Applying the Lens Model When the Judgment Affects the Outcome

Shawn P. Curley	Mary L. Pfohl	Susan J. Wells[a]
University of Minnesota	St. Cloud State University	University of Minnesota

Running Head: Lens Model with Intervention

Corresponding Author: Shawn Curley
Department of Information & Decision Sciences
Carlson School of Management
University of Minnesota
321 19th Avenue South
Minneapolis, MN 55455 USA
612.624.6546
Fax: 612.626.1316
curley@umn.edu

[a] Now at University of British Columbia Okanagan

August 14, 2009

Abstract

The lens model is a representation of judgment in situations for which multiple cues relate to a criterion in the environment. Typically, the model is applied where the judgment and criterion are independent. For example, a judgment of whether or not it will rain does not impact whether it does in fact do so. In some situations, however, the two are dependent. A social case worker who judges the likelihood of a recurrence of maltreatment of a child will use this judgment to decide whether or not to intervene in the situation. This intervention is purposefully intended to impact the criterion of recurrence. The present paper presents a theory applying the lens model for assessing performance in these common situations. The theory is then demonstrated using actual judgments of the need for protective service intervention as determined by child welfare workers in the state of Minnesota.

Keywords: lens model, judgment quality, intervention assessment, expert assessment

Applying the Lens Model When the Judgment Affects the Outcome

Accuracy of judgments is a fundamental performance issue of interest in a variety of domains. The lens model is a representation of human judgment that captures some of the essential elements that impact accuracy. The model is a decomposition of the correlation between a judgment and a criterion (Hursch, Hammond, & Hursch, 1964). The model analyzes the relationship as arising from properties of the environment, properties of the decision maker's use of information, and the relationships among them (Stewart & Lusk, 2000). The model provides a useful framework for distinguishing and analyzing these different influences upon judgmental accuracy.

Typically, the model is applied in situations where the judgment and subsequent criterion are independent. For example, if the judgment is a precipitation forecast by a meteorologist for tomorrow, the criterion is a well-defined event of whether or not precipitation actually occurs tomorrow. There is no causal dependence between the two: The forecast does not alter the likelihood of rain. However, in other judgment situations, this independence is not the case nor even intended. Specifically, the model does not address accuracy when a judgment results in an intervention. There are occasions when a decision maker reviews information, reaches a judgment, and then acts on that judgment. For example, in child protection a child welfare worker must make a judgment regarding whether or not protective intervention is necessary. The judgment is based on the goal to prevent maltreatment recurrence. If the child welfare worker determines protective intervention is needed, the worker must act by providing intervention services to reduce or eliminate the risk that a child may be harmed. The outcome against which judgmental accuracy is typically measured, maltreatment recurrence, is expected to be impacted by the intervention.

The goal of this paper is to adapt the Lens Model to meaningfully be applied in such situations, situations in which the judgment is expected and even intended to impact the outcome. The next section summarizes the lens model in its standard form, where no dependency between judgment and criterion is present. The following section then identifies the expected differences for those measures that are impacted by introducing an intervention to the Lens Model framework. By so doing, we see a pattern that allows for the identification of good performance when an intervention is present. This expansion of the applicability of the Lens Model to this common situation is the main contribution of the paper. The argued pattern is then checked using a simulation. Finally, to demonstrate the contribution, we apply the analysis with intervention in a situation involving judgments of maltreatment recurrence and interventions of child protection services using data from Pfohl (2007).

Standard Lens Model

The lens model recognizes that judgments occur within an environment, and that an adequate theory of judgment should include a representation of that environment. It is not a process model describing how a judgment arises, but captures the connections between a judgment and elements of the environment from which the judgment derives and to which it relates. In particular, in assessing judgmental accuracy, the model recognizes that the ecological context and the decision both must be understood to grasp whether or not accuracy, as congruence between judgment and outcome, has been realized.

Figure 1 shows the basic structure of the Lens Model that operates under the principle of parallel concepts; the right, judgment side of the model is mirrored on the left, environment side (Doherty & Kurz, 1996). Both subject judgment (Y_s) and environmental criterion (Y_e) draw on cues $\{X_i\}$ illustrated in the center of the framework.

