Mental imagery and height interpretation bias after virtual reality height exposure

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Abstract

Literature shows that there is a link between mental imagery and overestimating heights which could potentially make heights more frightening and increase acrophobia symptoms. Understanding the relationships between height interpretation biases, mental imagery and fear of heights, is essential in improving interventions to treat these symptoms. The purpose of this research was therefore to investigate whether VR height exposure cues can influence mental imagery and height interpretation biases in individuals with elevated levels of fear of heights. A multiple baseline design was used. Three participants were screened and upon meeting the inclusion criteria filled out the acrophobia questionnaire, the height interpretation questionnaire and the fear of heights mental imagery scale for 11 to 13 days in a row. During this time participants were exposed to two VR height exposure cues. It was found that acrophobia symptoms decreased following the VR height exposure cues in each participant. Mental imagery and height interpretation biases decreased in participant one and three, but not in participant two. Falling related mental imagery decreased in participant one and three also, but again not in participant two. Each participant noted that they experienced mental imagery in the first person perspective. This pilot study provided the important first step to investigate the effect of VR exposure cues on height interpretation biases and mental imagery and found that height interpretation bias and mental imagery decrease after VR height exposure cues in individuals who are very fearful of heights.

Keywords: fear of heights, acrophobia, mental imagery, height interpretation bias, multiple baseline design

Mental imagery and height interpretation bias after virtual reality height exposure

"Fear of heights is a distressing phenomenon accompanied by individually varying amounts of anxiety and vegetative symptoms at the sight of towers, ladders, bridges, cliffs, or mountain ridges. It occurs when a visual stimulus causes apprehension of losing one's balance (control of stance and gait) and falling from some height" (Brandt & Huppert, 2014). Within fear of heights the term acrophobia is used to refer to a clinically relevant specific phobia of heights according to the classification of the Diagnostic statistical Manual of Mental Disorders, 5 (DSM-5) (American Psychiatric Association [APA], 2014). Prevalence of fear of heights is 28% whereas prevalence of acrophobia is only 3-6% (Huppert et al., 2020). It might seem redundant to say but fear is a big part of both subclinical fear of heights and acrophobia. In fact, Wuehr and colleagues (2019) found that fearfulness was with 70% one of the most common symptoms during height exposure besides instability of stance (70%). Besides that, there can also be symptoms of inner agitation (61%), queasy-stomach feeling (48%), sweating (39%), to-and-fro vertigo, palpitations, weakness in the knee (all 26%), light headedness (22%), and trembling (17%). Considering these symptoms it is not surprising that fear of heights and acrophobia can have a considerable impact in the daily life of those afflicted (Schläffler et al., 2014).

One concept that plays a role in many other anxiety driven disorders is mental imagery. The literature shows that mental imagery is related to anxiety related disorders such as social phobia, post-traumatic stress disorder, specific phobia of vomiting, and non-anxiety related disorders such as depression, schizophrenia and bipolar disorder (Clark & Mackay, 2015; Homer & Deeprose, 2017; Oertel et al., 2009; Pearson et al., 2013; Petit et al., 2021; Price et al., 2012; Schwarz et al., 2021). Mental imagery can be explained as "the experience of "seeing" with the mind's eye" which can be either voluntary or involuntary (Salge et al., 2021). A more vivid imagery is linked to a more sensory-like experience according to Salge and colleagues. Which is to say, more vivid imagery can make experiencing with the mind's eye feel more real. Pearson (2019) describes it as a weak form of perception. Moreover, mental imagery is thought to be related to emotion (Petit et al., 2021). Holmes and Matthews (2005) investigated this by having participants focus on an unpleasant situation either verbally and semantically or by picturing it. They found that those who imagined the situation experienced more anxiety and emotionality than those who thought about the situation verbally and semantically. . Nelis and colleagues (2012) likewise found evidence for the positive emotions that mental imagery can provoke. They found that there was a greater positive affect change after positive mental imagery than after positive verbal thinking. On

top of that, Wicken and colleagues (2021) found that a lack of visual imagery in individuals with aphantasia resulted in dampened emotional responses when reading fearful scenarios thereby providing evidence for the emotional amplification theory of visual imagery. So, mental imagery plays a role in emotional responses and can therefore maintain or reduce the severity of emotion based disorder. It is important to note that some images may evoke more emotions than other (Holmes & Mathews, 2010). That is to say, the emotion is influenced by the perspective from which a mental imager is viewed. Adopting a first person perspective has been found to induce more emotion than adopting a third person perspective (Holmes & Mathews, 2010). Franzen (2020) found that the vast majority of individuals with high levels of fear of heights used a first person perspective in mental imagery. Use of this first person perspective may increase the experience of anxious emotions. The relation between mental imagery and anxiety is important since treatments such as cognitive behavioural therapy often focus on thoughts and behaviour and can sometimes overlook mental imagery (Petit et al., 2021). However, it can be concluded that mental imagery can play a big role in the experiencing and maintenance of anxiety and should therefore be taken into account not just on an individual level but also in research.

Research has also found that there is a link between mental imagery and overestimating heights which could potentially make heights more frightening and increase acrophobia symptoms (Clerkin et al., 2009; Stefanucci et al., 2012). A good height related example can be found in the research by Clerkin and colleagues (2009) where they found that individuals overestimated heights more after imagining themselves falling, particularly when they were already fearful of heights. Dijkstra and colleagues (2021) try to explain this link between imagery and perception by hypothesizing that self-generated imagery sensory signals can be confused for actual perception which basically means that imagery senses can be mistaken for the perception of reality. This explanation of imagery links to Pearson's (2019) description of imagery as a weak form of perception. It follows that mental imagery is able to change perceptions and therefore interpretations of height related situations. Research by Steinman and Teachman (2011) confirms that there are biased interpretations in acrophobic individuals. They found that acrophobic individuals have biases in interpretation and judgment in general such that they overestimate danger and question their ability to cope with height related anxiety. Up until now the number one way to treat fear of heights is through exposure therapy (Steinman & Teachman, 2014). According to Hofmann (2008) exposure therapy is a form of cognitive intervention that specifically changes the expectancy of harm. It would therefore be likely that exposure could also change height interpretation biases, but

there is no reason to assume exposure would decrease the appearance of mental imagery.

