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The effects of process and outcome accountability on judgment process and performance

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ABSTRACT

This article challenges the view that it is always better to hold decision makers accountable for their decision process rather than their decision outcomes. In three multiple-cue judgment studies, the authors show that process accountability, relative to outcome accountability, consistently improves judgment quality in relatively simple elemental tasks. However, this performance advantage of process accountability does not generalize to more complex configural tasks. This is because process accountability improves an analytical process based on cue abstraction, while it does not change a holistic process based on exemplar memory. Cue abstraction is only effective in elemental tasks (in which outcomes are a linear additive combination of cues) but not in configural tasks (in which outcomes depend on interactions between the cues). In addition, Studies 2 and 3 show that the extent to which process and outcome accountability affect judgment quality depends on individual differences in analytical intelligence and rational thinking style.

Introduction

Helping people to make better judgments and decisions is a prime purpose of research in organizational behavior and human decision making. Several authors have documented positive effects of raising the stakes for decision makers by holding them accountable (Arkes, 1991). For example, it has been shown that accountability makes professional auditors more accurate in judging the financial quality of industrial bond issues (Ashton, 1992), reduces primacy effects in person impression formation (Tetlock, 1983), eliminates the fundamental attribution error (Tetlock, 1985), reduces self-enhancement (Sedikides, Herbst, Hardin, & Dardis, 2002), and reduces sunk cost effects (Fennema & Perkins, 2008; Simonson & Nye, 1992). Accountability is a social factor that can be externally imposed and is therefore particularly useful to avoid judgment errors based on suboptimal cognitive predispositions or abilities of the individual decision maker (Payne, Bettman, & Johnson 1993).

Accountability, however, is not a unitary phenomenon and can be implemented in at least two ways (Lerner & Tetlock, 1999). Sometimes people are evaluated based on the outcomes of their decisions (i.e., outcome accountability). For example, many professional investors are evaluated based on the monetary outcomes of their decisions, regardless of whether they came to their decisions based on solid understanding and analysis or not. In other situations, people are evaluated not so much on the outcomes of their decisions, but need to justify the process that underlay those decisions (i.e., process accountability). Thus, under process accountability the investor would be evaluated solely on how an investment portfolio was chosen, regardless of whether it proved to be profitable. Academic research has shown that increasing process accountability leads to superior judgment quality in a variety of tasks (Ashton, 1992; Chaiken, 1980; De Dreu, Beersma, Stroebe, & Euwema, 2006; Hagafors & Brehmer, 1983). In addition, research indicates that outcome accountability, despite its prevalence in managerial practice, can have negative effects on performance (Arkes, Dawes, & Christensen, 1986; Siegel-Jacobs & Yates, 1996). The divergent effects on performance of process accountability vs. outcome accountability have been confirmed among students participating in experimental research (Brtek & Motowidlo, 2002; Siegel-Jacobs & Yates, 1996; Simonson & Staw, 1992), but also in real-life settings, for example among purchasing professionals who were members of the National Association of Purchasing

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Management (Doney & Armstrong, 1996). Thus, empirical findings suggest that to help people make better judgments and decisions, process accountability is consistently more desirable and uniformly superior to outcome accountability (see Slaughter, Bagger, & Li, 2006, for a lone exception).

The origins of a negative effect of outcome accountability on judgmental or decision performance have, to the best of our knowledge, not seen any direct empirical investigation. However, indirect evidence relying on Janis and Mann's (1977) Conflict Theory suggests that outcome accountability's detrimental influence may be due to an increase in decision stress and a narrowing of attention that does not occur with process accountability (Brtek & Motowidlo, 2002; Lerner & Tetlock, 1999; Siegel-Jacobs & Yates, 1996; Simonson & Staw, 1992).

The beneficial effects of process accountability are attributed to greater attention to the problem at hand, better encoding and retrieval of information, and more even-handed and consistent use of available information. For example, Brtek and Motowidlo (2002) found that process accountable participants, relative to outcome accountable participants, gave more accurate judgments of managers' leadership potential based on an interview. This effect was mediated by an attentiveness score reflecting attention to the interview, alertness of posture, note taking, and thoughtfulness after the interview. De Dreu et al. (2006) found that process accountable participants recalled more distinct negotiation tactics from a description of a group discussion scenario than participants who were not held accountable. Process accountable participants in a pretest by Scholten, van Knippenberg, Nijstad, and De Dreu (2007) reported that in an upcoming group discussion they would strive for thorough and balanced decisions, would think deeply before reaching a judgment, and thought that thinking through every possibility would be more important than making efficient decisions. Siegel-Jacobs and Yates (1996) found that process accountable participants were more consistent and better calibrated in their judgments than outcome accountable participants.

Jointly, these prior inquiries suggest that process accountability has a universal and uniform positive effect on cognitive processing and judgment quality relative to outcome accountability. However, it is possible that the effect of process vs. outcome accountability is more specific. In this article, we argue that process and outcome accountability do not affect all cognitive processes to the same extent. Specifically, we establish that process accountability (vs. outcome accountability) boosts the use of a cue abstraction process but not exemplar-based processing. Because cue abstraction is not equally effective in all situations (Juslin, Karlsson, & Olsson, 2008; Olsson, Enkvist, & Juslin 2006), the superiority of process accountability over outcome accountability is not as uniform as previous results would suggest.

In the next section of this article, we describe two cognitive processes based on different memory representations that can be used to make judgments (i.e., cue abstraction and exemplar-based processing). We then elaborate on the impact of using these processes on judgment quality in different types of tasks. Subsequently, we relate process and outcome accountability to differential use of the two cognitive processes. Finally, we generate predictions regarding the impact of holding people process vs. outcome accountable on judgment quality in different types of tasks. These predictions are tested in three experimental studies using a multiple-cue learning paradigm.

Theoretical background

Judgment based on cue abstraction and exemplar memory

Two cognitive processes based on different memory representations have taken a central place in the cognitive science literature over the past few decades, (1) an analytical cue abstraction process based on abstract knowledge about the relationship between individual features of a stimulus and an outcome to be judged and (2) a more holistic exemplar-based process based on concrete representations of previously-encountered stimulus-outcome configurations (e.g., Erickson & Kruschke, 1998; Hahn & Chater, 1998; Juslin et al., 2008; Pothos, 2005; Smith & Sloman, 1994).

To illustrate this distinction, consider the case of two experts (Expert A and Expert B) trying to predict the commercial success of a new type of mobile phone. Expert A argues that, because the phone has a long battery life (i.e., a positive feature) but the software is not user-friendly (i.e., a negative feature), it is likely to be moderately successful. Expert B agrees with this prediction, because the new phone is similar to a specific phone that was launched a couple of months ago, and that earlier phone has proven to be moderately popular among consumers. Although Expert A and Expert B arrived at the same prediction, their judgments can be traced to informational inputs of a fundamentally different nature. Whereas the prediction of Expert A is based on abstract information relating individual features of the phone to commercialization success (i.e., knowledge about individual cue-outcome relations), the prediction of Expert B is based on the storage and retrieval of previously launched phones together with their respective commercialization success (i.e., knowledge about exemplars made up of a configuration of cues and their relationships with an outcome). Judgments based on cue-outcome information involve the abstraction and representation of "mental rules" that relate individual attributes of a stimulus to an outcome to be judged. At the time of judgment, each cue is selectively attended to, its relation to the outcome is considered, and the judgment results from an additive integration of the independent effects of each cue on the outcome (e.g., Einhorn, Kleinmuntz, & Kleinmuntz, 1979; Juslin, Jones, Olsson, & Winman, 2003; Juslin, Olsson, & Olsson, 2003; Juslin et al., 2008). Judgments based on exemplar-outcome information, on the other hand, depend on the holistic storage of stimuli (i.e., a configural pattern of cues) and their respective outcome values in long term memory. Judgments are constructed by assessing the overall similarity of the stimulus under consideration to the stimuli that are stored in memory, with relatively more similar stimuli having a greater influence on the final judgment (e.g., Juslin et al., 2008; Medin & Schaffer, 1978; Nosofsky, Shin, & Clark, 1989).

Effects of two cognitive processes on judgment quality in different tasks

Crucially, both types of information are not equally adaptive for judgment in all task environments. Knowledge about individual cue-outcome relations is only useful in *elemental* task structures. These are task structures in which the true outcome can be relatively well approximated by a linear additive combination of cue values, i.e. tasks where individual cues are elementally and linearly related to the outcome to be predicted. For example, cue abstraction should work well when cell phone weight has a consistent negative relationship with the success of cell phones in the market (higher weight means less success and this relationship is constant over the whole range of realistic weights). However, knowledge about individual cue-outcome relations is not useful in *configural* task structures. These are task structures in which cues interact with each other to predict the outcome. In tasks where cues are related to the outcome in a configural way judgments based on cue-outcome relations allow at best only for a linear additive approximation of the outcome values (Juslin et al., 2008; Olsson et al., 2006). For example, cue abstraction should work badly when flashy colors are positively related to market success when combined with MP3 player functionality but negative when combined with more business-like features such as an extra-powerful battery.

Exemplar-based knowledge does not suffer from this constraint and is a useful source of information in any task structure, provided that similar instances have similar outcomes (Juslin et al., 2008). As a result, whereas both reliance on cue-outcome information and reliance on exemplar-outcome information enhance judgment quality in elemental tasks, only reliance on exemplar-outcome information remains equally adaptive in configural tasks. Thus, cue abstraction becomes less beneficial as task structures become more configural.

