

Cue Combination in Control Risk Judgments

ABSTRACT

Judgment quality depends on the extent to which the judge's weighting and combination of cues matches the cue-criterion relationships in the environment (Hogarth and Karelaia 2007). This paper builds on the research of Brown and Solomon (1990, 1991) by developing a continuum of cue-criterion relationships and then testing whether auditors judge those cue-criterion relationships using the appropriate form of cue combination.

I propose that five generic forms of relationships exist between control cues and control risk. Furthermore, I propose that each of these cue-criterion relationships require a specific form of configural cue combination in order to be judged appropriately. Finally, I conduct an experiment where I vary cue-criterion relationships and ask auditors to judge control risk. My results show that auditors generally vary cue combination so that it appropriately matches cue-criterion relationships in the judgment task. The developed theory may help auditors improve control risk judgments and thereby conduct better audits.

Key Words: *Control Risk Judgments, Configural Cue Processing, Cue Combination, Policy Capturing*

Data Availability: Please contact author

I. INTRODUCTION

The policy capturing framework has been an important model for research on judgment and decision making, both in auditing and in other fields (Solomon and Trotman 2003; Hogarth and Karelaia 2007). The framework defines both judgments and the criterion being judged as functions of the cues in the environment. The quality of a judgment thus depends on the extent to which the judge's weighting and combination of cues matches how the cues relate to the criterion in the environment (Libby 1981, 3; Hogarth and Karelaia 2007). The identification of relevant forms of cue-criterion relationships, and the matching of these relationships to the appropriate forms of cue combination, is therefore an area where research can provide knowledge with a potential for improving practice. Karelaia and Hogarth (2008, 404) state:

“The person’s judgment and the criterion being predicted can be thought of as two separate functions of cues available in the environment of the decision. The accuracy of judgment therefore depends on (...) the extent to which the function describing the person’s judgment matches its environmental counterpart”

Audit research has a long history of investigating how auditors combine information cues (Brown and Solomon 1990; Trotman 2005). The primary task used in this line of research has been control risk judgments (Trotman 1998, 2005). In audit practice, control risk judgments are important because judgment errors can lead to serious consequences for audit planning and reporting.¹ Since judgment accuracy depends on the appropriateness of cue combination, it is of value to know (1) how control cues should be combined in control risk judgments, (2) how

¹ Although few studies directly examine the consequences of judgment errors, serious consequences cannot be ruled out (Brown and Solomon 1990, 1991; Bonner 2007, 155). Examples include: (1) judgment differences may impact audit planning and thereby audit efficiency and effectiveness (Brown and Solomon 1990 and 1991; Hooper and Trotman 1996; ISA 315, IFAC 2008; AS5, PCAOB 2007), (2) due to erroneous audit judgments about the presence or absence of internal control deficiencies, audit clients might initiate unnecessary remediation efforts (i.e., reorganization), or not initiate necessary remediation efforts, and (3) judgment differences may lead to different audit reports under the Sarbanes-Oxley regime, and these audit reports may impact cost of debt and equity (e.g., Doss and Jonas 2004; Ashbaugh-Skaife et al. 2008; Ogneva et al. 2007).

auditors' actually combine control cues when making control risk judgments, and (3) whether improvement in cue combination is needed.

With the exception of Brown and Solomon (1990), all prior research on control risk judgments has used tasks with linear cue-criterion relationships and correspondingly found that auditor's judgment policies can be modeled using simple linear models, compared to more complex (i.e., configural) forms of cue combination (Trotman 1996, 99).² Brown and Solomon (1990), however, used a task with two forms of nonlinear cue-criterion relationships, and found that approximately one in six auditors processed at least one of the nonlinear cue-criterion relationships by using an appropriate form of configural cue combination. Although this was the first consistent evidence of configurality in control risk judgments, the majority of auditors did not combine cues appropriately.

To the best of my knowledge, there have been no studies of control risk judgments since Brown and Solomon (1990). Meanwhile, the passage of the Sarbanes-Oxley Act (SOX) in 2002, and its requirement for reporting on internal control, has brought the importance of auditor's internal control judgments to the forefront again. As a result, it is important for researchers to re-examine (1) whether the cue-criterion relationships developed in prior research represent the relevant task characteristics in today's audit environment, (2) whether prior research has developed models that represent the forms of cue combination that may be appropriate today, and (3) whether today's auditors use appropriate forms of cue combination, given the cue-criterion relationships they are exposed to.

² Linear cue combination means that that the relationship between a cue and the judgment does not depend on the level of other cues (i.e., there are only main effects of cues). Configural cue combination means that the relationship between a cue and the judgment may depend on the level of other cues (i.e., cue pattern- or interaction effects). Different forms of configural combination are discussed later in this paper.

This paper makes three important contributions: First, based on a review of control research and new audit regulation, I propose five generic forms of relationships between control cues and control risk - four of these relationships have nonlinear forms. Second, I propose that each of these cue-criterion relationships require a specific form of cue combination in order to be judged appropriately - four of these cue combination forms are configural. Third, I conduct an experiment where I vary cue-criterion relationships and ask auditors to judge control risk. My results show that auditors generally vary the form of cue combination so that it appropriately matches the cue-criterion relationships in the judgment task.

The remainder of this study is organized as follows: Section II reviews relevant literature and develops the theory and hypotheses. Section III presents the experimental design and procedures. Section IV presents and discusses the experimental results. Section V summarizes the study and ends with a discussion of limitations, suggestions for future research and audit practice.

II. BACKGROUND AND HYPOTHESES DEVELOPMENT

Background and Motivation

Internal control judgment research started with Ashton (1974) and was popular in the 1970's and 1980's (Solomon and Trotman 2003; Trotman 1998). During this period, no consistent evidence of configural cue combination was found. The general understanding at the time was that auditors combined cues linearly, and not configurally. No theory was developed as to whether this lack of configurality was appropriate or not.³

³ Audit judgment literature relevant to this study has been extensively reviewed in dedicated literature reviews (e.g., Libby and Lewis 1982) and in the literature review sections of conducted studies (e.g., Brown and Solomon 1990). These reviews give an extensive overview of the state of policy capturing studies of auditor's internal control judgments at various points in time. For example, Solomon and Shields (1995) identified 28 policy capturing studies of auditors' judgments; 14 of which used internal control judgment tasks. Trotman and Wood (1991) provide a meta-analysis of findings on internal control judgments. Trotman (1998, 2005) and Bonner (2007) provide updated literature reviews that include findings from policy capturing studies of auditor's internal control judgments.