(Insert Figure 1 about here.)

The cues are evidential pieces of information that are available to the decision maker. Decision makers combine and weight cues to make inferences or judgments leading to decisions (Connelly, Arkes, & Hammond, 2000), as illustrated on the right side of the model. The environmental context of the judgment is ambiguous (Brehmer, 1988; Brehmer & Joyce, 1988; Doherty & Kurz, 1996; Hammond, Stewart, Brehmer, & Steinmann, 1975) creating uncertainty for the decision maker. Ideally, cues having greater covariation with the judged event will carry greater weight. Analytically, the judge's use of the cues can be modeled, e.g., using standard regression methodologies. The modeled component of the judgment is represented as $\hat{Y}_s$. For a linear model,

$$\hat{Y}_s = \sum_i w_{si} X_i \quad . \qquad (1)$$

However, as with regression in general, the model can be formulated to describe non-linear and interactive relationships. The residual of the judgment, $(Y_s - \hat{Y}_s)$ thus, although sometimes called the nonlinear component of the judgment, is better described as the unmodeled component (Cooksey, 1996). Judgment analyses focus on this part of the Lens Model as a means of describing judgmental policies of decision makers or of comparing the policies of different judges.

As pictured on the left side of the Lens Model, the environmental context contains the target being judged. Generally, this corresponds to a measurable goal or criterion. Cues correlate to the criterion at varying degrees (Doherty & Kurz, 1996). The environmental side can be comparably modeled $(\hat{Y}_e)$ with accompanying residual $(Y_e - \hat{Y}_e)$.

Of particular interest in judgment is its accuracy as described by the achievement of the judgment (r_a), capturing the relationship between the criterion in the decision task environment and the judgment (Cooksey, 1996; Doherty & Kurz, 1996; Hammond & Stewart, 1975). Achievement is the successful attainment of goals by the decision maker (Brehmer & Joyce, 1988). The model provides a framework for relating this achievement to aspects of the environment (on the left side), information use by the judge (on the right), and the various interrelationships within and between these. Mathematically, one form of this relationship is captured by the lens model equation:

$$r_a = r_m R_e R_s + C\sqrt{(1 - R_e^2)}\sqrt{(1 - R_s^2)} \qquad (2)$$

where the terms are correlations between the parameters as indicated in Figure 1. Consistently with Equation 2, high achievement *(r_a)* is generally reflected in high values of model correspondence *(r_m* , sometimes denoted as G*)*, and good model capture for the judge and criterion *(R_s* and *R_e).*

The novel element for the lens model, introduced for our analysis is the additional factor included in Figure 2—the intervention. In the child protection case, this would capture the influence of the services received and completed by the family that occur as a result of the child welfare worker's judgment. How does the introduction of an intervention impact the determination of accuracy and other aspects of the Lens Model? What does good judgment performance look like when an intervention is present, compared to the traditional analysis where outcome and judgment are independent? Is there an identifiable pattern of relationships that allows us to identify good performance? We turn to these questions in the next section.

(Insert Figure 2 about here.)

Lens Model with Intervention

Introducing an intervention prior to the outcome that is based upon the judgment creates a causal dependence between judgment and criterion that is not present in the traditional model, where the two are presumed to be mutually independent. The main contribution of this paper, and the content of this section, is to outline the expectations in this general situation to attempt to identify a pattern of results indicative of good performance.

First, we distinguish between two main drivers of performance in the situation: the ability of the judge and the quality of the intervention. The judge can be good or poor at making judgments. For example, a case worker can be better or worse at deciding whether a maltreatment recurrence is likely. Based on this judgment, an intervention occurs. This intervention can be more or less successful. So, even if a case worker is good at making judgments, perhaps the intervention to prevent recurrence is not effective.

If the intervention is ineffective, whether or not the judgment is accurate, then it is as if the intervention is not there. Consequently, the standard model is expected to apply. Similarly, if the judgments are poor, the intervention is not well-targeted to those who need it. Those not needing the intervention may still get it, but should do well in either case (although with an unnecessary cost). Those needing intervention may or may not get it. So, there will be some improvement among this group, though limited. To the extent that those requiring intervention are not receiving it, the intervention is not being applied effectively. The situation again reduces to the standard model. Thus, we can focus on the situation in which the judgment and intervention are both effective. Does this lead to an identifiable pattern in the analysis?