Accountability and cue abstraction

To the best of our knowledge, no previous research has even considered the possibility that process accountable and outcome accountable judges differ in the extent to which judgment is formed based on cue abstraction vs. exemplar memory.

Early research using multiple-cue learning paradigms has found that process accountable participants outperform control participants in predicting an outcome value that is related in an elemental (i.e. linear additive) way to some predictive cues (Ashton, 1992), and that relative to a control group, the judgments of process accountable participants in elemental tasks can be better approximated by linear additive regression models (Hagafors & Brehmer, 1983; Weldon & Gargano, 1988). However, since an elemental task structure can also be successfully acquired by an exemplar-based process, it cannot be concluded from these studies that an increase in cue abstraction accounts for the improvement in judgment quality.

De Dreu and his colleagues have argued in an impressive series of social-psychological articles that process accountability increases epistemic motivation which promotes effortful and systematic information processing (De Dreu & Carnevale, 2003; De Dreu, Koole, & Steinel, 2000; De Dreu, Nijstad, & van Knippenberg, 2008; De Dreu et al., 2006; Scholten et al., 2007). To the extent that the abstraction of cue-outcome information requires a more effortful and systematic analysis of a judgment task, this research might be taken to suggest that process accountability promotes cue abstraction. However, the mapping of systematic, effortful processing on cue abstraction vs. exemplar-based processing is far from unambiguous. For example, recall is widely used as a measure of systematic information processing (De Dreu et al., 2006; Petty & Cacioppo, 1986) but is evidently also a mainstay of exemplar-based processing (e.g., Juslin & Persson, 2002; van Osselaer, Janiszewski, & Cunha, 2004).

Regarding the association between outcome accountability and cue abstraction, research by Arkes et al. (1986) may be taken to suggest that outcome accountability decreases the likelihood that people consistently base their judgments on linear additive rules. In this research, participants were asked to judge whether a student graduated with or without honors based on information about the student's grades for three randomly selected courses. Participants were told that they would be accurate 70% of the time by guessing "honors" when a student has two or three A's and guessing "not honors" when a student has zero or one A. Participants who were evaluated and incentivized based on the accuracy of their predictions (i.e. those who were held outcome accountable) were more likely to step away from following the linear additive rule, and therefore performed relatively worse than control participants. This study may tell us more about rule compliance and the possibility that outcome accountable participants set out to find new, better rules. Nevertheless, it may also suggest that outcome accountability made participants decrease their reliance on cue abstraction.

Combining insights from these studies, we hypothesize that process accountability (relative to outcome accountability) stimulates cue abstraction.

Accountability and exemplar-based processing

Previous research has also not considered the potential consequences of process and outcome accountability for exemplar-based processing. Because there is no consensus to date about the extent to which exemplar-based reasoning benefits from or is deteriorated by increased attention (Neal, Hesketh, & Andrews, 1995), it is difficult to make unambiguous predictions with regard to this matter. Under the assumption that exemplar-based processing does not just require basic attentiveness to stimuli but also the effortful encoding, storage and retrieval of exemplars (e.g., PROBEX; Juslin & Persson, 2002), process accountability is likely to boost it considerably, as process accountability has been shown to increase attention, encoding and retrieval of information (De Dreu et al., 2006). To the extent that this motivational effect is stronger for process than outcome accountability, this would lead to an exemplar-based processing advantage for process over outcome accountable people. However, even in this case extra effort may have a stronger beneficial effect on the abstraction of rules than on the storage of exemplars as the former is likely to be more cognitively involved than the latter (Patalano, Smith, Jonides, & Koeppe, 2001).

Alternatively, if exemplar-based processing is a largely automatic cognitive process and merely requires basic attention to the stimuli (e.g., MINERVA-DM; Dougherty, Gettys, & Ogden, 1999), neither process nor outcome accountability is likely to boost it significantly. Some research even hints that process accountability may be harmful for exemplar-based processing (Reber, Kassin, Lewis, & Cantor, 1980; Wilson, Dunn, Kraft, & Lisle, 1989). For instance, social-psychological inquiries suggest that introspection in the form of thinking about reasons can reduce (1) attitude–behavior consistency (Wilson, Dunn, Bybee, Hyman, & Rotondo, 1984), (2) agreement with expert opinion (Wilson & Schooler, 1991), and (3) post-choice satisfaction (Wilson et al., 1993). As an instruction to analyze one's reasons is closely related to a justification requirement for one's decision process, these findings imply that process accountability may be detrimental in some circumstances.

One of the follow-up papers exploring the mechanism underlying these effects is of particular interest because it benchmarks performance of participants instructed to analyze their reasons against a group of participants instructed merely to remember past instances (Wilson, Hodges, & Lafleur, 1995), the latter closely resembling exemplar-based reasoning instructions (Olsson et al., 2006). In the first study of this paper, participants were asked to form an impression about a target person based on a list of 14 descriptions of that person. Afterwards, participants were primed with positive or negative thoughts about the target person and were instructed either to analyze their reasons for why they liked or disliked the target person, or to recall as many as possible past behaviors of the target person. Whereas participants in the recall condition relied more on the impression they formed initially about the target person, participants in the reasons condition were much more influenced by the thoughts that were made accessible by the priming manipulation. While the conceptual and methodological overlap between this line of research and our research is partial at best, it hints that process accountable participants (like people instructed to analyze reasons in the Wilson studies) may rely less on instances that were previously stored in memory (i.e., initial impression about a person or attitude towards an object in the Wilson studies), but engage in a blind and unsuccessful search for elemental cue-outcome effects.

In sum, it is difficult to make specific predictions regarding the effects of process vs. outcome accountability on exemplar-based processing, but most of the admittedly only remotely related research would suggest that the superiority of process over outcome accountability would be smaller or even reversed for exemplar-based processing relative to cue abstraction.

The resulting effects of accountability on judgment quality in different tasks

Existing research has documented seemingly-universal positive effects of process accountability relative to outcome accountability on judgment quality. However, a more fine-grained analysis of the processes that are likely to drive people's judgments and decisions suggests that the superiority of process over outcome accountability may depend on the nature of the judgment or decision task at hand. We predict that process accountability (relative to outcome accountability) boosts a cue abstraction process whereas it may leave an exemplar-based process unaffected. This cue abstraction process should be beneficial for judgment quality when cues have elemental (i.e., additive, main) effects on an outcome-to-be-judged. However, cue abstraction should not ameliorate judgment performance when cues have configural (i.e., multiplicative, interaction) effects on the outcome-to-be-judged. Thus, we predict that the superiority of process over outcome accountability for judgment quality becomes smaller as judgment tasks become more configural. The main purpose of Study 1 was to empirically verify this prediction.

Study 1

Process or outcome accountable participants engaged in a multiple-cue learning task in which they learned to predict the popularity (i.e., the outcome) of EasyPhones[3] that differed with regard to three binary cues: color (blue vs. red), shape (tall vs. wide), and number of buttons (four vs. five). Over a number of trials participants were presented with pictures of EasyPhones. In each trial they were asked to predict the popularity among groups of elderly consumers of the phone that was presented to them. After having made a prediction, outcome feedback was provided regarding the "actual" popularity of the presented EasyPhone. This enabled participants to learn from their experience and improve the quality of their predictions over time.

The elemental or configural nature of the task was manipulated by altering, between-participants, the mathematical formula relating the features of the EasyPhones to the popularity scores (i.e., the cue-outcome function). In the elemental task structure, the cue-outcome function was constructed such that the cues had only orthogonal linear effects on the popularity scores, whereas the cue-outcome function in the configural task was set up such that there were no independent but only configural effects of the cues on the popularity scores.

Furthermore, Study 1 explored how accountability type and the resulting judgment quality in elemental and configural tasks are related to a participant's epistemic motivation during the judgment task. Epistemic motivation is the need to achieve a thorough, rich, and accurate understanding of a decision problem and fuels systematic and effortful information processing (De Dreu et al., 2006; Kruglanski, 1989). Earlier research, mostly adopting group paradigms, has consistently shown that process accountability stimulates epistemic motivation (De Dreu et al., 2008). However, as we argued above, the influence of epistemic motivation on cue abstraction and exemplar memory is unclear, making it hard to predict how epistemic motivation is related to judgment quality in elemental and configural tasks. Because epistemic motivation is closely related to an individual's need for cognition (Cacioppo & Petty, 1982; De Dreu et al., 2008), epistemic motivation during the judgment task was assessed by measuring participants' situation-specific rational thinking style or need for cognition with a previously validated questionnaire (Novak & Hoffman, 2009).[4] The effects of process and outcome accountability on epistemic motivation and the subsequent impact on judgment quality in elemental and configural task structures were explored using a mediated moderation analysis (Muller, Judd, & Yzerbyt, 2005).

Method

Participants and design

The study used a 2 (accountability type: process vs. outcome) × 2 (task structure: elemental vs. configural) between-participants design. Participants were 131 undergraduate students who received course credits in return for their participation (M_{age} = 20.63, SD_{age} = 1.80; 27 females).

Procedure

Participants were assigned to individual cubicles. Computer-based instructions mentioned that the study investigated how people learn from experience and that participants would have to learn to predict the popularity of several EasyPhones among a group of elderly consumers. To encourage participants to discount pre-existing beliefs about the attractiveness of different mobile phone features, EasyPhones were described as a completely new product category specifically targeting a special population of elderly consumers.

