2.0	1.0	0	-1.0	-2.0		Weighting
$x_{n1}$	harmless	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	worrying	*1.0
$x_{n2}$	safe	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	unsafe	*1.0
$x_{n3}$	familiar	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	unfamiliar	*0.5
$x_{n4}$	controllable	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	uncontrollable	*0.5
$x_{n5}$	riskless	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	risky	*0.5

Scores ranging from  $y_n = 7.0$  to  $y_n = -7.0$  were possible and every respondent could be assigned according to predefined categories of concerns. The outcome can be seen in Fig. 3.

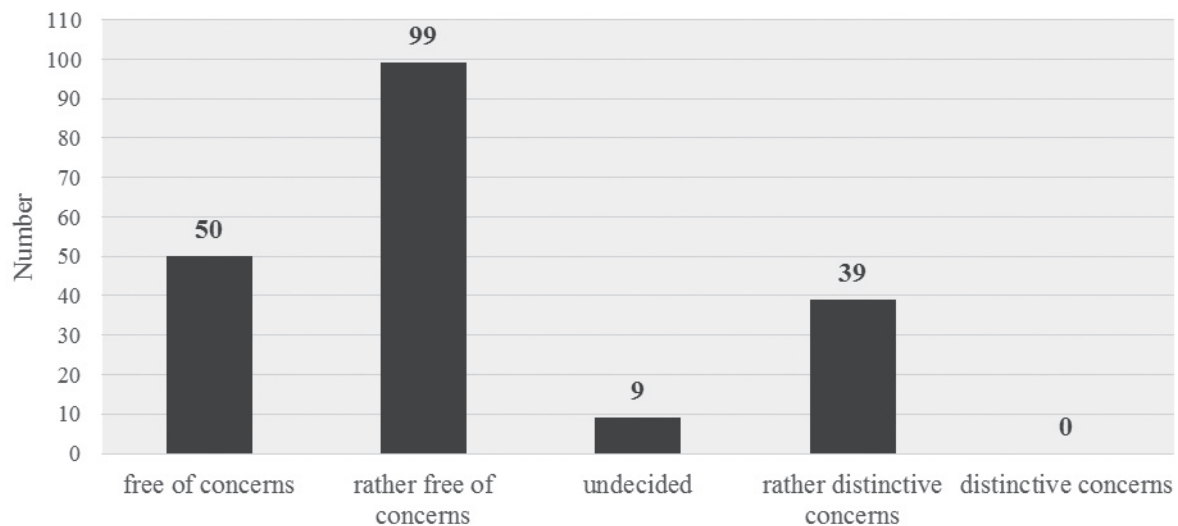


Fig. 3. Individual consideration of the total sample (N=197)

In total, 25.4 % could be classified as persons who seemed fundamentally free of concerns on the basis of their subconscious assessment. 50.2 % appeared to be rather free of concerns while nine persons fell into the category 'undecided'. Above that, 19.8 % of the sample appeared to have subconsciously expressed rather existing concerns by answering the polarity profile. Whereas apparently nobody

showed strong concerns the following needs to be noted: an application of the calculation to the total sample resulted in a categorization as ‘rather free of concerns’.

Deeper analyzes have shown that among people with quite pronounced concerns in about four out of five were able to express these in concrete, thus to substantiate them.

- Which quantitative and qualitative characteristics can be determined by an open questioning of concerns? Are concerns expressed and, if so, which ones?

The open questioning resulted in approximately one-third really concretizing aspects with more than half of them already being categorized as not free of misgivings. Below both causes for as well as manifestations of concerns are described.

Most frequently articulated were misgivings regarding suspected effects of power failure on the magnetic field stability (eleven times), followed by the absence of ropes (nine times) and doubts over the influence of magnetic fields on health (six times) of especially regular users and particularly on people with pacemakers (eight times). Furthermore, on a shared fourth place (six times each) felt uncertainty due to the innovation of the technology and therefore general risks associated with it as well as unspecified concerns relating to power loss would be expressed.

Followed by general doubt over the stability of such magnetic levitation (four times), concerns thanks to the pending cabins as well as felt uncertainty due to lacking knowledge about the technology itself and concerns relating to aspects of driving comfort came up as the divided eight place (three times each) of the most frequently mentioned aspects.

Eventually, with either two or less nominations followed: doubts about the technical/electrical functionality of the system; concerns over possible collisions or crashes of cabins; misgivings towards assumed possibilities of technical influence by “cyber-attacks”; reservations due to assumed negative leverage of magnetic field presence on electronic devices owned by users of the elevator.