Brown and Solomon (1990), however, contended that the linear cue combination was appropriate since all of the prior control judgment studies had used tasks with linear cue-criterion relationships, and that research on control judgment tasks with nonlinear cue-criterion relationships was needed.

To that end, Brown and Solomon's (1990) conducted a control risk judgment study that included nonlinear cue-criterion relationships. This was done through a five-cue judgment task where two of the control cues related to the criterion in a compensating manner and two of the control cues related to the criterion in an amplifying manner (defined below). Their finding of configural cue combination in 40.5% of auditor judgment models was the first consistent evidence of configurality in control risk judgments. However, only 13 out of 74 auditors (i.e., 17.6%) processed the compensating cue-criterion relationship appropriately, and 9 out of 74 auditors (i.e., 12.2%) processed the amplifying cue-criterion relationship appropriately. Of these 22 auditors, only 3 processed both of the nonlinear cue-criterion relationships appropriately.

No subsequent studies of cue combination in control risk judgments have been identified by the author. The current research is important for the following reasons. First, changes in the regulatory landscape since 1990 have been significant (e.g., COSO 1992; ISA 315, IFAC 2008; Revised EU 8th directive 2006; AS5 PCAOB 2007). It therefore seems reasonable to assume (1) that the importance of control judgments has increased (e.g., due to SOX 404 introducing audit reports on internal controls), and (2) that audit firms have increased training, guidance and review related to control judgments correspondingly. Auditors may therefore be better at making control judgments than they were in 1990. Due to the increased importance of control judgments, it should be of value to provide updated, and extended, evidence on auditor's control risk judgments.

Second, prior internal control studies used judgment tasks with controls at the transaction level (e.g., payroll, accounts receivable, sales and purchasing) (Trotman and Wood 1991). Recent audit regulation and practice (AS5.16, PCAOB 2007; ISA 315, IFAC 2008) puts increased emphasis on entity-level controls in order to increase audit efficiency and effectiveness. An analysis of cue-criterion relationships in some important entity-level controls (e.g., risk assessment and control monitoring) shows that they can be characterized as multi-step control processes where each control step is completely dependent on the previous step in such a manner that the multi-step control is deficient unless each step is effective.⁴ The completely-dependent cue-criterion relationships in such multi-step controls are fundamentally different from the cue-criterion relationships found in the transaction level controls employed in prior research.

Third, prior research recognized the effect on control risk judgments resulting from compensating and substitutable controls.⁵ Brown and Solomon (1990, 22) stated “(...) control risk would be judged to be as low as (...) assuming full compensation, or would be judged somewhere between (...) assuming only partial compensation”.⁶ However, no theory has been

⁴ The clients’ risk assessment process is an internal control component (COSO 1992). Risk management is a multi-step process with several sequential steps (see COSO 2004 p.3-4). AS5.18 (PCAOB 2007) and ISA 315.43b (IFAC 2008) refer to “the company’s risk assessment process”. ISA 315.77 details the steps in the risk assessment process “The auditor when evaluating the client’s risk assessment process should consider how client management: (1) Identifies business risks relevant to financial reporting, (2) Estimates the significance of the risks, (3) Assesses the likelihood of their occurrence, and (4) Decides upon actions to manage them.” ISA 315 appendix 2.5 further describes risk assessment as a process.

⁵ Hooper and Trotman (1996, 134) analyzed subject’s reasons for judgments and found that the perceived degree of compensation between controls varied from “none” through “slight” and “some” up to “substitutable” (i.e., complete compensation). Furthermore the main difference between configural versus non-configural judges was that the former considered cue-criterion relationships to be nonlinear while the latter did not. Thus, the perception of the degree of compensation seems to be related to the presence and magnitude of configural cue combination. However, no systematic contrast of substitutable and partly compensating controls has been done. The relevance of fully compensating/substitutable/alternative controls is also recognized by the SEC (2007, 25); “(...) when more than one control exists that individually addresses a particular risk (i.e., redundant controls) (...)”, and the PCAOB “(...) *implement alternative controls to achieve its control objectives (...)*” (AS5.12 PCAOB 2007).

⁶ In Brown and Solomon (1991, 104), the two interacting cues (in experiment one) were presumably intended to be fully substitutable; “(...) either procedure alone can provide sufficient competent evidence (...)”. However, in the next sentence they describe the second cue as providing “little incremental benefit”. The term “little incremental

developed that explicitly defines (1) the difference between compensating and substitutable cue-criterion relationships and (2) the appropriate forms of cue combination for such cue-criterion relationships.

Fourth, a number of prior studies (e.g., Brown and Solomon 1991; Hooper and Trotman 1996; Leung and Trotman 2005) found that many auditors used the appropriate form of configural cue combination when performing a misstatement risk judgment task (compared to a control risk judgment) that included two cues with a compensating cue-criterion relationship. The general finding on auditor's cue combination is therefore that auditors are capable of combining cues in an appropriate configural manner (Brown and Solomon 1990, 1991; Trotman 1998, 2005; Bonner 2007, 155).⁷ This finding is consistent with results from psychology research that uses other kinds of expert judges and tasks (Einhorn 1979; Brown and Solomon 1990, 1991; Brehmer 1994; Hooper and Trotman 1996; Stewart et al. 1997; Elrod et al. 2004; Bonner 2007, 155).

Hypotheses Development

Generally, the form of cue combination (hereafter CC) should match the form of cue-criterion relationships (hereafter CCR) in the environment (Hogarth and Karelaia 2007). The form of CCR thus determines the appropriate form of CC. Brown and Solomon (1990 and 1991) developed theory that stated that (1) CCR with linear forms should be judged with CC of linear form, (2) CCR of compensating form should be judged with CC of configural compensating form, and (3) CCR of amplifying form should be judged with CC of configural amplifying form. I propose that,

benefit" is, however, relevant for compensating controls, while the term "no incremental benefit" is appropriate for fully substitutable controls. Furthermore, the hypothesized judgment models in Brown and Solomon (1990 and 1991) (i.e., of compensating form) are assumed relevant for partly compensating controls, but not for fully substitutable controls which are assumed to require disjunctive cue combination.