Right before engaging in the prediction task, participants were informed that they would be evaluated. Process accountable participants were told that their evaluation would be based on their judgment strategy rather than on the accuracy of their predictions. They were notified that, to assess the quality of their decision process, upon completion of the prediction task they would be interviewed and asked to justify how they went about making their predictions. Outcome accountable participants were informed that their evaluation would be based only on the accuracy of their predictions. All participants were told that an evaluation score would be computed. Process accountable participants were told that this score would be based on the quality of the justification they provided for their judgment process. Outcome accountable participants were told that the evaluation score would be based on the accuracy of their predictions. To further enhance accountability, all participants were asked to sign a form granting permission to share their evaluation score with other participants and instructors once the entire experiment had been completed. This manipulation of process vs. outcome accountability is similar to prior manipulations of process and outcome accountability (Siegel-Jacobs & Yates, 1996; Simonson & Staw, 1992).

The prediction task consisted of 120 trials. On each trial, a picture of an EasyPhone was presented and participants were asked to predict the popularity (expressed as a score ranging from 0 to 8). Upon entering a prediction, feedback about the real popularity of the EasyPhone was provided. The EasyPhones differed with regard to three binary cues (color, shape, and number of buttons), leading to a total number of eight different EasyPhones. Each EasyPhone

[3] EasyPhones are mobile phones designed for elderly people and/or people with bad eyesight. With their distinctive big buttons, EasyPhones are easy to grip and simple to use.

[4] This scale is based on the rationality subscale of the Rational–Experiential Inventory (Pacini & Epstein, 1999), which is in turn adapted from the need for cognition scale (Cacioppo, Petty, & Kao, 1984). Whereas the rationality subscale of the Rational–Experiential Inventory is a measure of individual differences in dispositional tendencies to adopt a rational thinking style (i.e., a trait measure), the situation-specific rational thinking style measures an individual's momentary thinking orientation in a specific situation (i.e., a state measure).

was presented 15 times, and the presentation order of the EasyPhones was randomized with the restriction that each EasyPhone occurred once within each block of eight trials.

Task structure (elemental vs. configural) was manipulated between-participants by altering the cue-outcome function form relating the EasyPhone features to the popularity scores. In the elemental task structure, popularity (POP_E) was a linear, additive function of three binary cues (C_1, C_2, and C_3), in which the cues can take on values of 0 and 1:

$$POP_E = 1 + 3 \times C_1 + 2 \times C_2 + 1 \times C_3 + \text{Random} \quad (1)$$

Thus, each individual cue had a positive, linear effect on the popularity scores and the relative weight of each cue was different. Color (blue or red), shape (thick or thin) and number of buttons (four or five) were randomly assigned to the abstract cues, such that the importance of the different EasyPhone features varied across participants. In the configural task structure, there were no independent linear effects of cues on popularity scores. This was achieved by subjecting the outcomes in the elemental task to a quadratic transformation (cf. Olsson et al., 2006):

$$POP_C = -2/3 \times (POP_E - 4)^2 + 7 + \text{Random} \quad (2)$$

Table 1 provides an overview of the task structures. As can be seen, the popularity scores in the elemental task can be produced by summing the independent effects of the cues on the outcome, while this is not possible in the configural task structure. A normally and independently distributed random error component was added to the popularity scores, with a variance chosen such that the multiple correlation between cues and associated popularity scores was around 0.90. In both task structures, the random error component was restricted such that outcome values ranged from 0 to 8.

Epistemic motivation during the prediction task was assessed by administering a questionnaire consisting of 10 statements at the end of the study. The questionnaire was based on Novak and Hoffman's (2009) situation-specific rationality scale. The wording of the items was slightly adapted in order to fit the specifics of the prediction task. Items were for example, "I tackled this task systematically", and "I was very focused on my thinking strategy to arrive at my predictions". Participants indicated on a scale from 1 (definitely false) to 5 (definitely true) to what extent these statements were true or false with regard to their judgment strategy in the prediction task. The scale proved to be reliable ($\alpha = .83$), hence an overall index of epistemic motivation was computed by averaging a participant's responses over all items.

As a measure of judgment quality, the root mean square error (RMSE) between predicted and real popularity scores was computed. This was done for every participant for each of the 15 blocks. An overall index of judgment quality was then computed collapsing the RMSEs over the 15 blocks. Hence, in the analyses below lower scores reflect smaller judgment errors and higher judgment quality.

Table 1
The elemental and configural task structure used in Study 1.

EasyPhone #	Cue			Outcome	
	C_1	C_2	C_3	POP_E	POP_C
1	1	1	1	7	1
2	1	1	0	6	4.3
3	1	0	1	5	6.3
4	1	0	0	4	7.0
5	0	1	1	4	7.0
6	0	1	0	3	6.3
7	0	0	1	2	4.3
8	0	0	0	1	1.0

Note: $POP_E = 1 + 3 \times C_1 + 2 \times C_2 + 1 \times C_3$; $POP_C = -2/3 \times (POP_E - 4)^2 + 7$.

Results and discussion

To verify that learning occurred over time, a repeated-measures analysis compared judgment error in the first block of trials with judgment error in the last block of trials. This analysis confirmed a significant decrease in judgment error in both the elemental task, $F(1, 61) = 169.62$, $p < .01$, and the configural task, $F(1, 66) = 10.56$, $p < .01$ (all p-values in this article are based on two-sided tests).

The link between accountability type, epistemic motivation and judgment quality, was explored by estimating three regression models (see Table 2). The first model regressed judgment error on accountability type, task structure, and the interaction between both factors. This analysis yielded a main effect of task structure (β_{12}), $F(1127) = 330.21$, $p < .01$, such that judgment error was smaller in the elemental task ($M = 1.37$, $SD = 0.32$) than in the configural task ($M = 2.35$, $SD = 0.31$). This finding validates previous research indicating that elemental and linear relations are generally learned more easily than configural and nonlinear relations (Mellers, 1980; Sheets & Miller, 1974). Crucially, the regression also revealed a significant interaction between accountability type and task structure (β_{13}), $F(1127) = 5.18$, $p < .05$, indicating that the effect of accountability type on judgment error differs across task structures. Follow-up contrasts established that process accountable participants made more accurate predictions than outcome accountable participants in the elemental task, $t(127) = -2.67$, $p < .05$, while there was no difference in judgment accuracy in the configural task, $t(127) = 0.51$, $p > .61$. The overall main effect of accountability type was not significant (β_{11}), $F(1127) = 2.47$, $p > .11$. Fig. 1 illustrates this pattern of results. The manipulation of the elemental vs. configural nature of the multiple-cue judgment task used in this study is crucial. Prior research has only considered elemental tasks and documented positive effects of process accountability (Ashton, 1992; Siegel-Jacobs & Yates, 1996). The current study confirms the positive effect of process accountability on judgment performance in an elemental task, but additionally shows that this positive effect cannot be generalized to configural task structures.

Better performance for process accountable than for outcome accountable participants in the elemental task combined with equal performance in the configural task suggests that the difference in judgment error in the elemental task can be traced to superior cue abstraction among process accountable participants. Indeed, if the improved judgment quality in the elemental task had been due to improved exemplar-based processing a significant difference in judgment quality should have been observed in the configural task too, because exemplar-based processing facilitates learning of configural relations (as well as elemental relations). This was not the case, signaling that the improved performance among process accountable participants in the elemental task cannot be explained by superior exemplar-based processing, but is likely due to better cue abstraction among process accountable participants.

The second model regressed self-reported epistemic motivation during the prediction task on accountability type, task structure, and their interaction. This analysis revealed a main effect of accountability type (β_{21}), $F(1127) = 8.72$, $p < .01$, and a main effect of task structure (β_{22}), $F(1127) = 10.51$, $p < .01$, in the absence of an interaction between the two factors (β_{23}; $p > .26$). As expected based on existing literature (e.g., Scholten et al., 2007), process accountable participants ($M = 3.82$; $SD = 0.49$) showed a greater motivation to engage in thorough and systematic information processing relative to outcome accountable participants ($M = 3.54$; $SD = 0.66$), regardless of the elemental or configural nature of the task. Moreover, participants in the elemental task structure ($M = 3.84$; $SD = 0.66$) showed greater epistemic motivation relative to participants in the configural task structure ($M = 3.53$;

Table 2
Results for the mediated moderation analysis in Study 1.

Predictors	Model 1 DV = judgment error		Model 2 DV = EM		Model 3 DV = judgment error	
	β	F	β	F	β	F
AT	−0.042 (β_{11})	2.46	0.146 (β_{21})	8.70**	−0.020 (β_{31})	0.56
TS	−0.492 (β_{12})	330.15*	0.160 (β_{22})	10.50**	−0.472 (β_{32})	303.80**
AT × TS	−0.062 (β_{13})	5.20**	0.055 (β_{23})	1.25	−0.041 (β_{33})	2.34
EM					−0.112 (β_{34})	6.10*
EM × TS					−0.095 (β_{35})	3.96*

Note: AT = accountability type; TS = task structure; EM = self-reported epistemic motivation.
* $p < .05$.
** $p < .01$.

