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Delightful Daylighting: A Framework for Describing the Experience of Daylighting in Nordic Homes and Coupling It with Quantitative Assessments

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Abstract: In this conceptual article we propose a framework for describing the experience of delightful daylighting in Nordic homes and a method to correlate it with an existing quantitative daylighting assessment. In contrast to earlier research on daylighting, the present work gives priority to developing the methodology for researching the experience of the inhabitant in a real situation and relying the quantitative assessment on an existing method. In this way, we shift the focus of daylight studies from quantitative evaluations towards qualitative descriptions of the human experience of daylight. The framework enables future research that can broaden the way the experience of daylighting is described and to see if the quantitative assessment according to the standard EN 17037:2018 Daylighting in buildings correlates with these descriptions. Firstly, the current state of research on subjective daylight preferences and daylight assessment is reviewed. Secondly, a novel method, the long-term spatial interview, is introduced. The aim of the method is to describe a long-term experience of a spatial phenomenon, in this case, delightful daylighting of Nordic homes, through a phenomenological perspective and enable localisation of the qualitative research results. Finally, the use of the existing EN-standard as a tool to quantitatively describe the daylight situation of spaces is explained and a correlation analysis of the quantitative and qualitative results is explicated. Future research based on the framework can provide useful information for designers aiming at creating delightful daylighting experiences in Nordic homes.

Keywords: daylight; residential buildings; qualitative research; methodology; human perception; phenomenology; visual comfort; light quality; cold climate; framework; mixed methods

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1. Introduction

Daylighting of residential spaces concerns almost everyone but has been scarcely studied [1,2]. The importance of daylighting in apartments is expected to increase as the time spent at home during the day increases with remote working [3]. Daylight is the most preferred light source by building users [4]. Moreover, daylight has one of the greatest impacts on the atmosphere and aesthetics of space [5] and many famous architects have studied the essential role of daylight for the experience of a space [6–8]. Daylighting affects our perception of space, and according to architects like Peter Zumthor can have almost a spiritual quality [9]. Therefore, there is a need for understanding the human experience of daylighting in residential buildings.

Buildings are often designed and evaluated through research-based study of design functionality, efficiency, and performance [5]. Current daylight metrics mainly assess daylighting quantitatively by similar threshold-driven criteria as other environmental aspects in buildings, such as air quality, energy usage, and thermal comfort. Daylight affects much more than quantifiable factors such as task or visual performance and visual discomfort, and addressing only these does not assess the full experience of daylight. Most

studies concerning the perception of daylighting are studies on user preferences where the main research focus is not on the methodology to study the experience of daylighting but the quantitative assessment of the lighting situation [2,10–12]. This rationalist and socioeconomic discipline differs significantly from phenomenological architecture which is based on human experiences and behaviours, analysed through sensory influences, and which augments the atmosphere of the place. The emphasis of phenomenological architecture is largely on the role of light, as light is known to have a strong effect on the experience of space [5]. To be able to design spaces that takes into consideration the human experience, human perception must not be neglected. We argue that one possibility why daylighting studies are struggling with finding a consensus on metrics to analyse the quality of daylighting is that there is a lack of focus on the human cognitive and perceptual aspects of it and on the methodology to investigate experience. The authors believe that it is necessary for a shift from evaluating performance to researching experience in the analysis of people's interactions with space and daylight [13].

In this article we describe a developed framework for future research. The purpose of the research to be done based on this framework is to broaden the perspective of daylighting research and to focus on how the experience of the inhabitant is studied. To be able to incorporate certain experiences of daylight in the spaces we design, we need to know how people perceive daylight and not only how they evaluate it. By incorporating qualitative research methods, often used in other fields of science, it is possible to shift from evaluations of daylight situations to descriptions of the experience. The framework presented in this article can be used to describe and understand culture and climatic specific perceptions of the long-term experience of delightful daylighting in residential spaces. The significance of the framework is enhanced by studying the correlation between these descriptions and an existing quantitative daylight assessment method EN 17037:2018 Daylight in buildings [14]. In this way, we can evaluate whether there is a correlation between the type of experience and the quantitative daylight situation. Understanding this connection would be significant for architects aiming to evoke certain experiences in space.

2. Background

In this chapter, we firstly present the current situation in studies on the assessment of daylight perceptions and preferences and the methods used to study the human experience in these studies (Section 2.1). Secondly, we describe phenomenology as an approach to study human experience (Section 2.2). Finally, we introduce the methods implemented and combined in the proposed framework (Section 2.3).

2.1. Current State of Research on Subjective Daylight Assesment

To motivate this study, a literature review has been conducted to describe the current situation in studies on daylight perceptions and preferences. The review was conducted based on database searches and using the snowball method, starting from an initial set of studies and reviews based on the authors' knowledge and following the trail of references.

In daylight research there is a huge interest in the preferences of the viewer. Assessment of daylighting today (e.g., EN 1703:2018, daylight autonomy, spatial daylight autonomy, and useful daylight autonomy) is the assessment of the user preferences for certain aspects of daylighting and do not include, for example, health aspects or assessment of energy consumption [15–17]. All glare rating indices are based on subjective assessments [18]. Thresholds for recommended illuminances, e.g., 300 lux, are based on preference studies [19,20].

A measurement review on subjective assessments of lighting quality found no agreement on which lighting characteristics should be included in a subjective assessment of lighting quality [21]. Still, research on visual comfort focuses mainly on three aspects: daylight provision, view out, and glare protection (Figure 1) [2]. The European Standard (EN 17037:2018) addresses the same factors, also adding sunlight exposure to the aspects assessed. These aspects can be quantified with several metrics such as the static metric

Daylight Factor (DF) [22]; or dynamic metrics based on climate-based daylight modelling (CBDM), such as Daylight Autonomy (DA), Useful Daylight Autonomy (UDI), and Spatial Daylight Autonomy (sDA) [15–17]. Dynamic metrics have been proved to correlate with the user satisfaction with daylight access, view interest, too low lighting levels and visual comfort [10]. Metrics for assessing glare protection such as Daylight Glare Probability (DGP) [23], simplified DGP (DGPs) [24], or enhanced DGPs (eDGPs) [25] have been developed. Studies still show the difficulty to assess glare [13] as it depends on many factors [26], some of them related to the psychology and physiology of human beings [27].