⁷ Although no further audit research on cue combination has been identified by the author, Bedard and Biggs (1991), Maletta and Kida (1993) and Hammersley (2006) have findings that are consistent with auditors being able to process cues configurally.

in addition, CCR of completely-dependent form should be judged with CC of configural conjunctive form, and CCR of substitutable form should be judged with CC of configural disjunctive form.⁸ Table 1 (below) presents formal definitions of the five forms of CCR and CC by defining the form of the mathematical function describing the CCR and CC.^{9, 10}

[Insert Table 1 here]

I propose that these five forms of (CCR) are sufficient for describing the expected relationships between control cues and control risk found in audit practice, and that the five forms of (CC) are sufficient for judging them appropriately. Furthermore, I propose that auditors combine cues appropriately when exposed to these five forms of CCR in a control risk judgment task. In auditor's control risk judgments, CCR thus determines the form of CC.

In order to test the predictions, the number of cues in the task and the form of CCR need to be specified. I use five three-cue tasks to test the hypotheses. Table 2 describes the forms of CCR.¹¹

[Insert Table 2 here]

⁸ Models of conjunctive and disjunctive form are known to the audit literature (see Einhorn 1970, 1971; Libby 1981, 46), but they have not been applied in internal control research. Psychology research has developed such models in an additive form, and these may be useful in policy capturing research since they can be estimated in ordinary least squares (OLS) regression (Elrod et al. 2004, 5-6).

⁹ The mathematical functions are developed for two-cue tasks, but they can be generalized by adding more cues. This study uses three-cue judgment tasks to test the hypotheses and thus develops specific predictions for the used three-cue tasks. Further generalization is left to future research.

¹⁰ For example, CCR of amplifying form imply that cues have both individual and interactive relationships to control risk. An interactive relationship of amplifying form implies that the effect of two control cues combined is larger than the sum of the two individual cue effects (i.e., $f(1,1) > f(0,1) + f(1,0)$). For example, control "c₁" working alone (i.e., without control "c₂") may reduce control risk by 20% (i.e., $f(1,0)=20%$). Similarly control "c₂" working alone (i.e., without control "c₁") may reduce control risk by 25% (i.e., $f(0,1)=25%$). However, if both controls are present, control risk may, for example, be reduced by 60% (i.e., $f(1,1)=60%$). The combined effect of the two controls is therefore larger than the sum of their individual effects; $60% > 20%+25% = 45%$.

¹¹ The reason for using three-cue tasks (e.g., cue A, cue B, cue C) is that it is the minimum number of cues that permit predictions of specific cue interactions; two cues are needed to show a specific interaction and a third cue is needed to show that it does not interact with the two cues that interact. The third cue is a thus counterfactual; since it relates linearly to the criterion it should not interact with other cues.

In three-cue judgment tasks a mathematical model of the judgment policy can potentially have three main effects (A, B, C), three two-way interactions (AB, AC, BC), and one three-way interaction (ABC). The generic judgment model for a three-cue task thus has the following form, where “ α ” represents weights for cue- and cue interaction effects:

$$\text{Judgment} = \alpha_1A + \alpha_2B + \alpha_3C + \alpha_4AB + \alpha_5AC + \alpha_6BC + \alpha_7ABC$$

The following hypotheses are proposed.¹² Table 3 shows the predicted forms for each judgment model.

[Insert Table 3 here]

- H1: If cue-criterion relationships are completely-dependent then cue combination will be configural with a conjunctive form.**
- H2: If cue-criterion relationships are substitutable, then cue combination will be configural with a disjunctive form.**
- H3: If cue-criterion relationships are linear then cue combination will be linear (i.e., non-configural).**
- H4: If cue-criterion relationships are of compensating form cue combination will be configural with a compensating form.**
- H5: If cue-criterion relationships are of amplifying form then cue combination will be configural with an amplifying form.**

III. EXPERIMENTAL METHODS

Research Design

The overall research design is a 5×2^3 within-participants design. There are five forms of cue-criterion relationships (CCR), with each form containing a full factorial design of three binary

¹² The predictions are based on auditors risk judgments, where 100% is maximum risk. If a control cue is effective it is coded as “1” in the analysis. Negative coefficients therefore imply that risk is reduced.

cues. The independent variables (i.e., cue-criterion relationships (CCR) are operationalized by manipulating the relationship between control cues and control risk. The five treatment levels (see table 2) are: (1) one task containing three cues with completely-dependent CCR (H1), (2) one task containing three cues with linear CCR (H3), and (3) three tasks containing one cue with linear CCR and two cues with either amplifying CCR (H5), compensating CCR (H4) or substitutable CCR (H2). A cue with linear CCR was included in task two, four and five so that specific predictions could be made about which control cues interact and which do not.¹³

Participants

Fifty-nine emails were sent out from a database with the names of all audit managers from one office of a Big 4 firm in Norway. The email came from the national leader of the firm. Twenty-three of the managers were not working at the office at the time of the study (e.g., maternity leave, overseas work, etc.). Of the remaining 36 potential participants, 28 agreed to participate (78 percent response rate). Seven participants were deleted from the analysis due to failing the manipulation check.¹⁴ Of the remaining 21 participants, mean audit experience was 7.3 years, with minimum of 2.5 years and maximum 12 years

Dependent Variables

¹³ The order of the independent control was varied between series two, four and five (see table 1); for H5, Cue A was the independent control. For H4, Cue B was the independent control. For H2, cue C was the independent control.

¹⁴ Individual responses to cases revealed that seven out of 28 participants had responded to the control risk judgment by using mostly 0% or 100% responses. Such a response pattern indicates a systematically different perception of cue-criterion relationships than what was intended. These seven participants were therefore contacted and asked open questions about their understanding of the background material in the experiment and their judgment logic. Responses revealed that they had interpreted the background information on inherent risk as all locations having at least one material error or as all transactions being erroneous prior to company control. The intention was for participants to perceive inherent risk as there being one material error somewhere in the company (i.e., one of the locations had one material error). This misinterpretation of inherent risk results in cue-criterion relationships being different from intended. These seven subjects were therefore deleted from further analysis.