When the judgment is diagnostic and the intervention is effective, the standard model does not apply. The block arrows in Figure 2 illustrate the expected relationships where an effective intervention is made and judgmental performance is good. As with the standard model, these expectations can be analytically checked in practice as an indication of the quality of the judge's performance.

Judgments

Since the judgment precedes the intervention, there is no effect of the intervention quality expected on the judgment side of the Lens Model. So, the relationships captured by the weights relating cues to the judgment and the degree to which the model captures the judgment (R_s) have the same expectations as with the standard model. When the judge is performing well, we expect strong relationships between the relevant cues and the judgment, and the judgments are expected to be captured by a model (high R_s^2).

If both judgment and intervention are effective, different results are expected compared to the standard model, however, for all those measures involving the left, environmental side of the model. Conceptually, and using the notation for a linear model without loss of generality, we can extend the model described by Equation 1 to model the judgment as arising from a modeled component and a random error ε , according to the standard regression procedure:

$$Y_s = \sum_i w_{si} X_i + \varepsilon_s \ . \qquad (3)$$

The outcome Y_e and the model of the criterion $\hat{Y}_e$ are described by parallel equations. The intervention is applied depending on the judgment according to a function $f(Y_s)$. The intervention then has an effect according to a function $g(f(Y_s))$. Although the multiple functions make the analysis mathematically intractable without assumptions, a general analysis and reasoning provide insight. At the extreme, suppose perfect judgment (and assume there is minimal multicollinearity among the cues) and intervention. The former would imply that the weights $\{w_{si}\} \approx \{w_{ei}\}$. If in turn, the intervention is applied and has an effect commensurate with the judgment, then the outcome with the intervention (Y_e') approximates:

$$Y_e' = Y_e - g(f(Y_s)) = (\sum_i w_{ei} X_i + \varepsilon_e) - (\sum_i w_{si} X_i + \varepsilon_s) = \varepsilon_e - \varepsilon_s \ , \qquad (4)$$

leaving only random error in the criterion. More generally, Y_e' can be seen to represent a residual criterion. To the extent that the cues are correctly incorporated into the judgment and the intervention is successful in dealing with the judged condition, the environmental cue weights $\{w_{ei}\}$ will decrease, as indicated by the block arrow between Y_e' and the $\{X_i\}$ in Figure 2. Consequently, the variance in the criterion connected to the judgment is lessened by the effective intervention.

The recognition of Y_e' as a residual has implications for the other relationships involving the left, environmental side, as well. Since the judgment Y_s is directed at predicting the criterion without an intervention present, while Y_e' is the residual outcome following the intervention, the two would be expected to become disjoint. Unlike the standard lens model for which (barring multicollinearity) a correspondence between the environmental weights $\{w_{ei}\}$ and the judgmental weights $\{w_{si}\}$ is indicative of an aspect of judgmental accuracy, this is not the case when Y_e' is the criterion. The cue weights in the model $\hat{Y}_e'$ will correspond to aspects of the cues that still relate to the outcome following the intervention, i.e., to those aspects of the cues that were missed by the judgment/intervention. Thus, the degree to which the judgment and intervention are good, the environmental cue weights are capturing the residual variation following the intervention, and there should be reduced correspondence between the two sets of cue weights.

This reduced correspondence, in turn, should lead to a distancing of the two models, $\hat{Y}_e'$ and $\hat{Y}_s$. This leads to a reduction in the model correspondence correlation, r_m Also, since Y_e is the residual variation related to the environment, there should be less variation explainable by the cues, thus reducing the degree to which the criterion can be captured by the model; R_e is expected to decrease.

Thus, as indicated by the block arrows in Figure 2, high performance leads to a different set of expectations compared to the standard model when an effective intervention is present. Overall, an identifiable pattern of results arises from the introduction of an intervention into the Lens Model, thereby introducing a causal connection between judgment and criterion. Paradoxically, in this case, good performance is expected to lead to a lower level of achievement measure (r_a). Referring to Equation 2, this expectation is connected to the reduced values for r_m and R_e , as discussed. The pattern of the relationships at the left, environmental side of the model still helps to signal the quality of performance, though not in the same manner as with the standard model. This is a paradoxical result—good performance showing a low level of achievement—but is entirely expected under this analysis.