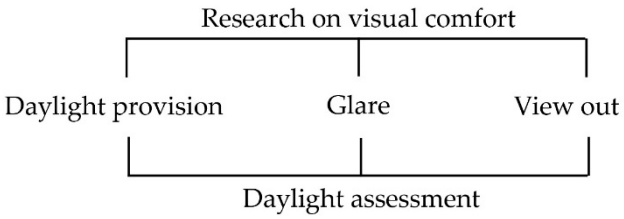


Figure 1. Research on visual comfort focuses mainly on three quality components. Daylight assessments are mainly conducted on the same components.

Metrics for other characteristics of daylighting such as contrast and luminance variability have been developed [28,29]. Luminance variability has been proven to impact space perception [30] but there might be even more aspects affecting the perception of daylighting. Non-visual effects, those that considers the effect of daylight on our health, are being intensively studied and first assessment tools have been developed [31]. Non-visual effect assessments do not directly assess user preferences or perception but as knowledge on the positive effects of daylight on our health increases this might change how we perceive daylighting [32,33].

Researchers should also be open to the possibility that dividing a phenomena like daylighting or space perception in parts might change the results. As architect Juhani Pallasmaa puts it: "When experiencing a work of art, the whole gives meaning to the parts, not the other way round" [34]. A tool that would combine five perspectives on daylighting: work plane illuminance, discomfort glare, solar gains management, perceptual daylight (contrast and variability), and non-visual effects, has been developed [12]. Combining satisfactory sunlight exposure and comfortable thermodynamics has shown to be difficult [35]. A connection between the perceived indoor temperature and glare perception has been found [36]. Still, these are tools combining certain pre-set components instead of studying the overall phenomena of daylight and space.

A literature review by Dogan and Park [37] showed that residential spaces are rarely considered in daylight research where the focus has been on work environments. Similarly, Shafavi et al. [2] conducted a review of 58 studies on visual comfort assessments that shows that assessment studies mainly investigate office spaces (60%) and educational spaces (34%). There are only a few studies on residential spaces (4 papers, 7% out of the reviewed). A database search in May 2021 on Scopus using the keywords (daylight AND preference* AND housing OR residential OR dwelling) gave a result of only 14 studies after refinement. At the same time, the review by Shafavi et al. noticed that thresholds for visual comfort and discomfort differ according to the context in which the metric is used. The authors of the review claim that finding one threshold suitable for different situations might be difficult. In addition, preferences for other quality components of daylight vary according to the different uses of space [38,39]. The preferred window size varies in different settings [40]. A need for specific metrics for residential spaces that consider temporal and qualitative aspects of daylight has been recognised [1]. Still, standards like the EN 17037:2018 define one threshold for all space types regularly occupied by people for extended periods, regardless of use.

The relationship between light and atmosphere perception or aesthetics can depend on culture [41]. Nevertheless, results from studies on daylighting preferences conducted in

a certain location and culture are used as global references for standards and recommendations as the European standard 17037:2018. Some researchers have raised critique of results from studies in one climate and cultural context being transferred to another [10]. As Carlo Volf [42] points out, aesthetics is more likely to be considered a regional phenomenon than an absolute, global experience. One of the main characteristics of daylight is its variability not only over time but according to climate. Despite this, daylight studies are conducted mainly in latitudes between 30 and 60° N, only 2% of reviewed studies were conducted in higher latitudes [2]. For the Nordic climate the seasonal changes are dramatic and there is evidence that light is especially important for people in the north and they tend to adjust to the seasonal daylighting by organising their lives accordingly [43,44].

The currently available metrics have mainly numerical goals [14–17,24]. A review study by Allan et al. highlights the difficulty for the research community to find a consensus on a unique threshold for comfortable and qualitative luminosity, and suggests that a cut-point does not solve the issues with lighting assessments and can create questionable results [21]. There are huge individual differences in quantitative thresholds for perceiving glare [23] and illuminance levels [40]. It is quite difficult to find the source for the often used threshold value for illuminance ratios of 300 lux. To the author's knowledge, the study by Lisa Heschong [19] is one of the very few that really has worked on finding the threshold values for illuminance and, as a result, recommends the threshold of 300 lux. Even in their case, the recommendation was made by the choice from three alternatives (200, 300, and 500 lux) that the study had found preferable. According to Heschong, threshold values should be used to enable consistent comparisons rather than being threshold values for acceptance.

Some researchers see the difficulties in quantifying qualitative aspects of daylighting [18]. One explanation for the research gap could be that building simulation models for daylighting have not traditionally been developed to examine people's preferences on aesthetics and atmosphere. Instead, they have been developed for more easily quantifiable causes like preferences on daylighting for task performance through work plane illuminance [45], calculating energy impacts or comfort that is often seen as glare [24,40,46]. Meanwhile for an architect designing a space, the most important knowledge might not be how to optimise but instead to know what to look for [18]. Heschong [19] claim that the greatest need in daylight research is a better understanding for the 'human factors' of daylighting. Andersen [18] states that the perceived qualitative aspects of daylighting are underserved by the metrics available, and that sustainable design should start with perspectives on quality of life, occupant satisfaction and psychophysiological human well-being. She proposed three levels of human-space interactions that are fundamental to how we experience a space but still not integrated as design guiding factors. These factors consider the effect of the space on human health, the task performance of a user who behaves dynamically in a space and is "a witness of a delightful space who wants to enjoy it" [18]. Therefore, the framework proposed in this article will focus on the experience of "delightful daylighting" introduced by Andersen and Guillemin [12], but without pre-set quality components.