Lately, an up and coming way to treat but also research fear of heights is to use Virtual Reality (VR) environments. This way individuals can be exposed to heights without the actual danger and at much more convenience. VR can be an analogy to in vivo exposure. For instance, Gromer and colleagues (2018) show that VR can be used to trigger phobic fear in acrophobic patients. Also, according to Bzdúšková and colleagues (2022) exposure to heights in a VR environment evokes a realistic experience accompanied by psychological distress which is enhanced in individuals with fear of heights. These treatment options, whether they are in vivo or in VR do not focus explicitly on mental imagery or height interpretation biases even though these factors might play a role in the experience and maintenance of fear of heights. That is why it is important to investigate the relationship between exposure, mental imagery and height interpretation biases. This pilot study therefore aims to investigate how mental imagery and height interpretation biases respond to VR height exposure cues. Since mental imagery and interpretation biases can potentially make heights more frightening it is important to know how these factors respond to VR height exposure cues. Understanding the relationship between height interpretation biases, mental imagery and fear of heights, can help to sharpen existing interventions to treat these symptoms. The following hypotheses will be investigated:

1. Do VR height exposure cues influence height interpretation biases?

Hypothesis 1: it is hypothesized that height interpretation biases will decrease after being exposed to VR height exposure cues. This is hypothesized since Hofmann (2008) concluded that exposure therapy is a form of cognitive intervention that specifically changes the expectancy of harm and would therefore likely change negative height interpretation biases.

2. Does VR height exposure influence the appearance of mental imagery?

Hypothesis 2: It is hypothesized that VR exposure will lead to an increase of mental imagery concerning heights. For a lack of empirical evidence this is hypothesized based on the theory that (height related) situations will activate visual perception and the visual memory network which will create a mental image of the situation (Kosslyn et al., 2003).

Besides this, it will be explored whether the appearance of mental imagery concerning falling will or will not change after being exposed to VR height exposure cues. Exposure is not known to change mental images and very specific images about falling are not included during the exposure cues either, however exposure is known to decrease fear of heights and if mental images of falling are connected to this they might decrease too.

3. Does mental imagery take place in the first person or third person perspective?

Hypothesis 3: it is hypothesized that mental imagery takes place in the first person perspective. This is hypothesized based on results from Franzen (2020) where 42 participants used a first person perspective compared to 2 participants who used a third person perspective.

Methods

Participants

To select participants a screening instrument was developed. Participants were screened on three height related situations to ensure they experienced at least some difficulty concerning anxiety and avoidance of heights. The screening instrument is further explained in the materials section of this study. Only when participants scored above the cut off values of the screening instrument were they included in the research. Participants aged 18 and up were eligible to participate. A priori exclusion criteria were when participants did not identify with having fear of heights or when they were unable to enter the virtual reality environment. Participants were obtained via (online) marketing, social networks of the researcher and/or SONA systems of Utrecht University. There were three participants included in the multiple baseline design. The first participant was a 56 year old woman. The second participant was a 24 year old woman. The third participant was a 57 year old woman. All of them gave written informed consent. The Ethics Committee of the Faculty of Social Sciences from Utrecht University gave ethical approval (FETC17-103).

Materials

Screening instrument

To screen potential participants a screening instrument (Qualtrics) with 7-point Likert scale was used. Potential participants were presented with six statements concerning three situations on both avoidance and anxiety. The items assess how anxious participants would be in daily height related situations and the extent to which participants would avoid these height related situations in daily life. They were asked to answer to what extent they agreed with the statements. Respondents scoring a 5 or higher on each anxiety and avoidance statement (on a scale ranging from 1 = completely disagree and 7 = completely agree) were eligible to participate. Included participants had a mean score between 5.83 and 7 on the screening instrument with no discernible difference in scores between anxiety and avoidance statements. The screening instrument has been attached in Appendix A.

Demographics

Participants were asked about their age, sex and to what extent they believe they think either visually, verbally, both or they do not know. There are other more reliable

measures to test visual versus verbal thinking styles but they are beyond the scope of this study (Warford & Kunda, 2018). Besides that, participants were asked about the content of their mental imagery after each of the two virtual reality sessions. Finally, participants were asked whether when they see mental images like this they see them from the first person perspective, third person perspective, both or whether they do not know.

Acrophobia

To determine the presence and severity of a participants' acrophobia a translated version of the Acrophobia Questionnaire (AQ) was used (Cohen, 1977). The AQ consists of 40 items within two subscales concerning anxiety and avoidance. The anxiety subscale consists of 20 height related situations that participants have to rate on a 7-point Likert scale ranging from 0 (not at all anxious) to 6 (extremely anxious). The avoidance subscale consists of the same 20 height related situations where participants have to rate their avoidance on a 3-point Likert scale ranging from 0 (would not avoid doing it) to 2 (would not do it under any circumstances). Possible scores for the anxiety subscale range from 0 to 120 and for the avoidance subscale range from 0 to 40. Baker and colleagues (2010) reported that the AQ has adequate internal consistency, good test-retest reliability and good convergent validity.

Fear of Heights Mental Imagery

To measure mental imagery concerning fear of heights the goal was initially to create an adjusted questionnaire based on the Dutch version of the Spontaneous Use of Imagery Scale (SUIS; Reisberg et al., 2003; Nelis et al., 2012). Adjusting the items of the SUIS to fit height related situations proved unsuitable. Therefore, new items on height related situations were created instead. The Fear of Heights Mental Imagery Scale (FohMIS) was developed for this study based on fearful mental imagery concerning height related situations. The scale consist of 8 items within two subscales: imagining heights and imagining falling. An example of a height related item is "When I think of a view point on a mountain, I see the depth beyond the railing" and an example of a falling related item is "When I am at the top of a high staircase, I can picture myself falling from it". The participants were asked to report to what extent the statements apply to them on a 5-point Likert scale ranging from 1 (doesn't apply) to 5 (applies very much). The FoHMIS has been attached in Appendix B.

Height Interpretation bias

The height interpretation bias was measured with a translated version of the height interpretation questionnaire (HIQ; Steinman & Teachman, 2011). The questionnaire is translated to Dutch and translated back to English to ensure the meaning of the questionnaire remained the same. The translation can be found in Appendix C. The scale is designed to

measure height fear relevant interpretations bias and to assess the relationship between biased interpretation and acrophobia symptoms. It consists of 16 items about two height related situations: climbing a ladder that is leaning against the side of a two story house and being on a balcony on the 15th floor of a building. Within these 16 items there are four factors: dangerousness of being on a balcony, dangerousness of climbing a ladder, physical consequences of anxiety, and emotional consequences of anxiety. The participant is asked to report how likely they find it that an item would come true on a 5-point Likert scale ranging from 1 (not likely) to 5 (very likely). Total scores range from 16 to 80 with higher scores indicating more interpretation biases. Internal consistency of the original HIQ has been found to be good with α ranging from .86 to .89 (Steinman & Teachman, 2011).

