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Implications and Ramifications of a Sample-Size Approach to Intuition

There are several different meanings attached to “intuition”, which has become a prominent concept in research on judgment and decision making (Betsch, 2006; Epstein, Pacini, Denes-Raj, & Heier, 1996; Gilovich, Griffin & Kahneman, 2001; Hogarth, 2001). In the context of dual-process theories (Chaiken & Trope, 1999), intuitive processing may be considered an opposite of systematic processing, or intuition appears as an affective processing style that is driven by feelings rather than arguments and reasons (Betsch, 2006). In decision-making research, the notion of intuition would be applied to bounded rationality due to limited resources (Simon, 1956). In the area of meta-cognition, intuition could refer to the absence of monitoring and control processes. Some researchers have even come to consider intuition a personality trait (Betsch, 2004; Epstein, 2006; Scott & Bruce, 1985).

In the present article, we delineate a different approach, which is by no means inconsistent, but largely overlaps with the aforementioned definitions. However, our approach is simpler and refrains from a number of rather strong assumptions to which other conceptions subscribe. Using a simple and straightforward criterion, we define intuition in terms of the size of the sample used in reaching a decision: Judgments and decisions are intuitive to the extent that they rest on small samples.

To be sure, there is no absolute numerical measure for a “small” sample. What is small, rather, depends on the task setting and the knowledge domain. However, on a domain-specific ordinal scale, the distinction of small and large samples would appear to be easy and natural. A personality scale with 10 items (such as the PID measuring intuitive dispositions, Betsch, 2004) constitutes a small sample, compared to another scale comprising over 100 items. Hiring a candidate after a five-minute job interview, rather than an extensive assessment, would be said to rely on a small sample, and so would judging somebody’s intelligence or honesty after ten seconds of acquaintance (Ambady & Rosenthal, 1992). Thus, using short versions of personality tests, making fast hiring decisions, or quick judgments at almost zero acquaintance would be classified as intuitive, according to the above definition.

We believe that such a simple operational approach to intuition has several advantages. First, of all the attributes supposed to characterize intuition – the gut feeling, its phenomenological experience, the wholistic strategy –sample size would appear to be the most objective and straightforward measure. Second, an operational definition in terms of small information samples is compatible with most other measures, as already mentioned. Third, with respect to the principle of parsimony, we avoid the problems associated with the strong assumption that intuition is a stable personality trait, or the dual-process assumption that at any point in time, cognitive processes are either in a reflective or in an intuitive mode, but never in both.

Finally, and most importantly, sample size is a theoretically fertile variable, giving rise to a rich set of testable implications that can be derived from statistical decision models. These implications lead to a theory of intuitive decision making that goes beyond global statements like “intuitive decisions are better than expected”, “intuition is a key to satisfaction”, or “less is more”. Rather, the intuition = sample-size approach leads to clear-cut predictions about antecedent conditions of intuitive decisions, their benefits and costs, and the advantages and disadvantages of intuitive decisions.

Preview

Having introduced our basic definition, we can now provide a preview of the present chapter. In the next section we introduce an information-sampling approach that has been proven to elucidate the relationship between sample size and decision accuracy. We review the basic findings obtained within that framework, showing that paucity of information can help or hinder accurate decision making. We introduce a distinction between two kinds of accuracy, estimation accuracy and choice accuracy, and point out that, whereas large samples lead to accurate estimates, small samples exhibit their superiority when it comes to making clear-cut choices.

In the following sections, we extend and elaborate on the basic sampling model in the theoretical context of a three-dimensional learning environment, encompassing three generic dimensions: the valence of information (positive vs. negative), the distance of decision outcomes (distant vs. proximal), and the decision criterion (lenient vs. conservative). Several antecedents, consequences, and concomitants of intuition can be described within this three-dimensional space. To anticipate, we shall see that natural learning environments facilitate intuitive decisions in negative domains, based on small samples and lenient decision thresholds. In signal-detection terms, such lenient decision thresholds tend to produce many false alarms but few false negatives. In contrast, in positive domains, information samples tend to be large, imposing a stricter decision criterion with more false negatives than false alarms. We also show that distant decisions are characterized by smaller samples than proximal decisions, with corresponding differences in terms of false alarms and false negatives. Finally, the analogous influence on intuition (i.e., decisions informed by small samples) of (positive vs. negative) valence and (large vs. small) distance reflects the fact that these two dimensions are not independent. A negative attitude toward an object, or an avoidance tendency, is naturally represented as a large or increasing distance. As in multi-dimensional scaling, distance expresses dissimilarity between the attitude holder and the attitude object. In contrast, a positive attitude or approach tendency is evident in small distance or increasing closeness, proximity, or intimacy. Proximity means similarity. Thus, the moderators of intuitive processing can be reasonably understood within a three-dimensional theory space spanned by the variables of valence, distance, and sample size.