Simulation

To support the logic outlined in the previous section, we conducted a simulation of the impact of an intervention upon the lens model parameters. We modeled an environment in which the criterion derived from an equal weighting of four cues. Values for each cue were derived from a normal distribution with mean 0 and standard deviation 15. The criterion values were derived by summing the four randomly generated cue values and then adding a random error component, also drawn from a normal distribution with a mean of 0 and standard deviation of 30. For each criterion, a judgment was generated. For each judgment, four cue weights were generated for the four cues separately from normal distributions having a mean of 1 (thus the judge's cue weights were presumed to be non-biased) and standard deviation of 1. The cue values from the environment were then combined with these cue weights. A random error component was then added to obtain the simulated judgment, drawn from a normal distribution with a mean of 0 and standard deviation of 30.

For the intervention, a very simple effect was modeled. If the judgment was greater than 0, an intervention was presumed to be put in place. The modeled effect was to reduce the criterion by 25. If the judgment was not positive, no adjustment to the criterion was made. Thus $f(Y_s)$ was a 0/1 step function, either an intervention was made or not, with no gradation. And, $g(f(Y_s))$ was a scalar effect of 25 for those receiving the intervention. Figure 3 shows a sample worksheet with the simulated environmental values in the left part of the table and the simulated judgment values to the right. Values that were generated using a random distribution are shaded. Note that in the illustrated case, the resulting simulated judgment is 40.98. Consequently, the simulated criterion of 49.47 is reduced by 25 as an intervention effect, for an adjusted post-intervention criterion value of 24.47.

(Insert Figure 3 about here.)

For a single run of the simulation, 1000 sets of values were created using these specifications. The lens model parameters were calculated from the set of 1000 data points. The simulation was repeated for 10 runs. Across all the runs and for every cue the correlation between cue and criterion decreased. The mean achievement level (r_a) without an intervention was .42 across the 10 runs of the simulation, so the judgments captured 17% of the variation in the criterion. With the intervention the mean achievement decreased to .20. Without the intervention, a linear model fitted to the data captured a mean of $R_e = .71$ of the criterion. With the intervention the value of R_e decreased to .61. Overall, the results support the logic of the previous section; the parameters of the lens model reacted to an intervention in the expected direction.

Example

To demonstrate the application of the Lens Model with a real intervention following judgment, we analyze case record reviews from four counties in the Minnesota child welfare system. The details of the sample, procedures, and analyses are available in Pfohl (2007). For this study the judgment was the need for protective service intervention as determined by child welfare workers. For the analysis, the workers are treated as a single judge, following the system's policies as a unit. The intervention was a provision of protective services and the criterion was maltreatment recurrence.

Figure 4 summarizes results of the study within the Lens Model framework. The correlations for the log linear models are shown for the judgments (R_s) and for the criterion (R_e), as are the correlations between the judgment and criteria (r_a), and between the models (r_m). Those cues which had a significant relationship to the criterion and predictor are included in the figure with a connecting line where significant at a 0.05 significance level. The highest r^2 value between these cues is 0.076, so multicollinearity is not an issue. With a level of achievement $r_a^2 < 1\%$, the performance of the case workers' judgments would be considered to be very poor under the standard model. However, recognizing the impact of the intervention leads to a different assessment.

(Insert Figure 4 about here.)

The judgments show use of a number of relevant cues with an $R_s^2 = 0.40$, reflecting a reasonably consistent use of the available information. Following the intervention, there is less variability in the criterion compared to the judgments: On the judgment side, 55% of the cases had a finding by child welfare workers that protective service intervention was needed for the child and family. On the criterion side, 18% of cases had at least one maltreatment recurrence within twelve months. These figures are comparable to those for the state in 2001 (Children and Family Services, 2003), suggesting a positive effect of intervention. The positive effect is also indicated by the reduced impact between the cues and the criterion, and the lowered model fit to the criterion, with $R_e^2 = 0.096$. The judgments are therefore capturing most of the information value in the cues; and, the intervention is being effectively applied in lowering the variance.