The participants made control risk judgments on a 0 – 100 scale.¹⁵ The control risk judgment was used in a series of regressions to test each hypothesis.¹⁶

Case and Control Materials

I used controls within the purchasing cycle to test the hypotheses. Controls over accuracy of booked invoices were selected as the primary setting for operationalizing control cues. A hypothetical audit client with three similar locations and three accounting controllers was developed (see exhibit 1 below).

[Insert Exhibit 1 here]

Each controller represents a cue. Furthermore each controller performs one or two control activities. The auditor's tests disclosed whether each controller had performed all or none of his control activities (see Exhibit 2). In the base case, each controller performs accuracy controls over invoices from one location (i.e., CCR of linear form). CCR of substitutable form is achieved by having two controllers double check each others work (i.e., complete overlap in work performed). CCR of compensating form is achieved by having two controllers double check half of each others work (i.e., partial overlap in work performed). CCR of completely-dependent form is achieved by having each controller perform one control step in a basic three-step risk management process (i.e., a fully joint effort). CCR of amplifying form is achieved by having a controller perform a compound control where part of the control is performed independently and part of the control is a joint effort with a second controller. Amplification is achieved since the

¹⁵ Participants were also requested to judge whether controls were overall effective (yes or no). The control effectiveness judgment was not used in the study.

¹⁶ Most prior studies have used ANOVA instead of OLS regression (Libby and Lewis 1982; Brown and Solomon 1990, 1991; Solomon and Shields 1995; Trotman 1996, 1998, 2005). Both are, however, variations of the general linear model and yield identical results as long as the regression model includes all potential interaction forms (such as in this study). Regression is preferred over ANOVA since it is more efficient when higher order interactions are part of the hypotheses.

reduction in control risk due to the first controller's effort increases if the second controller performs his part of the joint effort.¹⁷

[Insert Exhibit 2 here]

Experimental Procedures

The experiment was administered by the author in a controlled setting at the firm's office. Participants were told that a survey was being conducted in order to understand auditors' internal control judgments. In order to increase accountability, participants were asked to write their name on the folder containing the materials.¹⁸

Each participant received a folder containing an introduction and six numbered envelopes; one envelope to test each of the five forms of cue-criterion relationships, and a sixth envelope containing post experimental questions.¹⁹ The introduction contained instructions regarding the task to be performed and brief background information about the hypothetical company being audited. Participants were told that they were audit managers and that they were to review the documented results from tests of operational effectiveness of internal controls in order to judge control risk in the area being audited. The instructions also included a framework for classifying cue-criterion relationships (i.e., in the form of five definitions of controller cooperation).

After reading the instructions, participants opened envelope one and documented their responses to the questions being asked. After responding, participants sealed their responses in envelope one and repeated the same procedure for envelopes two to five. Each envelope

¹⁷ The introductory materials, a selection of 20 cases and the post experimental survey were pre-pilot tested on 12 consultants from the participating firm (all of which had relevant internal control experience). A final, and full, pilot test was performed with 11 audit seniors from the participating firm.

¹⁸ The fact that participants wrote their name in the materials may have contributed to increased performance compared to prior research. However, it should not have any effect between treatments.

¹⁹ Six orders of envelopes were developed. Within an envelope, 4 orders of cases were developed. This gave 24 variations in orders. Twenty-eight auditors participated in the study. Three of the orders were thus repeated once. Order effects are therefore unlikely.

contained nine pages. The first page was a description of three control cues (i.e., the control work performed by the three controllers) with accompanying control objectives. Participants were asked to classify each cue as belonging to one of the five definitions in the controller cooperation framework. The primary purpose of the classification exercise was to stimulate participants to engage in deeper processing of the cue-criterion relationships prior to completing the cases, but without creating a demand effect.²⁰ A secondary purpose was to obtain a direct measurement of participant understanding of cue-criterion relationships (i.e., as a manipulation check of the cue-criterion relationship treatment).

Each of the following eight pages (i.e., cases) in an envelope contained the manipulation of the cue levels within the series (i.e., a “YES” or “NO” response to whether each cue was operationally effective), and a requirement to document a control risk judgment as a percentage score.²¹ Each envelope thus contained a full factorial manipulation of three binary cues

²⁰ The purpose of the classification exercise can be explained by a metaphor; if studying how fast subjects run, subjects must first be stimulated to run instead of walking, but without the stimulation affecting how fast they run. Hooper and Trotman (1996) found that one of the main differences between configural and non-configural processors was that the former believed cue-criterion relationships to be linear, while the latter considered them to be nonlinear. Auditor perception of cue-criterion relationships may therefore increase the general likelihood of configural cue processing occurring. The classification exercise in this study thus makes the treatment more salient, and this may increase the likelihood of configural cue processing. Since cue-criterion relationships in general are made more salient, there is no reason to expect a bias as to how different cue-criterion relationships impact the form of cue combination (i.e., the likelihood of presence of configurality in general is increased (given nonlinear cue-criterion relationships), but the form of configural cue combination should not be differentially affected between treatments). This is consistent with Schepanski et al. (1992) who noted that, “after all, cue salience is not viewed as a causal variable per se”, and that “although salience may alter effect sizes of a variable that is causally relevant, it would not do so for a variable that is causally irrelevant”. Any potential effect size impact of cue-criterion relationship salience is irrelevant to this study since separate analysis is conducted for each cue-criterion relationships treatment.

²¹ “Control risk” was loosely defined as the risk of error after the company has performed controls. This is similar to the judgment response scale applied in Brown and Solomon (1990), which is the only prior study of internal control judgments finding evidence of configurality. Participants were informed that “inherent risk had been fixed at 100% and should therefore not impact the control risk judgment. It was furthermore referred to “CR” in the Audit Risk Model: $AR=IR*CR*DR$, where AR =Audit Risk, IR=Inherent Risk, CR=Control Risk, DR=Detection Risk (see ISA 200.29 (IFAC 2008) for a description of the model). In addition to judging control risk, participants were for each case also asked to circle a “YES” or “NO” response to the following question: “Please assess the audit test results again: Does the client (i.e., all locations) have sufficient operationally effective controls for the given audit area?”

representing one of the five cue-criterion relationship treatments. Within one envelope, participants were allowed to respond to the cases in the order they wished, and to change their previous answers if they wished (pages were stapled together to preserve the order, but participants could flip back and forth as they wished). However, when one envelope was completed, the answers were sealed in the supplied envelope and could not be changed.²²

The post experimental survey and manipulation checks (i.e., envelope six) were responded to after the five envelopes containing cases were completed and sealed.