Virtual Reality equipment

For the virtual reality exposure intervention an Oculus Rift S was used on a Windows 10 x64 computer. The VR environment that was used is a replica of a concertbuilding in Amsterdam: the Muziekgebouw aan 't IJ and had 6 degrees of freedom (DoF) which means that participants were able to move inside the environment. In Figure 1 to 4 the positions that participants were exposed to can be seen. These positions are further elaborated on in the procedure section. Participants were exposed to each position for about three to five minutes in which they were able to set a step or two in any direction and experience 360 degrees of the environment.

Figure 1

Accustom position in the VR environment

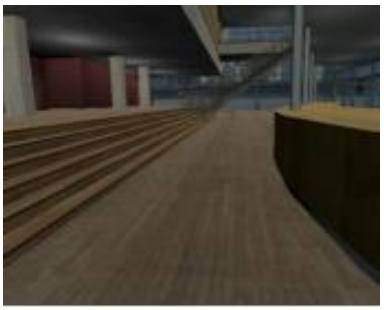


Figure 2

First height position in the VR environment

Figure 3

Second height position in the VR environment

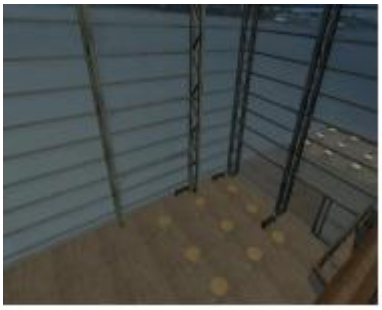


Figure 4

Third height position in the VR environment

Procedure

Participants were screened on anxiety and avoidance concerning heights using screening questionnaires via an online survey in Qualtrics (see Appendix A). Three eligible participants then completed baseline measurements consisting of the translated Acrophobia Questionnaire (AQ; Cohen, 1977) to assess fear of heights, the Fear of Heights Mental Imagery Scale (see Appendix B) to assess mental imagery concerning fear of heights, and the translated heights interpretation questionnaire (HIQ; Steinman & Teachman, 2011; see Appendix C) to assess heights interpretation biases. After having filled in the baseline measurements via Qualtrics, VR height exposure cues started for each of the participants after a different amount of time. The first participant filled in the baseline measurement 5 times, the

second participant 6 times and the third participant 7 times. All participants underwent two VR height exposure cues. The VR height exposure cues started with an accustoming phase. The accustom position was set on ground level with no clear views of heights (while looking down or up). The participant stood on the ground floor underneath a ceiling. The participant was then asked to slowly turn around, look around and describe what they see. They remained in this position for about 2 to 3 minutes or longer if they need to get used to the environment. Next there were three height related positions. The first height position was situated on the first floor of the building where participants were instructed to set foot on a glass floor and to look down to the restaurant area underneath. The second height position was situated on the third floor of the building near the railings of the balcony. There were railings in the lab room that corresponded to the railings in the VR environment. The third position was outside the building on the terrace and near the water that seems to be a couple foot down the dock. In this position participants were also able to look up and see the height of the building. In all positions participants were again asked to slowly turn around, look around, look down and describe what they see. In the second height position they were also asked to grab the railing and bend over it to look down. They remained in these positions for about 3 to 5 minutes each and after the initial look around they were asked to focus on ground level except in the third position where they were also asked to look up to the building.

Study design

This study used a multiple baseline design between subjects. "In a multiple baseline design, researchers stagger their introduction of an intervention across a variety of individuals, times, or situations to rule out alternative explanations" (Morling et al., 2017). In this multiple baseline design the introduction of the VR height exposure cues was staggered across three participants.

The baseline measurement was completed five times for the first participant, six times for the second participant and seven times for the third participant. Establishing a baseline in this manner eliminates the risk of outcome scores regressing to the mean and thereby increases internal validity (Morley, 2017). Participants also filled in each of the assessments three times after each VR height exposure cue. Increasing the number of measurements in this way can help to consider and eliminate various explanations about change and discover systematic changes in the pattern of data between individuals (Morley, 2017).

Data analysis plan

When data has been collected all analyses will be performed using SPSS statistics 28 and Excel. Since this study uses a multiple baseline design there has been no a priori

statistical power analysis. In line with Morley (2017) visual analysis of the data will take place. Data preparation and inspection will be executed first. Then total scores will be calculated and plotted into graphs based on the time of each measurement. Visual analysis of the response to VR height exposure cues will be conducted for each participant on mental imagery, height interpretation bias and acrophobia symptoms.

Results

Participants

The sample consisted of three female participants aged 56, 24 and 57. Two of the participants worked parttime, the other was a student. Descriptive statistics of the baseline measurements on acrophobia, height interpretation bias and mental imagery are presented in Table 1. For reference, Steinman and Teachman (2011) used cut-off scores for the AQ set on 45.45 for anxiety and 8.67 for avoidance. These numbers are one standard deviation below the mean of a previous acrophobic sample. Baseline measurements of all participants scored above these cut-off scores.

Table 1

Descriptive statistics of the baseline measurements on acrophobia, height interpretation bias and mental imagery for participant 1, 2 and 3

Participants	AQ						HIQ		Fohmis	
	Total		Anxiety		Avoidance					
	M	SD	M	SD	M	SD	M	SD	M	SD
Participant 1	142.8	4.38	98.6	3.36	44.2	1.30	54.2	3.70	30.6	2.79
Participant 2	89.3	1.75	60	2.28	29.3	0.82	51.6	3.98	24.3	0.52
Participant 3	138.4	6.63	97.1	7.40	41.29	0.95	52.1	3.29	32.6	2.37

Participant 1

Visual analysis of acrophobia scores show a slight decline as can be seen in Figure 5. The same goes for scores on mental imagery and height interpretation bias as can be seen in Figure 7. However the decline of height interpretation bias seems to start before the height exposure cues do. Visual analysis shows that falling related mental imagery specifically declines after the height exposure cues as can be seen in Figure 8.