Sample size: A fruitful theoretical concept

Consider a simple binary consumer choice problem: a consumer wants to purchase a car, with the decision problem reduced to a binary choice between two different brand models, A and B. Assume there is objective evidence for assets (denoted +) and deficits (denoted –) of both models but that the manufacturers do not reveal the entire universe of all + and – data that define the objective quality. Suppose that in (latent) reality, the rate of all + experiences with model A is higher (80%) than that of model B (40%). The consumer does not have access to this objective population parameter but only to a sample of data, the acquisition of which is restricted, time-consuming, and expensive. However, information acquisition is unbiased, that is, every bit of information, whether + or –, is equally likely to be sampled from the objective data base. Within this simple environmental task setting, consumer decision making amounts to drawing an n-item sample of observations (describing + or – aspects associated with option A or B) and making a choice in favor of the option with the higher proportion of + data in the sample. Thus, if p*(+/A), the proportion of positive outcomes for A, is higher than p*(+/B) – let us call this a positive contingency between alternatives and outcomes – then a correct choice will be made. If the observed contingency p*(+/A) – p*(+/B) is negative, the decision will be wrong. To be sure, the accuracy of this strategy (i.e., the likelihood to choose the better alternative, A) relies heavily on the faithfulness of the samples considered.

In the context of this task setting, comparing intuitive to more exhaustive strategies means to compare the relative success of small and large samples. Think of two large groups (each including 1000 individuals): intuitive consumers who gather only about 8 observations to make a decision and exhaustive consumers who sample three times as many observations (i.e., 24). How would the intuitive group fare when compared to the exhaustive group with respect to the number of consumers who choose A, the better option? Could one imagine that the success rate of the intuitive group is similar to that attained by the exhaustive group?

A STATISTICAL MODEL FOR UNDERSTANDING THE ASSETS OF INTUITION

Indeed, statistical sampling theory tells us that under clearly specified conditions, the intuitive group may not only match the achievement of the exhaustive-search condition but may actually outperform it. That is, the number of consumers whose observed sample contingency is (correctly) positive can be higher for the intuitive group that relies on only eight observations than for the exhaustive-strategy group with 24 observations.

How this seeming paradox is possible can be explained with reference to the model depicted in Figure 1 (after Kareev, 2000). The two curves represent sampling distributions of correlation coefficients for different sample sizes. Thus, when a sample of size *n* is drawn repeatedly from a population in which the true contingency is $\Delta = p(+/A) – p(+/B) = .8 – .4 = .4$, the distribution is like the solid line for small samples of size $n = 8$ (intuitive group). By comparison, the dashed line shows the distribution for large samples of size $n = 24$ (exhaustive group). Apparently, the distribution of all the sample contingencies drawn that way is left-skewed, so that the majority of contingencies observed in samples drawn from a population with $\Delta = .4$ is higher than $\Delta = .4$. Moreover, the skew is more apparent for the solid than the dashed curve. Over a wide range of sample sizes, the skew of the sampling distribution increases with decreasing sample size. When cases in which the correlation is undefined (e.g., all outcomes positive or all negative) are also taken into account – and this is more likely to happen, the smaller the sample size – the amplifying effect of small samples reaches a maximum around $n = 7$. It is widely known that this magical number corresponds to the capacity of human working memory (cf. Kareev, 2000).

Thus, small samples in the range specified by the model in Figure 1 have the property of increasing the likelihood that actually existing differences can be recognized correctly, reflecting an environmental, pre-cognitive advantage of intuitive processing. That the sample size resulting in maximum effect ($n = 7$) coincides with memory capacity suggests that evolution may have exploited (or even brought about) this intuition advantage, increasing the chance that people can hold in mind samples of data that accentuate actually existing contingencies. A good deal of empirical evidence supports the prediction derived from this model, that a narrow window size can facilitate accurate decisions, such as Elman’s (1993) demonstration that effective language acquisition is facilitated by small samples of linguistic input, or else by restricted memory capacity, both "implementing" in effect an intuitive strategy. Likewise, adult memory span is negatively correlated with performance on contingency detection tasks (Kareev, Lieberman, & Lev, 1997).

However, there are good reasons not to overstretch this notable evidence for increasing performance with decreasing sample size. On the one hand, the skew in the sampling distributions of contingencies or correlations is only apparent when the actual contingency in the population is markedly different from zero. If the actual contingency is too small, no advantage of small samples will be obtained. On the other hand, the small-sample advantage depicted so far only pertains to hit rates, that is, the rate of correctly detecting a (pronounced) contingency which really exists. With respect to error rates, no doubt, small samples are also more likely to produce false alarms (i.e., indicate erroneous contingencies), although false positives seems to be less serious than false negatives (Kareev, 2005).