How has the perception on daylighting become so narrow that most studies describe daylight quality through the same aspects? One explanation could be the way occupant preferences have been studied. Most studies use similar methods. Shafavi et al. [2] found three main categories of lighting assessments in their review: questionnaires, measurements, and simulations. Most studies used questionnaires and measurements together (57%). As simulations and measurements do not tell anything about user perception or preferences, but only assess spaces against existing thresholds, questionnaires seem to be the main research method for human perception. Shafavi et al. found that most studies used multiple short questions (91% of studies) [2]. These surveys usually included Yes/No, multiple-choice, numerical, or visual analogue scales. The questionnaires mainly included the same aspects as most daylight assessment tools (daylight availability and uniformity, glare source and intensity, and view to the outdoors) (Figure 1). A study on brightness and perceived

uniformity [47] and a study of atmosphere perceptions of Chinese students in a living room [41] used a questionnaire originally developed to study atmosphere concepts found in answers from Dutch respondents [48]. The questionnaire with perceptual attributes based on emotion theory and the visual appearance of space have been used to study the windows size effects on the impression of daylit spaces [11]. Heschong [19] used questionnaires for daylighting experts and occupants in their broad study, but note that they cannot be sure if the two groups would have a comparable understanding of the questions and their interpretation of 'lighting jargon'. When the terms and aspects are set in questionnaires it is difficult to ensure that no biases are created as the questions are usually set by experts in the field, even if the respondents are non-experts. It is impossible to say whether the aspects in the questionnaire reflect the thoughts of the respondents in similar ways as if they would be asked to describe the situation in their own words. Moreover, Shafavi et al. points out the inaccuracy of questionnaires [2]. Concepts like visual comfort can be interpreted in many ways, which might have an impact on respondents' answers. Allan et al. also highlight the impact of wording and the order of questions. They found that existing questionnaires tend to focus on individual lighting characteristics instead of asking for broader evaluations [21].

Nine percent of the studies in the review by Shafavi et al. asked the participants to draw the boundary of the daylit area, wherever they found a significant change of contrast in the room plan. Correlations between some existing metrics (DA) have been found in a public space visited by architectural students [49]. On the other hand, similar studies show the need of refinement of other metrics (sDA) [50]. Comment boxes, open-ended questions, and interviews were used in 19% of the studies in the review by Shafavi et al. [2]. Jovanović et al. interviewed student dormitory dwellers on their preferences concerning building orientation in a dormitory with rooms opening in four directions [51]. Interviews were conducted to examine earlier made survey results in detail. Inspecting the interview sheet, one can see that the short interviews of 15 min resembled a questionnaire with only two open-ended questions referring to the relation of lighting quality and thermal comfort, and possible changes the student wished for concerning the daylighting environment. Still, the interviews showed the complexity of daylight preferences as students preferred to live in rooms that they felt were overexposed to daylight and sunlight.

Based on a qualitative research project in Denmark, Bettina Hauge used in-depth interviews, observations, photos, and postcards for storytelling to study the significance of daylight to the Danish participants lives and bodies in their own homes [43]. She highlighted the actions relating to daylight and how daylight intertwines with their everyday lives. The aim was not to study the perception of daylight qualities, but the impact on human life. The result of Hauge's analysis was that daylight should be considered a sense among people that affects their daily considerations and actions instead of merely a perceived sensation. She found that it is not only daylight that changes the environment we live in, but people construct their lives and environment according to daylight. This gives a far more complex picture of our engagement with daylight than instantaneous studies with fixed view directions in laboratory settings. Hauge emphasises how daylight has been seen mainly as a physiological element when light hits the eye, but the significance of it to human lives is best studied psychologically and socially. This might give us a deeper understanding of the phenomenon.

Jakubiec et al. [52] has written about visual comfort metrics being rarely applied in practice even if other fields of building analysis have become more detailed. They believed that one reason for this is research inadequacies as most visual comfort research focuses on individuals at a single instant. This might be problematic as occupants might find a space agreeable overall even if they experience some instantaneous visual discomfort [52]. This can also be seen in the results from the study on student dormitory dwellers mentioned earlier in this section [51]. Long-term subjective data is rare in daylighting studies, especially field studies which tend to use cross-sectional studies [2]. Researchers have tried to overcome this by relying on self-assessment by participants over a longer period [10].

Heschong [19] disclose how they cannot be sure that the respondents who were asked to consider the average of the year would not reflect their most recent experiences. A semi-annual human factors research project showed inaccuracies in existing metrics such as daylight glare probability (DGP), the daylight glare index (DGI), IES luminance ratios, and horizontal illuminance [13].

Studies on daylight perception and preferences are often conducted in staged scenery [13,39] or by visualisations [47] and virtual reality (VR) [11,38]. The effect of choice of methodology for using visualisations have been carefully studied [53] and the perceptual accuracy of VR-based studies have been shown [54–56]. The accuracy has been studied by questionnaires and comparisons with staged spaces that the respondent visits for a short time. As mentioned earlier this might cause different results than long-term studies in spaces familiar to the respondent.

The review presented shows the huge interest in user preferences on daylighting, but at the same time, the narrow coverage of assessed factors of daylighting. As preferences and visual comfort are studied mainly through questionnaires with pre-set quality components such as daylight provision, glare, and view out, it is natural that the existing assessment tools also assess these aspects (Figure 1). The background for using these components has not been properly explored [2,21]. There is no indication that the aspects included in the assessments today would not be of importance for the perception of daylighting, but neither has it been studied if these are the aspects most important in every culture and space type. The authors of the review on the subjective assessment of lighting quality hoped for a broad coverage of characteristics in future research [21] and this is what we are trying to achieve with the proposed framework.

Science tends to prefer third-person and reductionist methodologies even in the study of human behaviour and experience. This can be seen also in the studies on daylighting preferences where most inquiries are done by pre-set questions in questionnaires and different measurements. A more natural method of choice for studies on human experience and preferences would be at the qualitative end of the research spectrum. The use of qualitative research methods for studies on building performance is not ordinary practice but is becoming more common. This is expected to increase human-centric policies and comfort in buildings while optimising energy performance [57]. Preferences depend on a subject's experience and is, therefore, subjective, personal, and first-person. Some aspects are lost in research processes that try to study subjective and first-person matters, as preferences, experiences, and perception, with a purely objective, third-person method [58]. Furthermore, even if we want to explain the experience—in this case, the experience of daylighting—through such objective matters as illumination and contrast, we need to know what we are trying to explain (the experience).