Figure 5

Mean scores of acrophobia over an eleven day period with height exposure cues taking place after the (baseline) measurement on the fifth and eighth day

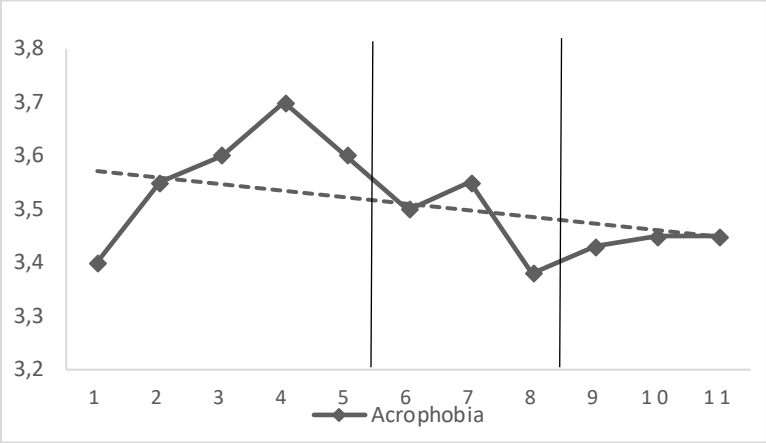


Figure 6

Mean scores of mental imagery and height interpretation bias over an eleven day period with height exposure cues taking place after the (baseline) measurement on the fifth and eighth day

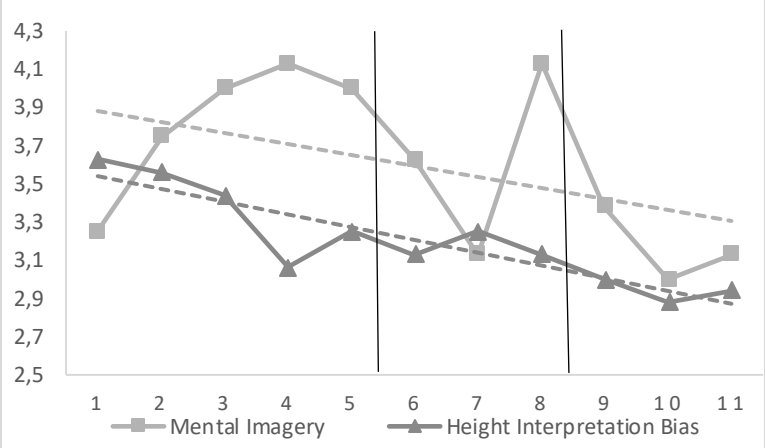
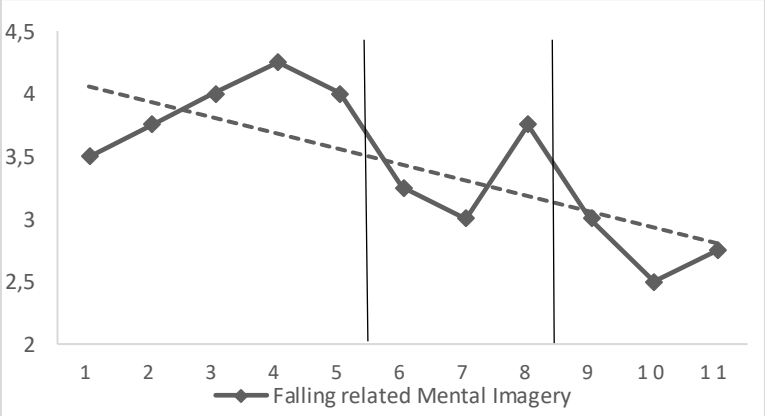


Figure 7

Mean scores of falling related mental imagery over an eleven day period with height exposure cues taking place after the (baseline) measurement on the fifth and eighth day



Participant 1 reported to think both verbally and visually. This participant reported seeing height related mental imagery from a first person perspective.

Participant 2

Visual analysis of acrophobia scores show a slight decline as can be seen in Figure 9. Scores for height interpretation bias seem to increase slightly and scores for mental imagery do not show any change at all as can be seen in Figure 10. Falling related mental imagery specifically does not show any change in scores as can be seen in Figure 11.

Figure 8

Mean scores of acrophobia over a twelve day period with height exposure cues taking place after the (baseline) measurement on the sixth and ninth day

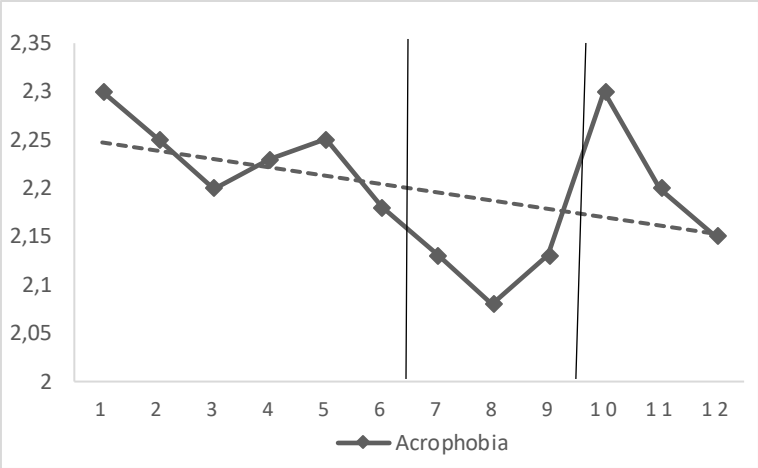


Figure 9

Mean scores of mental imagery and height interpretation bias over a twelve day period with height exposure cues taking place after the (baseline) measurement on the sixth and ninth day

