# Brunswik's Lens Model

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The lens model is a conceptual framework for describing and evaluating how people make judgments. For example, the lens model can be used to study physicians assessing the severity of disease, investors judging the quality of stocks, weather forecasters predicting tomorrow's weather and personnel staff rating job candidates. In each case these individuals must use available information ("cues") to make an inference about some unknown quantity (e.g., the weather). The cues for judgment (e.g., today's temperature) are analogous to a lens through which the person views an 'object'.

These "multiple-cue probability tasks" (Smedslund, 1955) suggest that the person may have available to them more than one cue when making a judgment (e.g., today's temperature and the today's amount of rainfall). The cues are, however, typically imperfect indicators of what is to be achieved i.e., accurate prediction of weather – in other words the cues are only probabilistic indicators and so may be fallible.

Egon Brunswik developed the lens model as a representation of his theory of probabilistic functionalism, which describes how people function in an uncertain world – the sort of world that describes most judgment tasks such as the weather forecasting task mentioned above. One side of the lens represents the environmental system that is the context for judgment i.e., the task. The other side of the lens represents the cognitive system of the human i.e., their judgment. Fully understanding human judgment requires the study of both sides of the lens, i.e., the task and the human.

## 1. Elements of the lens model

As the lens model has been adapted and applied to a variety of judgments, it has appeared in versions that differ from Brunswik's original - in form but not in substance (e.g., Hammond, 1955; Hammond et al., 1975; Stewart & Lusk, 1994). A modern version (Figure 1) used by Cooksey (1996) incorporates developments from Hammond's Social Judgment Theory (SJT; Hammond et al., 1975; Hammond, 1996, for an overview see Dhami & Mumpower, 2018) into Brunswik's original model.

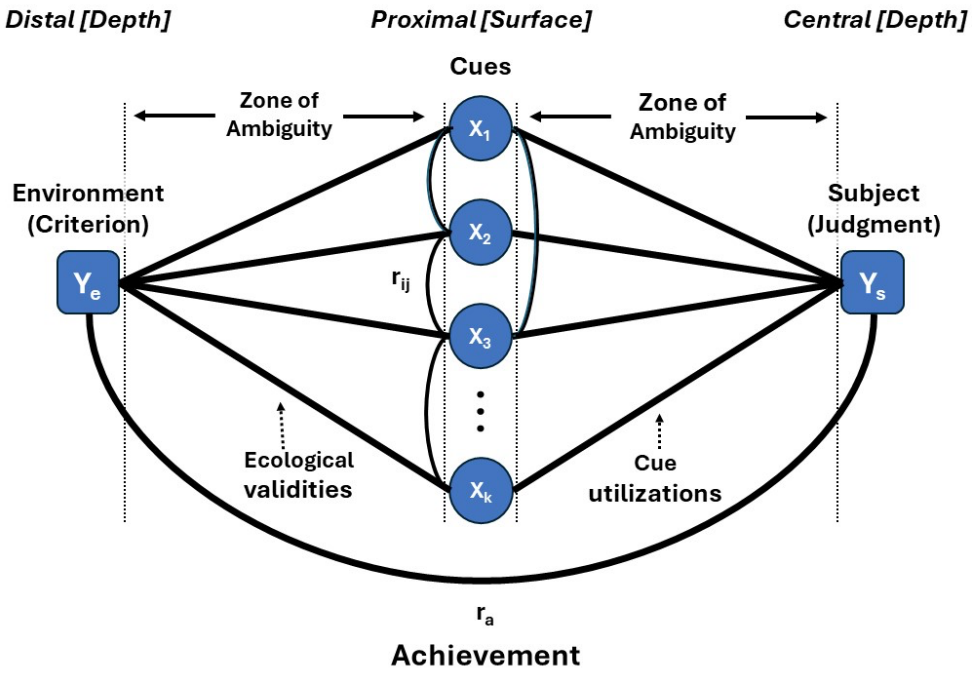


*Figure 1.* The lens model (adapted from Cooksey, 1996).

