Abstract: Manipulations that draw attention to extensional or set-based considerations are neither sufficient nor necessary for enhanced use of base rates in intuitive judgments. Frequency formats are only one part of the puzzle of base-rate use and neglect. The conditions under which these and other manipulations promote base-rate use may be more parsimoniously organized under the broader notion of case-based judgment.

Although we agree that the two-system nested set account provides a better fit to the data reviewed in the target article than the alternative frequency-format accounts, we believe that the nested set account is an overly narrow lens through which to view base-rate use and its relation to probability and frequency judgments. In particular, manipulations making nested set representations more transparent may not be sufficient to improve base-rate use and such manipulations are not necessary to improve base-rate use. In terms of the dual systems model, base-rate use is not improved solely by rule-based processes, nor is base-rate neglect always driven by associative processes. By focusing only on areas where frequency formats increase base-rate use, the target article oversells the value of frequency formats – and rule-based or System 2 processes more generally – in improving intuitive judgment.

A case-based judgment account built on Kahneman and Tversky's early theorizing (e.g., Kahneman & Tversky 1973) provides a perspective on intuitive judgment that is compatible with yet broader than the nested set account. The case-based account provides a parsimonious explanation of patterns of base-rate use and neglect across both probability reasoning tasks and experience-based probability judgments, and also provides a more realistic view of the debiasing value of frequency formats. According to the case-based account, intuitive judgments focus on assessing the strength of evidence relevant to the current case at hand (Brenner et al. 2005; Griffin & Tversky 1992). Strength of evidence is commonly evaluated by associative processes such as similarity or fluency, but can also be evaluated by rule-based processes. However, to the extent that both associative and rule-based processes focus on the strength of impression favoring a particular hypothesis about the current case, background evidence about class or extensional relations is not included when the strength of evidence is mapped onto a probability (or related) scale. This produces neglect of base rates, as well as neglect of cue validity in intuitive judgments.

According to the case-based account, any evidence that influences the strength of impression regarding the case at hand will affect probability judgment. This explains why base rates that can be interpreted (associatively, via System 1 processes) as a propensity of the single case are highly influential. Racial or gender stereotypes, for example, can be interpreted as base rates but also can yield a strong expectation about a particular individual. Similarly, the win-loss record of a sports team can yield an impression of the strength of that team (Gigerenzer et al. 1988). The debate about "causal" base rates can also be interpreted in this way (Tversky & Kahneman 1980). When provided with a statistical summary of the number of blue versus green cabs in a city, people rely on the testimony of a fallible accident witness and disregard the base rate; however, when base rates are given a causal significance by describing the differential likelihood of accidents for the cabs, both the witness's testimony and the accident-proneness of cabs contribute to the strength of impression for this particular accident. In these contexts, the use of base rates per se does not indicate a System 2 rule-based process.

Furthermore, improved judgment resulting from a diagram or other aid to viewing a problem in terms of nested sets does not necessarily implicate rule-based reasoning. Diagrams prompting an immediate comparison of the size of circles may allow a low-level perceptual computation to solve the problem. If wording or outcome formats allow a judge to represent such relationships visually or symbolically, the line between associative and rule-based solutions becomes blurred. From the perspective of the case-based account, such manipulations may operate through their impact on the case-specific impression of evidence strength. The results of the Girotto and Gonzalez (2001) study described in the target article could be interpreted in this manner.

According to the evolutionary frequency module account, "our hunter-gatherer ancestors were awash in statistical information in the form of the encountered frequencies of real events: in contrast, the probability of a single event was inherently unobservable to them" (Cosmides & Tooby 1994, p. 330). In several recent studies (Brenner et al. 2005; 2006), we have examined probability judgment in a learning paradigm similar to the Gluck and Bower (1988) study described in the target article. In this simulated stock market study, case-specific evidence is provided in terms of a company's sales and costs. A participant's task is to estimate the probability that the stock price will increase, given the financial information and experience in the market which provide evidence about the base rate of stock increases and the validity of financial cues. Notably, participants were extremely accurate in estimating the base rates that they had experienced. However, despite this – and despite being awash in encountered frequencies – participants' probability judgments were largely unaffected by base rates or cue validity. When juxtaposed with case-specific information, apparently, such extensional considerations can be readily available, yet be viewed as largely irrelevant to the judgment. A more evolutionarily grounded outcome measure would assess the resources that an individual is willing to commit to a decision based on uncertain evidence. A natural measure is thus the price one is willing to pay for a stock certificate for a particular company. When price is used as an outcome measure in our learning paradigm, however, the neglect of base rate and cue validity remains.