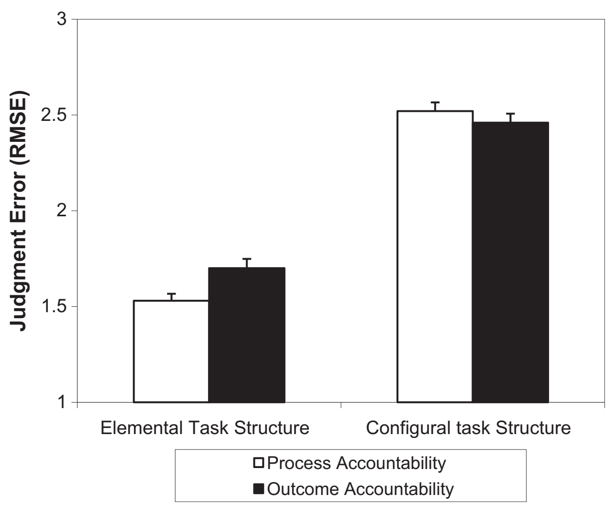

Fig. 1. Task structure by accountability type interaction effect on judgment error in Study 1.

SD = 0.50), irrespective of whether they were held outcome or process accountable.[5]

To verify whether the interactive effect of accountability type and task structure on judgment quality was mediated by epistemic motivation, a third model regressed judgment quality on accountability type, task structure, their interaction (see the first regression model), as well as epistemic motivation and the interaction between epistemic motivation and task structure. This analysis showed an interaction effect between epistemic motivation and task structure (β_{35}), $F(1125) = 3.97$, $p < .05$, indicating that higher epistemic motivation is associated with better judgment quality in elemental task structures, $F(1, 61) = 19.30$, $p < .01$, but not in configural task structures, $F(1, 66) = 0.04$, $p > .84$. This result supports our reasoning that epistemic motivation drives cue abstraction, but not reliance on exemplar memory. Crucially, unlike in the first regression model, the interactive effect of accountability type and task structure on judgment quality was no longer significant (β_{33}), $F(1125) = 2.35$, $p > .12$. Jointly, the results of these three regression models indicate that the differential effect of accountability type on judgment error in elemental and configural task structures is mediated by epistemic motivation (see Table 2; Muller et al., 2005).

In sum, results in Study 1 confirm that the superiority of process over outcome accountability for judgment quality becomes smaller as judgment tasks become more configural. Indeed, we found no significant advantage of process over outcome accountability in a purely configural task. Moreover, three regression analyses revealed a pattern of mediated moderation. Process accountability instructions increase epistemic motivation relative to outcome accountability instructions in both elemental and configural tasks. This increase in epistemic motivation however only enhances judgment quality in elemental tasks. These results substantiate the idea that process accountability and epistemic motivation facilitate cue abstraction but not exemplar-based processing. Because only exemplar-based processing but not cue abstraction is adaptive in configural task structures (Juslin et al., 2008; Olsson et al., 2006), the beneficial impact of process accountability and epistemic motivation on learning is not generalizable to the acquisition of configural cue-outcome relations.

Study 2

The main finding in Study 1 was that the superiority of process accountability over outcome accountability was restricted to the learning of elemental, linear cue-outcome effects. The goal of Study 2 was twofold. First, we wanted to replicate the interaction effect between accountability type and task structure on judgment error and, second, provide additional converging evidence that cue abstraction underlies the learning of elemental but not configural cue-outcome relationships. For this purpose, a shortened version of Raven's Standard Progressive matrices was administered (Raven, 1938). This test was selected because (1) it is widely used as a measure of analytical reasoning ability in both applied and research settings (Prabhakaran, Smith, Desmond, Glover, & Gabrieli, 1997; Raven, 2000), (2) it accounts for performance in a great variety of intellectual tasks (Marshalek, Lohman, & Snow, 1983), and most importantly (3) the cognitive processes distinguishing higher scoring and lower scoring individuals on the test have been extensively studied (Carpenter, Just, & Shell, 1990). In particular, two key determinants of performance in this test are the ability to abstract rules and the ability to dynamically manage a large set of problem solving goals in working memory. Because these mental operations are quintessential to cue abstraction but not to exemplar-based processing, participants' performance on the Raven matrices should especially predict judgment quality in elemental task structures but not in configural task structures. This argument resonates with recent neuropsychological research indicating that the same brain circuit is underlying problem solving in the Raven matrices and in rule-based categorization tasks (Patalano et al., 2001; Prabhakaran et al., 1997).

[5] This main effect of task structure suggests that epistemic motivation is closely related to cue abstraction. Indeed, previous research has shown that people adaptively shift from cue abstraction to exemplar memory depending on the structural properties of the task, for instance as tasks become more configural or nonlinear (Juslin et al., 2008; Olsson et al., 2006). The parallel observation that epistemic motivation is lowered in configural tasks therefore suggests that epistemic motivation is more closely related to cue abstraction than it is to exemplar-based processing.

It is generally recognized that individual predispositions and social contextual factors jointly determine cognitive processing (Beach & Mitchell, 1978; McAllister, Mitchell, & Beach, 1979; Payne et al. 1993). This suggests that the effect of analytical ability and accountability type on judgment quality in elemental task structures is unlikely to be independent. More specifically, because individuals with a lower analytical ability are less likely to engage in cue abstraction autonomously than individuals with a higher analytical ability, process accountability should especially boost cue abstraction and enhance judgment quality for individuals with a lower analytical ability and less so for individuals with a higher analytical ability. Similarly, process accountability is likely to be a sufficient social contextual cue to engender cue abstraction in elemental tasks regardless of analytical ability. As a result, individual differences in analytical ability should have stronger effects on cue abstraction, and judgment quality, in elemental tasks under outcome than process accountability.

Method

Participants and design

Eighty-seven undergraduate students participated in exchange for course credits ($M_{\text{age}} = 21.22$, $SD_{\text{age}} = 2.34$), and were randomly assigned to a 2 (accountability type: process vs. outcome) $\times$ 2 (task structure: elemental vs. configural) between-participants design.

Procedure

The setup of the prediction task used in Study 2 was similar to Study 1. Popularity scores in the elemental task structure were again determined by a linear additive function of three binary cues:

$$\text{POP}_E = 1 + 5 \times C_1 + 3 \times C_2 + 1 \times C_3 + \text{Random} \quad (3)$$

Again, popularity scores in the configural task resulted from a quadratic transformation of the elemental outcomes, such that there were no consistent independent linear effects of cues on popularity scores:

$$\text{POP}_C = -2/5 \times (\text{POP}_E)^2 + 4 \times \text{POP}_E + \text{Random} \quad (4)$$

As in Study 1, a normally and independently distributed error component was added to the outcome values such that the multiple correlation between cues and popularity scores was around .90. The resulting outcome values were constrained between 0 and 10.

After finishing the prediction task, participants completed a short version of Raven's Standard Progressive Matrices Test (Raven, 1938). This test is composed of several visual analogy problems, each consisting of a 3×3 matrix, in which eight cells contain figural elements, and the bottom right cell is empty. The test taker is instructed to determine the rules that tie the cells together by looking across the rows and down the columns, and to select the figure that correctly completes the matrix from a set of eight response alternatives presented below the matrix (for an isomorph of a typical standard progressive matrices item, see Carpenter et al., 1990). Six matrices, increasing in difficulty, were selected from Set D and Set E of the test,[6] and were presented to participants on computer. The time participants received to solve the puzzles was constrained to 30 s for each of the first two matrices, 45 s for the third, and 60 s for puzzles 4, 5 and 6. One point was awarded per matrix that was solved correctly within the time limit. Hence, analytical intelligence scores could range from 0 to 6 ($M = 2.70$, $SD = 1.31$).

Results and discussion

To verify if learning had occurred in both task structures, a repeated-measures analysis comparing judgment error in the first block and the last block was conducted. This analysis confirmed that judgment error diminished significantly over time in both the elemental task structure, $F(1, 41) = 53.08$, $p < .01$, and the configural task structure, $F(1, 42) = 7.42$, $p < .01$.

The overall index of judgment quality (RMSE) was regressed on accountability type (process vs. outcome), task structure (elemental vs. configural), and analytical intelligence (mean-centered). Replicating Study 1, this analysis yielded a main effect of task structure, $F(1, 79) = 367.49$, $p < .0001$, such that overall judgment quality was better in the elemental task ($M = 2.61$, $SD = 0.47$) than in the configural task ($M = 3.41$, $SD = 0.28$). The two-way interaction between accountability type and task structure was also significant, $F(1, 79) = 4.19$, $p < .05$. Consistent with Study 1, process accountable participants ($M = 2.46$, $SD = 0.37$) were more accurate than outcome accountable participants ($M = 2.73$, $SD = 0.51$) in the elemental task, $t(79) = -2.33$, $p < .05$, while there was no significant difference in judgment quality in the configural task, $t(79) = 0.61$, $p > .54$.