The level of achievement is also consistent with good performance. With good judgments being made and effectively treated, the correlation between the judgments and the criterion is very low, with $r_a^2 = 0.0046$. There is little to no residual variation in the outcome that the judgment and intervention are not handling. The sole exception is that the judges may be underweighting the Assessment History cue. The model correspondence, $r_m^2 = 0.16$, is low, but positive and is primarily likely also reflecting the underutilization of this cue.

It is also of note that the pattern is not consistent with poor judgment performance. In particular, the reduced environmental fit would not be expected if the judge and intervention were performing poorly. Despite that factors have been identified as related to maltreatment recurrence (e.g., DePanfilis & Zuravan, 1999a & 1999b; Fluke et al., 2003; Pfohl, 2007), the correlations are low on the environmental side of Figure 4. Poor judgment performance would imply a minimal effect on the criterion. In such case, the cue correlations on the left side of the model would be several and significant; this is not the case.

So, overall, the picture is very positive in terms of the effectiveness of the judge and the intervention. The example demonstrates that with proper interpretation the Lens Model can be used as a framework for analyzing judgmental performance in the case where an intervention mediates between the judgment and the criterion. Although paradoxical in terms of the standard model, an interpretable pattern emerges when an intervention is present.

References

Brehmer, B. (1988). The development of social judgment theory. In B. Brehmer, & C. R. B. Joyce (Eds.), *Human judgment the SJT view* (pp. 13-40). North-Holland: Elsevier Science Publishers.

Brehmer, B., & Joyce, C. R. B. (1988). Introduction. In B. Brehmer & C. R. B. Joyce (Eds.), *Human judgment: The SJT view* (pp. 1-12). North Holland: Elseview Science Publishers.

Children and Family Services. (2003). *Minnesota's child welfare report for 2001: Report to the 2003 Minnesota Legislature*. St. Paul, MN: Department of Human Services.

Connelly, T., Arkes, H. R., & Hammond, K. R. (Eds.). (2000). *Judgment and decision making*. Cambridge: Cambridge University Press.

Cooksey, R. W. (1996). The methodology of social judgement theory. *Thinking and Reasoning, 2*(2/3), 141-174.

DePanfilis, D., & Zuravin, S. (1999a). Epidemiology of child maltreatment recurrences. *Social Services Review, 73*, 218-239.

DePanfilis, D., & Zuravin, S. (1999b). Predicting child maltreatment recurrences during treatment. *Child Abuse & Neglect, 23*(8), 729-743.

Doherty, M. E., & Kurz, E. M. (1996). Social judgement theory. *Thinking and Reasoning, 2*(2/3), 109-140.

Fluke, J., Hollinshead, D., & Walter R. McDonald & Associates. (2003). *Child maltreatment recurrence: A leadership initiative of the National Resources Center on Child Maltreatment* (pp. 1-33). Duluth, GA: National Resource Center on Child Maltreatment.

Hammond, K. R., & Stewart, T. R. (1975). Social judgment theory. In M. F. Kaplan & S. Schwartz (Eds.), *Human judgment and decision processes* (pp. 271-312). New York: Academic Press.

Hammond, K. R., Stewart, T. R., Brehmer, B., & Steinmann, D. O. (1975). Social judgment theory. In H. R. Arkes & K. R. Hammond (Eds.), *Social Judgment Theory in judgment and decision making: An interdisciplinary reader.* (pp. 56-76). Cambridge: Cambridge University Press.

Hastie, R., & Dawes, R.M. (2001). A general framework for judgment. *Rational Choice in an Uncertain World* (pp. 47-72). Thousand Oaks, CA: Sage Publications.

Hursch, C.J., Hammond, K.R., & Hursch, J.L. (1964). Some methodological considerations in multiple-cue probability studies. *Psychological Review*, *71*, 42-60.

Pfohl, M.L. (2007). Quality of Child Welfare Workers' Judgments and Decisions Associated with Maltreatment Recurrence. Doctoral dissertation, University of Minnesota.

