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Indexicality in the theory of inferior mirage
Master's Thesis

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Abstract

The notion of the index and the activity of indexicality are used to constitute the semiotic reality in the theory of the inferior mirage. Andrew T. Young's model of the inferior mirage is referenced (2015) where from the activity of indexicality is applied. Indexicality describes the cause and the articulation of the model of inferior mirage to get at its semiotic reality. The semiotic reality that guides the physical reality of the inferior mirage is described as it becomes real. Resulting in a wholly original description about the entice phenomena of mirages that interconnects semiotic indexicality and mirage theory.

Keywords: index, indexicality, inferior mirage, mirage theory

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Introduction

“Like a mirage” is a puissant metaphor that makes creative meanings about the significance of actual mirage phenomena. Tempting pareidolia, infused with cultural narratives (see Pinney 2018), and often mistaken for an optical illusion, so-called mirages are anything but physical phenomena that distort, invert and magnify the appearance of objects on the ground (Ives 1951). Genuine understanding of a real mirage, however, involves ascribing the blind forces behind these natural phenomena. Still, behind every model of a mirage lies another confounding and dormant reality (Sebeok 1986: x). Thus, my thesis is about an aspect of the semiotic reality that gives structure to the physical reality of actual mirage phenomena.

The real meaning of a mirage is often misapprehended, misinterpreted or misunderstood. A mirage is frequently mistaken for something that does not exist, like; undiscovered islands (Freitage 2013; Gjerset 1924), a tsunami at sea (Steenstrup 1871), a floating palace (Reinecke 1800), a marching army (Beauford 1802), —to name but a few misperceived resemblances. Nonetheless, these atmospheric optical phenomena have been theoretically explained by the study of terrestrial refraction and corroborated in observation (Gruber 1781; Huddart 1796; Wollaston 1800). Theories about these protean phenomena and their reality moreover reveal the ends as to why mirage phenomena occur and why mirage phenomena are expected (Humphreys 1940; Pernter, Exner 1922; Schmidt 1878; Wegener 1918), but do little to reveal how the reality of these phenomena arises and becomes modeled. Thus, I intend to describe how the semiotic reality becomes the physical reality that models an actual mirage.

Mirage theory, which is concerned with the mathematical modeling and study of the behavior of mirage phenomena forms the object of study. The study object is taken from *Inferior mirage: an improved model* (Young 2015). Inferior mirages are chosen because of their common sighting to depress the horizon (Kelly 1846: 394). This particular theory of the inferior mirage is chosen because it presents the result of recent advancements made to correctly model the phenomena (Farmer *et al.* 2014; Young 1999). The sampled mirage theory thus forms the basis of the study object and guides my description for the happening of its semiotic reality. Allowing me to illustrate how the theoretical case of the inferior mirage becomes actual.

I approach the case of the theory of inferior mirage from the semiotic point of view of the index. Index, meaning ‘that which points out’ (Wellisch 1983: 147), I use in a normative sense of indexicality. As a semiotic activity interlacing indexes into a single process. Semiotics defines an index as an object relation that introduces further subject matter that functions to specify more characteristics of said object (Encyclopedic Dictionary of Semiotics 1986 *sub index*). Thereunder, the normative sense of the index shifts its semiotic meaning into a kind of activity as an interpretive practice. The interpretive practice of indexicality inverts causality (Sebeok 1990: 20) and is used to work out how the semiotic reality of the theory of inferior mirage is fitted together. Hereby, my thesis is about indexicality and how it gives structure to the physical reality of the inferior mirage. Thereby showing an aspect of the semiotic reality of the physical reality behind the inferior mirage as it is scientifically modeled.

I must disclaim that I am in no way making a controlled study on the ‘book of nature’, but a semiotic study on the ‘book of man’, as the study material comes from an astronomer. Additionally, I do not intend to stipulate on the measurement of the refractive index used to quantify mirage theory. Nor am I interested in the fidelity with which mirage theory is able to simulate the mirage or how the concept of indexicality relates to reality. I aim to know how indexicality makes the mirage real as it is presented in Young (2015). Doing so, I document the semiotic activity of indexicality as it happens in this particular theory of a mirage. Thus, I reason about indexicality and its activity by asking of mirage theory:

How indexicality causes the theory of inferior mirage?

How indexicality articulates the physical reality that becomes the inferior mirage?

How indexicality structures the physical reality of the inferior mirage to become real?

An interdisciplinary case study that interrelates mirage theory and semiotic indexicality, to my knowledge, has yet to be written. I structure the case study into three subsections that syllogistically ascend. The first section colors the study object. The happenings of mirage phenomena are reviewed so to delimit the particular mirage theory that forms my study object. The second section explains my study method. This section shows how I understand the object relation of the index and its normative shift into indexicality—along with a few illustrations of indexicality in life. The third section draws out my work. Following the three study questions, I work out the indexing aspect of the semiotic reality that becomes the meaningful physical reality of the inferior mirage. Together, all three subsections produce an original contribution wherein the interpretive practice of indexicality discusses how the meaning of the mirage

becomes real. The case study then concludes with an acknowledgment of the new knowledge produced and a short overview of everything presented hereunder.

1. Mirage happenings

Knowledge about naturally occurring mirage phenomena¹ is used to color the study object, while the theory of inferior mirage specifies it. Salient characteristics of the mirage are introduced. What is the distinctive feature of the mirage, how the mirage is differentiated and the classical classification of the mirage is briefly introduced. Subsequently, a physical model for understanding the formation of an inferior mirage is introduced as got from the study material; *Inferior mirage: an improved model* (Young 2015). The study material establishes the physical framework where from the study object is defined and understood. Mirage happenings provide the empirical basis for modeling the specific mirage theory at the center of my case study on indexicality and mirage theory.

Mirage phenomena, being the stronger version of terrestrial refraction phenomena, are marked by the distinct appearance of an object seen double or more and are explained by the arrival of multiple pathways of light rays to an observer (Pernter, Exner 1922: 109). This multiplicity of light ray paths gives rise to the distinctive feature of the mirage which produce the marked appearance of at least one inverted image of a distant object (Young 2026). The mirage, is then a refraction phenomenon that is understood by light rays that come off of an object and arrive at an observer by multiple pathways (Pernter, Exner 1922: 109) and appear upward and downward images (Löw 1990: 14). In contradistinction to the weaker terrestrial refraction phenomena of looming, towering, sinking and stooping: the mirage is distinguished by its feature to invert an image. Thus, the mirage is defined as: a refraction phenomenon that contains multiple images that are alternately erected and inverted (Young 2026).

Just like there are multiple kinds of terrestrial refraction phenomena, there are multiple kinds of mirage phenomena. To merely recognize a mirage by its distinctive feature of an inverted image does not suffice to differentiate the varied appearances of mirage phenomena. Different kinds of mirages are contiguously associated with different kinds of atmospheric structures (Humphreys 1940: 470-475; Pernter, Exner 1922: 109-155). Nonetheless, because

¹A systematic study of the mirage integrates; fluid dynamics, geodesy, geometrical optics, boundary-layer meteorology, navigation, practical astronomy, surveying, air-sea interactions, turbulent heat transfer and precise observation all to corroborate theory.

mirage images are produced by terrestrial refraction, which usually displaces light into the vertical, mirage images appear directly stacked up on top of one another (Young 2026). And by this element alone the mirage can be differentiated into two major categories. The first case describes a depression of objects while the second case describes an elevation of objects (Bravais 1853: 264). These two descriptions split the mirage into two major classes and respectively describe the inferior mirage and the superior mirage. Thus, by making a differentiation of the relative distortion of the distinctive feature a classification of the mirage becomes possible. At the core of this classification are the two major categories of the mirage.

The opposition of the inferior mirage and the superior mirage constitute the two major classes of the mirage where from a system for the classification of various mirages is made possible. The inferior mirage, happening by light that is totally internally reflected into the denser overlying air (Young *et al.* 1997: 2692), is the distinct appearance of an image below an object (Pernter, Exner 1922: 129). Which describes the first major class and the basic physics behind it. The superior mirage, also happening by total internal reflection by a temperature inversion where warmer air lies above colder air (Young *et al.* 1997: 2692), is the distinct appearance of an image above its object (Pernter, Exner 1922: 117). And describes the second major class and its basics physics. The inferior mirage; featuring a downward refracted image, and the superior mirage, featuring an upward refracted image, in opposition to one another, form the key differential for mirage classification. Sometimes tricky though is to differentiate an inferior mirage from a superior mirage which can lead to difficulty to correctly classify what kind of mirage is present (Schmidt 1878: 14). All the same, these two major categories of the mirage form the basis from which mirage phenomena get classified. Which is done by a differentiation of kind according to the distinctive feature of the invert and stacked images.

Typified, mirages are recognized by their distinctive feature of their inverted image and differentiated by the type of distortion they exhibit. Table 1, below, reproduces the traditional classification of the mirage according to the refracted image the phenomena may produce.