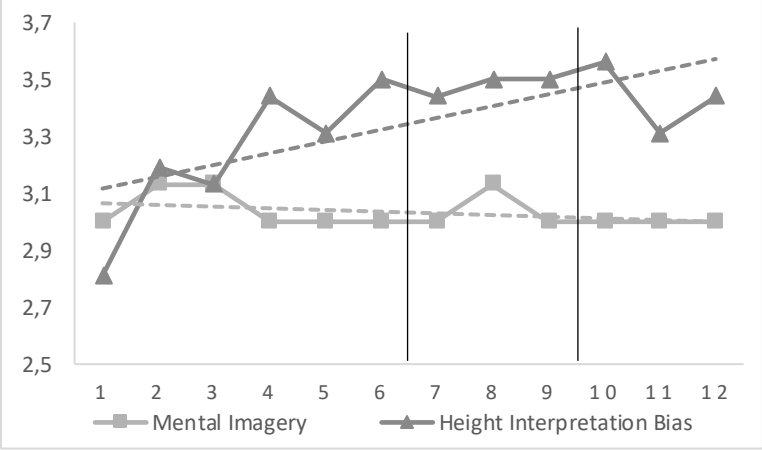
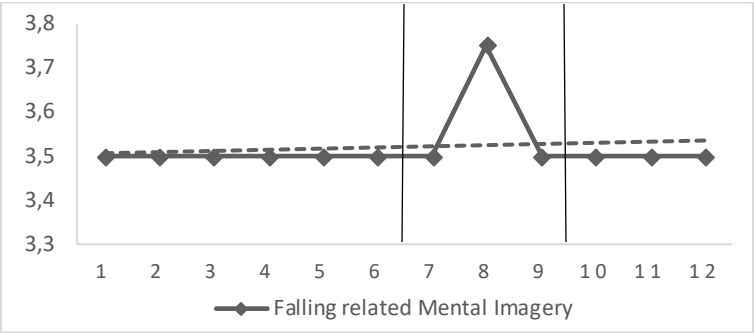


Figure 10

Mean scores of falling related mental imagery over a twelve day period with height exposure cues taking place after the (baseline) measurement on the sixth and ninth day



Participant 2 reported to think both verbally and visually with about 70% being verbal and 30% being visual. This participant reported seeing height related mental imagery from a first person perspective.

Participant 3

Visual analysis of acrophobia scores show a decline as can be seen in Figure 12. Scores on mental imagery and height interpretation bias also show a slight decline as can be seen in Figure 13. Visual analysis shows that falling related mental imagery specifically declines after the height exposure cues as can be seen in Figure 14.

Figure 11

Mean scores of acrophobia over a thirteen day period with height exposure cues taking place after the (baseline) measurement on the seventh and tenth day

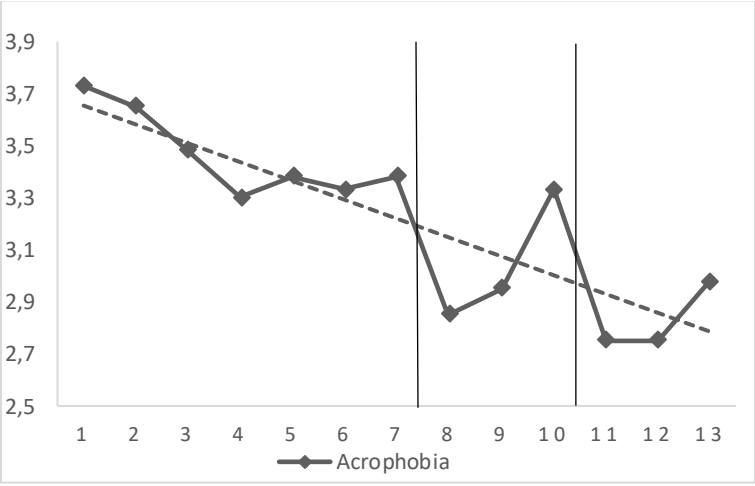


Figure 12

Mean scores of mental imagery and height interpretation bias over a thirteen day period with height exposure cues taking place after the (baseline) measurement on the seventh and tenth day

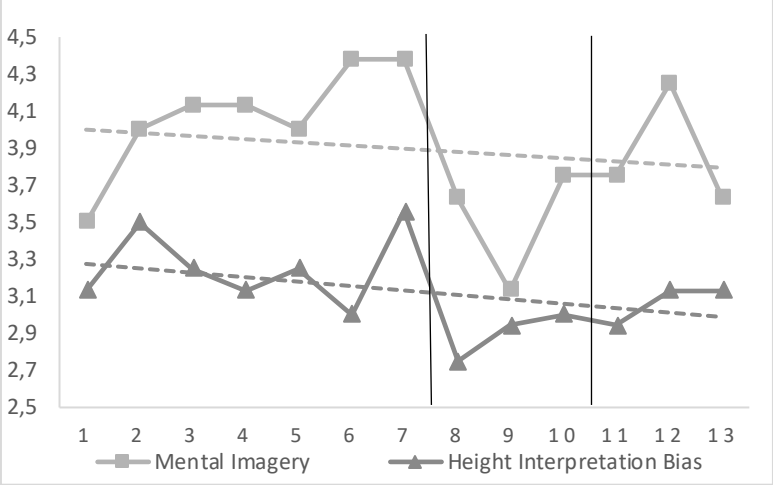
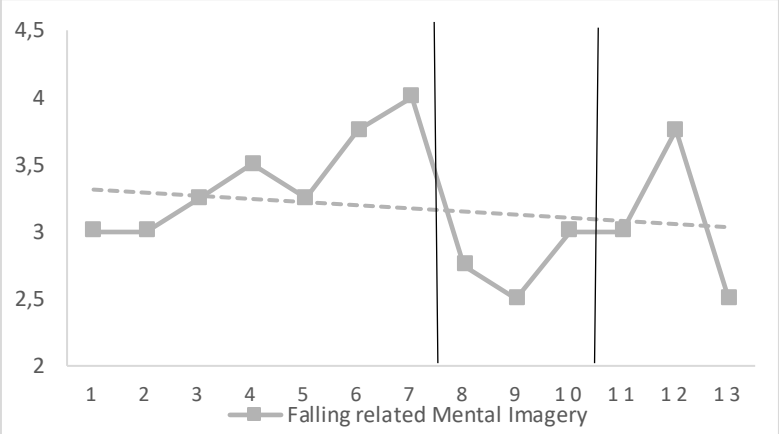


Figure 13

Mean scores of falling related mental imagery over a thirteen day period with height exposure cues taking place after the (baseline) measurement on the seventh and tenth day



Participant 3 reported to think both verbally and visually with about 40% being verbal and 60% being visual. This participant reported seeing height related mental imagery from a first person perspective.