The lens model represents the essential symmetry between the environment (left side of the model, sometimes called the "task system" in laboratory studies) and the person, or subject, (right side of the model, sometimes called the "cognitive system"). This reflects the "principle of parallel concepts" (Hammond et al., 1975).

The cues ($X_i$) are "proximal" because they are directly available to the person making a judgment whereas the criterion is only distally available. In the case of weather forecasting, for example, the cues would include today's temperature and other weather data. In the case of predicting college GPA, cues might include high school grades and test scores.

Hammond et al. (1975) describe the distinction between "surface" and "depth" in the lens model as follows:

> This distinction is essential to SJT. It derives from the proximal-distal separation in perception theory and thus refers to the separation between what is given and what is inferred. Surface data are (given) cues to (inferred) depth conditions in the judgment task. By virtue of the principle of parallel concepts, this distinction also applies to organismic judgment systems…. Separation of surface and depth is critical to any theory of judgment (or inference), for it raises the question of the properties of the region that intervenes between them. Because of the importance of this region, we have named it the *zone of ambiguity*. (p. 275)

The lines from the cues in the lens model converge on the object or event on the left that is the target of judgment. It is "distal," that is, it is not directly available to the person but must be inferred from the available cues. This distal variable is often called the "criterion" ($Y_e$), that is, the variable that is being judged. The criterion might be tomorrow's temperature or the future college GPA of an applicant.

Lines from the cues also converge on the judgment ($Y_s$) at the right. This is a person's judgment or inference about the unknown criterion based on the known cues.

The lines between the criterion and the cues represent "ecological validities," that is, the strength of the relations between the cues and the criterion. Similarly, the lines between the cues and the judgments represent "cue utilization validities," that is, the relative strength of the relations between each cue and the judgment.[1]

The lines between the cues ($r_{ij}$) indicate that the cues themselves are not fully independent. Typically, they are correlated with one another to some degree.

The arc between the criterion and the judgment is achievement or accuracy. It is typically measured by the correlation ($r_a$) between $Y_e$ and $Y_s$. Accuracy is typically the goal of the person making judgments.

Uncertainty or "zones of ambiguity" exist between the cues and both the criterion and judgment. Hammond et al. (1975) describe these zones of ambiguity as follows:

> The region between depth and surface variables in a given judgment task involves the relations between cause (depth) and effect (surface). Because a single effect may be produced by several causes, as well as because multiple effects may be produced by a single cause, there is ambiguity from cause to effect and effect to cause. Because causes may be related, and because effects are interrelated, the network of task relations can be said to be entangled. Moreover, causal ambiguity is produced because (1) surface data are less than perfectly related to depth variables, (2) functional relations between surface and depth variables may assume a variety of forms (linear, curvilinear), and (3) the relations between surface and depth may be organized (or combined) according to a variety of principles (for example, additivity or pattern). (p. 275)

Ambiguity on the person side of the lens exists because people are not perfectly consistent (reliable) in using the cues to make a judgment. Given identical cues, people often do not make identical judgments. The amount of inconsistency in judgment varies among people this means that there is a variation both within a person who evaluates the same task several times and between people who evaluate the same task. These variations within and between people's judgments are affected by such factors as the uncertainty in the environment (Harvey, 1995) and the number of cues (Lee & Yates, 1992).