Moreover, the two-way interaction between accountability type and task structure was qualified by a three-way interaction with analytical intelligence, $F(1, 79) = 4.51$, $p < .05$. Whereas accountability type and analytical intelligence did not alter performance in the configural task (all ps > .45), in the elemental task a significant effect of accountability type emerged, $F(1, 39) = 3.99$, $p = .05$, together with a marginally significant effect of analytical intelligence, $F(1, 39) = 3.52$, $p = .07$, and a significant interaction between accountability type and analytical intelligence, $F(1, 39) = 7.05$, $p < .05$. The two-way interaction between accountability type and analytical intelligence in the elemental task was further explored by (1) analyzing the effect of accountability type at low (1 *SD* below mean) and at high (1 *SD* above mean) levels of analytical intelligence, and (2) analyzing the effect of analytical intelligence within the outcome accountable and the process accountable group separately (Aiken & West, 1991). The first analysis revealed that, in the elemental task, process accountability instructions improved judgment quality for participants scoring lower on the Raven Matrices, $F(1, 39) = 12.29$, $p < .01$, while there was no difference for participants with higher scores on this analytical intelligence measure, $F(1, 39) = 0.04$, $p > .84$. The second analysis indicated that higher performance on the Raven matrices was associated with higher judgment quality in the elemental task within the outcome accountable group, $F(1, 22) = 8.51$, $p < .01$, while there was no significant relation between analytical ability and judgment quality in the elemental task within the process accountable group, $F(1, 17) = 0.39$, $p > .53$.

These results, as illustrated in Fig. 2, are interesting in at least two ways. First, we found that performance on the Raven matrices is positively related to judgment quality when elemental cue-outcome relations have to be learned but unrelated to judgment quality when configural relations have to be learned. Because performance on the Raven matrices reflects an individual's ability to analytically abstract rules (Carpenter et al., 1990), it substantiates the idea that analytical thought in the form of cue abstraction is only effective for the learning of elemental, linear cue-outcome relations (Juslin et al., 2008; Olsson et al., 2006). From a practical point of view, the finding that analytical intelligence is uncorrelated with performance in configural tasks is important because it suggests that standard psychometric techniques assessing analytical intelligence are only predictive with regard to the learning of elemental linear relations but may not tell us very much about an individual's performance in more complex, configural environments. Second, with regard to judgment quality in the elemental

[6] The selected matrices were: D4, D9, D11, E7, E8, E9.

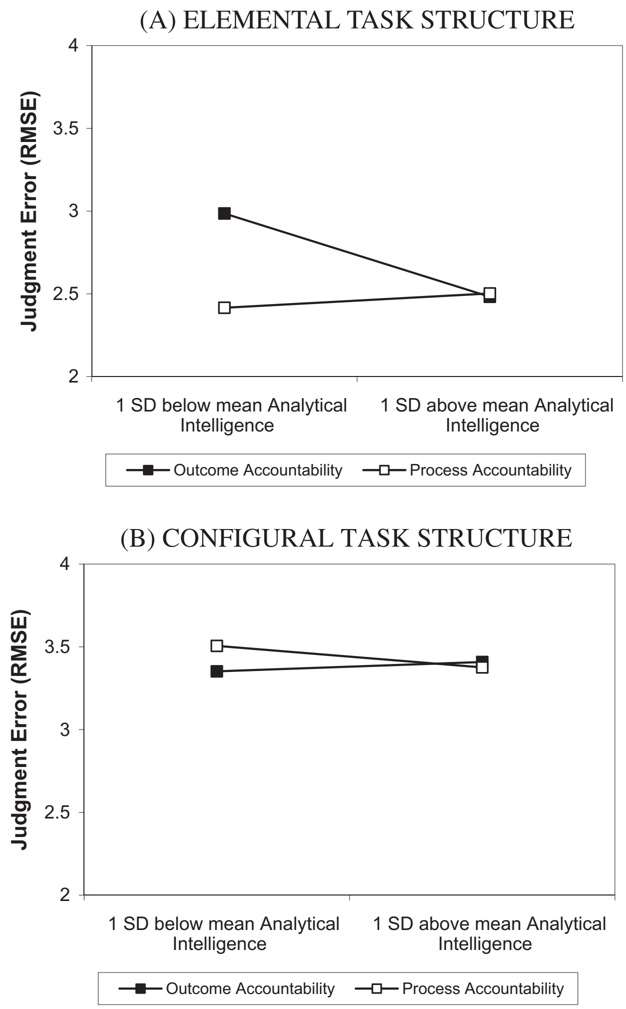

Fig. 2. Task structure by accountability type by analytical intelligence interaction effect on judgment error in Study 2.

task we found (a) that process accountability specifically has a positive effect for participants scoring lower on the Raven matrices, and (b) that analytical ability specifically has a positive effect for participants who are held outcome accountable. This pattern of results suggests that process accountability and analytical ability are respectively a social contextual factor and an individual predisposition facilitating a very similar cognitive process that is adaptive in elemental tasks.

Study 3

The previous studies established that the superiority of process over outcome accountability depends on the nature of the task. Specifically, we found a significant advantage of holding people process accountable for elemental but not for configural tasks. In addition, the previous studies showed that epistemic motivation as well as analytical intelligence are positively associated with performance in elemental but not configural tasks. These findings are consistent with our claims that (a) process accountability specifically promotes cue abstraction and (b) measures of analytical thinking (i.e., epistemic motivation and analytical intelligence) are associated with cue abstraction but not exemplar-based processing. However, the previous studies do not provide a direct test of these two claims because cue abstraction and exemplar-based processing *per se* were not assessed. Study 3 addresses this concern by probing participants' judgment process using cognitive modeling techniques.

In Study 3, formal representations of the cue abstraction process and the exemplar-based process were fitted to participants' judgments in an elemental task (see Appendix). Differences in model fit between process and outcome accountable participants reflect differential use of cue abstraction and exemplar memory, and can subsequently be employed to predict judgment quality. If cue abstraction underlies the difference in performance between process and outcome accountable participants in elemental tasks, then (a) the cue abstraction model should fit better for process accountable than for outcome accountable participants, (b) differences in the cue abstraction model fit should mediate differences in judgment quality, and (c) this should not be the case for the model fits of the exemplar-based model.[7]

To avoid problems of overfitting (Campbell & Bolton, 2005), the judgment task used in the previous studies was adapted slightly. The number of cues was increased from three to four (yielding 16 possible EasyPhones instead of eight in the previous studies), and the multiple-cue learning task was divided in a training phase and a test phase. In the training phase, participants learned to predict the popularity of a subsample of 11 EasyPhones, while in the test phase all possible EasyPhones had to be judged. Thus, in the test phase participants were presented with EasyPhones that were familiar to them (i.e. EasyPhones that were also presented in the training phase) and EasyPhones that were new to them (i.e. EasyPhones that were presented for the first time in the test phase). This modification yields three non-overlapping judgment datasets: (1) judgments in the training phase, (2) judgments of the new EasyPhones in the test phase, and (3) judgments of the familiar EasyPhones in the test phase. These data sets were used for parameter estimation, model validation, and assessment of judgment quality, respectively. Parameters of the cue abstraction and the exemplar-based model (see Appendix) were estimated based on participants' judgments in the second half of the training phase (parameter estimation sample). These parameter values were consequently cross-validated by predicting judgments for new EasyPhones in the test phase (model validation sample). Differences between process and outcome accountable participants in cue abstraction and exemplar-based model fits for the cross-validation sample reflect differential use of cue abstraction and exemplar-based processing. These model fit statistics were consequently used in a mediation analysis to explain differences in judgment quality for the familiar EasyPhones presented in the test phase.

An additional goal of Study 3 was to examine how individual differences with respect to one of the most widely used self-report measures of rational – analytical thinking style relate to cue abstraction and exemplar-based processing. Specifically, we administered the rationality subscale of the Rational–Experiential Inventory (Pacini & Epstein, 1999). This subscale consists of two sub-subscales probing (1) rational engagement or motivation to process analytically and (2) rational ability or capacity to process analytically. These sub-subscales are conceptually highly related to epistemic motivation (see Study 1) and analytical intelligence (see Study 2), respectively, allowing us to capture both components from the previous studies with a single measure.[8]

[7] Note that we did not include configural task conditions in this experiment, because there were no significant performance differences between process and outcome accountable participants in Studies 1 and 2. Hence, a configural task would not lend itself to the process mediation approach in Study 3.

[8] Whereas epistemic motivation was measured as a state in Study 1, the rational engagement sub-subscale is a self-reported trait measure of epistemic motivation. Whereas analytical ability was assessed with an intelligence test in Study 2, the rational ability sub-subscale is a self-report measure of analytical ability.

Since its conception this scale has been validated cross-culturally (Bjorklund & Backstrom, 2008; Witteman, van den Bercken, Claes, & Godoy, 2009) and studied extensively in the context of normative vs. heuristic decision making (e.g., Bartels, 2006; Pacini & Epstein, 1999; Shiloh, Salton, & Sharabi, 2002). Despite its popularity, to our knowledge no research to date has related rational thinking style to cue abstraction and exemplar-based processing. Given our findings in Studies 1 and 2, we expected the rationality scale to correlate positively with cue abstraction but not with exemplar-based processing. Thus, hinging on the idea that a rational thinking style signals an individual's motivation and ability to engage in cue abstraction, and process accountability is a contextual factor triggering cue abstraction (cf. Study 2), we predicted that (a) process accountability should have a positive effect on cue abstraction and performance especially for participants scoring lower on the rationality scale, and (b) rational thinking style should be especially predictive of cue abstraction and performance when participants are held outcome accountable.

Method

Participants and design

Eighty-six undergraduate students ($M_{\text{age}} = 20.96$; $SD_{\text{age}} = 2.12$; 43 females) were paid €10 to participate. Participants were randomly assigned to the process or outcome accountability condition of an elemental learning task.