Barbey & Sloman (B&S) offer a helpful reappraisal of the impact of frequency representations on base-rate use in probability reasoning tasks. We agree that the evidence clearly does not support the strong claim that frequency formulations yield effortless Bayesian reasoning. The view that base-rate use proceeds only or primarily through application of rules of set inclusion, however, may also be too strong. On the one hand, Bayesian solution rates are far from perfect when set relations are explicitly highlighted (see Table 4 of the target article). On the other hand, under the right circumstances, base rates may be used effortlessly, if they are captured in the immediate impression of the strength of evidence regarding the case at hand.

One wrong does not justify another: Accepting dual processes by fallacy of false alternatives

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Gideon Keren,[a] Iris van Rooij,[a] and Yaacov Schul[b]

[a]*Department of Technology Management, Eindhoven University of Technology, 5600 MB Eindhoven, The Netherlands;* [b]*Department of Psychology, The Hebrew University, Mount Scopus, Jerusalem 91905, Israel.*

g.b.keren@tue.nl **i.v.rooij@tue.nl** **yschul@huji.ac.il**

Abstract: Barbey & Sloman (B&S) advocate a dual-process (two-system) approach by comparing it with an alternative perspective (ecological rationality), claiming that the latter is unwarranted. Rejecting this alternative approach cannot serve as sufficient evidence for the viability of the former.

The target article's title suggests two messages to take home. Current theories of ecological rationality rest on weak grounds (we generally agree), and data patterns of base-rate neglect provide empirical support for dual-process theory (we generally disagree). Barbey & Sloman's (B&S's) analysis is mistaken on two grounds.

First, they commit the fallacy of false alternatives: Demonstrating that 4 out of 5 theoretical accounts are false does not necessarily imply the truth of the remaining one unless the list of hypotheses is exhaustive, which it is not (we label the 5 accounts considered by B&S as T1–T5). T1–T5 do not instantiate an exclusive set of (plausible) theoretical possibilities. This becomes evident when analyzing T5 into its conjunctive parts: (1) the hypothesis that explicating nested set relations facilitates Bayesian reasoning (T-NESTED), and (2) the hypothesis that the mind has a dual-process architecture with associative processing occurring in parallel with rule-based processing (T-DUAL). Clearly, T-NESTED and T-DUAL are two distinct and separable theoretical claims (hence we already have T1–T6 different accounts, with T6 being equal to T-NESTED without T-DUAL). There is no reason we can see – nor do the authors provide one – for the nested set hypothesis to be married specifically to a dual-process architecture of mind. It seems as plausible (a priori at least) that a single-, or multi-process architecture can implement the benefits from nested set representations.

This leads directly to B&S's second fallacy: Even if the non-rejected account (nested sets) has some merits, in no way does it imply or support a dual process (two-systems) perspective. It is well known that representation and computation can trade spaces, in the sense that computation can be facilitated, or otherwise affected, by changing between (logically equivalent) representational formats (Clark & Thornton 1997; Marr 1982). This general cognitive principle has been demonstrated in areas as diverse as problem solving, memory retrieval, and visual imagery. Also, the cognitive facilitation afforded by Venn diagrams, and diagrams in general (Larkin & Simon 1987), is well known (yet, unrelated to dual process theories). Framing effects in decision making also illustrate how changes in representational format affect cognitive judgments. The nested sets facilitation hypothesis, reported by B&S, seems to be yet another (potential) example.[1] As such, the hypothesis, though viable, is neither novel nor surprising. Because of its generalized flavor it seems particularly ill-suited as a basis for conjecturing a particular architecture of mind: almost any architecture of mind (whether single-, dual- or multi-process; whether associative, rule-based, both or neither) could accommodate the effect.