2.2. Phenomenology as a Research Approach

In this section we introduce phenomenology as an approach to study human experience. The original task of phenomenology is to explicate the meaning of a phenomena (experience) as they show themselves in and as human consciousness and experience [59]. Phenomenology is often seen as a philosophy of research, although, in cognitive and social sciences, phenomenology is used as an empirical approach to study human experience [60]. Much is written on the theory of phenomenological architecture, e.g., by architect Juhani Pallasmaa [34,61], but fewer studies have been done on concrete phenomenon [62]. Experiences of situations that typically go unnoticed in everyday life can be studied with an open mind with phenomenology [63].

Unlike quantitative science, phenomenology does not seek empirical generalities but rich descriptions of lived experiences [63]. Phenomenologists study experience through collecting descriptions of that particular first-person experience [58]. Even if the starting point for most phenomenological studies are the descriptions of singular lived experiences, researchers have repeatedly been able to discover generic structures of experience from the collection of descriptions of singular experiences for a given study [64].

2.3. Introducing the Methods Implemented in the Framework

The framework consists of a mixed methodology as the experience of daylighting concerns several fields of research such as cognitive, architectural, and engineering. For describing the experience of the participants, three existing methods are implemented (Table 1); the micro-phenomenological interview technique developed by Claire Petitmengin [64,65], the go-along method described by Richard Carpiano [66] and further developed by James Evans and Phil Jones [67], and photo-elicitation [68]. The EN-standard has been chosen as the quantitative assessment method for the framework as it is the only standard concerning only daylight that has been set as a national standard in Nordic countries [14]. In this chapter, the methods are described to show how the techniques complement each other, and to raise discussion on the methodological questions. The phases of the proposed framework and the implementation of the methods are discussed in Section 3.

Table 1. The three main phases of the framework combine existing methods in a novel approach.

	Phase	Methods Used	Expected Results
1.	Long-term spatial interview	Micro-phenomenological interview Go-along interview Photo-elicitation	General structures of the experience of delightful daylighting in homes (coded). Localised codes on floorplans.
2.	Spatial daylight descriptions	EN 17037:2018 Daylight in buildings	Quantitative daylight assessments localised on floorplans.
3.	Evaluation of correlations	Combining the results from phase 1 and 2 on the same floorplan. Correlation analysis	Possible correlation of general structures of experience and quantitative assessments.

2.3.1. The Micro-Phenomenological Interview

When studying people's experiences, data collection needs to be carefully planned. The experience of a place where one feels at home usually goes unnoticed [65,69]. This makes it difficult to explain the perception of such spaces. Therefore, simple unstructured interviews might not capture the full experience and phenomenological interviews need to employ a methodologically controlled framework [60,70]. The aim of the phenomenological interview is to change the focus from what we experience to how we experience it [58,60].

To be able to gain access to these real experiences, interviewees need to suspend pre-conceived opinions and theories about daylighting. For instance, these could be that the participant automatically thinks that big windows and much light cause delightful daylighting and starts talking about the biggest windows in the apartment. If this is not based on an actual experience it is a false conception according to phenomenology. This suspension—called *epoché* (Greek), often translated as bracketing—is of primary importance for a phenomenological interview. It is important to understand that this does not only apply to the participant, but also the researcher [58]. The researcher must bracket earlier theories about daylighting [71,72]. For example, they should not prompt the interviewee to describe his/her experience through categories usually used in daylight studies such as glare, views, or amount of light. The questions used can be described as 'non-inductive but directive'. The aim is that the interviewer does not induce any content and questions are, therefore, 'content-empty'. It is important that the interviewer does not use professional or specialised language and words, but rather allows the interviewee to find his own words. The trained phenomenological interviewer leads the interviewees back to their experience and encourages to describe them in their own terms. The focus is kept on the experiential matters rather than attitudes, beliefs, or theories about the experience [58]. By studying particular situations when the resident has experienced delightful daylighting, the attention

is turned from what the interviewee thinks or imagines he/she has experienced to what he/she really experienced.

For the interviewee to become aware of all the dimensions of his experience, he will be asked to go through it several times to provide a rich description. This description is divided into main phases and subphases according to the level of detail needed. In this way, a structure for the singular experience is created and can be found by handling the transcribed material according to the micro-phenomenological method (Figure 2). By comparing several structures of singular experiences, a generic structure and possible variants can be found [65]. This focus on structure reduces the interpretation by the researcher and allows the results of the analysis to be reproduced. After the structure has been found, it can be used as a hypothesis and tested in other studies on experiences of the same type [64].