Discussion

The purpose of this pilot study was to investigate how mental imagery and height interpretation biases respond to VR height exposure cues in individuals with fear of heights. It was found that acrophobia symptoms decreased following the VR height exposure cues in each participant, which was in line with the expectations. Mental imagery and height interpretation biases decreased in participant one and three, but not in participant two. Falling

related mental imagery decreased in participant one and three also, but again not in participant two. Each participant noted that they experienced mental imagery in the first person perspective. Notably, participant one and three started with higher baseline measures for acrophobia than participant two. Given this information the hypotheses are answered as follows.

First of all, it has been confirmed in participant one and three, that height interpretation biases decreased after being exposed to VR height exposure cues. However, this was disconfirmed in participant two where there is a slight increase in interpretation bias. Secondly, It has been disconfirmed in all three participants, that mental imagery would increase after being exposed to VR height exposure cues. Participants one and three even showed a slight decrease instead of increase in use of mental imagery. Falling related mental imagery specifically seems to decrease in participant one and three as well, but not in participant two. Lastly, that height related mental imagery takes place in the first person perspective, is confirmed with all three participants.

Against expectations, participants showed a decrease rather dan increase in mental imagery after the VR height exposure cues. For a lack of empirical evidence in the literature the expectation for this hypothesis was based on theory by Kosslyn and colleagues (2003). The results go against their idea that when visual perception and the visual memory network activate, while experiencing VR height exposure cues, mental imagery occurs (Kosslyn et al., 2003). An alternative explanation for this occurrence could be that experiencing mental imagery and experiencing fear is not just a one way street. Not only can mental imagery cause the emotional response of fear, it can also be a symptom of psychopathology for example in the form of flashbacks or intrusions (Ji et al., 2016). According to Hofmann (2008) exposure therapy is a form of cognitive intervention that specifically changes the expectancy of harm. In this case, the VR height exposure cues can be seen as a form of cognitive intervention. When the intervention decreases the expectancy of harm it would decrease fear and symptomatic mental imagery like flashbacks or intrusions.

Also of note is the difference between participant one and three and participant two on height interpretation bias and mental imagery. This difference could be a coincidence but it could also be related to the accompanying difference in initial acrophobia baselines. Participant one and three had higher acrophobia baseline measurements than participant two suggesting that in people with a smaller amount of fear of heights height interpretation bias and mental imagery might play a smaller role in perpetuating the fear. This possible connection between acrophobia symptoms and height interpretation bias or mental imagery is

worth exploring in further research. A clear link would increase the relevance of including these factors in interventions. For instance, if the link between height interpretation bias and acrophobia symptoms is stronger in very acrophobic individuals then this emphasizes the importance of addressing this bias in interventions for this target group in particular. Interpretation bias modification as described in Steinman and Teachman (2014) might be suited as an additional intervention for this target group in particular. Likewise, if the link between mental imagery and acrophobia symptoms is stronger in very acrophobic individuals then this emphasizes the importance of addressing fearful mental imagery concerning fear of heights in interventions for this target group in particular. According to Petit and colleagues (2021) mental imagery is often overlooked in cognitive behavioural interventions. If it turns out that mental imagery plays a bigger role in perpetuating fear of heights in very acrophobic individuals then changing fearful mental imagery should be addressed in interventions for this target group in particular. However, these proposed connections require further research to establish. It could prove beneficial to use quantitative measures to establish whether there is a significant difference in occurrence of mental imagery and height interpretation bias in individuals with high or low levels of fear of heights and whether occurrence of mental imagery and height interpretation bias changes differently for these target groups after a form of exposure intervention.

Finally, in conversations with all three participants after the study they all voiced their believe that the last height related position was on the roof of the building. Participants continued to believe this third position was at great height even after they were explicitly told that they stood on the terrace about two or three meters above the water. This information is in line with findings of Clerkin and colleagues (2009) and Stefanucci and colleagues (2012) on how imagery and fear can influence hight perception to make heights appear higher than they actually are. It also confers with the finding of Steinman and Teachman (2011) that acrophobic individuals have biases in interpretation and judgment in general such that they overestimate danger. On a critical note however, this qualitative information was coincidentally obtained after the procedure and not during. In spite of that, the observation could be worth exploring in further research given that it appeared to be a stubborn conviction that not only relates to mental imagery but overestimation of heights well.

Use of the FohMIS as a new created measure to measure mental imagery concerning fear of heights in particular makes this research stand out. There are no other mental imagery questionnaires that specifically target mental imagery concerning fear of heights and using a ‘generic’ mental imagery questionnaire might not measure what we want to know for

individuals with fear of heights. However, since this is a new instrument that has not been validated yet the use of this instrument is a limitation as well. Further research could focus on validating and improving this instrument. The same is true for the translated version of the height interpretation questionnaire (Steinman & Teachman, 2011). Validation of the translated version of this instrument could improve the use of this questionnaire in further research.

Overall, understanding the relationship between height interpretation biases, mental imagery and fear of heights, is essential in improving interventions to treat these symptoms. This pilot study provided the important first step to investigate the effect of VR exposure cues on height interpretation biases and mental imagery and found that height interpretation bias and mental imagery decrease after VR height exposure cues in individuals who are very fearful of heights. To be able to make a substantiated conclusion on these relationships the key is to investigate this further with bigger samples. Besides that, another promising point of inquiry that has been found is the possible presence of overestimation of heights within mental imagery.

References

American Psychiatric Association (2014). Handboek voor de classificatie van psychische stoornissen (DSM-5). Nederlandse vertaling van Diagnostic and Statistical Manual of Mental Disorders 5th Edition. Arlington: American Psychiatric Association.

Baker, A., Mystkowski, J., Culver, N., Yi, R., Mortazavi, A., & Craske, M. G. (2010). Does habituation matter? Emotional processing theory and exposure therapy for acrophobia. *Behaviour Research and Therapy, 48*(11), 1139-1143. https://doi.org/10.1016/j.brat.2010.07.009

Brandt, T., & Huppert, D. (2014). Fear of heights and visual height intolerance. In *Current Opinion in Neurology, 27*(1), 111–117. https://doi.org/10.1097/WCO.0000000000000057

Bzdúšková, D., Marko, M., Hirjaková, Z., Kimijanová, J., Hlavačka, F., & Riečanský, I. (2022). The Effects of Virtual Height Exposure on Postural Control and Psychophysiological Stress Are Moderated by Individual Height Intolerance. *Frontiers in Human Neuroscience, 15*. https://doi.org/10.3389/fnhum.2021.773091