Number of images	Name	Description
2	Inferior mirage	Inverted image below the erect one
2	Superior mirage	Inverted image above the erect one
3	3-image mirage	Inverted image between the erect ones
many	Fata Morgana	Complex alternation of distorted erect and inverted images, greatly stretched vertically

Table 1. The classical mirages (Young 2026).

Central to my case study however is the inferior mirage which demarks the type of mirage that informs my study object. Happening by strong refractive gradients in a cool atmosphere close to a warm surface (Farmer *et al.* 2014: 215) the inferior mirage is the distinct appearance of an inverted image below its erect image. The physical model for understanding this kind of mirage comes from the study material which constructs a theory about the inferior mirage. *Inferior mirage: an improved model* (Young 2015) is selected as the study material because it presents the current state of the art in the literature on inferior mirage phenomena. The study material thus establishes the physical framework for understanding the inferior mirage and is presented below.

1.1. Theory of inferior mirage

Inferior mirage: an improved model (Young 2015) constructs an interdisciplinary model of the inferior mirage and presents the system supporting my study. Being a quantitative model, the model under review works by describing the features of a particular surrounding environment from which the mirages physical reality is built. The physical reality of the model understands that heat rising upward from a warm surface contiguously increases the air above which in turn bends light upwards and produces the inverting appearance, classified as the inferior mirage. And because the inferior mirage occurs in the lowest few meters of the atmosphere (*Ibid*, B172), the model is based on a physical understanding of the lowest few meters of the atmosphere also known as the surface layer (which is described by the subfield of boundary layer meteorology²).

²Atmospheric science subfield of boundary layer meteorology describes the characteristics of the lowest 100 to 3000 meters of the atmosphere (Stull 1988: 1). Segmented into three regions, the boundary layer is comprised of; a thin laminar sublayer that sits directly atop earth's surface, a turbulent logarithmic layer responsible for mirage formation, above which is the free atmosphere (Young 2015: B171). The sublayer and turbulent layer make up the

The model also takes into consideration the optical obstruction of surface elements that work to constraint the lowest extent of the mirage. The study material explains the real meaning of the inferior mirage by the construction of its physical reality which is where my study object comes from.

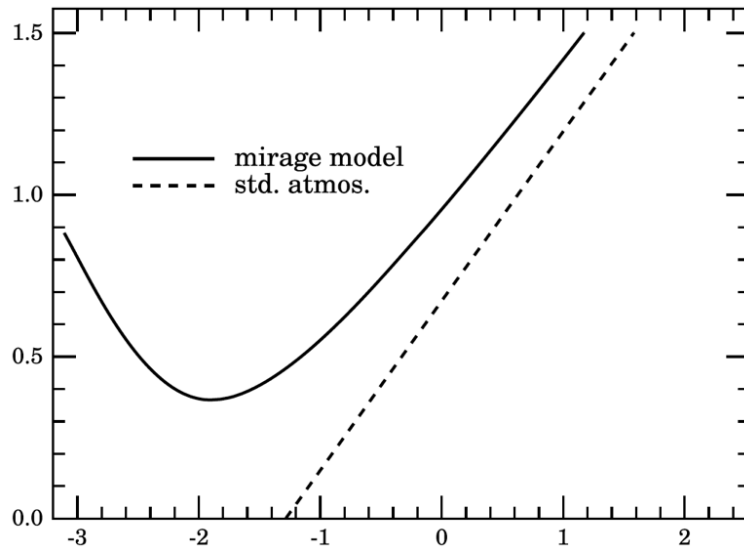
Conceptually summarized, the model that the study material builds is constructed from similarity theory and is made visually accessible by a geometrical idealization of optics. Similarity theory works out a potential temperature profile from surface temperatures that is corrected for adiabatic temperature change (Young 2015: B172). While geometrical optics shows how light exactly curves to form the inferior mirage (*Ibid*, B174). Similarity theory describes the physical reality behind the mirage and geometrical optics maps the mirage. Together, these conceptual formulizations bring about the behavior and extent of the inferior mirage.

However, the model can also be described through a causal chain. Starting from the basic principle that heat rises, the model ends by revealing the full structure of the mirage. Following the model: heat flows upward into the atmosphere across a laminar sublayer. Sitting directly over the surface of the earth, the laminar sublayer is quantified by the thermal roughness length (Young 2015: B172). Above the thermal roughness length, the upward flow of heat is not uniform, decreasing in intensity as heat ascends further up into the atmosphere. Here similarity theory shows that when a warm surface heats the air from below a logarithmic temperature profile forms as a result of the fluxes and gradients (*Ibid*, B171). Similarity theory characterizes the logarithmic temperature profile from three physical parameters; temperature amplitude, Obukhov length and the aerodynamic roughness length (*Ibid*, B172) which parametrize the first principles behind the model. Together these variables determine the shape and amplitude of the temperature structure of the lowest few meters of the atmosphere. Now, to reproduce the extent of an actual inferior mirage phenomena, the refractive index of the air is got from the described temperature profile. This is done to reproduce the physical distortions resembling the inferior mirage. Refractivity is a measure of how much a medium slows and bends light (*Ibid*) which the temperature profile describes. Because how much light bends in the air is dependent on the refractive index of the air which depends on the density of the air which ultimately depends on the temperature of the air, the temperature profile becomes important to reproduce the full extent of the mirage. This means that light traveling through this

atmospheric surface layer which is described by Monin-Obukhov similarity theory (Young 2015: B171). The framework of similarity theory allows Young to construct a granular model of the first principles behind the inferior mirage.

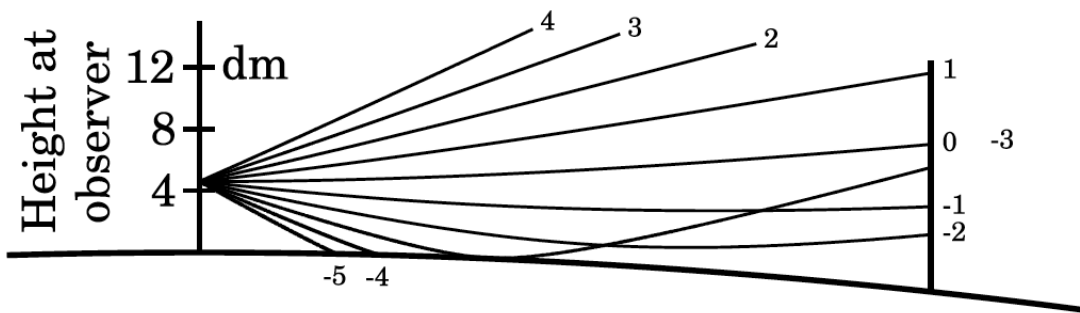
temperature profile bends towards denser (cooler) air, that is upward and is marked by regions with a higher refractive index. Which shows that a light ray does not travel in a straight line rather it curves continuously upward through the refractivity gradient. And if the curvature of the refractivity profile is sufficient, the light rays follow an arc and because light rays come from different heights must also travel through this curved refractivity profile – ray crossing is produced. Young's model also includes the lower limit of what an observe can actually see of the inferior mirage. In principle the logarithmic temperature profile extends from the free atmosphere all the way down to the laminar sublayer. However, because of surface roughness elements (pebbles, road texture, surface waves, vegetation) the lowest extent of the model constrains the most thermally intense portion of the temperature profile. Next, from the previously constructed thermal structure, the light bending mechanism and surface occluding elements the full structure of the mirage can be revealed. The model then traces light rays numerically from an observer's eyes through the logarithmic refractivity profile. Plotting each light ray against a target object's height gives the transfer function which encodes the physical reality behind the inferior mirage. Described through the causal chain of a warm surface, logarithmic profile, ray curvature, surface occultation, transfer function, the model of the inferior mirage encodes the optical signature of a particular atmospheric structure that transforms light that reaches an observer's eye.

Causal chain, as such, that transforms initial values into a particular output all together represent the ends of the inferior mirage. Parceled into three additive outputs, the study material builds the real meaning of the inferior mirage by the; (a) transfer curve, (b) ray diagram and a final (c) visualization which together represent the real meaning of the inferior mirage. These three outputs successively fit together the representation of an actual inferior mirage. Copied from the study material, the (a) transfer curve, the (b) ray diagram and the (c) visualization are shown below to demonstrate how the real meaning of an inferior mirage is fit together (see Figures 1, 2 & 3 respectively).



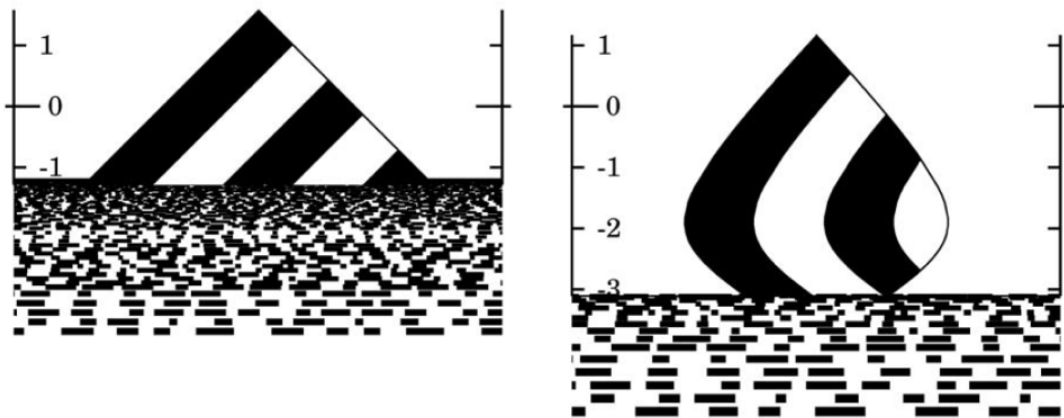
(a) A transfer curve that is derived from the refractivity profile from the study material.