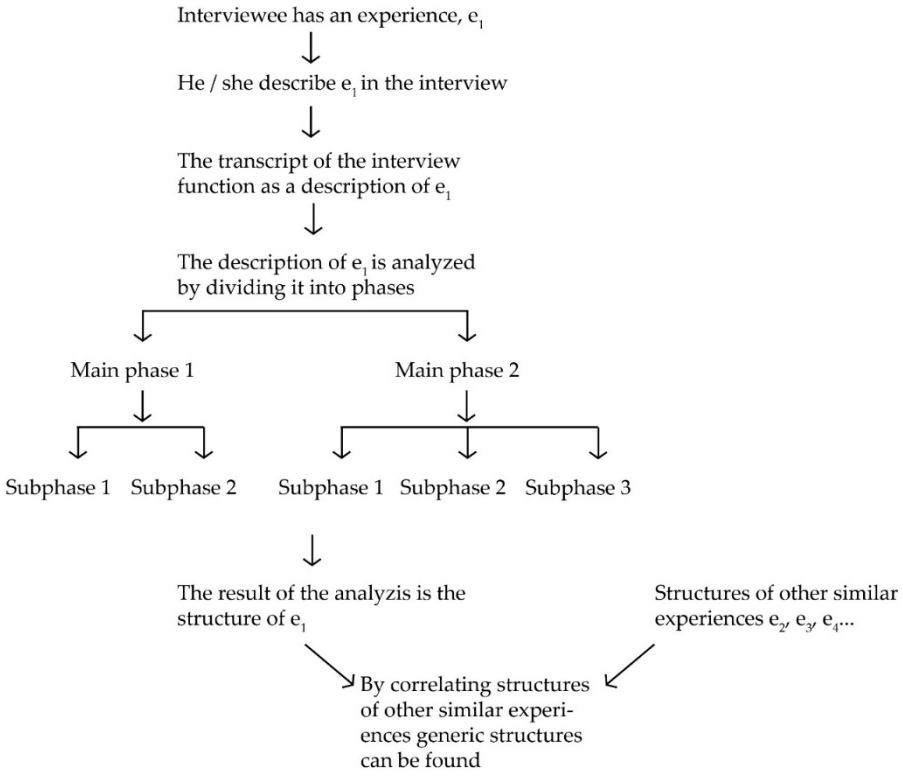


Figure 2. The unfolding of generic structures of experience with the micro-phenomenological process.

2.3.2. The Go-Along Method

The go-along method (hereafter 'go-along') has been introduced by Richard Carpiano [66] to study how people experience their neighbourhoods and larger local areas. It is a form of in-depth qualitative interview method, using either open-ended or semi-structured interviews, where the researcher is guided by the respondent in a walk through their lived experience of the environment. In the health and place literature it is a tool to meet the need to study different dimensions of space and place within and across time for individuals. The go-along provides a method to combine qualitative research information with information on location [66]. James Evans and Phil Jones [67] have developed the go-along method to be used with 'spatial transcripts' that allow the conversation to be mapped.

As the go-along is used to study people's perception of their environment and spatial practices, we believe it is possible to modify it to smaller scales than the neighbourhood: in our case, the home of the participant. The home can be seen as a small-scale neighbourhood that is familiar to the interviewee and, therefore, he/she hardly notice his/her interactions with the environment [69]. It has been shown that data collected after the experience in-space can be more concrete than data collected through later reflections and interviews

outside the environment of the experience [58]. The go-along complements the micro-phenomenological interview as it has been noticed that the interviewee takes the role of a 'guide' and continues talking, entering the unconscious experience without the interference of the interviewer [66,67]. Encountering the environment creates rich data instead of the interviewee trying to give 'right' answers [67].

2.3.3. Photo-Elicitation

Digital photographs and smartphones have become a part of everyday communication and can, therefore, provide a more natural way for participants to share their everyday experiences. In 'participant-driven photo-elicitation' the researcher decides the specific area of focus, but the participant has control of data collection. In this way, it is possible to capture what the participant felt was worthy to record and to capture the perspective of the participant at the time of the experience. By empowering the participant and making him/her the expert, the power dynamic between participant and researcher is shifted and allows for a greater insight into the perspective of the participant. Combined with existing interview methods, the data collected can be richer and the participant is able to critically reflect in their lived experiences and share them with others [68].

2.3.4. Standard EN 17037:2018 Daylight in Buildings

The European standard EN 17037 [14] recommends the assessment criteria for the following aspects of the daylight in buildings: exposure to sunlight, view out, daylight provision, and glare protection. Recommended threshold values are given for recommendation levels: minimum, medium, and high.

Sunlight exposure requirements are expressed in terms of number of hours per day that the sun is visible from a certain reference point on the inner surface of each window. Even if the calculations are done on a singular point at the window, the standard suggests that the result describes the exposure to sunlight in the whole room according to the levels of recommendation.

According to the standard view out from reference points (Qs) corresponding occupants' positions should be assessed. From any Q, the view quality depends on five factors: the size of the daylight opening(s), the width of the view (horizontal sight angle), the outside distance of view, the number of layers, and the quality of the environmental information of the view. A view is considered to comprise three distinct layers: sky, landscape (buildings, nature and/or horizon), and ground (information about outdoor activities).

EN 17037 defines the concept of "daylight provision" as "level of illuminance achieved across a fraction of a reference plane for a fraction of daylight hours within a space" [14]. According to the EN 17037, an indoor space provides adequate daylight if a target illuminance level is achieved across a fraction of the reference plane within a space, which is the plane where the illuminance values are calculated, for at least half of the daylight hours. This criterion accounts not only for the spatial characteristics of daylight, but also temporal. Target illuminance values and corresponding daylight factors are given for 50% of the space and minimum target values for 95% of space. The calculations are done on grid cells over the reference plane. The EN 17037 proposes two daylight assessment methods. Method 1 is based on the static daylight metric known as daylight factor (DF), which can be calculated as the ratio between indoor and outdoor illuminances under overcast conditions. Method 2 is based on climate-based daylight metrics (e.g., sDA), which requires higher computational time (e.g., annual hourly calculations) than DF calculations.

The EN 17037 recommends an annual evaluation of the glare protection based on Daylight Glare Probability (DGP), which considers contrast (related to luminance ratios within the field of view) and saturation (related to illuminance levels) effects. DGP threshold values are given for imperceptible, perceptible but mostly not disturbing, and perceptible and often disturbing glare. Specifically, it is necessary to investigate the temporal behaviour of the occurrence of glare. For critical glare situations, the annual percentage of discomfort glare hours (fDGPt) should be lower than 5% for a shading device to protect against glare.

3. The Framework

3.1. Objectives and Research Questions

The main aim of the framework is to shift the focus of daylight studies from quantitative evaluations towards qualitative descriptions of the human experience of daylight. Whereas earlier studies that combine quality evaluations with climate-based daylighting metrics [10,11] pay little attention to the methodology of the quality evaluations and more focus on the metrics, we want to emphasise the experience of the user also in the choices of methods. The developed framework focuses on the phenomena (experience) of daylighting by using a phenomenological methodology and combines this with the quantitative description of daylight. As Merleau-Ponty, one of the founding philosophers of phenomenology, points out, we first need to understand the experience of space, which is not the same as the physical description of it [73]. The objective of the framework presented is not to find generic truths for a broader population. Instead, the aim is to find options of descriptions on the experience of delightful daylighting in residential spaces that can give a more profound explanation of human perspective on daylighting than the existing quantitative measures. Still, the method chosen for the analysis of data enables detecting generic experiential structures from singular experiences if such structures exist [64].