IV. RESULTS AND DISCUSSION

Method and Level of Analysis

I use Ordinary Least Squares (OLS) regression to estimate five judgment models. For each of the five CCR conditions, the responses from all participants were regressed on the cues. The hypotheses were tested by comparing the obtained judgment model parameters with the hypothesized parameters in table 3 (see above).²³

Post Experimental Questions

The response to this question is to be used in the author's dissertation for analysis of judgment policies in judgment tasks with binary responses.

²² Allowing subjects to change answers within an envelope (i.e., for one cue-criterion relationship condition) is thought to reduce noise since subjects are allowed to process variation in control cue levels taking into account the entire variation in the cue set. Furthermore, this should not create a bias since cue level variation is not part of the hypotheses (i.e., the research question is about how different cue-criterion relationships affect judgments, not about how cue levels affect judgments). Subjects could therefore not alter judgments in a completed and sealed envelope (i.e., for different cue-criterion relationship conditions).

²³ Analysis is performed at the aggregate level since the number of observations per participant was not designed for individual analysis: The generic model has seven coefficients while there are only eight observations per participant per model. Including more cues in the experiment is not a feasible solution to this issue since the number of potential interactions grows faster than the number of observations. Alternatively, cases could be repeated five times each in order to achieve 40 observations per participant, but this would create boredom and/or fatigue since each participant would receive 200 cases in total. Using an arbitrary 4% criterion (i.e., similar to Brown and Solomon 1990) is also rejected as a solution since an arbitrary criterion would be too sensible to the degree of overlap in controller work.

Participants on average reported the case materials to be easy to understand (5.1 on a 7 point scale; #3 in table 4) and realistic (4.7 on a 7 point scale: #4 in table 4). Providing the instructions in English did not cause difficulties (1.8 on a 7 point scale: #5 in table 4). Participants generally assessed their understanding of the controller cooperation framework as good (5.3 on a 7 point scale: #6 in table 4). When asked to circle any framework elements they found difficult to understand or apply, 11 participants reported difficulties with amplifying cue-criterion relationships,²⁴ two with completely-dependent relationships, and one with substitutable relationships. Participants reported that, overall, understanding and completion of the case materials required some effort (4.1 on a 7 point scale: #7 in table 4). Overall this indicates that the experimental task was not perceived as trivial. Furthermore, responses indicate that participants generally understood the materials and that the overall effort was not too difficult. It can, however, be noted that issues with understanding and applying the amplifying cue-criterion relationship definition were reported by the majority of participants.²⁵

[Insert Table 4 here]

Test of Hypotheses

Each hypotheses is tested by comparing the predicted coefficients (see table 3) to the results from the OLS regression of participant judgments on cue values for the relevant CCR (i.e., treatment condition). The regression coefficients can be interpreted as the percentage risk reduction obtained from each coefficient.

²⁴ Six participants had difficulties with both understanding and applying the definition, Three participants had difficulties understanding the definition (i.e., but did not report difficulties applying the definition), and two participants had difficulties applying the definition (i.e., but did not report difficulties understanding the definition).

²⁵ A covariate analysis was done by including years of audit experience in the regressions. Results did not change. Results from the covariate analysis are not reported.

H1: Completely-Dependent CCR

Table 5 shows the results of the data analysis of the treatment condition with completely-dependent cues. As predicted, only the three-way interaction coefficient (i.e., α_7) is significant ($p < 0.01$). This result supports H1; if cue-criterion relationships are completely-dependent then cue combination will be configural of conjunctive form.

[Insert Table 5 here]

H2: Substitutable CCR

Table 6 shows the results of the data analysis of the treatment condition with substitutable cues. As predicted, all three main effects (i.e., α_1 , α_2 , α_3) and the interaction between the substitutable cues (i.e., α_4) are significant ($p < 0.01$ level) (see table 6 below). Furthermore, as predicted, when 95% confidence intervals are created for cue coefficients $\alpha_1 = \alpha_2 = -\alpha_4$ ($\alpha_1 = -0.58$, $\alpha_2 = -0.60$ and $\alpha_4 = 0.52$, with confidence intervals of ± 0.006 , 0.006 and 0.008 respectively).²⁶ For substitutable cues, findings are therefore consistent with the predictions in H2: If cue-criterion relationships are substitutable, then cue combination will be configural of disjunctive form.

[Insert Table 6 here]

H3: Linear CCR

Table 7 shows the results of the data analysis of the treatment condition with linear cues. As predicted, all three main effects (i.e., α_1 , α_2 , α_3) are significant ($p < 0.01$) and no interactions are found to be significant (see table 7 below). Results are therefore consistent with the predictions in

²⁶ $\alpha_1 = \alpha_2 = -\alpha_4$ implies that $f(1,0) = f(0,1) = f(1,1)$ (see table one). In other words, if one of the substitutable controls is effective, the second substitutable control does not reduce control risk further. The interaction effect (i.e., α_4) thus serves to remove the effect of the second effective substitutable control (i.e., statistically $\alpha_1 + \alpha_2 - \alpha_4 = \alpha_1 = \alpha_2$)

H3: If cue-criterion relationships are linear, then cue combination will be linear (i.e., non-configural).

[Insert Table 7 here]

H4: Compensating CCR

Table 8 shows the results of the data analysis of the treatment condition with compensating cues. As predicted, all three main effects (i.e., α_1 , α_2 , α_3) and the predicted interaction (i.e., α_5) are significant ($p < 0.01$). Furthermore, as predicted, the interaction is of the opposite sign from main effects (i.e., the interaction is compensating) (see table 8 below). Findings are therefore consistent with the predictions in H4. If cue-criterion relationships are of compensating form, then cue combination will be configural of compensating form.

[Insert Table 8 here]

H5: Amplifying CCR

Table 9 shows the results of the data analysis of the treatment condition with amplifying cues. All three main effects (i.e., α_1 , α_2 , α_3) are significant ($p < 0.01$ level).²⁷ However, the predicted interaction (α_6) is not significant ($p = 0.45$) (see table 9 below). Findings are therefore not consistent with the predictions in H5: When cue-criterion relationships are of amplifying form, cue combination was predicted to be configural of amplifying form. Instead, participants combined cues in a linear manner (i.e., with only main effects).