Fortunately, the small-sample advantage is more pervasive than the model in Figure 1 suggests. A more recent sampling model (Fiedler & Kareev, 2006; cf. Figure 2) demonstrates that (1) small samples may inform better decisions than large samples when population contingencies are weak; (2) the advantage of small samples is maintained when both hits and false alarms are taken into account, and (3) the equal, or even superior performance of intuitive strategies generalizes across a large area of the parameter space.

The assumptions of this more recent model are simple and plausible. When repeated samples are drawn from a population in which the true contingency is, say, $\Delta = .2$, the observed sample contingency will not always exactly match the population parameter, but will be scattered around the true value. As a matter of rule, the dispersion of the sample statistics will be larger for small than for large samples, as shown by the solid and dashed graphs in Figure 2. This holds for contingencies of any strength; estimates of contingencies are closer to the actual value when samples are large rather than small. For very large sample sizes n, estimates will approximate $\Delta = .2$. For very small n, the contingencies observed in different samples vary considerably. An intermediate n will yield medium dispersion.

With respect to this universal model the "home domain" of intuition can be easily identified with two assumptions. First, we have to introduce the distinction between estimation and choice. When the task is to make an accurate quantitative estimation of the contingency in the population, then large samples are clearly superior to small samples. This simply follows from the smaller dispersion of the dashed curve in Figure 2. However, when the task is only to make a qualitative choice of the better option, that is, a binary decision of whether the contingency is positive or negative, regardless of its precise size, then, under a second assumption, small samples can be superior. Namely, assume that individuals do not always choose A when A dominates B (in the following denoted A > B). Assume, rather, that for A to be chosen the observed dominance of A over B has to be strong enough, that is, the contingency Δ_{sample} in the sample has to exceed a threshold θ, which is often higher than the population contingency Δ. For example, whereas real differences in the environment may often be modest (such as $\Delta = .2$ in the present case), a choice will only be made when the observed differenceΔ_{sample} exceeds some significant criterion (say, $\theta = .4$). When this is the case, that is, when organisms only make choices using a threshold that is higher than the real underlying difference or contingency, then small samples will most of the time produce more correct choices than large samples.

To illustrate why this happens, consider the vertical threshold lines at $\theta = \pm.4$ in Figure 2. A sample differences of +.4 or larger, leading to a correct choice, will be observed more often for small than for large samples, as evident from the areas under the solid and dashed line that exceed the threshold. Thus, the higher dispersion of small samples, which leads to inaccurate estimates, at the same time enables many correct threshold-based choices. To be sure, small samples will also lead to more incorrect decisions, as evident from the left distribution tails that exceed –.4. However, the intuition costs of incorrect choices on the left are clearly lower than the intuition gains of correct choices, or “hits”, on the right.

Evidence for the Statistical Model of Intuition

In fact, extended computer simulations confirm that intuitive decisions based on small samples outperform large samples over a wide range of sample sizes, contingency levels, thresholds, and cognitive load assumptions. Furthermore, decision makers actually do often use implicit thresholds that are higher than the contingencies to be detected, leading to a real intuition advantage. For instance, Fiedler and Kareev (2006) asked their participants to make binary choices between pairs of products, or pairs of job applicants. They could sample as many observations about a pair of options (A, B) as they considered useful. At the end of this free information search, they could either choose A or B or discard a sample when they felt the sample did not allow for a choice. Across different levels of actual contingencies (i.e., true differences between A and B), ranging from $\Delta = .1$ to $\Delta = .4$, choice accuracy correlated negatively with sample size: The smaller the samples drawn, the higher the proportion of correct choices. In accordance with the line of reasoning advanced above, this small-sample advantage came along with judges’ applying rather high decision thresholds. That is, the observed differences, Δ_{sample}, that were considered sufficient to stop information choice and to make a choice tended to be higher than the real Δ that held between A and B. Consistent with this high-threshold account, the small-sample advantage was particularly pronounced when correctness (coded +1 vs. –1) was weighted with confidence of choice, reflecting the fact that confidence tends to be high at high decision thresholds. This is related, in turn, to people's well-documented tendency to over-weigh strength of evidence (the strength of the observed correlation, in our case) and under-weigh its weight (the number of cases on which it is based; Griffin & Tversky, 1992).

The advantage of small samples – that is, of intuitive strategies – was already evident at the environmental sampling stage – prior to the cognitive process proper. An analysis of the samples drawn at random from a universe in which A was slightly better than B [i.e., p(+/A) > p(+/B)] revealed that small samples were more likely to show an above-threshold A-advantage than larger samples. Indeed, this pre-cognitive sampling effect exhibited the advantage of small samples more strongly than the subsequent cognitive decisions, reflecting the environmental (rather than mnemonic) origin of the phenomenon.