For the aim of developing a phenomenological framework for researching daylighting in residential spaces in the Nordic climate, we argue that the bases of studies on daylight preferences should be an approach that grasps daylight as a qualitative atmospheric entity on a long-term basis. By approaching the phenomena this way, future research based on this framework might find aspects and views that have been neglected before. The neurophenomenologists often repeat a precisely similar situation for different subjects and asks them to describe the experience so that it can be analysed how this correlates with neurological processes [58]. Architects often try to evoke a certain experience rather than trying to form a certain lighting scene. Therefore, we reverse the research setting and we ask for people's experience of delightful daylighting in different settings to see if there are correlations in the daylight situations. The framework will also study whether there are correlations between how the daylighting of spaces is described by quantitative methods in EN 1703:2018 and the descriptions of experience of the inhabitants. Therefore, we set three research questions for future studies based on the framework:

1. How do inhabitants describe the experience of delightful daylighting?
2. Are there common structures in these descriptions?
3. Do these structures correlate with the quantitative description of daylighting according to daylighting assessments such as the EN 17037:2018?

3.2. Phases of the Framework

The proposed framework consists of three main phases:

1. Long-term spatial interviews;
2. Spatial daylight description according to the EN 17037:2018;
3. Evaluation of correlations.

For the first phase we have developed a novel method—the long-term spatial interview—for collecting qualitative data about long-term spatial experiences. This mixed method approach combines three existing methods (micro-phenomenological interview, go-along, and photo-elicitation) introduced in Section 2.3. In the second phase, the physical daylight settings of the experiences are described according to the methods in the EN 17037:2018 Daylight in buildings. Finally, in the third phase, the results of the first two phases are compared to find correlations or deficiencies in correlations. Methods used in each phase and expected results are combined in Table 1.

3.2.1. Long-Term Spatial Interviews

For the data-collection through interviews in the first phase, there is a need to consider the communication between the interviewer and the interviewee, but also how to incorpo-

rate the physical environment and timespan. The foundation of the mixed method is the micro-phenomenological interview technique developed by Claire Petitmengin [64,65]. To be able to localise the results to certain places, we use the go-along method described by Richard Carpiano [66] and further developed by James Evans and Phil Jones [67]. To catch the long-term aspect, two interviews with the same interviewee will be conducted with one year in-between and during different daily daylight settings (Figure 3). Interviewees are encouraged to work with photo-elicitation to capture the experiences in between the interviews.

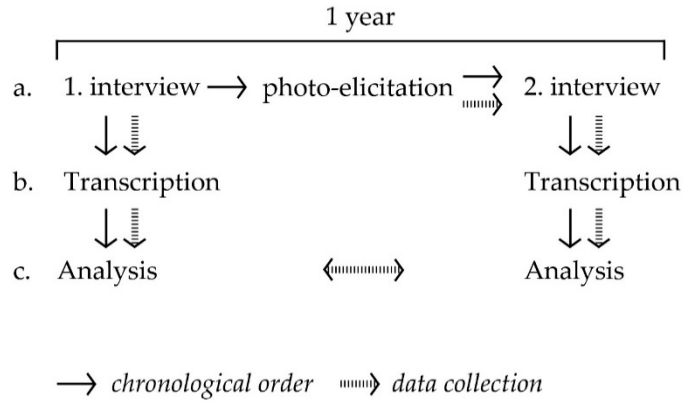


Figure 3. The structure (a, b, c) and the process of the long-term spatial interview with one interviewee.

The structure of long-term spatial interviews:

a. Data collection through in-situ interviews
   - First interview
   - Photo-elicitation
   - Second interview

b. Transcription of data collected through interview

c. Analysis of transcription
   - Categorisation of general structures
   - Localisation of structures

Three evident characteristics are required by the interviewee in a phenomenological interview on the experience of delightful daylighting in one's home:

1. The interviewee has experienced delightful daylighting in his/her home;
2. He/she is able to describe it;
3. He/she is willing to do so [74].

As in most qualitative studies, the number of interviewees is not as important as in quantitative science. Some phenomenological studies have even noticed that too many participants cause essential themes to be lost in the copious data [75]. Usually, phenomenological methodologies do not suggest sample sizes [63], rather the number of participants will be based on categorical saturation (when new interviews only produce the same categories as the previous) [64]. As the method already requires substantial effort from the interviewee, we have decided to use the alternative of 'frontloading phenomenology', where the participants do not have to learn to bracket but are led by an interviewer who is trained in this [71,72].

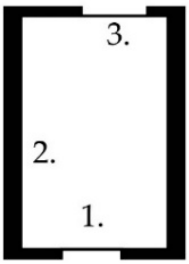
Before the actual interview, the inhabitants are handed a floorplan of their home and asked to trace with a marker the spots and areas where they find pleasant or meaningful daylighting. This floorplan exercise is similar to Carpiano's [66] mapping exercise of neighbourhoods to 'set the stage' for the go-along interview and to get the participants to specify and localise the exact experience of delightful daylighting. This will also help the

interviewer to direct the discussion (if needed) to certain situations. The interviewer can also use this floorplan to place notations during the interview.

To be able to discuss real experiences rather than representations and generalisations, we need to choose singular experiences. As an experience can never be had 'in general', neither should we talk about the experience of daylighting in general. Therefore, the choice of singular experience is of primary concern for the success of the interview. For long-term processes, such as the one we are studying, Petitmengin [65] recommends choosing one or several specific decisive moments. We are interested in situations where the interviewees have experienced delightful daylighting in their homes. The actual situations are chosen together with the participant during the interviews. As we are interested in the experience of daylighting in the Nordic countries, where the lighting situation changes drastically between different annual and daily timeframes, we are conducting two interviews with the same interviewee during two different times of the day and with one year in-between (Figure 3). To get access to all possible delightful experiences of daylighting during the whole year we use participant driven photo-elicitation between the two interviews. After the first interview at the participants' home, the participants are asked to send a digital image to the researcher whenever they encounter a daylight situation that they experience as delightful. The image can be sent through a platform most convenient for the participant (e.g., Facebook Messenger or WhatsApp). During the second interview, these pictures will be used as a base for the discussion to help the participants to access the long-term experience of daylight in their homes. Going back to photographs helps the interviewee to re-live the experience [65].