[Insert Table 9 here]

At least two potential explanations arise: (1) the form of cue-criterion relationships was not perceived as amplifying, or (2) participants perceived this as intended, but did not combine cues in the predicted manner. The post experimental questions revealed that when asked to circle any

²⁷ One of the participants received an empty envelope in the amplifying series. The analysis of amplifying cues is therefore based on 20 participants. The empty envelope is due to manual error in sorting and filling envelopes.

framework elements found difficult to understand or apply, eleven participants reported difficulties with amplifying cue-criterion relationships. Furthermore, the classification of cues in the amplifying form treatment condition reveals that all 20 participants classified the independent cue correctly (i.e., cue A), 14 participants classified the first amplifying cue correctly (i.e., cue B), 12 participants classified the second amplifying cue correctly (i.e., cue C). The participant's judgments, the cue classification exercise and the post experimental questions therefore indicate that a potential problem may exist with participant perception of cue-criterion relationships of amplifying form. This is a potential explanation for not observing the appropriate form of cue combination. However, it can not be ruled out that cue-criterion relationships were perceived correctly and that participants just combined cues inappropriately.

V. CONCLUDING REMARKS

This study proposes that five forms of cue-criterion relationships exist in control risk judgments. Furthermore, it is proposed that, normatively, each of these cue-criterion relationships require a specific form of cue combination – four of which are configural. In other words, cue-criterion relationships determine the appropriate form of cue combination. Finally, it is hypothesized that auditors are able to combine cues in an appropriate manner when exposed to these forms of cue-criterion relationships; (1) if cue-criterion relationships are completely-dependent, then cue combination will be configural of conjunctive form, (2) if cue-criterion relationships are substitutable, then cue combination will be configural of disjunctive form, (3) if cue-criterion relationships are linear, then cue combination will be linear (i.e., non-configural), (4) if cue-criterion relationships are of compensating form, then cue combination will be configural of a compensating form, and (5) if cue-criterion relationships are of amplifying form, then cue combination will be configural of an amplifying form.

A policy capturing experiment shows that, overall, auditors generally make judgments by using normatively appropriate forms of cue combination, given cue-criterion relationships. However, an exception occurred for auditor's cue combination when cue-criterion relationships were of amplifying form: On average auditors exhibited a linear form of cue combination instead of the hypothesized amplifying form. It is, however, not unlikely that the exception was due to participants not absorbing the cue-criterion relationship treatment as intended (see discussion under results for H5).

Contribution to Research and Practice

This study contributes to research by expanding the range of studied cue-criterion relationships to include completely-dependent relationships, and by clarifying the difference between compensating and substitutable relationships. Furthermore, disjunctive and conjunctive forms of cue combination are introduced to control risk judgment research and proposed to be normatively appropriate for judging substitutable and completely-dependent cue-criterion relationships (respectively). Finally, the study provides updated evidence on auditor's ability to use appropriate forms of configural cue-combination in control risk judgments. The construct development (i.e., forms of cue-criterion relationships) and normative theory development should also be relevant for judgment research in other fields (i.e., other judges and/or other tasks) where similar task characteristics are relevant. For audit practice, the normative propositions in this study may serve as benchmarks for analyzing actual judgment tasks and policies, and for developing training and decision aids

Limitations

In addition to the usual experimental limitations, the following limitations apply: First, seven out of twenty-eight participants were deleted from analysis since their judgments and responses to follow-up questions revealed that they may have perceived cue-criterion relationships

differently from what was intended. Future studies should provide clearer background information on inherent risk to avoid deviating cue-criterion relationship perceptions. Second, findings for amplifying cue-criterion relationships may be influenced by participants not absorbing the treatment as intended (see discussion under results for H5). Third, the level of analysis is aggregated and not individual. The study does therefore not quantify the proportion of judges using appropriate forms of cue combination. This may be a question for future research.

Suggestions for Future Research

This study has raised issues that may provide interesting questions for future research. First, the judge's perception of cue-criterion relationships may be important for the effect of cue-criterion relationships on cue combination. It would therefore be useful to learn more about what affects the judge's ability to perceive cue-criterion relationships correctly. Research on this issue would need to be based on other methodologies than policy capturing. Second, why is the evidence of auditor's ability to combine cues in a manner appropriate to amplifying control cue-criterion relationships so weak? A first step in resolving this question is to find out whether auditors have a problem with perceiving amplifying these relationships correctly, or whether the problem lies with their ability to apply an amplifying form of cue combination, conditional on a correct perception of cue-criterion relationships. For auditors, and others making control risk judgments, appropriate combination of amplifying cues may be important since entity level controls are generally thought to relate to the remaining control system in an amplifying manner (i.e., less reliance is placed on internal controls if entity level controls are deficient). Finally, future research could study the usefulness of the proposed theory in settings with other tasks and judges. A first approach could be to cross validate the findings using other controls as cues, and other auditor judges. A next step could be using audit tasks other than internal control judgments,

but with similar cue-criterion relationships. At the more generic level, studies could use a setting with non-audit tasks and non- auditor judges.

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Table 1: Definition of forms of cue-criterion relationships (CCR) and cue-combination (CC)

Cue-criterion relationship (CCR)	Mathematical function describing CCR and CC	Appropriate form of Cue Combination (CC) for judging the form of CCR
Linear	$0 < f(0,1) + f(1,0) = f(1,1)$ $0 < f(1,0), 0 < f(0,1)$	Linear
Compensating	$0 < f(1,1) < f(0,1) + f(1,0)$ $0 < f(1,0), 0 < f(0,1)$	Compensating
Amplifying	$0 < f(0,1) + f(1,0) < f(1,1)$ $0 < f(1,0), 0 < f(0,1)$	Amplifying
Completely-dependent	$f(1,0) = f(0,1) = 0$, and $f(1,1) > 0$	Conjunctive
Substitutable	$0 < f(1,0) = f(0,1) = f(1,1)$	Disjunctive

Assume “y” represents the criterion and that “y” is a function of cues “ c_i ”

Let $y = f(c_i)$, where there are two cues ($i=1,2$) and cues take on the values 0 or 1 ($c_i = 0,1$)

Assume “z” represents the judgment and that “z” is a function of cues “ c_i ”

Let $z = f(c_i)$, where there are two cues ($i=1,2$) and cues take on the values 0 or 1 ($c_i = 0,1$)

Assume: $0 = 0/100 \leq f(c_1, c_2) \leq 100/100 = 1$ and $f(0,0) = 0$ for all functions

An appropriate form of cue combination implies that the mathematical specification of “z” and “y” be equal (Hogarth and Karelaia 2007).