## 2. An example of the application of the lens model to clinical judgment

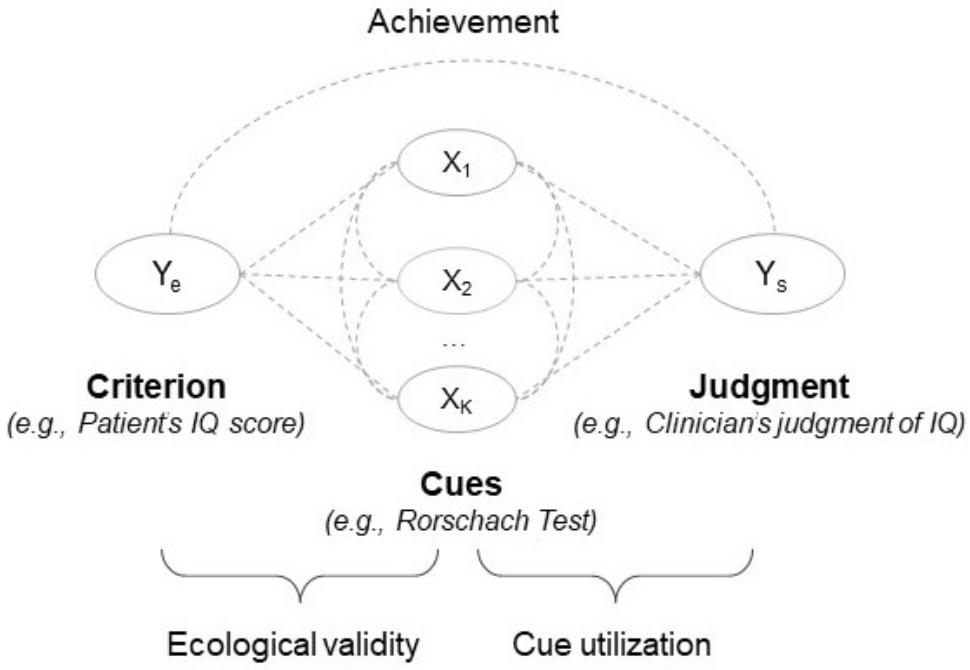


*Figure 2*. An example of the application of the lens model (adapted from Hammond, 1955).

Hammond (1955) provides an excellent example of Brunswik's lens model applied to clinical psychologists' judgments about their patients (Figure 2). In this study, 10 clinical psychologists judged IQ ($Y_s$) from the responses to four Rorschach test factors (Cues – $X_1$ …$X_4$). Each clinician judged 78 patients based on their records. The clinicians' judgments of IQ ($Y_s$) were then compared with patients' scores on a standard IQ test ($Y_e$). The IQ test score was the objective outcome criterion.

Each clinician's achievement was measured by the correlation between the clinician's judgments of IQ and the patients' actual IQ test scores for the 78 patients. The resulting median achievement was 0.47 across the 10 clinical psychologists. Correlational statistics and multiple regression analysis were also used to capture the relationships (e.g., correlations) among (1) each cue and clinician's judgments (cue utilization, Figure 1), (2) the cues and the environmental criterion – IQ test score (ecological validity, Figure 1), and (3) the correlations among the cues themselves (inter-cue correlations – $r_{ij}$ in Figure 1).

## 3. The origin of the lens model in perception research

Early in his career, Egon Brunswik investigated perceptual constancy, and developed a keen interest in analyzing the consistency of individuals' behaviors within their respective contexts. He was interested in how people maintain coherence amidst a dynamically changing environment.

In order to grasp Brunswik's concept effectively (for biographical details on Brunswik, refer to Wolf, 1995, p. 16), it is imperative to rewind to the 1930s and the prevailing research focus of that era. During this period, numerous researchers were engrossed in perception research based on Gestalt psychology. Their investigations drew on a broad spectrum of perceptual illusions, eventually evolving into an examination of errors in perception.

Some psychologists, including Brunswik and Gibson advocated against the fixation on studying illusions, emphasizing instead the importance of investigating behavior within natural environments, a perspective that earned them recognition as ecological psychologists. Brunswik's interest in understanding the relationship between an organism and its environmental structure can be traced back to his early collaboration with Tolman in 1935. Their joint work, "The Organism and the Causal Texture of the Environment," (Tolman & Brunswik, 1935) placed a spotlight on environmental texture. They posited that individuals strive to navigate through an environment comprised of interconnected and hence "textured" objects and events.

This viewpoint diverged starkly from the prevailing trend among psychologists of that era, who drew heavily from the principles of determinism borrowed from physical sciences, focusing on elucidating the precise mathematical laws governing behavior (see Hammond, 2007). In addition to his collaboration, Brunswik conducted his own rat experiments in Berkeley in response to Tolman's invitation in 1939. These experiments showcased Brunswik's findings that rats adhered to a probability-matching rule, reflecting their assessment of the likelihood of obtaining food or prevailing environmental conditions. For interested readers we refer to Athanasou and Kaufmann (2015, Table 1) showing the development of the probabilistic concepts during Brunswik's work which finally leads to the lens model framework.