In similar experiments (Fiedler, Renn & Kareev, 2006), decision makers underwent a positive or negative mood treatment (based on funny or sad films) before entering the choice task. Positive mood is a well-established determinant of intuitive processing strategies (Bless & Fiedler, in press; Fiedler, 2001), and indeed, good-mood participants tended to base their choices on smaller samples than participants in bad mood. Consequently, good mood participants exhibited superior performance under specific task conditions.

Convergent findings were obtained by Kareev et al. (1997), showing that contingency detection improves when the size of the sample made available to participants was restricted. In the "out of sight" condition of Experiment 2, participants were presented with items that varied along two continuous attributes. Items were presented one at a time and removed before the next one appeared. Sample size was smaller than, equal to, or larger than the estimated STM capacity. Once the entire sample had thus been presented, judges were given one attribute value of a new item, and asked to predict the value of the other attribute. Predictions were compared to the actual value, and accuracy was rewarded. Predictions were more extreme, more in the right direction, and more accurate, when sample size was small.

Estimation versus Choice

However, it is important to keep in mind that this counter-intuitive advantage of intuition is but one side of the coin. It only holds for choices, not for estimation tasks. It is uncontested that quantitative estimates become more accurate with increasing sample size. For example, when participants had to figure out the proportions of correct answers given by different students in a simulated classroom environment, they arrived at more accurate performance estimates of those students whom they had asked many questions (Fiedler, Walther, Freytag & Plessner, 2002). For example, assume two pairs of students A, B and a,b, whose ability parameters (i.e., proportions of correct answers) differ by the same amount (e.g., A and a being 80% correct, but B and b being only 50% correct), but a larger sample of observations is available about A,B than about a,b. Then the accuracy of estimates is higher for A,B than a,b, and the estimates of A,B are less regressive (i.e., approach the actual ability differences more) than a,b estimates. This large-sample advantage holds for estimation accuracy, not for clarity and confidence of choice, which is often higher for small samples (for a similar, enlightening simulation model, see also Hertwig & Pleskac, 2006).

A synthesis of both phenomena – a choice advantage for intuition, but an estimation advantage for extended information samples – was found by Fiedler, Kemmelmeier, and Freytag, (1999) in the context of intergroup judgments. Information samples are normally smaller for outgroups than for ingroups, producing more intuitive judgments about outgroups than ingroups. Both computer simulations and experimental data showed that ingroup judgments were more accurate than outgroup judgments when the task called for the estimation of the precise position of groups with regard to antonymous traits. Thus, the actual position of groups on two antonymous trait dimensions – extraversion and introversion, or honesty and dishonesty – was more accurately assessed for the group on which the larger sample was available (i.e., the ingroup). However, when the task called for a (forced) choice of which attribute – either extraversion or introversion – dominates, then ingroup judgments were in conflict. There was too much evidence for both antonyms to allow for the simplifying choice required. As a consequence, choices were more readily made for outgroups, apparently based on small samples and intuitive strategies that were less constrained by decision conflicts. Technically speaking, the difference in the observed evidence for two competing antonyms is more likely to exceed a threshold when outgroups rather than ingroups are being judged.

Note that estimation means to compare A and B separately to an *absolute* accuracy criterion, whereas choice involves a *relative* comparison of A versus B, regardless of their absolute level or accuracy. Small samples facilitate choices, even though exhaustive strategies involving larger samples support accurate estimation. Once this formal explication is understood, seemingly unrelated phenomena can be explained as reflecting the same influence of intuition. Thus, just as choices between two competing antonyms are easier for outgroups or small groups than for ingroups or large groups, the work of Algom and his colleagues (Chajut & Algom, 2003) points to a conceptual analog in a completely different task domain. In a selective-attention task, involving a forced choice to attend to A rather than B, distracters or cognitive load that reduce the overall sample size in working memory serve to improve performance. Thus, intuitive strategies enforced through cognitive load facilitate the concentration on the task-relevant aspect, A, rather than the task-irrelevant aspect B. More exhaustive strategies in the no-load condition are more likely to induce attention conflicts.

Detecting and Affecting Change

The models and findings reviewed so far all assume a static environment, in which the parameter values to be assessed remain stable. However, a large part of daily life calls for the assessment of changes in the environment. It is interesting to note in passing that small samples are particularly functional for the detection of change. In dynamic environments, reliance on large samples of past experience may constitute a liability, rather than an asset. In contrast, monitoring but a narrow window of recent events provides the most relevant data for the detection of change. The exact size of the optimal window depends of the rate of change (the faster, the smaller the window) and the quality of the data (the noisier, the larger the window). Still, it is clear that the detection of change is best served by considering a small sample of recent events – by engaging in intuitive decision making.

Lest the force of this argument rest only on its logical appeal, we would like to point out a list of cases in which taking into consideration even only the last, most recent item (i.e., n=1!) results in effective, efficient behavior.