Stewart, T.R., & Lusk, C.M. (2000). Seven components of judgmental forecasting skill: Implication for research and the improvement of forecasts. In T. Connolly, H.R. Arkes, & K.R. Hammond (eds.), *Judgment and decision making: An interdisciplinary reader* (2nd ed.)(pp. 395-421). Cambridge, UK: Cambridge University Press.

Figure Captions

Figure 1. Structure of the Lens Model

Figure 2. Structure of the Lens Model with Intervention Along with Predictions when There is Good Judgment and an Effective Intervention

Figure 3. Sample values from the simulation. Randomly generated values are shaded.

Figure 4. Example of Lens Model with an Intervention

Figure 1: Structure of the Lens Model

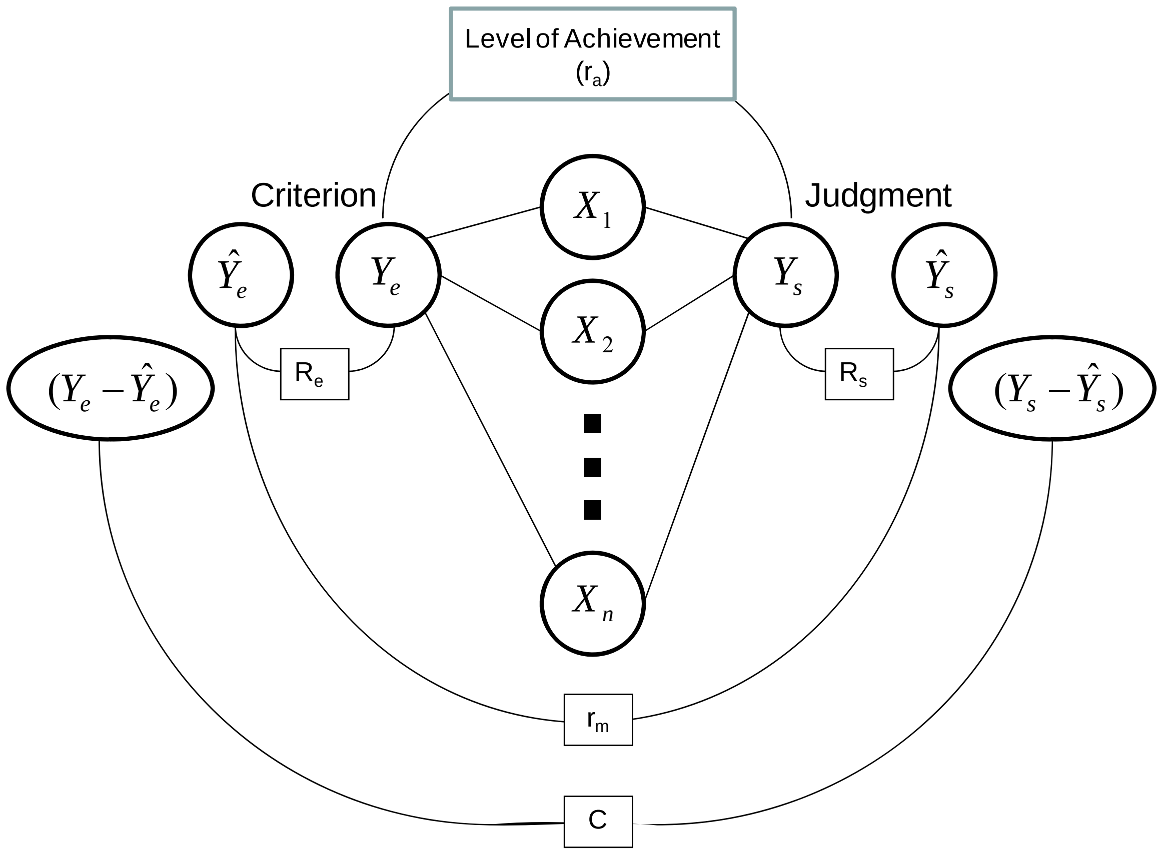


Figure 2: Structure of the Lens Model with Intervention Along with Predictions when There is Good Judgment and an Effective Intervention