Clark, I. A., & Mackay, C. E. (2015). Mental imagery and post-traumatic stress disorder: A neuroimaging and experimental psychopathology approach to intrusive memories of trauma. *Frontiers in Psychiatry, 6*. https://doi.org/10.3389/fpsyt.2015.00104

Clerkin, E. M., Cody, M. W., Stefanucci, J. K., Proffitt, D. R., & Teachman, B. A. (2009). Imagery and fear influence height perception. *Journal of Anxiety Disorders, 23*(3), 381–386. https://doi.org/10.1016/j.janxdis.2008.12.002

Cohen, D.C. (1977). Comparison of self-report and overt-behavioral procedures for assessing acrophobia. *Behavior Therapy*; *8,* 17-23. https://doi.org/10.1016/S00057894(77)80116-0

Dijkstra, N., Mazor, M., Kok, P., & Fleming, S. (2021). Mistaking imagination for reality: Congruent mental imagery leads to more liberal perceptual detection. *Cognition, 212*. https://doi.org/10.1016/j.cognition.2021.104719

Dreyer-Oren, S. E., Clerkin, E. M., Edwards, C. B., Teachman, B. A., & Steinman, S. A. (2019). Believing is seeing: Changes in visual perception following treatment for height fear. *Journal of Behavior Therapy and Experimental Psychiatry, 62*, 1–6. https://doi.org/10.1016/j.jbtep.2018.08.001

Franzen, E. (2020). Mental Imagery in Elevated Fear of Heights: a Virtual Reality Study.

Gromer, D., Madeira, O., Gast, P., Nehfischer, M., Jost, M., Müller, M., Mühlberger, A., & Pauli, P. (2018). Height simulation in a virtual reality cave system: Validity of fear

responses and effects of an immersion manipulation. *Frontiers in Human Neuroscience, 12*. https://doi.org/10.3389/fnhum.2018.00372

Hofmann, S. G. (2008). Cognitive processes during fear acquisition and extinction in animals and humans: Implications for exposure therapy of anxiety disorders. *Clinical psychology review, 28*(2), 199-210. https://doi.org/10.1016/j.cpr.2007.04.009

Holmes, E. A., & Mathews, A. (2005). Mental imagery and emotion: A special relationship? *Emotion, 5*(4), 489–497. https://doi.org/10.1037/1528-3542.5.4.489

Holmes, E. A., & Mathews, A. (2010). Mental imagery in emotion and emotional disorders. *Clinical psychology review, 30(3), 349-362*. https://doi.org/ 10.1016/j.cpr.2010.01.001

Homer, S. R., & Deeprose, C. (2017). Voluntary and Involuntary Imagery in Social Anxiety. *Behavioural and Cognitive Psychotherapy, 45*(3), 285–299. https://doi.org/10.1017/S1352465817000017

Huppert, D., Wuehr, M., & Brandt, T. (2020). Acrophobia and visual height intolerance: advances in epidemiology and mechanisms. *Journal of Neurology, 257,* 231–240. https://doi.org/10.1007/s00415-020-09805-4

Ji, J. L., Heyes, S. B., MacLeod, C., & Holmes, E. A. (2016). Emotional mental imagery as simulation of reality: Fear and beyond—A tribute to Peter Lang. *Behavior Therapy, 47*(5), 702-719. https://doi.org/10.1016/j.beth.2015.11.004

Kosslyn, S. M., Ganis, G., & Thompson, W. L. (2003). Mental imagery: against the nihilistic hypothesis. *Trends in Cognitive Sciences, 7*(3), 109–111. https://doi.org/10.1016/S1364-6613(03)00025-1

Morley, S. (2017). Single case methods in clinical psychology: a practical guide. First edition. Routledge. https://doi-org.proxy.library.uu.nl/10.4324/9781315412931

Morling, B., Carr, D., Heger Boyle, E., Cornwel, B., Correl, S., Crosnoe, R., Freese, J., & Waters, M. C. (2017). Research methods. Third edition. Norton & Company.

Nelis, S., Vanbrabant, K., Holmes, E. A., & Raes, F. (2012). Greater positive affect change after mental imagery than verbal thinking in a student sample. *Journal of Experimental Psychopathology, 3*(2), 178-188. https://doi.org/10.5127/jep.021111

Oertel, V., Rotarska-Jagiela, A., van de Ven, V., Haenschel, C., Grube, M., Stangier, U., ... & Linden, D. E. (2009). Mental imagery vividness as a trait marker across the schizophrenia spectrum. *Psychiatry Research*, *167*(1-2), 1-11. https://doi.org/10.1016/j.psychres.2007.12.008

Pearson, J. (2019). The human imagination: the cognitive neuroscience of visual mental imagery. *Nature reviews neuroscience, 20*(10), 624-634.

https://doi.org/10.1038/s41583-019-0202-9

Petit, F., Munuera, C., Husky, M. M., & M'Bailara, K. (2021). Mental imagery in bipolar disorder: A PRISMA-compliant systematic review of its characteristics, content and relation to emotion. *Journal of Behavioral and Cognitive Therapy, 31*(3), 267–284. https://doi.org/10.1016/j.jbct.2021.03.003

Price, K., Veale, D., & Brewin, C. R. (2012). Intrusive imagery in people with a specific phobia of vomiting. *Journal of Behavior Therapy and Experimental Psychiatry, 43*(1), 672–678. https://doi.org/10.1016/j.jbtep.2011.09.007

Salge, J. H., Pollmann, S., & Reeder, R. R. (2021). Anomalous visual experience is linked to perceptual uncertainty and visual imagery vividness. *Psychological Research*, *85*(5), 1848–1865. https://doi.org/10.1007/s00426-020-01364-7

Schwarz, S. M., Feike, M., & Stangier, U. (2021). Mental imagery and social pain in adolescents—analysis of imagery characteristics and perspective—A pilot study. *Children, 8*(12). https://doi.org/10.3390/children8121160

Stefanucci, J. K., Gagnon, K. T., Tompkins, C. L., & Bullock, K. E. (2012). Plunging into the pool of death: Imagining a dangerous outcome influences distance perception. *Perception, 41*. https://doi.org/10.1068/p7131

Steinman, S. A., & Teachman, B. A. (2011). Cognitive processing and acrophobia: Validating the Heights Interpretation Questionnaire. *Journal of Anxiety Disorders*, *25*(7), 896–902. https://doi.org/10.1016/j.janxdis.2011.05.001

Steinman, S. A., & Teachman, B. A. (2014). Reaching new heights: Comparing interpretation bias modification to exposure therapy for extreme height fear. *Journal of Consulting and Clinical Psychology, 82*(3), 404–417. https://doi.org/10.1037/a0036023

Warford, N., & Kunda, M. (2018). Measuring individual differences in visual and verbal thinking styles. In *40th Annual Meeting of the Cognitive Science Society*.