Figure 1. Transfer function (Young 2015: B174).



(b) Ray diagram which plots the light rays that produce the characteristic mirage.

Figure 2. Ray diagram (Young 2015: B174).



(c) Simulation of a target object that makes visual the characteristic mirage distortion.

Figure 3. Simulation (Young 2015: B174).

The (a) transfer function of the model is constructed from the first principles of similarity theory. The (b) ray diagram presents a minimum where the erect and inverted image of the inferior mirage are defined. While the (c) visualization encodes the previous outputs and shows the physical meaning of the inferior mirage. Young then constructs his model of the inferior mirage by the computation of initial inputs that are expressed by a transfer function which are used to map an analogous distortion of an actual inferior mirage phenomena. The real meaning of the inferior mirage thus comes about by a logarithmic transformation and geometrical mapping.

Young also makes note of the importance of the location of the observer in relation to the surface elements (2015: B173). The inferior mirage will appear wildly different, or not at all depending on where in the thermal structure an observer happens to be viewing the mirage. The caveat of the location of the observer in relation to the thermal structure of the mirage makes for all the difference. If viewed from an inopportune point the mirage may not even appear. The importance of this in the study material shows how a difference in height and temperature between the observer and the surface elements greatly effects the appearance of the mirage. Which will become important when articulating the physical reality of the inferior mirage.

1.2. Study object

The reviewed study material presents a model of the inferior mirage and defines my study object. The representation Young (2015) constructs of the inferior mirage not only describes the physical reality behind the mirage but also the real meaning of the mirage. Young's section 3. *Temperature Profiles* and section 4. *Missing Information* together constitute the theoretical core of the study material where from I described my study object (2015: B171-B173). The physical reality of my study object is described through the study material as; surface temperature, logarithmic temperature profile, refractivity profile, numerical ray-tracing and the predicted structure of the mirage. The real meaning of my study object is then got from the calculated refractivity profile that maps the light rays responsible for the image inversion which simulate the predicted distortions of the modeled mirage. The study object is the exact representation the study material produces and is defined as: the model of inferior mirage. The above reviewed theory of the inferior mirage introduces the model and is the model referenced to in my case study.

The study object is defined as the model of the inferior mirage and is referred to as a mirage theory. The mirage theory of my case study is described by a causal chain that begins with a warm surface upon which the real meaning of the mirage is constructed and ultimately visualized. A semiotic understanding of through the lense of the index and indexicality on mirage theory works out my case study and the semiotic reality guiding the physical reality of the model. Where the semiotic aspect of the notion of the index and the activity of indexicality can then become applied. The result being an analysis on the relations mirage theory constructs to become the physical reality of actual inferior mirage phenomena. Hereunder, how I treat mirage theory is forayed.

2. Semiotic understanding

Drawing on Kristeva's understanding of semiotics, I defined semiotics as the production of models (Kristeva 1986: 77). The physical reality and real meaning of the study object is also made present by a model. I approach the production of the model of inferior mirage from semiotic indexicality. Designated as my study object, the model of inferior mirage follows the core scientific idea of a physical environment that establishes the way things are. I however, treat the study object as an ordered representation of a semiotic system that makes meaning about inferior mirage phenomena. Thus, I rescind the physical reality and real meaning of the study object to the production of a semiotic meaning making system—so to get at the indexic process that produces the semiotic reality that guides the physical reality of the inferior mirage.

I approach the study object from the semiotic category of the index because natural sciences work by decoding and then interpretating them (Sebeok 1990: 20), which is generally how knowledge is developed and constructed (Ginzburg, Davin 1980). The natural knowledge the study material presents is also constructed by the identification of indexes (like the first principles forming the mirage model). Nonetheless, I am not interested in the exact construction of the model of inferior mirage but in the semiotic activity within the production of the model. Therefore, I choose to base my approach in the notion of the index because the index servers to work out the way the study object becomes distinct. Thus, I convey the notion of the index and present its normative shift into an interpretive practice of indexicality so to describe my method of studying how the model of inferior mirage becomes a production of the brute forces behind an actual inferior mirage.

2.1. The index

Foregoing the lengthy terms of Peirce's entire philosophy, the notion of the index and the activity of indexicality are introduced. Linguistic features of the index regarding (mis)reference, deixis and ostension are left aside. I am interested in the nonsystematic manifestations an index may characterize in the act of representing. Upon conveying the notion of the index in Peirce, secondary literature is referenced to add comment to the semiotic notion of the index, its definitory features and its shift into indexicality. Functioning to link an apprehension to its referred object (Pape 1980: 216), Peirce's theory of the sign provides the foundational start to convey the notions used in my study method.

Defined to represent an object by a real correspondence (W 1.475), indexic relations function to locate, introduce, or identify subject matter which further specifies characteristics thereof (Encyclopedic Dictionary of Semiotics 1986 *sub index*). Flowing from the Peircean categorization of signs, the sign object relation of the index is what is really in physical connection, existential or causal link with its object (CP 2.299). The index thus functions to show, to point, to bring about, to come and to act by some object. Unlike a symbolic relation that stands for its object through a convention, or an iconic relation which stands for its object through resemblance, the indexic relation is defined by virtue of its connection with its object. On which the study object itself also relies on (e.g., refractive index of air) to produce the construction through which the inferior mirage becomes modeled. In practice the index shows what exactly a mirage is by a contiguous association of the physical distortions apprehended of a surrounding environment and the semiotic meaning making system representing these apprehensions. In this sense the index stands for the link between the object and the sign to bring about that what is shown to, but not describe.

Peirce's theory of the sign provides the starting point to understand the sign category of the index forming the foundation of my study method. Peirce's theory of the sign brings together three distinct facets that stand for an object monadically, dyadically and triadically (Short 2007: 207). Metaphysically these categories are respectively derived from the universals of Firstness, Secondness and Thirdness and make up the irreducible triadic structure of Peircean trichotomies (*Ibid*). Firstness means a category of pure potential. Secondness means the category of an opposing potential, while Thirdness is a regularity comprising the previous two categories. Each universal category intimately ties into Peirce's definition of the sign which is

addressed to “somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. That sign which it creates I call the interpretant of the first sign. The sign stands for something, its object.” (CP 2.228). In this regard, Peirce is able to define distinct types of relations which signs come to stand for, going from Firstness to Thirdness. The sign classification that is most useful for my case study is the icon-index-symbol triad. This division of signs determines the nature of a sign’s relation to its object, for example the effects an object has on the creation of its interpretation (Atkin 2005: 163). In this regard, the particular object relation of the index becomes vital for my case study to show how the model of inferior mirage becomes distinct.

Understanding that a sign is the relation to an object for the object’s representation (CP 1.540), the notion of an index may be conveyed. Distinguished from yet other types of classified object relations, the index is confined to a dynamic spatial connection to both an individual object and its sensed interpretation (CP 2.305). In accounting for the index, Peirce asserts indication threefold. The index has no resemblance to its object, it refers to a single individual, or single continua, and it calls to attention by blind compulsion (CP 2.306). Marking the index as a denotative link. Like the practice of forensic ballistic analysis, Peirce examples the notion of an index to a fissure: “Such, for instance, is a piece of mould, with a bullet-hole in it as sign of a shot; for without the shot there would have been no hole; but there is a hole there, whether anybody has the sense to attribute it a shot or not” (CP 2.304). Hence, the power to correctly attribute specifics to the fissure, cunningly directs an investigator towards the responsible shot firearm. Thus, the index is asserted by Peirce to “represent an object by virtue of its connection with it” (CP 8.368). A representation that is in virtual connection and denotes its object is indexic in nature. Which will shortly become important for describing the function of indexicality.

Looking beyond the scattered works of Peirce to the secondary literature, Goudge (1965) systematically collects various features of the index, which Atkin (2005) later comments on and refines. Considered under the guise of a general theory of identification, Goudge discriminates six main features of the index in Peirce. Goudge defines the index as such: the index is to be really affected by a physical connection, which an interpreter may only take note of (1965: 53). The index is of a compulsive influence forcing attention to itself (*Ibid*). The index involves the existence of the object, forming an inseparable pair (*Ibid*). The index is always of a singular identity (*Ibid*). The index asserts nothing, merely shows its object (*Ibid*). And finally, the index is a brute fact of a non-rational relation (*Ibid*). Taken together, Goudge construes the

semiotic features of an index, characterizing the kind of sign object relations that fulfill indexical representation.