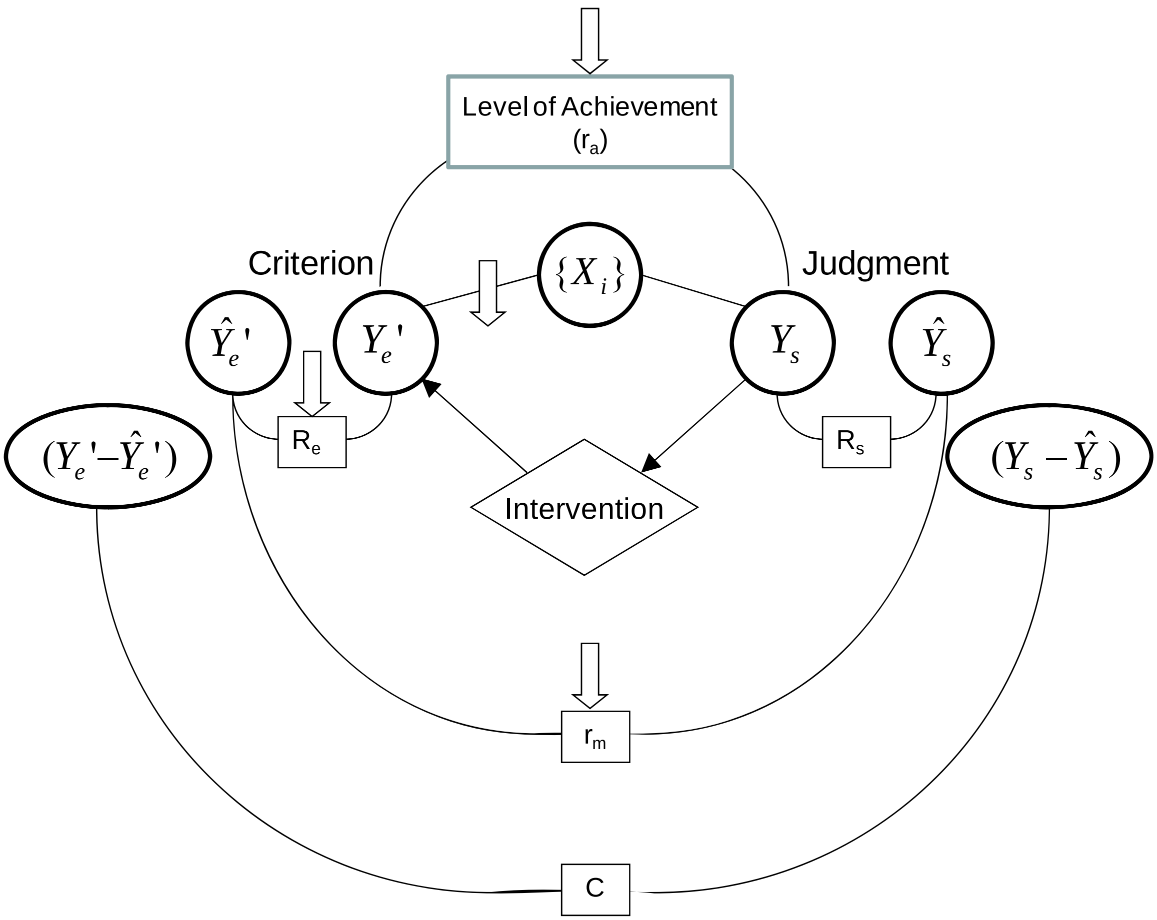


Figure 3: Sample values from the simulation. Randomly generated values are shaded.