Procedure

The procedure and accountability manipulation were similar to the previous studies. Participants learned to predict the popularity of EasyPhones that were different with regard to four binary features: color (red or blue), number of buttons (four or five), shape (flat or thick), and presence of an antenna (yes or no). The attributes of the EasyPhones were assigned randomly to four abstract cues related to popularity by the following linear, additive function:

$$\text{POP} = 4 \times C_1 + 3 \times C_2 + 2 \times C_3 + 1 \times C_4 + \text{Random} \quad (5)$$

The random error component was drawn from a uniform distribution ranging from −0.5 to +0.5. The popularity scores ranged from 0 to 10. Different from the previous study, the learning task consisted of two phases: a training phase and a test phase. The training phase consisted of 110 trials in which only a subset of 11 EasyPhones was presented. Participants received trial-by-trial outcome feedback. The test phase consisted of 32 trials in which participants were presented two times with all possible 16 EasyPhones, including the EasyPhones that were excluded in the training phase. In the test phase, participants were asked to give their best prediction for each of the EasyPhones, and received no feedback about the real popularity of the EasyPhones.

Mathematical representations of the cue abstraction and the exemplar-based process (see Appendix) were fitted to the judgments of each participant separately in the second half of the training phase. Parameter estimation for the cue abstraction model was done with ordinary least squares (OLS), while the Newton–Raphson method was used for estimating the parameters of the exemplar-based model (see Appendix). Participant-specific parameters from the training phase were then used to predict each participant's judgments for the completely new EasyPhones in the test phase. Model performance was assessed for each participant separately by the coefficient of determination (r^2) and the root mean square error (RMSE) between model-based (predicted) judgments and the participant's actual judgments.[9] Differences in model fits across participants indicate differences in cognitive processing. The differences in model fit were used in a mediation analysis to explain judgment quality.

When finished with the prediction task, participants completed three items measuring how important it was for them that they would be evaluated (1 = "not important at all"; 10 = "extremely important"), how motivated they were to obtain a positive evaluation score (1 = "not motivated at all"; 10 = "extremely motivated"), and how well they understood the instructions (1 = "not at all"; 10 = "perfectly"). No differences were found between process and outcome accountable participants on these measures (all $ps > .22$), indicating that differences in general motivation cannot account for differences in cognitive processing and judgment quality.

Finally, participants completed the rationality subscale of the Rational–Experiential Inventory (Pacini & Epstein, 1999). The scale consists of 20 items and measures an individual's motivation and ability to process information rationally ($\alpha = .86$; e.g., "I enjoy intellectual challenges", and "I am much better at figuring things out logically then most people.").

Results

Judgment quality

The overall index of judgment quality (RMSE) was regressed on accountability type (process vs. outcome) and rational thinking style (mean-centered; $M = 3.76$; $SD = 0.53$). This analysis yielded a main effect of accountability type, $F(1, 82) = 9.06$, $p < .01$, indicating that process accountable participants ($M = 1.38$, $SD = 0.47$) were relatively more accurate than outcome accountable participants ($M = 1.71$, $SD = 0.56$) in an elemental task (cf. Studies 1 and 2). In addition, a two-way interaction between accountability type and rational thinking style was observed, $F(1, 82) = 5.42$, $p < .05$. This interaction was further explored by (1) analyzing the effect of rational thinking style on judgment quality for outcome accountable and process accountable participants separately, and (2) a spotlight analysis exploring the effect of accountability type at low (1 *SD* below the mean) and at high (1 *SD* above the mean) levels of rational thinking style (Aiken & West, 1991).

As expected, the first analysis revealed that in an elemental task greater rationality is associated with an increase in judgment quality under outcome accountability, $F(1, 37) = 3.79$, $p = .06$. The effect of rational thinking style on judgment quality within the process accountable group was however not significant, $F(1, 45) = 1.58$, $p > .21$.

Also as expected, the second analysis exposed that the effect of accountability type was significant at low levels of rational thinking style, $F(1, 82) = 14.46$, $p < .001$, but not at high levels of rational thinking style, $F(1, 82) = 0.23$, $p > .63$. Hence, whereas type of accountability in an elemental task makes little difference for people who have a tendency to tackle problems rationally, process accountability (vs. outcome accountability) instructions significantly improve performance for people with no such predisposition. Fig. 3 illustrates this pattern of results.

[9] Note that the model fit RMSEs should not be confused with the judgment quality RMSE. Whereas the former reflect differences between model-based judgments and participants' judgments, the latter reflects differences between participants' judgments and real popularity scores. Although both the r^2 and model fit RMSE measures capture slightly different aspects of the model fit (Myung, Pitt, & Kim, 2005), the results for both goodness of fit statistics were identical and only the coefficient of determination will be used for exposition purposes. Statistical analyses for the untransformed and Fisher *z* transformed coefficients of determination yielded identical results. For ease of interpretation, we present only the results for the untransformed coefficients.

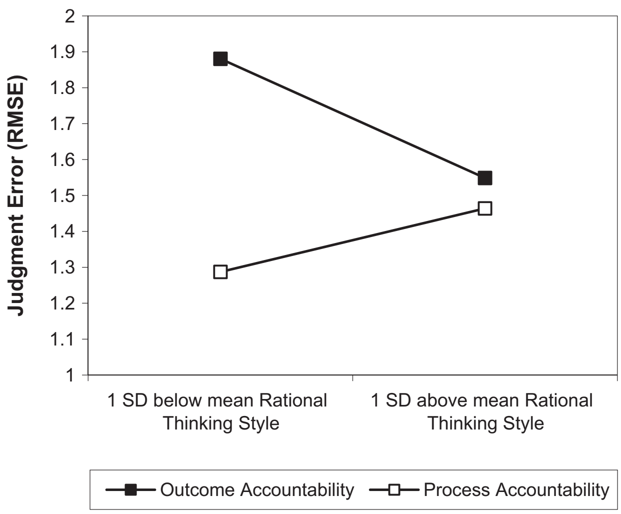

Fig. 3. Accountability type by rational thinking style interaction effect on judgment error in Study 3.

The finding that in an elemental task rationality significantly predicts judgment quality under outcome accountability but not under process accountability, in combination with the finding that process accountability especially improves judgment quality for low-rational people suggests that process accountability is a contextual factor and rationality a trait that facilitate a very similar cognitive process which improves judgment quality in elemental task structures. The exact nature of this cognitive process is explored next.

Cue abstraction and exemplar-based processing

Relative differences in cue abstraction and exemplar-based processing were explored by analyzing model fits (two r^2s per participant, one indicating the extent to which the cue abstraction model described a participant's popularity predictions and one indicating the extent to which the exemplar-based model described a participant's popularity predictions). These model fits were subjected to a Mixed General Linear Model in which type of cognitive model (cue abstraction vs. exemplar-based) was a within-participants factor, accountability type (process vs. outcome) a between-participants factor, and rational thinking style (mean-centered) a continuous predictor. This analysis revealed the expected three-way interaction, $F(1, 82) = 6.08$, $p < .05$, which can be traced to a significant two-way interaction between accountability type and rational thinking style for the cue abstraction model fits, $F(1, 82) = 8.54$, $p < .01$, and a non-significant two-way interaction between accountability type and rational thinking style for the exemplar-based model fits, $F(1, 82) = 0.34$, $p > .55$. For the exemplar-based model fits, there were no significant effects of accountability type and rationality at all (all $ps > .15$).

The significant two-way interaction for the cue abstraction model fits was further explored by (1) analyzing the effect of rationality on cue abstraction for outcome accountable and process accountable participants separately, and (2) a spotlight analysis verifying the effect of accountability type at low (1 *SD* below the mean) and at high (1 *SD* above the mean) levels of rationality (Aiken & West, 1991). The first analysis revealed that among outcome accountable participants the cue abstraction model fits better for high-rationality participants, $F(1, 37) = 7.38$, $p = .01$. For process accountable participants, there was no effect of rationality on cue abstraction model fits, $F(1, 37) = 1.20$, $p > .27$. Thus, under outcome accountability, high-rationality participants relied more on cue abstraction than low-rationality participants, whereas under process accountability, there was no significant difference in reliance on cue abstraction between high- and low-rationality participants.

The second analysis indicated that low-rationality participants who were held process accountable relied more on cue abstraction than low-rational participants who were held outcome accountable, $F(1, 82) = 9.63$, $p < .01$, while there was no significant difference in cue abstraction between process and outcome accountable participants for high-rational participants, $F(1, 82) = 1.10$, $p > .29$.

In sum, this pattern of results (see Fig. 4) indicates that accountability type and rational thinking style jointly determine cue abstraction, while they do not affect exemplar-based processing. Because there are no significant differences in exemplar-based processing for different accountability types and different levels of rationality, exemplar-based processing cannot underlie the differences in judgment quality. However, the observed patterns of results for cue abstraction model fits and judgment quality suggest that differential reliance on cue abstraction might drive the interactive effect of accountability type and rationality on judgment quality. This is verified by a mediated moderation analysis.