Situations in which the speedy detection of and reaction to change are required abound. Most prominent are interactions in dilemma situations, in which two or more agents attempt to maximize their own outcomes as they compete with each other for some environmental resource. In such environments, recognizing changes in strategies and outcomes is of paramount importance. Can intuitive, small-sample based monitoring be of any use in such situations, or is it bound to result in sub-optimal, even exploitable behaviors?

To illustrate, consider a game in which each of two agents has to decide on the allocation of some units of reward. Each agent has to decide whether to award 1 unit of reward to herself, or to have 3 units of reward awarded to the other agent. The decision is made secretly and simultaneously by both agents, then revealed and enacted. The four possible decision combinations and the ensuing payoffs are depicted in Table 1.

Although the cover story may be unfamiliar, the resulting payoff matrix is that of the well-known prisoner's dilemma (PD) game. If played once, "take the one for myself" dominates "give 3 to the other", as it yields a better outcome irrespective of the other player's decision. Note, however, that mutual defection results in a lower outcome – 1 for each – than would mutual cooperation. For the latter to become a stable (equilibrium) strategy requires trust, and the potential for credible threats, which is available if the interaction repeats. Prominent in numerous articles dealing with the PD game are suggestions on how to play it in a way that would lead to high payoffs. As it turns out, a very simple strategy, Tit-for-Tat (TFT), that calls for monitoring the other player's last move and respond in kind on the next trial performs amazingly well against a host of other strategies (Axelrod, 1984; Axelrod & Hamilton, 1981).

Note that the essence of TFT is an immediate, minimal-sample-based reaction. As it turns out, this intuitive strategy outperforms strategies based on more exhaustive histories, employing sophisticated weighting functions. Interestingly, after years of reigning supreme as the champion of PD tournaments, TFT was beaten by another strategy, Pavlov, which is based on a win-stay, lose-shift strategy (Nowak & Sigmund, 1993) – another minimal-sample based principle.

Consider a situation in which some resource (e.g., food) is provided to a group of consuming agents by two sources that differ in quality – one being more abundant than the other. If the overall supply is scarce, for all consumers to aggregate by the more abundant source would result in an inefficient solution. The efficient solution, known as the Ideal Free Distribution – with the number of feeding agents at each resource proportional to its abundance – may be achieved if each organism adopts a win-stay lose-shift strategy (Thuijsman, Peleg, Amitai, & Shmida, 1995). Thus, we see again how an intuitive decision, based on a minimal sample, results in an efficient solution.

ENVIRONMENTAL-LEARNING CONTEXT OF INTUITION

Having introduced our sampling approach to intuition, we can now start to elaborate on several intriguing implications of this theoretical approach. In the remainder of this article, we unfold a the three planes of a three-dimensional theoretical framework involving sample size x valence x psychological distance. We first discuss the relationship between (large vs. small) sample size and (positive vs. negative) valence, which turns out to be positive, reflecting search for positive and avoidance of negative information. We then turn to sample size and psychological distance, which are negatively related, as the amount of available information normally decreases with increasing distance. With regard to distance and valence, of course, positive and negative valence creates approach and avoidance, respectively.

However, although this three-fold relationship is balanced and ought to produce a stable tendency (i.e., reduced distance when samples are large due to positive valence that reduces distance further, and so forth), further reflection reveals that such a perpetuating spiral must be maladaptive. If organisms sample more information only about positive objects in their close proximity, they must be ill-prepared for dealing with negative information in the distance. Moreover, if many individuals strive for the same positive nearby objects, conflicts abound and resources are soon depleted. Truly adaptive behavior has to include a device that helps the organism engage in regulation proper and thereby to avoid the perpetuating spiral. Accordingly, in a final section, we will introduce a fourth dimension – let us call it dynamic change – that explains how decision targets change their nature as distance decreases and sample size increases, resulting in a shift from intuition to exhaustive processing. As we shall see, this dynamic shift prevents the adaptive system from perpetuation.

Sample size and valence

One basic law of the social ecology in which adaptive learning takes place relates sample size to valence. Other things being equal, social rationality implies that positive task settings create larger samples than negative settings. Quite in line with Thorndyke's (1916) seminal law of effect, saying that reinforcement increases the probability of repeating the reinforced behavior, Denrell's (2005) recent experience-sampling approach makes a strong case for the contention that positive impressions increase the likelihood of continued interaction. In forming impressions of other people, individuals will likely break up the interaction if it is unpleasant or aversive; they will likely continue to interact if the impression is pleasant or positive. A plethora of social-psychological phenomena can be explained by this basic law: Negative initial impressions, or priming effects, are more likely to be frozen and conserved than positive initial impressions, which are likely to be revised through continued interaction. Therefore, negative impressions tend to be more stable than positive impressions, unless the environment enforces continued interaction. Negative initial impressions are more likely to be revised if they refer to proximate others, who warrant continued interaction, affording a natural explanation of the self-serving bias and the ingroup-serving bias (cf. Fiedler, 1996; Fiedler & Walther, 2003).