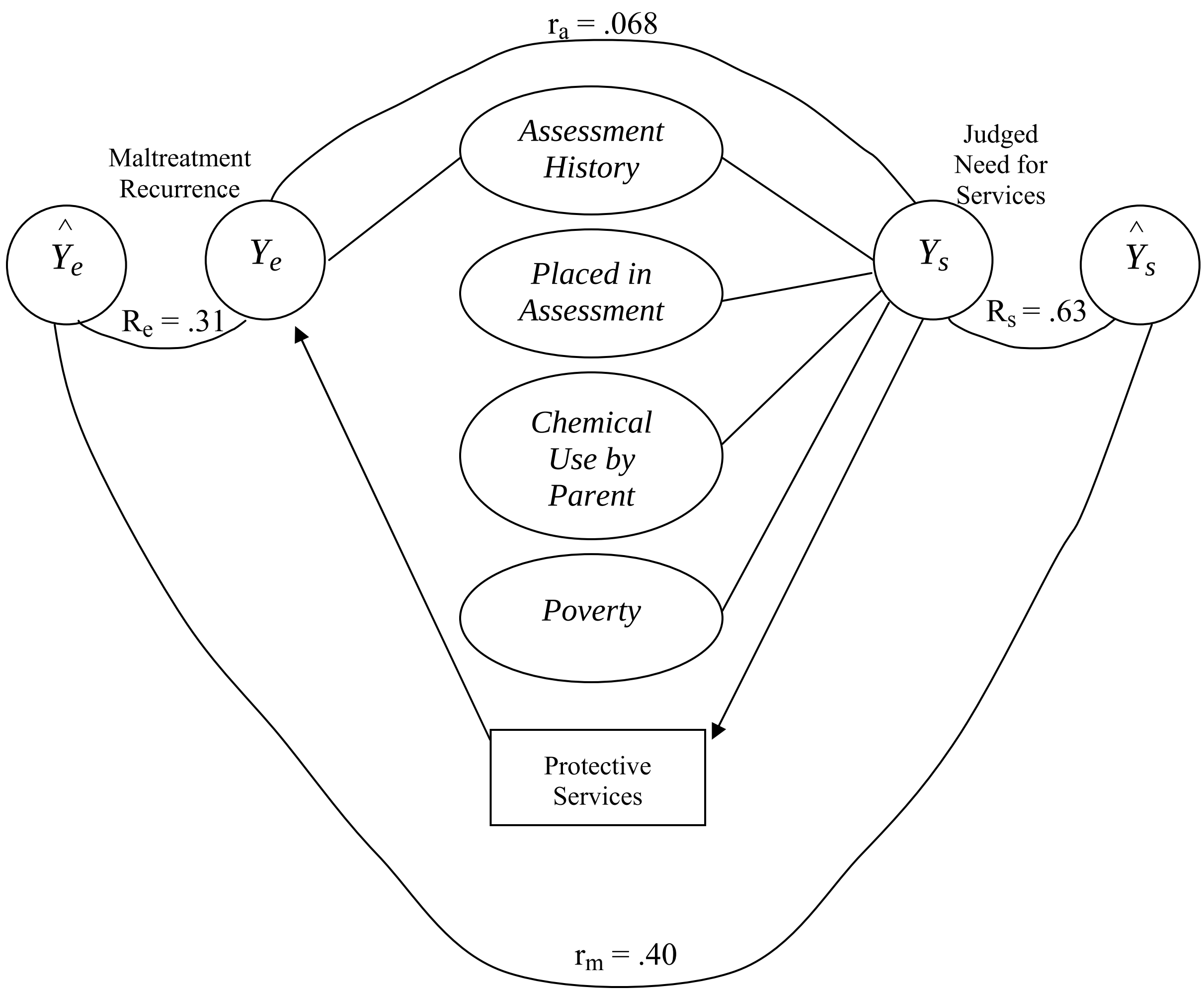
Environment

Index (i)	Cue Weights (bi)	Cue Values (Xi)	Cue Contribution (biXi)
1	1	10.52	10.52
2	1	15.34	15.34
3	1	-3.50	-3.50
4	1	8.06	8.06
		Sum	30.42
		Error	19.06
		Criterion (Ye)	49.47
		Criterion with Intervention (Ye')	24.47

Judge

Index (i)	Cue Weights (bi)	Cue Values (Xi)	Cue Contribution (biXi)
1	1.95	10.52	20.51
2	-0.73	15.34	-11.22
3	0.37	-3.50	-1.29
4	2.58	8.06	20.78
		Sum	28.78
		Error	12.20
		Judgment (Ys)	40.98

Figure 4: Example of Lens Model with an Intervention



Cue Definitions
Assessment History: prior history of maltreatment assessment
Placed in Assessment: out-of-home-placement of the child during the assessment
Chemical Use by Parent: use of alcohol or drugs by either parent
Poverty: receipt of or eligibility for public assistance or housing difficulties for the family