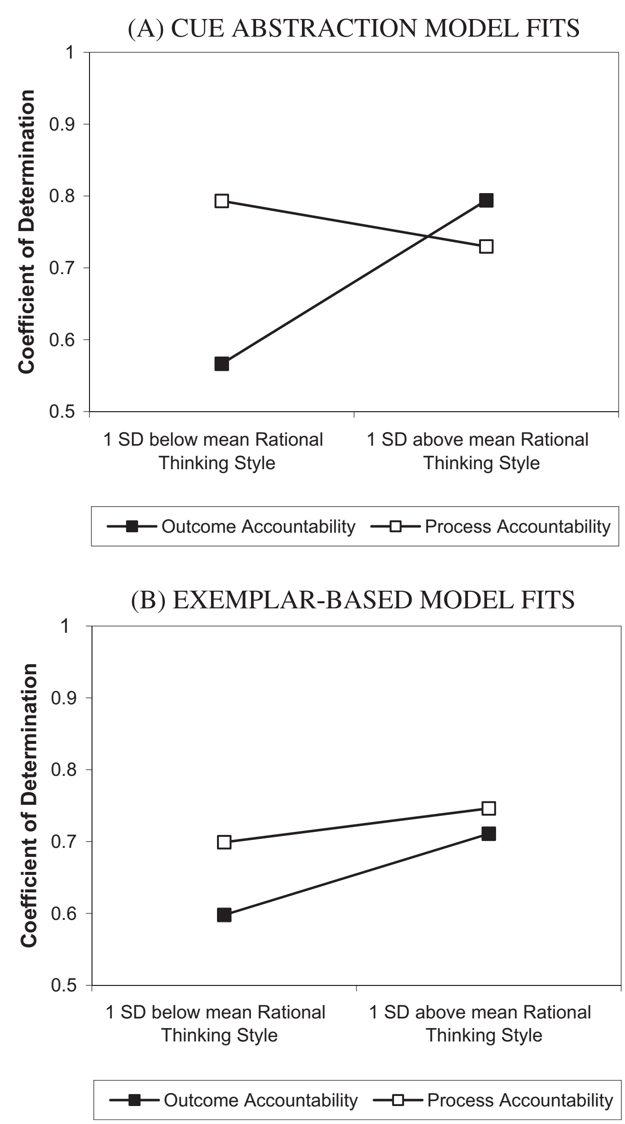

Fig. 4. Accountability type by rational thinking style interaction effect on cognitive model fits in Study 3.

Table 3
Results for the mediated moderation analysis in Study 3.

Predictors	Model 1 DV = judgment error		Model 2 DV = CA		Model 3 DV = judgment error	
	β	F	β	F	β	F
AT	−0.164 (β_{11})	9.06**	0.036 (β_{21})	2.04	−0.138 (β_{31})	6.81*
RAT	−0.074 (β_{12})	0.50	0.078 (β_{22})	2.72	−0.009 (β_{32})	0.01
AT × RAT	0.243 (β_{13})	5.43*	−0.139 (β_{23})	8.53**	0.131 (β_{33})	1.59
CA					−0.865 (β_{34})	14.29**
CA × RAT					−0.130 (β_{35})	0.12

Note: AT = accountability type; RAT = rational thinking style; CA = cue abstraction model fits.
* $p < .05$.
** $p < .01$.

Mediated moderation analysis

In line with the principles outlined by Muller et al. (2005) three regression models were estimated:

(1) $JE = \beta_{10} + \beta_{11}AT + \beta_{12}RAT + \beta_{13}AT * RAT + \varepsilon_1$.
(2) $CA = \beta_{20} + \beta_{21}AT + \beta_{22}RAT + \beta_{23}AT * RAT + \varepsilon_2$.
(3) $JE = \beta_{30} + \beta_{31}AT + \beta_{32}RAT + \beta_{33}AT * RAT + \beta_{34}CA + \beta_{35}CA * RAT + \varepsilon_3$.

As discussed above, the first regression model established that the effect of accountability type (AT) on judgment error (JE) is moderated by rationality (RAT; $\beta_{13} \neq 0$). The second regression model yielded a similar interaction effect on the cue abstraction model fits (CA; $\beta_{23} \neq 0$). Crucially, the third regression model revealed a significant effect of cue abstraction model fits on judgment error ($\beta_{34} \neq 0$), indicating that higher degrees of cue abstraction are associated with lower judgment error, $F(1, 80) = 14.28$, $p < .01$, while the interactive effect of accountability type and rationality turned to non-significance ($\beta_{33} = 0$; $F(1, 80) = 1.59$, $p > .21$). Table 3 provides an overview of the parameter estimates and associated F statistics of the regression analyses.

A similar analysis for exemplar-based processing revealed that model fits measuring exemplar-based processing were associated with lower judgment error, $F(1, 80) = 8.50$, $p < .01$, but were unrelated to both accountability type and rationality.

In sum, our analyses show that (1) process accountability and rationality jointly predict judgment quality, (2) that this effect of process accountability and rationality is mediated by their effect on cue abstraction, (3) that process accountability and rationality do not engender exemplar-based processing, but that (4) although exemplar-based processing is predictive of judgment quality in elemental tasks, it does not explain the effects of accountability type and rationality on performance in elemental tasks.

General discussion

Summary of findings

The goal of this research was to examine the effect of process and outcome accountability (a) on cue abstraction and exemplar-based cognitive processing and (b) on judgment quality in elemental and configural tasks. We made two primary predictions. First, we predicted that process accountability (relative to outcome accountability) boosts cue abstraction but not exemplar-based processing. Second, because cue abstraction is based on knowledge about linear, elemental cue-outcome effects, we predicted that process accountability improves judgment quality in elemental tasks but not in configural tasks. Inspired by a contingency perspective on judgment and decision making, according to which characteristics of the social context, characteristics of the decision maker and characteristics of the decision problem jointly determine cognitive processing and judgment quality (Payne et al., 1993), we additionally explored the role of a decision maker's predispositional analytical ability and rational thinking style. We predicted that, in addition to process accountability, higher analytical ability and a more rational thinking style positively influence cue abstraction, such that when a decision maker is held process accountable and/or has a high analytical ability or rational thinking style, the abstraction of elemental cue-outcome effects is facilitated, resulting in an improved judgment quality in elemental tasks only.

We tested these propositions in a sequence of three multiple-cue learning studies. Study 1 manipulated accountability type and task structure. Judgment quality was higher under process accountability than under outcome accountability in the elemental task but not in the configural task. By assessing participants' epistemic motivation during the specific prediction task (i.e., a state and not a trait measure), Study 1 provides initial insight into the cognitive process underlying differences in judgment quality. Although process accountability heightens epistemic motivation regardless of the elemental or configural nature of the task, the increase in epistemic motivation only results in better judgments in the elemental task. This suggests that process accountability, by increasing epistemic motivation, facilitates a specific cognitive process that is effective in elemental but not in configural tasks. Study 2 explored the interactive effect of accountability type, analytical intelligence and task structure on judgment quality. Analytical intelligence was measured by performance on Raven's Standard Progressive Matrices (Raven, 1938). We found that accountability type and analytical ability jointly determined judgment quality in an elemental task but had no joint nor separate effects on judgment quality in a configural task. Because (1) performance on the Raven Matrices is determined by an individual's ability to abstract and mentally integrate rules (Carpenter et al., 1990), and (b) analytical ability influenced judgment quality in interaction with accountability type in the elemental task, but (c) had no effect on performance in the configural task, Study 2 suggests that process accountability and analytical ability have a positive influence on cue abstraction. Study 3 examined the interactive effect of accountability type and rational thinking style (i.e., a trait and not a state measure) on judgment quality in an elemental task structure, and directly assessed cue abstraction and exemplar-based processing with cognitive modeling techniques. Consistent with our conceptualization we found that process accountability and rational thinking style stimulate cue abstraction but not exemplar memory, and that the boost in cue abstraction is responsible for the increase in judgment quality in elemental tasks. Fig. 5 provides an overview of the theoretical framework relating the variables that were manipulated or measured in the different studies.