Atkin (2005) updates our reading on Peirce's index, enumerating a reduced list of features that Goudge previously articulated. Atkin argues that the first two features Goudge spells, make up a singular feature of the index (Atkin 2005: 164). Atkin argues that the physical connection of an index is innately linked to the semiotic function of an index to possibly generate incipient meaning (*Ibid*, 167). Like in the case of a bullet shot, which can grab attention, a thorough investigation connects the physical deformations of the fissure to its responsible firearm, but need not. Combining the first two features of Goudge, Atkin construes the index into five definitory features. The indexical features are;

- (i) Some kind of physical contiguity that calls attention unto itself (*Ibid*).
- (ii) It has characteristics independent of interpretation (*Ibid*).
- (iii) It refers to an individual (*Ibid*).
- (iv) It asserts nothing (*Ibid*).
- (v) Is not an icon, nor a symbol (*Ibid*).

It may be assumed now that every sign can possess some or all of the listed features of an index, but Peirce reminds us that an absolutely pure index is not possible (CP 2.306) as a sign will always have some part resemblance and or convention mixed in with its representation. Showing that all representations, at the least, will have some indexical character or quality to them. Which will become important for the application of my study method to the study object.

The distinguishing element amplifying the key feature of the index is reference. Involving either an existential relation or a referential relation to an object (CP 2.283), the index can be further distinguished between either a genuine or a degenerate index. The existential relation of a genuine index is described by the word reagent, whereas the referential relation of a degenerate index is described as a designation (Goudge 1965: 55). Supposing a mirage phenomenon is seen, a pareidolic or factual observation may be differentiated respectively signifying either a degenerate or a genuine reference. For example, a mirage may appear quarrelsome, but remain just that, the physical distortions of a particular environment. Here a genuine reagent makes reference to the phenomena and expresses the factual nature of the mirage. Alternatively, the unfamiliar appearance of mirage phenomena, inspiring the inventive resemblance of cloud palaces (Reinecke 1800) or an island (Freitag 2013) makes a degenerate designation to the phenomena of a mirage.

Another important facet of the index is that the action of an index depends upon on association by contiguity (CP 2.305). Relations which have by virtue meanings associated with them function as indexes. That the action of the index is a “relation to their objects consists in a correspondence in fact, ... direct the attention to their objects by blind compulsion” (CP 1.558). Such a particular way of working with the index then makes meaning by showing how what is generally attached to an index. By this way the index is an overlap on its way to becoming meaningful before actually coming to stand for something outright. Thinking of the index as an association by contiguity presents a way to overcome the boundary in which meanings happening at the edge, so to say, bring about meaningful thought.

Because the index is characterized by asserting definitory features, different instances of actually intimating mirage phenomena exemplify how indexic elements function in terms of their scientific consequence. In the order of Atkin’s listed features, the known mirage is used to characterizes each feature of the index. First, mirage phenomena exemplify a physical contiguity with some associated temperature gradient (Meteorological 1991 *sub mirage*). Additionally, mirage phenomena grab onlookers’ attention, inspiring curious and often outlandish retellings (Pinney 2018). Second, assuming actual mirages are independent of an onlookers (mis)interpretation, a mirage is an index of an encompassing thermal structure of a particular environment (Young 2015). Third, the mirage exemplifies being an index by referring to a specific appearance of a particular miraging, happening as a continuous phenomenon (Jefferson 1787). Fourth, the physical distortions of a mirage meaning nothing, showing only the thermal signature of the atmospheric surface layer. Finally, the brute fact of a mirage, being of a protean behavior, does not resemble nor impose convention existing as a natural phenomenon of the world. Any relation with the thermal structure of the atmospheric surface layer being completely coincidental.

The main features of the index are given; namely its attention-grabbing physical contiguity, independence of interpretation or meaning, reference to a unity, its lack of assertion and that it is not of iconic or symbolic aspects. From here Goudge and Atkin provide further analysis of the index showing its designative and reagent distinction. Because Peirce asserts the index definitory and not as a qualification, various examples from the human developed knowledge of mirage phenomena are used to demonstrate the indexic features from documented examples. From the scientific understood explanation of a thermal structure that causes a mirage to the misapprehension of a mirage that beckons the curious out to sea, the various indexic features were demonstrated by examples and were formally defined.

In the field of semiotics, the index is that what points, showing back to or towards something. Then, indexicality is the process of becoming as an index works to point it out. The specific features of the index come to occasion the activity of indexicality. The concept of indexicality, as a state of being indexic, is like deductive reasoning and is in general how the natural sciences work. Constituting the premises of a deduction³ the index is what signals indexicality. And in this fashion the index and its interpretive practice relate a cause to its effect or of an effect to its cause in temporal succession (Sebeok 1990: 13), which I touch on shortly. Thus, sign structures that emerge by the dynamics of indexicality are described by such words as ‘signal’, ‘symptom’, ‘clue’, ‘cue’. Inasmuch, some argue that the index and indexicality are primary for the action of the sign (Zhao 2022; Kull 2024). I however do not intend to venture into the general semiotic theory of indexicality. I rather focus on the basic activity of indexicality as it provides the framework for my study method. In particular, the activity of indexicality and how it can be applied to my study object.

2.2. Indexicality

I use the semiotic activity of indexicality as my study method. Through the notion of the index, indexicality is introduced as an interpretation of a contiguous association. The study method is founded on the notion of the index where from the activity of indexicality is conceptualized. Never directly mentioned in Peirce, the inferential logic behind indexicality is cited. The semiotic concept of indexicality to assimilate, contextualize and succeed is discussed (Campbell 2016; Eragamreddy 2019; Sebeok 1990). Thus, from the concept of indexicality as an interpretive practice I understand my study method.

I understand the interpretive practice of indexicality as a kind of interpretation that maintains a direct and causal relation with its referred to object. Generated from indexic features, the process of interpretation that relies on contiguity and manifests a concurrent proceeding characterizes the practice of indexicality. As a practice, the semiotic activity of indexicality is rarely straightforward, calls for a direct relation and is sparked by some signal.

³Aptly explained, Peirce reasons how an index functions in deduction: “An Obsistent Argument, or *Deduction*, is an argument representing facts in the Premiss, such that when we come to represent them in a Diagram we find ourselves compelled to represent the fact stated in the Conclusion; so that the Conclusion is drawn to recognize that, quite independently of whether it be recognized or not, the facts stated in the premisses are such as could not be if the fact stated in the conclusion were not there; that is to say, the Conclusion is drawn in acknowledgment that the facts stated in the Premiss constitute an Index of the fact which it is thus compelled to acknowledge” (CP 2.96).

My study method thus applies the interpretive practice of indexicality to show how the semiotic reality of my study object becomes really meaningful.

Founded on the notion of the index, Kruse shows how indexicality is related to the logic of abduction from where I establish the framework through which I understand the interpretive practice of indexicality. Kruse (1986) connects the inferential experience of making a successful interpretation to the interpretive practice of indexicality. In contradistinction to deduction and induction, Kruse explains how indexicality becomes foregrounded upon making a correct abductive inference (*Ibid*, 439). Deduction, which draws a specific from a general, and induction which draws a general from a specific—both connect a premise with a conclusion. In these interrelated processes reasoning happens on to a determined or delimited consequence about some object (*Ibid*, 442). And in accordance with Peirce's definition of the index, as a correspondence by fact, the completed inference of an abduction becomes a sign of its object that is got by the indexic features that lead to such and such a correct interpretation (*Ibid*, 443). By describing the process of reasoning like this, Kruse makes the implicit explicit, and notes how there are indexic aspects underlying all major types of reasoning by the interconnection of before and after as an interpretive practice. I thus understand indexicality as a function of bidirectional representing that shows an end that simultaneously reconstructs the end. In moving toward a more adequate interpretation (*Ibid*), Kruse describes how indexic features beyond the mere constitution of a premises are necessary for reasoning. Underlying the interpretive process of indexicality I see a logical framework that becomes interconnected by relating a before and after in the here and now which is important for framing my study method.

The character of indexicality to produce a concurrent proceeding is formulized by Campbell (2016). Campbell formulizes indexicality in the process of having to adapt to novelty. Campbell contextualizes indexicality as a modality of actuality that is bound up in some attention and explains this process as an action upon and resisting a being (*Ibid*, 22). This way, Campbell understands indexicality as an embodied process wherein assimilations and accommodations are wherefrom actually becomes (*Ibid*, 23). How a novelty is adapted is what leads to the construction of knowledge and is described by Campbell as an asymptotic relationship which conceptually describes how contiguity and resistance come together and either absorb or reject the novel (*Ibid*, 26). By describing indexicality as an asymptotic relationship Campbell explains how indexicality works as an indexical rub that uncovers imprinted qualities of the novel and only after the fact does the novel become conceptualized (*Ibid*, 33). Indexicality is thus described as a reference to a novel that capitulates through

activity to then assimilate and accommodate the novel or outright reject it. Thus, I understand Campbells formalization to assimilate and accommodate as a feature that develops the character of indexicality as an activity that works in the present to represent as a contextual interaction.