- How are concrete and new aspects of magnetic levitation elevator technology assessed with regard to possible concerns?

Tangible aspects which seem to be novel to the user were – as Fig. 4 shows – all on average considered to be largely unobjectionable, especially the



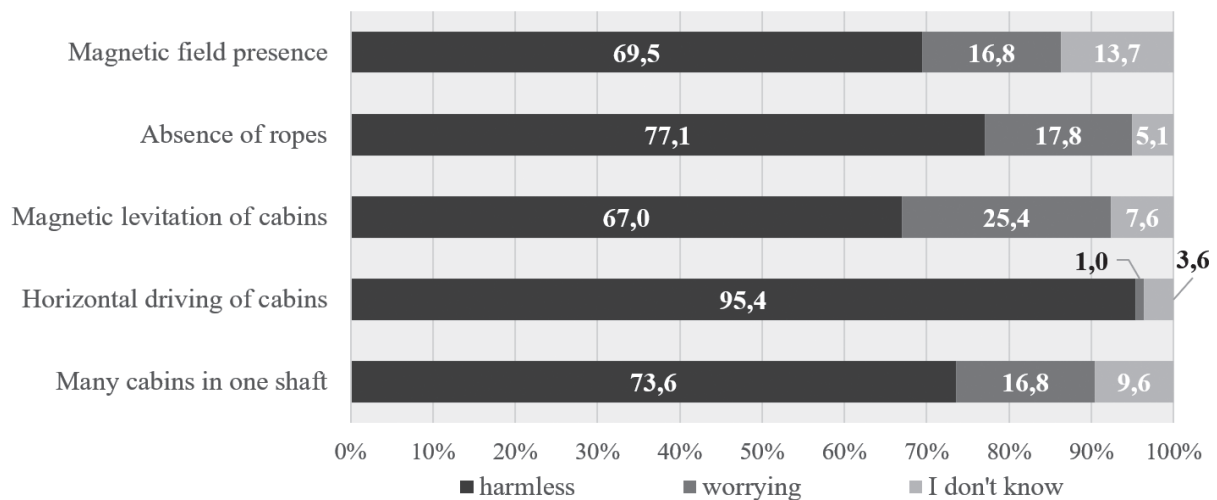


Fig. 4. Evaluation of predefined characteristics (N=197)

**Question:** How do you assess the following aspects of the magnetic levitation elevator?

locomotion of elevator cars in the horizontal. Nevertheless, there were proportionate differentiations. The presence of magnetic fields, a large number of circulating cabins in the elevator shaft and the absence of cables appeared to be of concern by averagely about one-sixth, while the levitation of the cabins by magnets was considered to be the comparatively most alarming aspect.

Specially, Magnetic levitation of cabins' as well as "Absence of Ropes" could be ranked and defined as significant and correlative content-related ( $r = 0.592$ ; level of significance 0.01) reasons for concerns. This relationship appears logical since both aspects are often highlighted in public reporting and appear to be related to one another: the lack of ropes results in a certain way from their replacement by the linear motor technology – ergo by 'magnetic levitation'.

## CONCLUSION

At the time of this study potential users in the overall trend appeared to be rather free of concerns about the safe use of magnetic levitation elevators. However, by an individual differentiation of this general bias, people with more pronounced concerns could be identified.

On closer inspection about a half of potential users could be categorized in said average trend, in about a quarter as completely free of misgivings and a small proportion as undetermined. As a result of subconsciously expressed reservations and clarification of concerns through naming, just under a sixth of potential users seem to have specific, significant concerns. After final compression of the data, those consist mainly of the following contentual nature:

- Health-related concerns due to suspected magnetic field presence
- Feelings of uncertainty due to mental perception of absence of ropes
- Concerns raised due to the magnetic levitation of the cabins, in particular with regard to doubted stability of the magnetic fields
- Uncertainty about possible effects of power outages in general and with regard to the stability of magnetic fields and cabin-maintenance

Using elevators has become part of everyday life for many people. Although there may be misgivings about conventional elevator systems, people have become accustomed to the use of elevators as a means of transportation – including potential disadvantages or perceived risks. This might be caused by the fact that characteristics and general conditions of the technology have changed little for a long time.

However, the magnetic levitation elevator technology will bring some new framework conditions whose actual perceptibility during the use itself remains to be seen but which are mentally both perceivable and conceivable for potential users.

While a large share of people in this respect seem to be free of thought, for some especially new characteristics and associated perceptions with it appear to lead to thoughts and assessments which primarily differ from traditional feelings related to elevators and partly eventuate in actual concerns.

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