However, to fully understand the development of the lens model, it is essential to acknowledge the contribution of Heider, a colleague of Brunswik at the time. While Brunswik is often credited with the creation of the so-called lens model, the research community frequently overlooks the collaborative efforts between the two researchers during the late 1920's and early 1930's. Therefore, it's somewhat misleading to attribute the lens model solely to Brunswik. In reality, the concept of the lens model was initially introduced by Heider. Bernhard Wolf extensively elucidates the inspirations behind their work in his 1995 book, "Brunswik and ökologische Perspektiven in der Psychologie" (Brunswik and Ecological Perspectives in Psychology), for further recommended historical readings, see Leary (1987), Radler (2015), Wieser (2014). For example, Wieser (2014) also describes the intellectual context that influenced Brunswik's thinking. He traced the evolution of the lens model from Heider's original hand-drawn figure in his private notebooks (Heider, 1987) to Brunswik's final version. He points out that Heider was not concerned with experimentation and quantification while they were central to Brunswik's work.

## 4. Brunswik's original lens model

Brunswik's original lens model was developed from a lens analogy by Heider (Heider, 1959; Wieser, 2014).[2] Brunswik emphasized the importance of both the environment and the person in

understanding judgment and determining achievement (Brunswik, 1943, 1952, 1955, 1957). Consequently, his lens model is symmetric. Properties of the environment (left side) are reflected in properties of the person (right side).