Indexicality, characterized as a contextual interaction also functions as contextual referencing in communication. Eragamreddy (2019) characterizes the activity of indexicality to extend beyond simple reference that emerges dynamically from situational environments. Words like ‘now’ and ‘this’ exemplify how meaning is carried only in relation to the immediate context wherein they appear. Features used to contextualize a situational environment and function to position a particular formation therein shape indexicality. Eragamreddy further emphasizes that indexicality rarely happens in isolation but always in conjunction with iconic and symbolic elements (*Ibid*, 2456). Eragamreddy makes bare that indexicality functions to orientate an immediate position within a situational environment and does not easily travel across different contexts—rather acting to stabilize situational contexts. Characterizing indexicality as an activity of orientation, the interpretive process describing my study method works out the orientation of the semiotic reality that positions the physical reality behind the study object.

Moreover, as a temporal succession indexicality faces the problem of selectivity. Sebeok points out this dilemma for indexicality in relation to the logic of deduction (1990). Outside the narrow confines of drawing a conclusion by deduction, the issue of selecting facts necessary for a deduction is problematic. Because deduction draws a specific from a general, selecting what exactly comprises the index from which to reason about, poses a challenge. Meaning, that the intertwined relationship the index stands for when deducting something lacks direct guidance. However, since my case study examines a preexisting production, identifying specifics of the study object does not pose a challenge for my case study. Furthermore, by tying the two concepts of deduction and indexicality together, Sebeok hints to what the epic terminology of *mêtis* means for indexicality (1990: 8). Insofar as indexicality is an interpretive practice, it can be thought of in terms of a scheming intelligence of appearance and becoming (Detienne, Vernant 1991: 45). Which the ancient skills of hunting and fishing embody. This brings us back to the ‘book of nature’. Neither straightforward nor final as in the case of the study material which really discloses the inferior mirage by the interpretive practice of mapping and tracing out the effects of a refractive index.

As it was shown, the activity of indexicality effects meaning by a process that forwards disparate aspects toward some cause. The connection indexicality forays makes present may yet remain latent, as it asserts nothing. Indexicality then functions as an interpretive practice

that comes to be shown or to be pointed out as an end. In this manner the semiotic concept of indexicality brings about the real and the actual by becoming presentable. Put another way, the index is anything but reified, rather presented as dynamic attributes that through indexicality come about and show back to some cause. Indexicality thus becomes real and actual through its direct relation with its object, be it a phenomena, continuum or object. Indexicality, therefore, connects yet does not completely yield, showing only processual ends and not terminating in meaning. Like a sandbox then, indexicality requires attention and care in prescinding an underlying constructing. Thus, indexicality requisites cultivation.

The many aspects of the index that converge into the activity of indexicality wherein indexicality gets characterized is what frames my study method. At its most basic, indexicality fits together space and time parameters to form some reference. In making reference to temporal and spatial localizations, indexicality is an activity that informs a practiced interpretation to something that is before and after. Indexicality is thus an activity of appearance and becoming once the problem of selection is overcome. Framing my study method, indexicality is understood as an interpretive practice that works out a cause by orientating assimilated indexical features that then become presentable.

Two brief illustrations of indexicality are presented to demonstrate the interpretive practice in action. Whereafter my study method is described.

2.2.1. Indexicality illustrated

Exemplifying the more practical aspects of indexicality, Morelli and Herschel should be mentioned as prime lived illustrations of indexicality. Two ectypes of indexicality present themselves. Beginning with Giovanni Morelli and his Morelli method named after him. The Morelli method is a method that is used to correctly attribute a painting to its painter (Ginzburg, Davin 1980: 7). Ginzburg explains this method as the concentration on minor details that then show whatever is peculiar to an art work and those identified specific features are sought across other artworks which together point out and attribute the specific artistic feature to an artist. By this method of paying attention to acute features subsequent art historians have been able to successfully attribute painters with their artworks long after the artists have passed. This method of art attribution can still be found in practice today. The second notable illustration of indexicality is the British administration of a Bengalis colony. Ginzburg shows how the practice of soliciting fingerprints (meant as a divinatory practice to the locals) was an effective way to

administer local populations (*Ibid*, 27). This practice of collecting fingerprints for administration and identification eventually developed into the modern conception of identification documentations and demonstrates the affinities indexicality affords knowing.

Together these two lived illustrations help demonstrate what the interpretive practice of indexicality entails. As an interpretive practice indexicality makes something to become presentable that is at once intimately tied up with its source. And through the logic underlying this interpretive practice of indexicality I describe my method of study. The study method is based on the notion of the index wherefrom the activity of indexicality characterizes its application. Next, I discuss how my study method is applied.

2.3. Study method

The study method I apply to the study object is based in the notion of the index and is described by the activity of indexicality. Understanding that semiotics is the production of models, my study method is a way to describe how the semiotic meaning making system that produces the model of the study object becomes produced. Based on the terms of the index the study object is indexed to cultivate the activity of indexicality. The study object thus presents the mirage theory that is the model of inferior mirage where from the interpretive practice of indexicality works out the semiotic reality that construes the physical reality behind the model. Supported by the framework of a semiotic understanding my study method fits together the dormant (indexical) reality operating to produce the physical reality of the inferior mirage.

Pursuant to the posed study questions, my study method answers the study questions descriptively. Initially a brief understanding of the semiotic meaning making system of the study object is described. There after my study method is applied. The application of my study method begins by marking the indexic features of the study object as reference points. Index, meaning: a virtual connection that denotes its object, frames the description of the indexic features of the study object. Thereby, the indexic features cultivate the activity of indexicality in the physical reality of the study object. Through the collected indexic references the virtual connection of the study object is established that becomes indicative of the semiotic reality behind the understood physical reality of the inferior mirage. From here the activity of indexicality functions to describe the semiotic reality that brings about the model of inferior mirage in the study object. Indexicality, meaning: a process that forwards disparate aspects toward a singular describes the entire case construing the reality of the model of the inferior

mirage. In section 3.1., I describe how indexicality causes the model of inferior mirage. Which shows how the model of inferior mirage is brought together. Next, in section 3.2., I localize the inferior mirage by articulating how the physical reality of the inferior mirage becomes produced through indexicality. And in section 3.3., I describe how indexicality structures the model of inferior mirage thereby describing the physical and semiotic realities behind the model. Thus, the treatment of the study object by indexicality describes the cause of the model, articulates how the model becomes and how the study object yields real meaning through a physical reality that worked out from its semiotic reality. From the description of the physical reality of the study object the dormant semiotic reality behind the inferior mirage is got. Fulfilling my objective of describing the semiotic reality that gives structure to the physical reality of mirage phenomena. Resulting in an original description how the inferior mirage model becomes fitted together through indexicality.

Describing how indexic features shift the study object into the interpretive practice of indexicality, the approach of the study method is laid out. The index, working as a definitory assertion and colored by its five dominate features outlines how indexicality is used to connect and interconnect the interpretive practice that forms the indexical aspect of the semiotic reality behind the study object. Indexicality as applied, functions to fit together the cause of the physical reality of the study object. Ultimately, showing how indexicality gives structure to the reality of the inferior mirage. Which lends itself to describing the semiotic reality that is indicative of the physical reality that models the inferior mirage.

3. Indexicality and mirage theory

Just as a dust devil is indicative of a whirl wind or extreme weather events get attributed to human activity, I describe how the activity of indexicality works out the semiotic reality that produces the model of the inferior mirage. My work is therefore about an (indexical) aspect of the semiotic reality that becomes the physical reality of actual mirage phenomena as it manifests in the study material I defined as the study object. I thus look at the production of the constructed mirage theory of the study material, but more specifically how the activity of indexicality comes to cause the theory, to articulate how it becomes and to describe how indexicality makes the physical reality of the theory become real. Before describing how indexicality produces the model of the study object, indexicality is cultivated through the identification of the four principal indexes of the study object. Accordingly, I aim to complete

the objective of describing how indexicality works out reality – an aspect of it at least – as modeled in the case of the inferior mirage. And in return describe the semiotic reality that brings about physical reality, specifically that reality that indicates the scientific inferior mirage.

Posed as a case study on the indexicality in mirage theory, I understand the study object as a model. The study object presents the inferior mirage as the transformation of indexic features through the framework of similarity theory from which geometrical optics simulates the distortions of a real inferior mirage. By describing the activity of indexicality in the particular mirage theory of the study object, I describe the production of the model-making of the inferior mirage as Young presents it. Thus, the representation of the inferior mirage which designates my study object and is defined as a model of the inferior mirage becomes reflected and becomes a type of model that corresponds to the activity of indexicality (Kristeva 1986: 77). My work, this way, cultivates indexicality in the study object by isolating the indexic features in the model of inferior mirage where from the activity of indexicality becomes the description of the production of inferior mirage theory.

Four indexic features of the study object are isolated. Each exists as a transition link the causal chain of the model of the inferior mirage, where one construction builds the next. These are not interpretations or assertions about what a mirage is, nor analogies or conventions. The four indexic features are points of described physical contiguity that call attention to themselves by the fact of their connection. Each index refers to a configuration of the study object like a specific temperature structure, a specific curvature, a specific limit and a specific mapping. Each describing characteristics of the mirage regardless of observation, which link directly back to the model of inferior mirages and thereby make up the indexic features of the study object.