Translating "small samples" to "intuition", this means that intuitive strategies evolve in negatively toned environment, whereas positive toned learning environments breed more exhaustive strategies. The underlying causal influence may be bi-directional, though. Positive environments breed large samples but, at the same time, small samples may signal negative situations whereas large samples may signal pleasant situations. For instance, data from experiments in a simulated classroom (Fiedler et al., 2002) suggest that teachers tend to direct more questions at students whom they consider good rather than bad students. On one hand, this means that enlarging samples will enlarge positive information on good students more than negative information about bad students. At the same time, the teacher's attentional preference is a diagnostic indicator of her implicit student evaluation.

In the context of statistical decision theories, such as signal-detection theory (Swets, Dawes & Monahan, 2000), the intuitive strategies resulting from negative settings should induce lower decision criteria than the exhaustive strategies that characterize positive settings, as illustrated in Figure 3. Such a response strategy is highly adaptive, to be sure, because in negative situations increasing the hit rate and avoiding misses (i.e., detecting aversive and threatening stimuli) is more important than decreasing the false-alarm rate and increasing correct rejections (i.e., wasting no energy with harmless situations). In contrast, in positive settings, a higher response-criterion is functional because too high a reaction rate might interfere with the consumption and enjoyment of the pleasant situation, and overlooking another pleasant stimulus does not cause much harm. It is impossible anyway to consume many pleasant stimuli at the same time.

The assumption that negative stimulus settings trigger quick decisions based on low thresholds is consistent with several lines of evidence (cf. Dijksterhuis & Aart, 2003), and theoretical conceptions. An analysis of cultural sign systems reveals a much higher diversity of signs signalling danger, threat, and aversive experience than signs pointing to positive referents (Fiedler, 1988), enabling organisms to react faster to negative than to positive stimuli. There are many more different negative traffic signs, action verbs, state verbs, basic emotion words, and facial expressions than positive items in the same sign systems. The very existence of highly elaborated systems of negative signs, does not contradict the assumption that positive stimuli create larger samples. Indeed, elaborated sign systems in the negative domain serve to quickly identify aversive stimuli, in order to avoid and terminate negative stimulation, as nicely delineated in Taylor's (1991) mobilization-minimization model.

There is empirical and anecdotal evidence to support the somewhat counterintuitive notion that intuitive (small-sample) processes are more common in negative than in positive situations. For instance, the so-called face-in-the-crowd effect highlights the readiness to react more quickly (i.e., based on smaller sensual samples) to negative faces hidden in a crowd than to positive faces (Hansen & Hansen, 1988). Analogous findings hold for semantic stimuli (Peeters & Czapinski, 1990; Pratto & John, 1991; Wentura, Rothermund & Wak, 2000).

Kruglanski and Webster's (1996) research on need for closure leads to the same conclusion. The tendency to come to a quick decision is facilitated by aversive states such as time pressure, processing difficulty, laborious and aversive task settings, fatigue, or noise. In contrast, the need to postpone closure and to remain open for additional information increases when the task is intrinsically enjoyable and interesting. The heightened need for closure in negative situations is also evident in an enhanced tendency to reject deviates and not to tolerate dissent (Kruglanski & Webster, 1991). A conceptual analog is the increasing tendency of eyewitnesses to identify a suspect in a line-up when the crime in question is severe and the social pressure is high (Deffenbacher, Bornstein, Penrod & McGorty, 2004). Thus, aversive situations motivate decision makers to adoptlenient decision criteria.

More generally, there is rich evidence for the contention that people spontaneously spend more time with, and search longer for, positive than negative information, but that they make quicker reactions and decisions about negative than positive stimulus objects or persons (Taylor, 1991). This is but a paraphrase of the well-known fact that, in the realm of morality and social inetraction, positive information is more common whereas negative information is more diagnostic or informative, exactly because it is uncommon and normatively unexpected (Gidron, Koehler, & Tversky, 1993; Reeder & Brewer, 1979; Wojciszke, 1994). To be classified as honest or conscientious, a large number of observations has to confirm that someone behaves honestly or conscientiously most of the time, calling for a conservative decision criterion (say, a minimum of 90% honest behavior to constitute honesty). In contrast, to be classified in negative categories, dishonest or unreliable, a small number of one or two negative acts is sufficient.