Wicken, M., Keogh, R., & Pearson, J. (2021). The critical role of mental imagery in human emotion: insights from fear-based imagery and aphantasia. *Proceedings of the Royal Society B, 288(1946), 20210267*. https://doi.org/10.1098/rspb.2021.0267

Wuehr, M., Breitkopf, K., Decker, J., Ibarra, G., Huppert, D., & Brandt, T. (2019). Fear of heights in virtual reality saturates 20 to 40 m above ground. *Journal of Neurology, 266*, 80–87. https://doi.org/10.1007/s00415-019-09370-5

Appendix A

Screening instrument

Geef alsjeblieft aan in hoeverre je het met de volgende stellingen eens bent. Antwoord op een schaal van 1 tot 7, waarbij 1 inhoudt dat je er volledig mee oneens bent en 7 inhoudt dat je er volledig mee eens bent.

1. Ik zou liever niet in mijn eentje een ladder beklimmen die tegen een huis aanstaat om de gevel te verven
2. Als ik in mijn eentje een ladder zou beklimmen die tegen een huis aanstaat om de gevel te verven zou ik erg bang zijn
3. Ik zou liever niet in mijn eentje in een hoge boom klimmen (voor tuinonderhoud)
4. Als ik in mijn eentje in een hoge boom zou klimmen (voor tuinonderhoud), zou ik erg bang zijn
5. Ik zou liever niet in mijn eentje in een groot reuzenrad gaan
6. Als ik in mijn eentje in een groot reuzenrad zou zitten, zou ik erg bang zijn.

1- Volledig oneens
2- Oneens
3- Enigszins oneens
4- Niet mee eens of oneens
5- Enigszins mee eens
6- Mee eens
7- Volledig mee eens

Appendix B

Fear of Heights Mental Imagery Scale (FohMIS)

Lees de volgende beschrijvingen en geef aan in welke mate elke beschrijving van toepassing is op jou. Denk niet te lang na over een beschrijving, maar ga op je eerste indruk af. Antwoord op een schaal van 1 tot 5, waarbij 1 inhoudt dat de beschrijving nooit van toepassing is en 5 inhoudt dat de beschrijving altijd van toepassing is.

1. Wanneer ik op een bospad langs een afgrond loop, zie ik visueel voor me hoe ik uitglij en val.
2. Wanneer ik een (niet transparante) lift in een hoog gebouw naar de 16e verdieping neem, dan stel ik me voor hoe hoog ik ben en zie ik de diepte voor me.
3. Wanneer ik aan een uitzichtpunt op een berg denk, zie ik de diepte voorbij de reling voor me.
4. Wanneer ik bovenaan op een hoge trap sta, zie ik voor me hoe ik daar vanaf val.
5. Wanneer ik langs een raam in een hoog gebouw loop, zie ik mezelf daar doorheen vallen.
6. Wanneer ik op een brug (zoals de Erasmusbrug) sta, zie ik visueel voor me hoe hoog de brug is van de zij of onderkant.
7. Wanneer ik een ladder beklim, zie ik voor me dat ik bevries en niet meer naar beneden durf.
8. Wanneer iemand anders langs de rand van een diepte loopt, kan ik voor me zien hoe die ander struikelt en valt.

Items specifiek over vallen: 1, 4, 5, 8

Appendix C

De Hoogte Interpretatie Questionnaire (HIQ)

Je zal worden gevraagd om een gebeurtenis in je hoofd voor te stellen. Denk zoveel mogelijk over jezelf in deze gebeurtenis. Nadat je over de gebeurtenis hebt gelezen, staan er een aantal gedachten over de gebeurtenis opgesomd. Het is jouw taak om aan te geven hoe geloofwaardig elk van deze gedachtes is. Geef niet aan hoe geloofwaardig je denkt dat elke gedachte nu is. In plaats daarvan geef je aan hoe geloofwaardig je denkt dat elke gedachte zou zijn als je in de gebeurtenis zou zijn. Bij elke gedachte kan je op een schaal van 1 (niet waarschijnlijk) tot 5 (heel waarschijnlijk) aangeven hoe waarschijnlijk het is dat de gedachte waar is. Onthoud dat het heel belangrijk is dat je jezelf zo veel mogelijk in de situatie voorstelt.

Situatie #1

Stel je voor dat je een ladder beklimt die tegen de zijkant van een huis met twee verdiepingen staat. Wanneer je van de ene tree naar de andere beweegt, voel je het koude metaal onder je handen. Je komt langs een raam op de eerste verdieping van het huis. Je gaat door met klimmen terwijl je de wind in je gezicht voelt. Je komt langs een raam op de tweede verdieping van het huis. Je kijkt naar beneden en de grond lijkt erg ver weg.

Hoe waarschijnlijk is het dat…

1. Je jezelf pijn zal doen.
2. Je zal vallen.
3. Je niet in staat bent je angst te tolereren.
4. Je in paniek zal raken en controle zal verliezen.
5. Je niet veilig bent.
6. Je zal flauwvallen.
7. Je zal bevriezen en niet meer met de ladder naar beneden kunt klimmen.
8. Op de ladder zijn gevaarlijk is.

Situatie #2

Stel je voor dat je op een balkon staat op de 15e verdieping van een gebouw. Terwijl je de warme metalen reling vasthoud die tot je middel komt voel je de hitte van de zon op je gezicht. Je luistert naar de geluiden van auto's en mensen van beneden. Je kijkt naar beneden en de mensen en auto's op de grond zijn klein en erg ver weg. Zelfs de boomtoppen daar beneden lijken ver weg.

Hoe waarschijnlijk is het dat…

1. Je jezelf pijn zal doen.
2. Je zal vallen.
3. Je niet in staat bent je angst te tolereren.
4. Je in paniek zal raken en controle zal verliezen.
5. Je niet veilig bent.
6. Je zal flauwvallen.
7. Je zal bevriezen en niet meer van het balkon af kunnen komen.
8. Op het balkon zijn gevaarlijk is.