The first indexic feature of the study object is the virtual link between the description of a warm surface and the logarithmic profile that similarity theory constructs from it. This index is not an assertion about the inferior mirage nor does it resemble the surface it describes. The relation is a point of physical contiguity between the thermal conditions of a particular environment and its mathematical formalization. Similarity theory registers the surface's temperature characteristics as a structured profile. Contiguously characterizing the gradient, shape and its heterogeneity, this index calls attention to the particular temperature structure of the environment. The index claims nothing about what the profile means for the mirage, merely functioning to anchor the causal chain of the study object to the conditions of a particular surface.

The second indexic feature of the study object is the transformation of the logarithmic temperature profile into ray curvature by way of a refractivity profile. Here the index functions

through physical contiguity between two states of the same quantity: the thermal profile and the extent to which light bends within it. The refractivity profile is not like the described temperature profile nor assert anything about the inferior mirage, but a physical outcome of it. The second index marks this resulting link. How steep or gentle the refractivity profile bends light is characterized by the temperature structure which is independent of any interpretation. Without asserting what a mirage is, this index calls attention to the character of the particular atmospheric environment to curve light.

Distinct to Young's model relative to other models of the mirage is surface occultation, which isolates the third indexic feature of the study object. Given the refractivity profile is derived from the logarithmic temperature profile and is used to show the extent of the mirage, surface elements outline the lower geometric limit where light rays cannot propagate and the mirage cannot extend. the mirage and is the consideration of surface occultation in comparison to other models of the inferior mirage and is the third indexic feature of the study object. By drawing a lower limit of the mirage and calling attention to the physically lowest extent of the mirage surface occultations function as the third index. This index does not assert what a mirage is, only bounding the individual phenomenon. The third index works to constrain the causal chain, further characterizing the mirage to make it more determined rather than interpreting the mirage.

Ray curvature and surface occultation together provide the physical basis for the fourth and final indexic feature of the study object. The final index of the study object is the transfer function. The transfer function neither asserts nor resembles what a mirage is but functions to map the structure of the inferior mirage. This index traces the bent light rays through the refractivity profile while accounting for the bottom limit of surface occultations. The index relates through physical contiguity between curved and actual light rays calling attention to the multiplicity of light pathways. Without asserting anything about the multiple light pathways, this index constitutes what defines the mirage in Young's model.

Together, the four indexic features of the study object; anchoring, curving, occluding and mapping accumulate characteristics that function to specify the make-up of the study object. None of the indexes (anchoring, curving, occluding and mapping) assert or interpret anything and work to close the causal chain described by the study object. As the indexes of the study object, each index adds specifics that bring about the real meaning of the mirage. The four described indexic features of the study object are define and each index functions to show what is hallmark about modeling the inferior mirage. Concurrently, the four described indexes

are used to cultivate the activity of indexicality. How indexicality causes the inferior mirage in the production of the study object is described next.

3.1. Cause

As a temporal succession, the activity of indexicality is used to place the case study and assimilate the semiotic cause of the theory of inferior mirage. The study object describes the model of the inferior mirage as a causal chain that constructs an actual mirage, where from the activity of indexicality describes the process of assimilating the previously isolated indexic features of the study object to describe the cause of it. Through the accommodation and assimilation of the found indexic features of the study object, the logical framework underlying indexicality may describe the cause of the theory of inferior mirage and herewith answer the first study question. How indexicality causes the constructed mirage theory is described through the aggregation of a system of indexes (Campbell 2016) that brings about the model. The interpretive practice of indexicality functions in this regard to work out how the indexic features cause the study object.

The four indexic features of the study object together form a narrowing of the study object that syntactically overlap onto the possibility and the generation of its indexical cause. From the anchoring of the warm surface unto the mapping of the structure of the mirage the given structure of the mirage is modeled. However, each index that links the causal steps of the study object also function as reference points wherefrom the activity of indexicality may describe the cause of the theory. This cause indexicality describes is structured through the logic underlying indexicality and interconnects the four indexes as a before and after in the here and now. The indexic features of the study object and their function is given in Table 2.

Index Function

Anchoring:	Links thermal condition of the warm surface and its logarithmic formalization through similarity theory
Curving:	Transforms the logarithmic temperature profile into ray curvature through the refractivity profile
Occluding:	Constrains the extent of the lower bounds of the model of the inferior mirage
Mapping:	Traces ray curvature that produces the optical structure of the inferior mirage

Table 2. Indexic features of the study object.

Each index relates to the study object by consisting in a correspondence in fact to the study object. Following the logic underlying the activity of indexicality, each index also designates a reference point that structures the context that produces the cause of the study object. The structure interconnecting the four indexes directs towards the cause of the theory of inferior mirage and thereupon a before and after that produces the logical structure underlying the cause of the theory. The logical structure thus lily pads from corresponding fact to corresponding fact and works out a cause by a dynamical relation that convergences to a point (Kruse 1986: 442). The result being the study object maps out the real meaning of the inferior mirage as indicated in (a), (b) and (c) of the study object. Nonetheless, the logic of indexicality converges the structure of the study object to a point of being caused.

Cause understood through the framework of indexicality either relates a cause to its effect or an effect to its cause in temporal succession (Sebeok 1990: 13). And to describe how indexicality is responsible for the study object and its cause, the indexic features are interconnected in such a succession to bring about model of inferior mirage. Understanding indexicality as a process that forward the indexic features of the study object the cause of the theory of inferior mirage is described. Once as a possibility and once as a generation the logic of indexicality together with the activity of indexicality describe this cause. Indexicality then causes the inferior mirage by operating as a causal chain where each isolated index is both a physical contiguity coming before and the physical contiguity of the one coming after. The cause indexicality describes is not in one index rather in their aggregated concatenation. The successive and contiguous transformation of the physical descriptions produce the model of the inferior mirage. Showing how a concatenation of the indexic features lead the study object to be caused through the temporal succession of indexes.

The study object's causal chain contiguously conveys about the warm surface to a point where a miraging is generated and produced. The model of inferior mirage accommodates the preceding indexic features by assimilating the features into a more and more distinct context wherein individual light pathways are mapped out and used to trace the optical structure of the mirage. The context of the object leads to the construction of the mirage that harkens back to the anchoring relation of a warm surface. The particularity of the context is pointed out by the transformation of the warm surface that becomes marked by the refractivity profile and surface occultations. Each proceeding index forwards the anchoring warm surface and respectively transforms characteristics thereon to produce the model of the inferior mirage. Like fitting jigsaw pieces together, the model of the inferior mirage comes together with fitted together indexes. From the warm surface to a logarithmic temperature profile, from thermal profile to ray curvature, from ray curvature to constrained ray curvature and from the constrained ray curvature to the transfer function the inferior mirage comes about. Indexicality forwards these disparate aspects into succession such that a preceding effects a proceeding to be caused. The cause of the theory of inferior mirage is thus an interaction of the indexic features of the study object and thereby produce a highly referenced context that is fitted together. Through the interconnection of the indexic features indexicality generates the theory of the inferior mirage and describes the cause of the model of the inferior mirage.

Underlying indexicality's description of the cause of the study object is the logical framework of indexicality that makes the possibility of a cause unavoidable. The logic of indexicality means that the indexic features, each constitute a premise and come together to converge to a point where the possibility of a cause becomes logical necessary. Because each index constitutes a premise, the logical activity of indexicality serves to bring about a general description to cause the model of the inferior mirage. Without the particular environmental context, the subsequent ray curvature could not be had and without the ray curvature surface occultations would not constrain ray curvature. This stepwise constructed from the anchoring warm surface premise to the mapping ray traces premises is the logical underlining of the model of the inferior mirage. The logic of indexicality thus cause the theory of inferior mirage by the possibly of a cause through fitted together indexes, read premises, that function to lay the foundation for the generation of mirage theory. Indexicality causes the model of the inferior mirage one premise after another without which the inferior mirage would not come about.

Indexicality causes the theory of inferior mirage by constituting through the successive aggregation of indexic features, that simultaneously function as premises, to cause the model of the inferior mirage. Like a jigsaw piece, each index functions in context to construe

characteristics about the particular environment where upon the cause of the inferior mirage is generated. While each premise construes a fact that is then passed forward and by the fourth fact constitutes the possibility of the model of the inferior mirage to be caused. This layered assembly as contextual references of physical contiguity is what transforms the possibility of a cause into the generation of a cause and in turn the model of the inferior mirage. The indexical features function to puzzle together an outcome which produces a general description about the mirage. Then, the theory of inferior mirage accommodates ascending facts that correspond to a particular environment from which the theory is caused. The theory of the inferior mirage is therefore produced by indexicality from within as an interconnection of indexes which function to point out through themselves the cause that is used to represent an inferior mirage. Indexicality therefor works out a theory of inferior mirage and thus cause the theory from the indexes defined. The model of the inferior mirage is the end that the aggregated indexes necessitate and indexicality is the process by which that conclusion is caused.