The interview will take place by moving around the apartment guided by the interviewee, as suggested by the go-along method. The interviewee will be video recorded, but to make sure that there is no confusion which space or spot the experience under discussion has occurred at, the interviewer will make explicit mentions of locations as suggested by Carpiano [66]. From the recordings and transcriptions of the interview it will be possible to check that the interviewer has used questions and prompts in compliance with the micro-phenomenological interview techniques [65].

The interviews will be transcribed word-for-word but also paraverbal information, as described by Petitmengin et al., should be included [64]. The go-along method is first of all used to combine qualitative information from the micro-phenomenological interview with information on location. The transcript is done in chart format on rows that are given spatial information in the form of numbers (Figure 4). As we are moving in an apartment, we cannot use gps-information as in the walking method by James Evans and Phil Jones [67], but instead, the locations discussed are numbered based on the video recording and notes by the interviewer.



Experience	Transcription 1.	Structure of experience
1.	*R: "The light brought nature..."*	A
2.	*R: "The sunlight gave me..."*	B
3.	*R: "I felt how the light was..."*	C

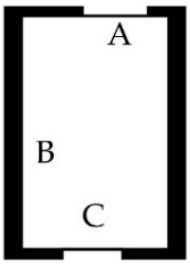


Figure 4. A fictitious example of how the experiences (1., 2., 3.) in a certain location is numbered on the floorplan and in the transcript. Each part of transcript is analysed to find a structure (A, B, C) that can be localised on the floorplan.

The singular transcriptions will be handled according to the micro-phenomenological analysis method. The aim is to find structures in these descriptions and, by comparing them with each other, possibly find generic structures that would describe the experience of pleasant daylighting at one's home. The iterative process of the micro-phenomenological

analysis enables detected structures to be used as a hypothesis that subsequent interviews can confirm, refine, or invalidate [64]. Being able to give descriptions of the experience of delightful daylighting at home would be an important addition to the research on daylighting. Further value is given by localising the results and thereby enabling comparison with existing quantitative assessment methods of daylighting. By giving a coded structure to every transcribed description, these generic structure codes can be placed on the floorplan of the apartment of the interviewee. A fictitious example of such a structure could be 'feeling connected with nature', coded as A.

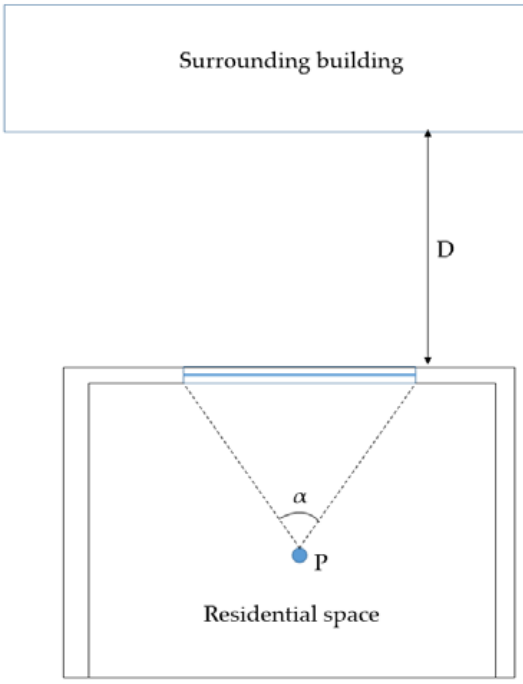
The fact that we use video recordings from people's homes requires special attention to ethics. Approval for the study will be applied for from the local institutional ethics committee in the country where the interview will be conducted. All interviewees will fill informed consent forms, and these will be reviewed with them. Video recordings, photographs, and transcriptions will be stored in secure electronic media during research. At the end of the project all photographs and video recording will be destroyed. In published material, all data will be de-identified and pseudonyms of the participants will be used if necessary.

3.2.2. Spatial Daylight Description According to the EN 17037:2018

This phase of the framework considers the results of the quantitative assessment according to the EN 17037:2018 [14] as a description of the physical daylight situation in a space rather than an evaluation. The aim is not to calculate exact amounts of daylight, glare, etc., during certain moments, but to get similar results as anyone using the standard in a design situation. Therefore, the spaces will not be assessed according to what the real situation is, using measurements in the room, but rather as simulations of the space. As the standard makes it possible to assess daylight provision, view out, and glare protection at certain grid cells, these will be calculated for the same points in the space as the interviewee's have described as delightful. For sunlight exposure, the EN 17037:2018 only gives one description for the whole room which will function as the quantitative description for all experiences in that room.

The material needed for the simulations is gathered from 3D-models provided by the cities and permit pictures of the given building. Typical meteorological year (TMY) weather files are used to obtain realistic DGP values. Information on indoor materials and glazing is gathered during the interviews by measurements. The standard suggests that if details of the space are not available, reasonable assumptions can be employed. These assumptions will be stated in the quantitative description of the daylight situation for each space. For the assessment of daylight provision, view out distance/angles, and DGP values, we use simulation with the validated software Radiance.

An example of a quantitative assessment of the daylight functions is shown in Figure 5. Daylight provision in the room is quantified in terms of the DF metric (DF_P) as the ratio between the horizontal illuminance (E_h) at the reference point (P) and the Median External Global Illuminance ($E_{v,d,med}$) defined per each country in the EN 17037:2018. For example, for Finland, a *DF* value of 1.8%, 3.0%, and 4.4% correspond with a minimum, medium, and high level of recommendation for daylight provision, according to the EN 17037:2018. View out for each point is quantified in terms of the level of recommendation for view out which depends on the horizontal sight angle, outside distance of the view, and visible number of layers. We consider the *fDGPt* metric for the comparison with results from interview in each delightful point as an average annual glare protection metric used by designers nowadays.