Apparently, B&S do consider evidence in favor of the nested set hypothesis as also constituting support for the idea that human minds have a dual-process architecture. Arguing for such a general theoretical position, based on the available performance data alone, is simply trying to do the impossible. This is also illustrated by the target article's Table 2. Close inspection of the table shows that the available data cannot decide between theories that assume modular or non-modular architectures (predictions for T1 and T2 are identical), and cannot decide between theories postulating evolutionary or non-evolutionary adaptations (predictions for T3 and T4 are identical). In the same vein, the available data cannot decide between theories that postulate dual- or single-process architectures. Table 2 may seem to suggest otherwise because the predictions of T5 appear to be unique. However, it should be noted that the table is missing a column and thus is incomplete. The authors should have included a sixth column listing predictions for T6 identical to the predictions for T5 (granting that T5 is really making the listed predictions – which seems questionable to begin with, yet is insubstantial for our claim that the reviewed findings cannot discriminate between T5 and T6). Including such a sixth column may have highlighted that the dual process assumption is superfluous in the authors' explanation of base-rate neglect.

Here B&S are confronted with the fact that theoretical frameworks in science generally cannot be justified on the basis of a small set of empirical phenomena (Lakatos 1977).[2] Rather, theoretical frameworks derive their explanatory power from making insightful a large corpus of seemingly unrelated findings that would otherwise be puzzling or anomalous. B&S make no attempt to argue for the explanatory superiority of dual-process architectures (compared to other architectures of mind); and as we have argued, effects of representational format (e.g. nested set relations) on cognitive processing are not puzzling in any event.

In short, B&S do not provide any argument for why support for the nested-set hypothesis constitutes evidence for dual-process (two-systems) theories. The presumed superiority of dual-process architectures is presumably established by citing other authors who advocate a two-systems theory (e.g., Evans & Over 1996; Kahneman & Fredrick 2002; Sloman 1996a; Stanovich & West 2000). Indeed, there has recently been an upsurge in theoretical frameworks alluding to the existence of two different processing systems that supposedly operate according to different rules. Recently, we (Keren & Schul, under review) have pointed to the lack of robust and reliable evidence that would support the two-systems architecture of the mind. The target article seems to offer arguments that question the viability of the natural frequencies approach, and more generally the ecological rationality framework. Yet, it does not add any forceful evidence in support of the alternative favored by the authors, namely the dual-process approach. The possibility that both theoretical frameworks (i.e., ecological rationality and dual processes) are undefendable, cannot be ruled out.

NOTES

1. B&S's attempt to rule out the possibility that explicating nested set relations simply affords easier computation is questionable. They draw on a study asking participants to judge ease of understanding of different presentation formats. Whether participants have introspective access to the nature and efficiency of their own cognitive processes is highly doubtful (Nisbett & Wilson 1977).

2. Certainly when the phenomenon under discussion remains controversial (Koehler 1996) on both theoretical and empirical grounds.

Implications of natural sampling in base-rate tasks

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Gernot D. Kleiter

Department of Psychology, Salzburg University, A-5020 Salzburg, Austria.
gernot.kleiter@sbg.ac.at

Abstract: The hypothesis that structural properties and not frequencies per se improve base-rate sensitivity is supported from the perspective of natural sampling. Natural sampling uses a special frequency format that makes base-rates redundant. Unfortunately, however, it does not allow us to empirically investigate human understanding of essential properties of uncertainty – most importantly, the understanding of conditional probabilities in Bayes' Theorem.

Barbey & Sloman (B&S) disentangle and systematize the various explanations of base-rate neglect/facilitation. They present strong arguments in favor of the hypothesis that the nested subset structure is responsible for facilitation effects. My comments try to further clarify the implications of natural sampling. Throughout the article, the authors adopt the terminology of "natural frequencies" used by Gigerenzer and his group. The adjective "natural" was transferred from "natural sampling." Let's therefore start with the origin of the latter concept.

The notion "natural sampling" was introduced by Aitchison and Dunsmore (1975) in their excellent book on statistical prediction analysis. In estimating probability parameters, frequencies are informative if and only if they are the outcome of a random sampling process and there is no missing data. Sampling is non-natural if, for example, sample sizes are planned by an experimenter. I used the term "natural sampling" in the Bayesian analysis of binomial sampling (Kleiter 1994) in the technical sense of Aitchison and Dunsmore. For several Bernoulli