Sample size and distance

An obvious ecological law says that the sample size of available information about a target object or person decreases with the psychological distance of that target. This pertains to spatial, temporal, cultural distance just as for any other distance dimension. We know more about ourselves than about others, about one’s ingroup than about outgroups. We know more about our own culture than about foreign cultures. We are more informed about the present than about the distant past, or the far-away future. We are exposed to larger samples of information about our own profession, hobbies, and interests than about distant topics of interest and expertise. From the rationale of our theoretical approach, therefore, it follows that decisions planned and drawn from a large distance should be typically intuitive, informed by small samples and relying on lenient response criteria.

What evidence is there to support this prediction? – With regard to temporal distance, to start with, there is indeed a good deal of evidence confirming that decision options in the far away future are mentally represented in more simplified, less multi-dimensional ways than present decision options. For example, in an investigation by Liberman, Sagristano, and Trope (2002), the number of factors required to account for the participants preferences among 25 daily activities was consistently lower when the activities were supposed to take place in 2 to 6 months, rather than the day after.

In a similar vein, simplifying judgment tendencies like the so-called fundamental attribution bias (Gilbert & Malone, 1995; Miyamoto & Kitayama, 2002; Ross, 1977) – explaining behavior only in terms of internal person traits while ignoring situational constraints – increases with temporal distance. Another attribution bias, the so-called actor-observer bias (Fiedler, Semin, Finkenauer & Berkel, 1995; Jones & Nisbett, 1972; Watson, 1982) consists in the tendency to provide more simplifying, intuitive internal attributions for others' behavior than for one's own behavior. In other words, the fundamental attribution error increases not only with temporal distance (from the immediate present to the distant future) but also with social distance (from self to other attributions).

Several language analyses using the linguistic category model (Semin & Fiedler, 1988) have shown that the predicates used to describe temporally and socially distant people and behaviors tend to be more abstract and to provide less contextual detail than descriptions of closer people and behaviors (Fiedler, Semin & Finkenauer, 1993; Semin, 2006).

While this evidence for simplifying representations is strongly but only indirectly suggestive of smaller underlying information samples, more direct evidence comes from free information search paradigms. The tendency to concentrate information search on focal rather than distant entities has been called a positive-test strategy (Klayman & Ha, 1987). Just as scientists use to sample more data about their own theory than about alternative theory, decision makers gather more observations about the decision option under focus (i.e., the low-distance option) than about other, more remote alternative options.

Perhaps the most extensive evidence for the assumption that sample size decreases with psychological distance comes from intergroup research (Fiedler et al., 1999; Linville, Fischer & Salovey, 1989). Simplifying tendencies in judgments of outgroups, as compared with more differentiated judgments of ingroups, are manifested in the outgroup homogeneity effect

(Judd & Park, 1988; Park & Hastie, 1987; Park & Rothbart, 1982), the outgroup-polarization effect (Linville & Jones, 1980), as well as the outgroup-covariation effect (Linville, Fischer & Yoon, 1996). The simple assumption that smaller samples are available for outgroups than ingroups provides a sufficient account of these diverse phenomena. Consistent with this account, reversals of the outgroup-homogeneity effect are typically obtained when ingroups are minority groups, characterized by small rather than large sample size (Simon, 1992).

As an inevitable consequence of the negative relationship that holds between sample size and distance, more lenient criteria have to be accepted for decisions about distal objects (such as outgroups) than for poximal objects (such as ingroups). Again, the causal direction of this assumption is not quite clear. Regardless of whether sample sizes are smaller because distal decisions call for more lenient criteria or criteria have to be more lenient because the available samples for distal decisions are smaller – the result is a negative correlation, pointing to distance as a prominent environmental factor that breeds intuitive strategies.

Distance and valence

Let us finally consider the relationship between distance and valence. For the triad to be balanced, or transitive, positive valence has to be associated with short distance or closeness. If positive samples are large samples and large samples are at a nearby distance, then nearby samples ought to be positive. Indeed, a hardly contested behavioral law states that positive valence induces approach, or reduced distance, whereas negative valence induces avoidance or escape, or increased distance (Brendl, Markman & Messner, 2005). Organisms approach pleasant things and avoid aversive things, exposing themselves to the stimuli they prefer. This notion seems so natural that we refrain here from further elaborations.

Thus, all three dyadic relations – between sample size, distance, and valence – create the consistent picture summarized in Figure 4. Positivity increases proximity which increases sample size. Conversely, negativity increases distance which decreases sample size. All three pairwise relations are mutually consistent and supported by a good deal of empirical evidence.

But nevertheless, something must be wrong with the cycle depicted in Figure 4. A moment of reflection is sufficient to understand that such a perpetuating loop must end up in maladaptive behavior. After a longer period of increasing the relative size of positive samples in close proximity and decreasing the exposure to negative and distant information, the perspective of an organism would be severely impaired. That is, over time, the ability to foresee distant events and to prepare for aversive threats would be lost. In the remainder of our article, therefore, we have to reconcile the incontestable rules summarized in Figure 4 with the needs of successful adaptation and behavior regulation.