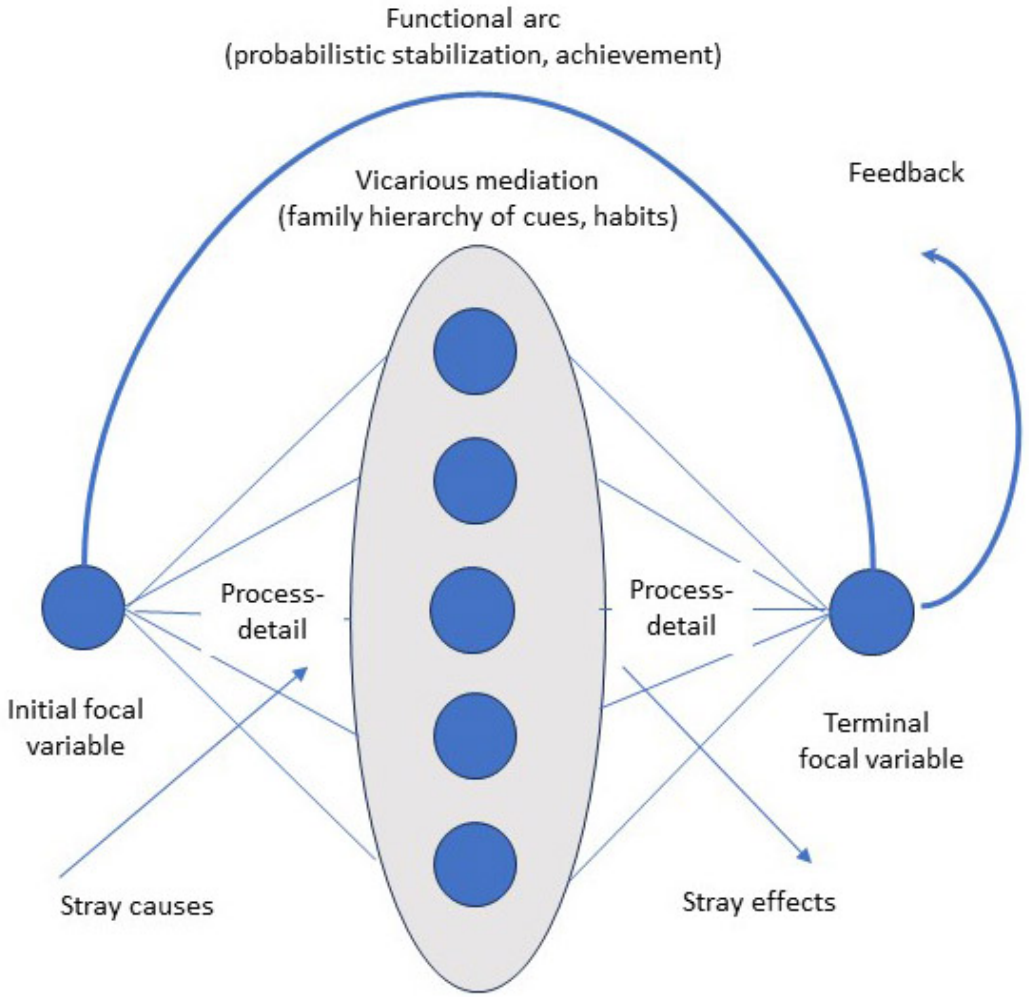


*Figure 3*. Brunswik's original lens model (adapted version).

As mentioned, Brunswik developed the lens model to examine visual perception (Brunswik, 1952). However, as it has been generalized to other kinds of judgments by Kenneth R. Hammond (1955) and incorporated into Social Judgment Theory (SJT, Hammond et al., 1975), some of Brunswik's original terms have fallen into disuse.

The "Initial focal variable" refers to a property of the object that is to be judged or perceived, e.g., size, weight, or distance from the observer. This is usually now called the distal variable, criterion, gold standard, or $Y_e$. In Figure 3, "Vicarious mediation" refers to the variables that describe the object (proximal variables, cues, sensory cues, items of information) such as color, clarity, retinal image. They must mediate vicariously between the object and the person because direct perception is not possible. The object gives rise to the cues by some process ("Process detail") but there are

other unknown variables that affect the cues ("Stray causes"). The "Terminal focal variable" is the observation (perception, judgment, $Y_s$) of a human. The cues are combined into a judgment by some process ("Process detail"), but other unknown variables affect the judgment as well ("Stray effects"). The "Functional arc" represents achievement or accuracy, that is, the degree of match between the actual property of the object and the judgment of that property. Accuracy is the goal of the observer. "Feedback" typically refers to knowledge of results, often called "outcome feedback." However, in Brunswik's words: "A semicircular arrow is appended to the terminal focus to indicate that lens patterns do not stand in isolation but are apt to reflect back upon the person in a future state in what is now sometimes called a "feedback" loop…" (Brunswik, 1952, p. 20). This suggests that Brunswik had something more in mind when he added the feedback arrow, perhaps related to his interest in cybernetics (Brunswik, 1956, p. 141).

The concepts of stray causes and stray effects were replaced with the zones of ambiguity by Hammond et. al. (1975). Brunswik (1956) described them as follows:

> **Impossibility of foolproof distal achievement. "Functional validity." Quasi-rationality**. In line with the inherent probability character of object-cue and of means-end relationships, gross organismic coming-to-terms with the environment can thus never become foolproof, especially so far as the more vital remote distal variables are concerned. It is in this sense that, as William James has phrased it, perception is "of probable things." In the terminology of Reichenbach's probabilistic empiricism, behavior and the inferences implicit in it must retain a certain "wager-" or "posit-"character. Perceptual and behavioral functioning is spoiled much in the manner in which stray rays … are apt to interfere with perfect focusing. Imperfections of achievement may in part be ascribable to the "lens" itself, that is, to the organism as an imperfect machine. More essentially, however, they arise by virtue of the intrinsic undependability of the intra-environmental object-cue and means-end relationships that must be utilized by the organism …. (p. 23)

## 5. Current Status of the lens model

The lens model has been applied as a framework to understand human judgment in many studies. Since Hammond (1955) first applied the lens model to clinical judgments, the analytic methods used in such studies generally include judgment analysis (Cooksey, 1996). Unfortunately, many judgment analysis studies, although they may cite Brunswik and Hammond, do not use representative design (see Dhami, 2012; Dhami et al., 2004; Dunwoody, 2006).

A powerful, though less often used, analytic method is the lens model equation (Hursch et al., 1964; Stewart, 2001; Tucker, 1964). This equation is a diagnostic tool that quantifies and evaluates people's judgment accuracy and breaks it down into several components. These components are linked to the task or the judge(s). Hence, this equation has the power to reveal reasons for judgment inaccuracy and provide feedback on how to improve it.