Describing indexicality's cause of the model of inferior mirage shows how the activity of indexicality functions within the study object. Now, to explicitly get at the semiotic reality behind the study object I describe how indexicality articulates the model of the study object and show its influence on the reality of the inferior mirage.

3.2. Articulates

Drawing on the causal chain of the study object, I answer the second study question by examining how the model-making of the study object becomes the physical reality of the inferior mirage itself. This process is articulated through indexicality as a situational environment. Articulating a situational environment that orients and positions the study object. Using indexicality to locate, I work out the orientation and position to show how the physical reality of the model of inferior mirage becomes. I thus work out the position and orientation of the study object to articulate its situational environment through the activity of indexicality.

The physical reality of the inferior mirage emerges through three interrelated articulations. The primary articulations that become the physical reality of the study object are the logarithmic temperature profile, the parameters that modify the profile and the occultation of surface elements. Each articulation adds to the orientation and positioning of the study object within the situational environment. In locating the study object with this framework of contextual reference, the process by which the model becomes the physical reality of the

inferior mirage. Thus, through indexicality the model-making production of the study object and the construction of the inferior mirage uncovers its physical presence.

Remembering that indexicality functions as a localization, the study object is situated though its described articulation. The production of the model of the inferior mirage is based on the logarithmic temperature profile from which the entire model is indexed from. Characterizing the temperature profile is similarity theory. The parameters of similarity theory add detail to the character of the temperature profile. The hallmark feature of Young's model is the occultation of surface elements which determines the bottom extent of the miraging (2015: B173). Concurrently, the study object builds the mirage from the assembled indexes which together roughly articulate the production of the physical reality of the inferior mirage.

The production of the physical reality of the inferior mirage through indexicality begins by establishing a context of a situational environment. The situational environment of the model of inferior mirage is comprised of the logarithmic profile, the parameters set out by similarity theory on that environment and the surface elements that occlude the bottom of the mirage. These three distinct yet important constructions of the study object articulate the situational environment. Environmentally, the logarithmic profile forms the environment. The logarithmic turbulent sublayer provides the curved profile for ray-crossing and inversion which defines a mirage and establishes the substrate that serves as the environment from which the parameters and occultation elements can be situate and contextualize the constructed environment. The parameters that similarity encodes is the primary environmental determination of the strength of the mirage. These parameters encode the environmental substrate and situation the logarithmic profile as a particular environment in relation to the convective intensity of the logarithmic turbulent sublayer (Young 2015: B172). The occluding surface elements add to the situational environment. The hinderance of surface elements hide the near-surface part of the environment where the steepest temperature gradients are (*Ibid*). Environmental occlusion constrains the lowest part of the mirage and completes an articulation of the study object. Articulated at this point, a situational environment of the study object is described.

The position of the model of inferior mirage is constituted by the observer's height and the effective horizon which further articulate the study object. The observer's height can be seen in the study object noted next to the (b) ray diagram. This point, where incident rays arrive at the observer's eye-level samples a position along the curved profile of the situational environment. And serves to articulate the exact position from which the inferior mirage becomes visible. The effective horizon is a bit more complicated. The underdetermined position of the effective horizon is bound up in the apparent horizon and the physical surface elements.

The articulation of the effective horizon is shown by a ray reaching a specific height at a specific distance from the observer. Such that, the effective horizon becomes a positional correction that compensates for the obstruction of surface elements by replacing the lowest bounds of the situational environment with a positional constant. In turn adding articulating to the observer's height. The second articulation points out a position within the situational environment that describes the physical reality of the study object.

Finally, the orientation of the study object is articulated and described. The orientation ties the model of inferior mirage together and is articulated by the direction of the gradient and the fold line. A curved profile is required for a miraging as the (a) transfer curve indicates. The direction of the curvature is concave upward, i.e., heat rising upward from a warm surface, and articulates the primary orientation of the study object. The curvature of the profile is what articulates the study object and geometrically orientates the vertical temperature gradient onto the situational environment. A fold line is where the mirage goes to infinity (Young 2015: B175) or the erect image folds down to its inverted image. The fold line articulates the study object by making a division in the situational environment. At the fold line the orientation articulates the study object and provides an optical trace atop the situational environment. This final articulation of the study object works to direct the model of the inferior mirage and show the orientation of the model.

Articulating the study object as it becomes the physical reality of the inferior mirage is the situational environment which constructs the mirages' context, followed by the position the model takes on within the context and finally the orientation by which model reads out the structure of the mirage. The situated environment is made up of the logarithmic temperature profile which articulates the point from where the mirage becomes described. Part of the situational environment are the parameters similarity theory encodes which articulate the strength of the mirage, and the surface elements that articulate the lower limit of the mirage model. Each part adding situational context to the environment and constructing the substratum where from the physical reality of the model becomes compounded. The position of the model is articulated by the height of the observer and the effective horizon. Together, both positions show exactly where in the constructed environment the mirage will appear. The last articulation is the direction of the gradient and the fold line. This articulation orientates the model and thereby shows the magnification gradient which are indicative of the characteristic features of the inferior mirage. Thereby notching together articulations wherefrom a distinctness arises that becomes the physical reality of the inferior mirage.

The articulation of the study object into terms of a situational environment that samples a position and is directionally orientated establishes the physical reality of the inferior mirage. Situated within an environment, the directional orientation of the model describes the exact characteristics of the inferior mirage. The position of the model within the situational environment points out the region of the physical distortions of the mirage. While the articulation of the situational environment brings about a description wherein the physical reality of the mirage becomes feasible. Indexicality thus localizes points that become articulated through the characteristic features an actual mirage signifies. And in doing so, establishes the physical reality that becomes located in a context of articulations.

Indexicality locates of the inferior mirage through articulations that become the physical reality of the mirage through notching together points. The articulation of the model of the inferior mirage shows how the physical reality of the inferior mirage becomes constructed through the localization of points on the substratum of the constructed situational environment. Thus, the articulation of the study object into its orientation and position within a situational environment is what becomes the physical reality of the inferior mirage. It is then through the articulations of indexicality that the physical reality of the inferior mirage comes about and becomes by cojoining born points. Indexicality hereby describes how the physical reality of the inferior mirage becomes through the localization of articulated points of the study object.

For this all to become real, how indexicality structures the physical reality of the model of inferior mirage is described next. The result being outputs which resemble the mirage but are not of interest here rather how together with the cause and the articulation of the model make the inferior mirage to become real. Which shows then the semiotic reality behind the physical reality that becomes the model of the inferior mirage.

3.3. Become real

One may address the structure of the physical reality behind the inferior mirage to become real through the depiction of the model's output, namely the (a) transfer curve, (b) ray-diagram and its (c) simulation. However, for the activity of indexicality to describe how the structure of the physical reality becomes real I decide to how each output is structured by the cause and the articulation of the study object. Drawing on the previous two subsections (3.1. and 3.2.) I answer the final study question wherefrom the semiotic reality and the physical reality behind the model of the inferior mirage take shape. The study object shows that after the transfer

function is derived three outputs become representable, each working out an aspect of the optical signature of a particular surface layer that together reveal the entirety of the mirage. Indexicality acts to draw together the outputs of the study object which successively compound the physical reality of the model to become real. The cause and the articulation of indexicality on the study object thus function to point out individual aspects of the model that structure the mirage to become real. Through which I describe how the model becomes real while illustrating the physical and semiotic reality behind the study object.

Central to how the inferior mirage becomes real is the structure of its cause from section 3. 1.. Indexicality shows that the cause is an assembled concatenation of indexes. The indexes point to a successive physical state that goes from the surface into the temperature on to curvature while accounting for surface occultation that results in a transfer function. The indexes point to the next physical states as the causal production of the one before it. This indexic chain generates the model of the inferior mirage that yields three depictions mapping the optical structure of the mirage. Because the depictions resemble the mirage they make it real, however, the reality of the mirage is not only based in resemblance. Because each index is striated into the next the resulting depictions make reference through the entire linkage of indexes. The mirage becomes real through this reference, not merely through likeness. The cause therefore does more than produce the model but also constitutes part of the structure which the mirage becomes real. Such that, through indexicality the fitted together constitution of each index is the mirage structurally made to become real.

The articulations of the model work out the other part of the structure. Through the compound index by which indexicality describes these articulations, the structure of physical reality is shown to come about whereby the model becomes real. Indexicality shows that the model-making of the physical reality is a unified process that results in the localized study object. Through localizing the study object does a situational environment that orientates and positions the model to become articulated. By notching together; the logarithmic temperature profile, parameters of the profile and surface occultations a situational environment is defined and located. Further articulations build on the situational environment and collect together the orientation and position of the mirage as physical reality. Here the height of the observer shows where the physical reality of the mirage is realized which orientates the model. While the fold line that indicates where the transition of the inverted image flips into the upward image further articulates the position of the model. Each articulation locks the next into place and together compose the mirage into existence. Thus, indexicality shows how the physical reality of the inferior mirage is brought about in a single, unified process. The articulations coincidentally point

to the physical reality that already exists and thereby are the means by which the entire mirage becomes real.