Table 2: Cue-criterion relationships (CCR) in judgment tasks

	Task 1	Task 2	Task 3	Task 4	Task 5
Cue A	Completely-dependent	Substitutable	Linear	Compensating	Linear
Cue B	Completely-dependent	Substitutable	Linear	Linear	Amplifying
Cue C	Completely-dependent	Linear	Linear	Compensating	Amplifying

Note: Participants respond to five three-cue tasks. Each column in this table shows how each of the three cues (i.e., cue A, B, C) relate to the criterion in the task

Table 3: Predicted Coefficients in Three-Cue Judgment Tasks

Cue-criterion relationships	Completely-dependent	Substitutable	Independent	Compensating	Amplifying
Judgment model predictions	H1 $\alpha_7 < 0$	H2 $\alpha_1, \alpha_2, \alpha_3 < 0$ $\alpha_4 > 0$ $\alpha_1 = \alpha_2 = -\alpha_4$	H3 $\alpha_1, \alpha_2, \alpha_3 < 0$	H4 $\alpha_1, \alpha_2, \alpha_3 < 0$ $\alpha_5 > 0$	H5 $\alpha_1, \alpha_2, \alpha_3 < 0$ $\alpha_6 < 0$

Note:

Each cell in the table is valid for a specific cue-criterion relationship treatment (see column headings) and contains the judgment model predictions for that specific cue-criterion relationship treatment. Listed alphas are predicted to be significant when regressing control risk judgments on control cues in the given treatment. Unlisted alphas are predicted to be non-significant. Negative alphas imply that control risk is reduced. For definitions of cue-criterion relationships it is referred to table 1.

$\alpha_1, \alpha_2, \alpha_3$ = main effects of cues

$\alpha_4, \alpha_5, \alpha_6$ = two-way interactions between cues

α_7 = three-way interaction between cues

Table 4 Responses to post Experimental Questions

#	Question content	Scale / Anchor	Average	Std.dev.	Max.	Min.
1	Years of experience as an auditor	Years	7,3	2,5	12	2,5
2	Time to complete the study	Minutes	50,6	8,1	65	35
3	Case materials were easy to understand	1=Never, 7=Always	5,1	1,2	7	3
4	Case materials were realistic	1=Never, 7=Always	4,7	1,4	6	2
5	Difficulties due to materials being in English	1=None, 7=Very Difficult	1,8	0,9	5	1
6	Understanding of framework	1=Poor, 7=Excellent	5,3	0,8	7	4
7	Effort needed to understand and complete materials	1=Easy, 7=Difficult	4,1	1,0	6	2

*For question #3 to #7 a seven point scale anchored in the ends was used.
Responses are from the 21 participants included in the judgment analysis.*

Table 5: Results from Linear Regression H1**Dependent variable: Control risk percentage judgment (n=21)**

Cue	Coefficient	Prediction	Coefficients	Std. Error	t	Sig.
	Intercept		0,99	0,03	34,77	0,00 ***
A	α_1	0	-0,06	0,04	-1,56	0,12
B	α_2	0	-0,02	0,04	-0,53	0,60
C	α_3	0	-0,04	0,04	-0,95	0,35
AxB	α_4	0	-0,05	0,06	-0,85	0,40
AxC	α_5	0	0,01	0,06	0,24	0,81
BxC	α_6	0	0,04	0,06	0,71	0,48
AxBxC	α_7	(-)	-0,85	0,08	-10,55	0,00 ***

Model Summary:
R-sq=0.852; Adjusted R-sq=0.845; F(7, 167)=131.2,
p<0.01

***p<0.01, **p<0.05, *p<0.10

*Note:**Cue A, Cue B and Cue C are completely-dependent* *$\alpha_1, \alpha_2, \alpha_3$ = main effects of cues* *$\alpha_4, \alpha_5, \alpha_6$ = two-way interactions between cues* *α_7 = three-way interaction between cues*

Table 6: Results from Linear Regression H2**Dependent variable: Control risk percentage judgment (n=21)**

Cue	Coefficient	Prediction	Coefficients	Std. Error	t	Sig.
	Intercept		0,99	0,02	46,40	0,00 ***
A	α_1	(-)	-0,58	0,03	-19,06	0,00 ***
B	α_2	(-)	-0,60	0,03	-20,02	0,00 ***
C	α_3	(-)	-0,31	0,03	-10,33	0,00 ***
AxB	α_4	(+)	0,52	0,04	12,27	0,00 ***
AxC	α_5	0	-0,04	0,04	-0,94	0,35
BxC	α_6	0	-0,02	0,04	-0,37	0,71
AxBxC	α_7	0	0,05	0,06	0,78	0,44

Model Summary

R-sq=0.917; Adjusted R-sq=0.913; F(7, 167)=251.3, p<0.01

***p<0.01, **p<0.05, *p<0.10

*Note:**Cue A and cue B are substitutable, cue C is independent.* *$\alpha_1, \alpha_2, \alpha_3$ = main effects of cues* *$\alpha_4, \alpha_5, \alpha_6$ = two-way interactions between cues* *α_7 = three-way interaction between cues*

Table 7: Results from Linear Regression H3**Dependent variable: Control risk percentage judgment (n=21)**

Cue	Coefficient	Prediction	Coefficients	Std. Error	t	Sig.
	Intercept		0,99	0,02	45,56	0,00 ***
A	α_1	(-)	-0,33	0,03	-10,75	0,00 ***
B	α_2	(-)	-0,35	0,03	-11,39	0,00 ***
C	α_3	(-)	-0,33	0,03	-10,77	0,00 ***
AxB	α_4	0	0,04	0,04	0,86	0,39
AxC	α_5	0	0,04	0,04	0,86	0,39
BxC	α_6	0	0,05	0,04	1,09	0,28
AxBxC	α_7	0	-0,08	0,06	-1,26	0,21

Model Summary

R-sq=0.888; Adjusted R-sq=0.883; F(7, 167)=181.5, p<0.01

***p<0.01, **p<0.05, *p<0.10

*Note:**Cue A, cue B and cue C are independent* *$\alpha_1, \alpha_2, \alpha_3$ = main effects of cues* *$\alpha_4, \alpha_5, \alpha_6$ = two-way interactions between cues* *α_7 = three-way interaction between cues*