A major application of the lens model has been in the study of multiple cue probability learning (Holzworth, 2001). The lens model has also been applied to studies in a clinical setting (e.g., Einhorn, 1974; Tape et al., 1991). It has also been applied to studying human judgment in many other domains including business (e.g., Ashton, 1982), education (e.g., Athanasou & Cooksey, 2001), medicine (Wigton, 1988, 2001), social psychology (e.g., Reynolds & Gifford, 2001), forecasting (Stewart & Lusk, 1994), weather forecasting (e.g., Stewart et al., 1997), evaluation research (e.g., Wittmann, 1985, 1988), accounting (Ashton & Ashton, 1995) and expert judgments (Stewart et al., 1997).

Due to the many lens model applications, there are also overviews on lens model studies across application fields like Karelaia and Hogarth (2008) or comparing different fields (Kaufmann & Athanasou, 2009; Kaufmann et al., 2013) or considering specific fields like education (e.g., Kaufmann, 2023).

Besides the introduced classical lens model, there are also further developments, such as hierarchical models (Schilling & Hogge, 2001) or models used for group decision-making (see Rohrbaugh, 2001) or focus on human-technology interaction (Kirlik, 2006).

In addition, the annual newsletter of the Brunswik Society keeps the field updated on current research (see Brunswik Society Homepage) and also provides critical discussion of further developments of the lens model at their annual meetings (see Brunswik Society Homepage for the meeting announcement and agenda).

## 6. Important Brunswikian concepts represented by the lens model

The lens model is a framework for understanding judgment and designing studies of judgment. It is not really a theory, but it embodies key concepts of Brunswik's Probabilistic functionalism, including:

- Achievement and functional validity
- Uncertainty/probabilism
- Vicarious mediation and vicarious functioning
- Representative design
- Idiographic research design and analysis
- Quasi-rationality

Vicarious mediation and vicarious functioning are described in a companion paper (https://brunswiksociety.org/resources/). Summaries of the others will follow.

## 7. Notes

[1]Technically, the lines describe models of the process relating the cues to the criterion or the judgment. If the process is non-additive, the relative importance of an individual cue may be difficult or impossible to assess (Einhorn, 1970).

[2]Aside from the considerations of the classical behaviorists on vicarious functioning, the ground for the development of the lens analogy was laid by two papers of F. Heider, "Ding und Medium," *Symposium*, Vol. I (1927) in which a regional stratification of the environment in general physical terms, emphasizing the pliable "messenger" character of such "media" as light-rays, is attempted, and "Die Leistung des Wahmehmungssystems,"*Zeitschrift fur Psychology* CXIV (1930), 381." addresses how people perceive objects in their environment. Humans cannot perceive objects directly, but rather through the "lens" of information that is directly available (i.e., the environment). We refer interested readers to Wolf (2004).

## 8. For further study:

- The Brunswik Society website includes relevant essays (e.g., Wolf, 2004) and current research activities.
- The *Essential Brunswik*, edited by Kenneth R. Hammond and Thomas R. Stewart (2001) for reprints of Brunswik's major papers with discussion and extensions of his theory of probabilistic functionalism, and subsequent applications.
- A tribute of Brunswik's work can be found in Tolman (1956)
- Wolf (2004) for a discussion of how Brunswik's lens model was adapted from Fritz Heider's.
- James J. Gibson argues contrary to Brunswik that humans perceive objects directly, but both he and Brunswik link cognition to the environment. Both Brunswik and Gibson wanted to study behavior in a natural environment, which led them to become known as ecological psychologists. See Chapter 13 in Hammond and Stewart (2001) for a discussion of their similarities and differences.
- Social Judgment Theory (SJT) developed by Hammond and his colleagues (e.g., Hammond et al., 1975; Brehmer & Joyce, 1988) is based on Brunswik's lens model. Brunswik's research was primarily in perception. SJT extended Brunswik's theory of probabilistic functionalism to the study of judgment in a range of social and applied settings including expert judgment, multiple-cue probability learning, interpersonal learning, cognitive conflict, and social policy.

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