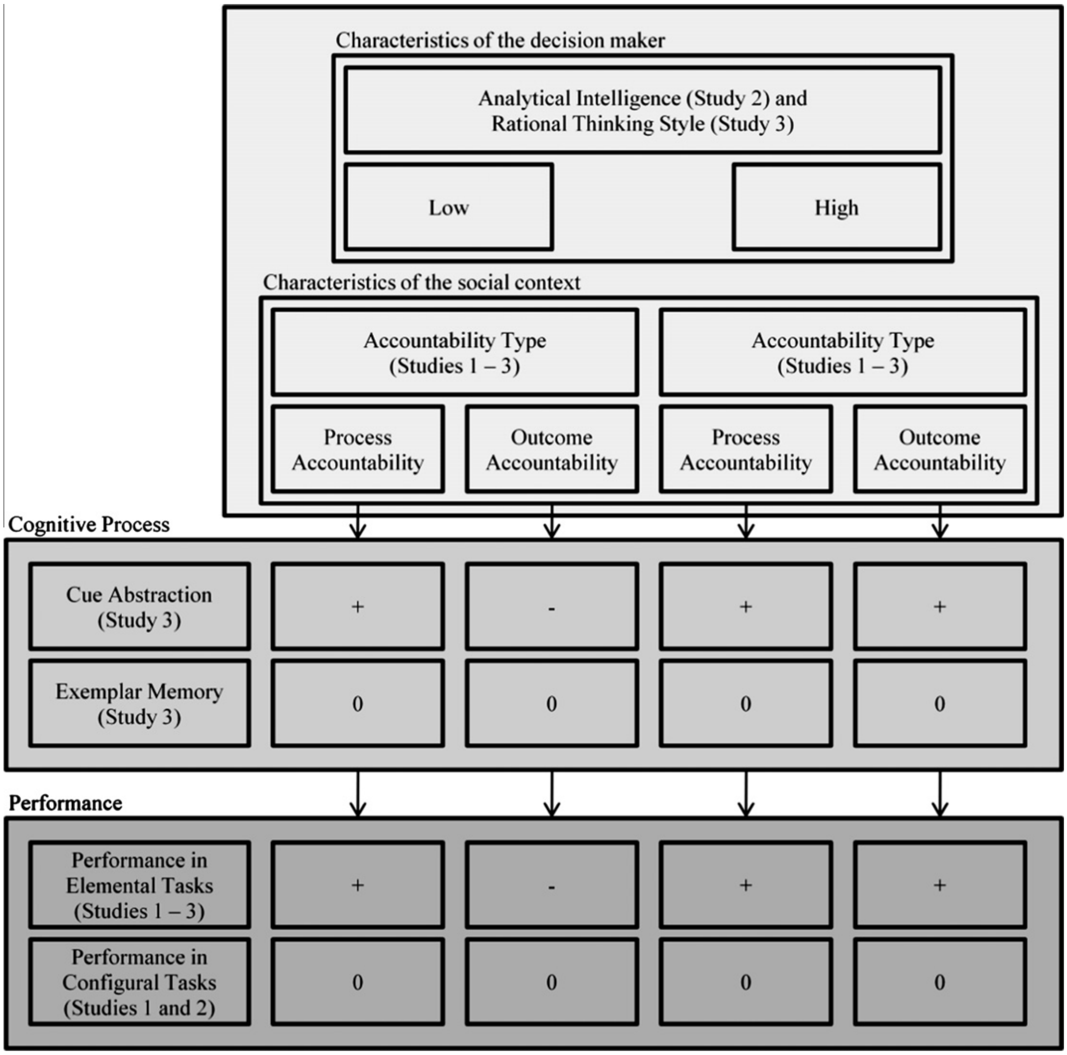

Fig. 5. Overview of the theoretical framework and manipulated/measured variables in Studies 1–3.

Theoretical and managerial implications

The current research is situated at the crossroads of social psychology, management research, and cognitive psychology and contributes to each of these streams of research.

To date, there is a consensus in the social psychological and management literature that in order to optimize judgment quality and performance decision makers should be held process accountable rather than outcome accountable. By pinpointing the exact nature of the cognitive process distinguishing process from outcome accountable decision makers, the current article shows that this insight needs to be qualified. In particular, our research shows that because process accountability promotes cue abstraction but not exemplar memory, and because cue abstraction is only viable in elemental tasks but not in configural tasks, the superiority of process over outcome accountability in terms of judgment quality is limited to tasks that involve the acquisition of elemental relations. This theoretical development may elucidate why, despite the negative effects of outcome accountability documented in the academic literature, outcome-based control systems are so widespread in private-sector institutions (e.g., in salesforce management; Challagalla & Shervani, 1996; Cravens, Ingram, Laforge, & Young, 1993). Business problems are typically nonlinear, stochastic, interactive, and downright difficult (Kotler, 1971), and managerial judgments and solutions are often based only on the recollection of previously experienced cases and similarity-based reasoning processes (Dane & Pratt, 2007; Kolodner, 1992). Our research shows that for these types of problems, process accountability does not yield superior performance compared to outcome accountability. Future research should focus on individual predispositions and/or contextual factors that do facilitate exemplar-based processing and could subsequently improve the learning of configural relations.

Besides fundamentally shifting the nature of the judgment task from elemental to configural, the presence of interactive effects of cues on outcomes also increases the complexity of the judgment task. This raises a question regarding the relative advantage of process over outcome accountability in terms of judgment quality in more complex, elemental tasks. For example, one could make the elemental task structure used in the current set of studies more complex by raising the number of cues determining the outcome, or by increasing the random variation in the outcome, or by forcing participants to make rapid judgments instead of giving them an open response time, and so forth. If more complex environments trigger greater reliance on heuristic processing than on analytic processing, individuals may be less likely to rely on cue abstraction as the complexity of the task increases. This may in turn weaken the positive effect of process accountability on decision accuracy.

Although we did not observe a processing advantage for outcome accountable decision makers in terms of exemplar memory, it is possible that outcome accountability has a positive influence on heuristic processing. In real-life settings it is often adaptive to rely on simple heuristic processing (e.g., "Take The Best" heuristic) because it outperforms more complex processing (e.g., multiple regression or cue abstraction) in terms of speed without a considerable loss in terms of accuracy (Gigerenzer & Goldstein, 1996). If future research shows that outcome accountability boosts heuristic processing, outcome accountability may in fact be desirable to optimize judgment speed and accuracy in real-life decision making.

Note that in the current research we have considered the effects of holding decision makers either process accountable or outcome accountable on judgment quality. Managerially it is however possible to simultaneously hold decision makers both process and outcome accountable. This possibility raises several questions for future research. For example, is process accountability sufficient to improve judgment quality regardless of whether outcome accountability is imposed or does outcome accountability negate the positive effect of process accountability in elemental task structures? Could there be any synergetic effects of imposing process and outcome accountability in configural task structures?

In cognitive psychology, great progress has been made in (a) defining cue abstraction and exemplar-based processing in terms of the cognitive operations that are involved (e.g., Hahn & Chater, 1998), and (b) exploring how task characteristics influence reliance on cue abstraction and exemplar memory (e.g., Juslin et al. 2003; Juslin et al., 2008). However, little or no research has explored how individual predispositions and an individual's social context influence cue abstraction and exemplar memory. Our research shows that process accountability, epistemic motivation, analytical intelligence, and rational thinking style are positively related to cue abstraction, but not to exemplar-based processing. Future research should explore how other social contextual cues and individual predispositions relate to cue abstraction and exemplar-based processing.

Over the last decades, there has been a proliferation of dual-process theories in psychology arguing that judgments can be rational or experiential (Epstein, Lipson, Holstein, & Huh, 1992), systematic or heuristic (Chaiken, 1980), analytical or intuitive (Hammond, 1996), global or local (Navon, 1977), conscious or unconscious (Dijksterhuis, 2004), rule-based or associative (Sloman, 1996), based on cue abstraction or based on exemplars (Juslin et al., 2008), implicit or explicit (Reber, 1989), etc. Our research shows that, although there are conceptual overlaps between these theories, there is no one-to-one mapping between the processes highlighted by different theories. For instance, previous research has argued that process accountability facilitates systematic processing due to an increase in epistemic motivation whereas outcome accountability facilitates heuristic processing because it decreases epistemic motivation (e.g., Scholten et al., 2007). Equating systematic processing with cue abstraction and heuristic processing with exemplar-based processing would yield the prediction that process accountability facilitates cue abstraction and outcome accountability facilitates exemplar-based processing. Our research shows that this is not the case, as exemplar-based processing was found to be constant across accountability types.

Conclusion

The present research examined how process and outcome accountability in interaction with individual predispositions influence cue abstraction and exemplar memory. We hope that our focus on cognitive processes and contingency stimulates future research and understanding of how judgment quality can be improved for different people under difference circumstances.

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Appendix

Cue abstraction model (Juslin et al., 2008; Olsson et al., 2006)

The cue abstraction process can be formally represented by a multiple linear regression model in which the regression parameters b_I represent the weights attached to each cue (C_I). The predicted outcome ($\hat{o}$) is based on summing the weighted cue values:

$$\hat{o} = a + b_1 \times C_1 + \cdots + b_I \times C_I \quad \text{(A.1)}$$

Two constraints are imposed on the parameters of the cue abstraction model. First, the sum of the linear weights (Σb_I) should be equal to the range of possible outcome values. The outcome values in Study 3 are bounded between 0 and 10, yielding a range of 10. Second, the intercept a is constrained such that:

$$a = .5 \times (10 - \Sigma b_I) \quad \text{(A.2)}$$

This restriction is imposed because it reduces the number of parameters of the cue abstraction model from 5 to 4, which makes it more easily comparable to the exemplar-based model that also contains four parameters. The parameters of the cue abstraction model are estimated with ordinary least squares based on the judgments of participants in the second half of the training phase.

Exemplar-based model

The exemplar-based process is modeled by the context model (Medin & Schaffer, 1978) applied to a situation with continuous outcome values (Juslin et al., 2003; Juslin et al., 2008; Olsson et al., 2006). The predicted outcome ($\hat{o}$) is the average of the outcome values (o_n) of previously-encountered exemplars, in which the outcomes are weighted according to their similarity (S_n) to the stimulus to be judged:

$$\hat{o} = \frac{\sum_N S_n \times o_n}{\sum_N S_n} \quad \text{(A.3)}$$

The similarity (S_n) is obtained by the multiplicative *similarity rule of the original context model*[10] *(Medin & Schaffer, 1978):*

$$S_n = \prod_{i=1}^{I} d_i \quad \text{(A.4)}$$

where index d_i equals 1 if both exemplars coincide on feature i, and s_i if they deviate. The four similarity parameters (s_i) lie in the interval [0, 1] and capture the impact of deviating features on the overall similarity S_n. The closer s_i is to 1, the less important the feature is for determining the similarity between the exemplars. The similarity parameters are obtained with the Newton–Raphson algorithm for

[10] In case of binary-valued stimulus dimensions, the multiplicative similarity rule of the original context model is a special case of the multidimensional scaling solution proposed by the generalized context model (Nosofsky, 1986).

maximum likelihood estimation based on the judgments of participants in the second half of the training phase.

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