Brought together, the cause of the model and the various articulations of the model show how the model becomes real. The cause constitutes the structure through which the model becomes real, while the articulations are the means by which the caused reality is located. Together they form a single process through which the inferior mirage is made a model and real. This process points out the semiotic reality behind the physical reality of the inferior mirage. Thus, indexicality structures the coinciding physical states where from a particular reality comes about where from the mirage is defined and made real. Ultimately, the model of the inferior mirage is bound up in its physical reality showing how semiotic indexicality gives structure to the physics of the inferior mirage.

3.3.1. Physical reality

The physical reality behind the study object produces an orderly model of the inferior mirage from within a particular surrounding. Young presents a precisely structured atmospheric state: an atmospheric surface layer which constructs a logarithmic temperature profile that increases with height, a corresponding refractivity gradient that curves light rays which consequently causes the inferior mirage along with the acknowledgment of the omission of the bottom of the mirage due to surface elements. The physical state of the model however is linked together through indexes as was shown to be caused by indexicality and located in articulations. The physical reality of the mirage therefore depends on and is grounded in its semiotic reality to give structure to the mechanisms of geometrical optics, refraction and a potential temperature profile. Hereby the brute forces that come to explain the ends of the inferior mirage seem to be completely rendered, yet only really come about in indexicality.

Physical reality is the temperature gradient as it exists. A continuous field from the surface upward which the study object understands through a framework of boundary layer meteorology. The gradient is assumed to exist regardless of observation through which rays of light happen to curve regardless of a theory about their curvature. By this description, the inferior mirage is always physically real. However, for such an understanding to come about the phenomena of a mirage must be constituted which the study material produces where under the activity of indexicality becomes intertwined with the cause and articulation of the model to become real.

3.3.2. Semiotic reality

The semiotic reality behind the physical reality of the study object, as I have described it, is caused by indexicality which articulates references that become real and thus representable. To understand the semiotic reality behind the study object it can be said that the mirage becomes a constituted phenomenon. And as a constituted phenomenon indexic chains are what cause the physical reality to come about from which articulations on the physics bring about the mirage to become real. Through the progressive interconnection of an indexical thread that goes from surface conditions through to the apparent horizon, the semiotic reality maps precisely into a physical surrounding the physical reality. Such that a distinction of the physical distortions that exists in a particular atmospheric environment become real, modeled and named.

3.4. Study discussion

In this case study I show how the semiotic reality is what is behind the physical reality of the model of the inferior mirage as Young presents it (2015). I described how the notion of the index and the activity of indexicality; cause, articulate and become real in the production of the model of inferior mirage. Indexicality causes the study object to model the inferior mirage by indicating to the possibility of a cause upon where the generation of the model of inferior mirage gets caused. Temporal succession of the indexic features of the study object describe how the temporal succession of indexes coming before-after cause the model of inferior mirage. Indexicality also articulates a localization of the study object. Articulating the study object at a position that is orientated within a situational environment as a structure of the physical reality of the mirage becomes real. The articulations of the model function to show the means whereby indexicality makes the physical distortions of the mirage real. Which lead into the physical and semiotic reality behind the scientifically apprehended mirage.

The perceptive that comes from my case study describe how indexicality shows through reference whereon reality gets assembled and detailed. This is the reason why I claim that the semiotic reality is behind the physical reality of the mirage. Physical was meant as an explication of the way things are. Whereon I have decided to describe how semiotics (especially indexicality) is what is confounding the relations knowing the inferior mirage that are not

immediately seen. I hope through my case study that the semiotic reality even in its interconnected form is able to be seen as that what comes about behind the ordered representations that 'reveal' the way things are.

The result of the case study is a description of the semiotic reality that is behind the physical reality that is behind the appearance of actual mirage phenomena. In selected a mirage theory and then isolating its indexes – indexicality becomes cultivated. And through the activity of indexicality does how the mirage become real get described. This novel description is the result of the study questions which are used to constitute the semiotic reality behind the physical reality. Indexic relations leading unto indexic relations, the semiotic reality of the model of the inferior mirage gets constituted and discussed.

Conclusion

The case study contained herein develops the idea of indexicality in relation to a theory of the inferior mirage. Conveyed through the notion of the index, three study questions are answered which mean to understand the semiotic reality that produces the structure of the physical reality behind the inferior mirage. Young's improved model of the inferior mirage (2015) is chosen because of its current status and provides the study material for the case. The thesis consists of five sections. By which a fully original work is produced at the interface of semiotic indexicality and mirage theory that shows how semiotic reality is interwoven within the physical reality of the inferior mirage.

Working with the aim of describing how indexicality gives structure to the model of the inferior mirage, I aim to understand how semiotics and physics interface. The study object that forms the basis of my case study is the delimited physical model of the inferior mirage as Young constructs it (2015). Approached for the first time from the field of semiotics, I narrow my treatment of the study object to that of the interpretive practice of indexicality. The notion of the index meaning to be in virtual connection with its object frames my study method and thus establish the semiotic perspective I understand the model-making of the study object. Posed as a case study only an aspect of the semiotic reality behind the model of inferior mirage is described.

Ending the fourth section of the case study is the study discussion which shows the result of the study. How indexicality causes, articulates and becomes real in relation to the model of inferior mirage is described. The final result being that semiotic reality is central to construing real meaning and through careful cultivation the process that becomes the real may define and render depth anew. The semiotic reality indexicality describes about the physical reality behind the inferior mirage is given structure through the interconnection of indexic features. And from here show the correspondence of fact between the dual production of the real and unreal.

The semiotic implications got from the case study indicate the dynamic possibilities indexicality may construe when in direct relation to an object. From continuously refining a description of a thermal structure, to the articulation of the process that becomes physical reality, or the actual connection of presented products that then become a real representation.

The semiotic and the physical rendering of orderly representation are interlinked by the activity of indexicality. Like one hand washing the other, the semiotic and physical reality of the inferior mirage not only show how representation confounds meaning in natural phenomena but also how natural phenomena inspire for new relations. Imply a perspective for the future in which the meaning of physical nature become permeable.

Before I bring the case study to an end, I would like to make pass at the knowledge crafted herein. To my knowledge I make a first approach at a physical theory of a mirage from the field of semiotics. Not only is it a first to describe the interrelation of semiotic indexicality and mirage theory, but I treat the model-making of the inferior mirage threefold; describing its cause, articulation and its process to become real. Together, which show how the relations the model of inferior mirage indexes is intimately tied to semiotic activity. Hallmark of all descriptions is then the model of the inferior mirage as semiotic meaning making system that produces an orderly representation capable of knowing and reproducing.

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Kokkuvõte

Pealkiri: Indeksikaalsus madalama miraaži teoorias.

Indeksikaalsus alumise miraaži teoorias käsitleb alumise miraaži füüsilise reaalsuse taga olevat (indeksilist) semiootilise reaalsust ja see on ka väitekirja pealkiri. Juhtumiuuringuna uurin alumise miraaži täiustatud mudelit (Young 2015) semiootilise indeksikaalsuse kontekstis. Miraažinähtused on alati valesti tõlgendamisele, kuid alumise miraaži teooria juhtumit käsitletakse indeksi mõiste kaudu. Juhtumiuuringu eesmärk on näidata, kuidas indeksikaalsus annab alumise miraaži füüsilisele reaalsusele struktuuri. Minu juhtumiuuring koosneb viiest osast: sissejuhatus, mis tutvustab probleemi ja uurimisküsimust, mis küsivad, kuidas indeksikaalsus põhjustab, väljendab ja saab reaalseks alumise miraaži mudeli loomisel. Osa minu uurimisobjektist ja osa minu uurimismeetodist. Sellele järgneb osa, mis kirjeldab, kuidas indeksikaalsus annab struktuuri alumise miraaži mudeli juhtumile. See lõpeb kokkuvõttega, mis kirjeldab juhtumiuuringus omandatud uusi teadmisi.

Juhtumiuuring näitab, kuidas indeksi mõiste ja indeksikaalsuse aktiivsus toimivad madalama miraaži mudelis. Näidatakse, et indeksikaalsus põhjustab madalama miraaži mudeli tekkimise võimalikkuse kaudu, mis omakorda genereerib mudeli põhjustatuse. Seejärel väljendab indeksikaalsus madalama miraaži mudelit kontekstuaalse viitamise kaudu kommunikatsioonis. Seejärel muutub madalama miraaži mudel reaalseks visuaalsete esituste loomise kaudu, mis muudavad parameetrilised sisendid ligipääsetavateks väljunditeks. Juhtumiuuring lõpeb seejärel füüsikaliste ja semiootiliste reaalsuste indeksikaalsuse struktuuride kirjeldusega. Kokkuvõtteks luuakse esimene uuring semiootika ja miraažifüüsika omavahelise seose kohta. Juhtumiuuringust saadud teadmised näitavad, kuidas indeksikaalsuse kultiveerimine annab tegelikkusele struktuuri ja referentsiaalse tõusu kaudu toob kaasa reaalsuse.

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