Function	Metric	Value	Evaluation
View out	α	45°	Minimum
	D	8 m	
	N° layers	2	
Daylight provision	DF *	3.0 %	Medium
Glare protection	$fDGP_{0.35}$	6.5 %	Minimum
	$fDGP_{0.40}$	6.0 %	
	$fDGP_{0.45}$	4.0 %	
Sunlight exposure	minSH	4.0	High

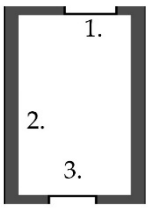
$* DF = (E_h/E_{v,d,med}) \cdot 100\ (\%)$

Figure 5. Example of daylight (DF_P), glare (*fDGP*), and view out (α, D, and N° layers) assessment for a generic point P where the delightful daylight experience is described by the interviewee. α = horizontal sight angle (°), D = distance between buildings (m), E_h = Horizontal illuminance (lux), $E_{v,d,med}$ = median external global illuminance (lux), *DF* = Daylight factor (%), $fDGP_t$ = Percentage of occupied hours with DGP above a threshold t (%), and minSH = minimum number of sun hours per day between 1 February and 21 March.

3.2.3. Evaluation of Correlations

The spatial categories of experience and the assessments according to the EN 17037:2018 will be located to the same points at the floorplan. A correlation analysis will be done to find if similar experiential structures can be found in locations assessed to have similar daylighting conditions by EN 17037 (Figure 6). By using the invented example, we might find that the 'feeling of connection with nature' is always found in spots described as having high daylight provision and view out but is not correlated to glare evaluations according to the EN 17037:2018.

Interviewee 1.

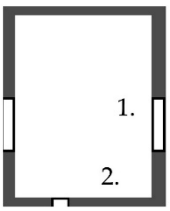


Point 1.	Evaluation	Structure of experience
View out	High	A
Daylight provision	High	
Glare protection	Minimum	
Sunlight exposure	High	

Point 2.	Evaluation	Structure of experience
View out	Minimum	B
Daylight provision	Minimum	
Glare protection	High	
Sunlight exposure	High	

Point 3.	Evaluation	Structure of experience
View out	Medium	A
Daylight provision	High	
Glare protection	Medium	
Sunlight exposure	High	

Interviewee 2.



Point 1.	Evaluation	Structure of experience
View out	High	A
Daylight provision	High	
Glare protection	Medium	
Sunlight exposure	Medium	

Point 2.	Evaluation	Structure of experience
View out	Minimum	B, C
Daylight provision	Medium	
Glare protection	Minimum	
Sunlight exposure	Medium	

Figure 6. Two fictitious floorplans showing locations of experience of delightful daylighting (point 1, 2, 3) and examples of combining the results of the spatial daylight descriptions according to the EN 17037:2018 and the long-term spatial interviews (A, B, C) for correlation analysis.

4. Expected Results

The review of studies on daylight preferences and perceptions revealed significant interest in the subject, but an incomprehensive way to describe the experience of daylighting and the similar methods to study the human perspective. Questionnaires using pre-set quality components: daylight sufficiency, glare, sunlight exposure, and view out seem to have led to assessment methods using the same categories. The few studies using interviews show that subjective daylight preferences can be more complex.

In this article, we have presented a new framework for studying qualitatively the spatial experience of daylighting in a certain cultural and climate context. The novel method

named 'long-term spatial interviews' combines the micro-phenomenological interview with photo-elicitation and the possibility to localise the results on a floorplan. This enables comparisons with existing quantitative assessment methods, such as the EN 17037:2018.

The focus on a rigorous interview method enables rich descriptions of real experiences rather than representations or generalisations and suspends pre-conceived opinions and theories about delightful daylighting. The set of criteria of the micro-phenomenological interview and analysis minimises interpretations of the subject and the interviewer [64,65]. The possibility to find generic experiential structures is part of the inter-subjective validation of the first-person results [64].

In relation to the research questions there are three kinds of results expected from research based on the proposed framework:

1. We can gain descriptions of delightful daylighting that give a richer view than numerical analysis, good/bad, or comfortable/discomfort;
2. It will be possible to find common factors and general structures in these descriptions made by different participants of different situations. Possibly, such structures cannot be found, and thereby we can conclude that the experience of delightful daylighting in homes in the Nordics is a highly subjective experience with no common features;
3. Finally, if we can find general structures, we will be able to compare them with the quantitative results for the same space and see whether there are correlations. Comparing several different spaces there might be correlation patterns evolving that describe the experience of delightful daylighting both qualitatively and quantitatively. This would be a powerful tool for architects as they would get information on the kind of experience but also on how to achieve it through design. If no correlations can be found between the qualitative descriptions and quantitative analyses, we would have evidence that the quantitative analyses do not give full descriptions of the experience of the inhabitants.

It will be possible to test if similar structures of experience on delightful daylighting are found in other cultures and space types. The framework developed can also be used for other spatial experience studies. It would be interesting to see the correlations of experiences of 'undelightful daylighting' with the results. The 'long-term spatial interview' method can be used to study most spatial experiences by adjusting the timespan of the method.

As the objective of the presented framework is to find options of rich descriptions on the human experience of delightful daylighting, the results are not directly meant for changing regulations or standards. The descriptions and results of the comparison can be used as hypotheses or bases for questionnaires in forthcoming quantitative studies [64]. In this way it can be tested whether the descriptions found are generalisable and suitable for assessments and regulations. The results of the comparison with the EN 17037:2018 might also raise questions on whether it is possible at all to regulate daylighting based on preferences and if preferable spatial experiences can be standardised quantitatively.

The change from quantitative studies of such an experiential phenomenon as daylighting towards qualitative research on the subjective experience broadens the perspective of daylight studies significantly. To combine the physical descriptions of spaces answering 'what' we experience with phenomenological descriptions explaining 'how' we experience them gives a more profound explanation of human interaction with space. This might change the way buildings and architecture are assessed, designed, and lived in.

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