Table 8: Results from Linear Regression H4**H4: Compensating controls****Dependent variable: Control risk percentage judgment (n=21)**

Cue	Coefficient	Prediction	Coefficients	Std. Error	t	Sig.
	Intercept		0,98	0,02	40,28	0,00 ***
A	α_1	(-)	-0,45	0,03	-13,04	0,00 ***
B	α_2	(-)	-0,31	0,03	-8,96	0,00 ***
C	α_3	(-)	-0,46	0,03	-13,32	0,00 ***
AxB	α_4	0	-0,01	0,05	-0,15	0,88
AxC	α_5	(+)	0,26	0,05	5,43	0,00 ***
BxC	α_6	0	0,04	0,05	0,87	0,39
AxBxC	α_7	0	-0,05	0,07	-0,68	0,50

Model Summary

R-sq=0.870; Adjusted R-sq=0.864; F(7, 167)=152.9, p<0.01

***p<0.01, **p<0.05, *p<0.10

*Note:**Cue A and cue C are compensating, cue B is independent* *$\alpha_1, \alpha_2, \alpha_3$ = main effects of cues* *$\alpha_4, \alpha_5, \alpha_6$ = two-way interactions between cues* *α_7 = three-way interaction between cues*

Table 9: Results from Linear Regression H5

H5: Amplifying controls

Dependent variable: Control risk percentage judgment (n=20)

Cue	Coefficient	Prediction	Coefficients	Std. Error	t	Sig.	
	Intercept		0,98	0,03	34,89	0,00	***
A	α_1	(-)	-0,33	0,04	-8,40	0,00	***
B	α_2	(-)	-0,24	0,04	-5,94	0,00	***
C	α_3	(-)	-0,35	0,04	-8,77	0,00	***
AxB	α_4	0	0,06	0,06	1,05	0,30	
AxC	α_5	0	0,02	0,06	0,28	0,78	
BxC	α_6	(-)	-0,04	0,06	-0,76	0,45	
AxBxC	α_7	0	-0,08	0,08	-0,96	0,34	

Model Summary

R-sq=0.837; Adjusted R-sq=0.830; F(7, 167)=111,3,
p<0.01

***p<0.01, **p<0.05, *p<0.10

Note:

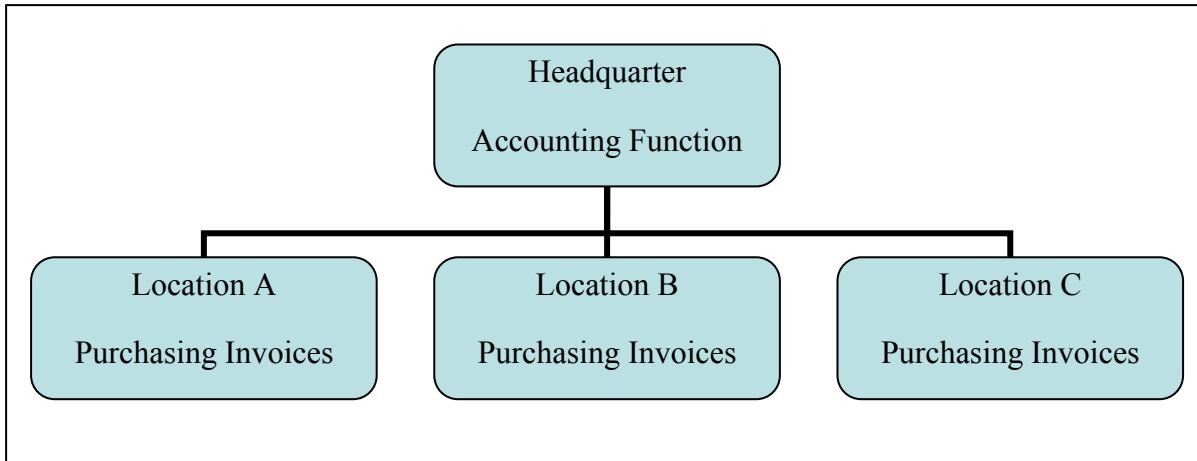
Cue B and Cue C are amplifying, Cue A is independent.

$\alpha_1, \alpha_2, \alpha_3$ = main effects of cues

$\alpha_4, \alpha_5, \alpha_6$ = two-way interactions between cues

α_7 = three-way interaction between cues

Exhibit 1: Hypothetical Audit Client



Model of hypothetical audit client: Three controllers are located in the headquarter accounting function. The audit client has three locations, each generating purchasing invoices. The controllers may control invoices in one or more locations, and they may work alone or in cooperation with other controllers.

Exhibit 2: Example of Compensating Control Case

Audit Area: accuracy of booked incoming invoices			
Control Design:	Control Objective	Operationally Effective? (Audit test result)	
1. Accounting controller “A” reviews <u>all</u> (i.e., 100) booked incoming invoices from <u>location “A”</u> to check that they are booked in the accounting system with the correct amount.	Accuracy	YES	
2. Accounting controller “B” reviews <u>all</u> (i.e., 100) booked incoming invoices from <u>location “B”</u> to check that they are booked in the accounting system with the correct amount. In addition, accounting controller “B” double checks <u>half of all</u> (i.e., 50) booked incoming invoices from <u>location “C”</u> to check that they are booked in the accounting system with the correct amount.	Accuracy	YES	
3. Accounting controller “C” reviews <u>all</u> (i.e., 100) booked incoming invoices from <u>location “C”</u> to check that they are booked in the accounting system with the correct amount. In addition, accounting controller “C” double checks <u>half of all</u> (i.e., 50) booked incoming invoices from <u>location “B”</u> to check that they are booked in the accounting system with the correct amount.	Accuracy		NO

Explanation of case: In this case cue 1 is independent of the other cues. Cue 2 and 3, however, are designed to compensate for each other. In this specific case, cue 3 is not operationally effective. The only effective control over invoices in location “C” is thus the control of 50 invoices performed by controller “B” (cue 2). Controller “B” thus compensates, but does not substitute, for controller “C” regarding the invoices in location “C”. Based on the percentage of invoices controlled, a control risk judgment of approximately 16% would be reasonable to expect.