Regulation through dynamic change of decision problems

Indeed, such an additional dimension exists and it is not hard to find in the current literature. We call it behavior regulation. Regulation means to prevent systems from perpetuation. Within the present cognitive-ecological framework, it means avoiding an infinite loop that always increases the positivity, density and proximity of some objects and the negativity, scarcity, and distance of others. Without such a regulatory mechanism, organisms would have no chance to recognize that proximal, familiar and seemingly pleasant stimuli have turned into dangerous enemies, or that disregarded distal alternatives have become interesting. Without such a regulatory counter-force there could be no learning, no invention, no minority influence, and no adaptive reaction to a changing environment. Granting the need for such regulation, the crucial theoretical question then becomes how this mechanism can be described.

Indeed, an answer to this question can be found in several psychological models that speak to the interaction of cognitive and environmental factors. No doubt, there is the selective search for pleasant information and the selective truncation of unpleasant settings, which serves to increase the exposure to positive stimuli and to avoid exposure to negative stimuli. However, even though, or exactly because, avoidance and truncation behavior renders negative stimulation so scarce, negative information becomes high in diagnosticity

(Skowronski & Carlston, 1989), highly salient and easy to detect (Hansen & Hansen, 1988), and is therefore given higher weight in judgment and decision making (Baumeister, Bratslavsly, Finkenauer & Vohs, 2001; Hodges, 1974). Thus, the lower density and higher distance resulting from avoidance of negative stimuli is compensated by enhanced sensitivity, diagnosticity, and decision weight. This compensatory rule is at the heart of Taylor's (1991) mobilization-minimization model, and it was anticipated in N. Miller's (1944) famous notion of steeper avoidance than approach gradients. Cahnges in negative valence loom larger than changes in positive valence.

N. Miller's seminal approach to psychological distance regulation was revived and revisited in the modern research program of Trope and Liberman's (2000, 2003) construal-level theory. There is a growing body of evidence showing that the cognitive representation, or "construal", of decision problems changes in a characteristic fashion as the distance from the decision decreases and the amount of information increases. As a matter of rule, decision problems are construed at a lower level of abstractness, or at a higher level of detail, when the decision comes closer. Therefore, cognitive representations of immediately faced, short-term decision problems tend to be more complex and multi-dimensional than representations of long-term decisions in the distant future (or in far-away places or groups). From a large distance, we clearly see the desirability, or intrinsic value, of the central goals or intended outcomes of decision objects. In contrast, from a short distance, we also have to be concerned with the feasibility of decision plans above and beyond their ideal value, or desirability.

For example, when anticipating a fancy holiday trip to South-East Asia next summer, one’s thoughts only revolve around overwhelming historical monuments, beautiful landscapes, friendly people, tasty food, and rich ancient culture. Only when departure time approaches do we begin to deal with the feasibility context, that is, bureaucratic visa affairs, inoculations, potential health threats, communication and transportation constraints, and financial requirements. Thus, with shrinking distance, the problem is getting more multi-dimensional, including feasibility concerns, in addition to the primary desirability dimensions (Liberman et al, 2002). Similarly, the so-called planning fallacy (Buehler, Griffin & Ross, 1994) which refers to the underestimation of the multitude of aspects and the costs of a planned project, can be reduced by “zooming-in” the planning project (Kruger & Evans, 2004), which means to reduce its distance.

However, crucially, the representations resulting from short versus large distance not only differ in dimensionality (i.e., amount of information), but the feasibility concerns associated with short distance also create a new kind of negative valence. The positive valence of large-sample objectives in one's proximity undergoes a shift toward unpleasant, negative aspects. Whereas focusing on desirability from a large distance typically means to focus on positive aspects of desirability, struggling with the feasibility of a near-by decision problem requires one to cope with negative, unpleasant aspects of realism. Although desirability and feasibility are logically independent, it is typically low desirability and high feasibility that correlates with short distance. Recent research by Eyal, Liberman, Trope, and Walther (2004) illustrates this principle. Pro reasons to support an action were more salient when planning a decision in the distant future, whereas contra arguments were relatively more salient from a short temporal distance.

An intriguing speculation to be derived from the present framework is that this shift from focusing the desirability of distant decision options to considering feasibility of nearby options comes along with a shift from choice tasks to estimation tasks. Thus, from a large distance, when information is scarce and the focus is on the intrinsic value of the options proper, we are merely concerned with choices, what is desirable. From a short distance, however, as the trade-off between the options' intrinsic desirability and their pragmatic feasibility becomes more and more apparent, decision problems would be more likely construed as precise quantitative estimation tasks, rather than simplifying qualitative choice tasks. It is important to note that such a shift from choice to estimation task construals is again adaptive, because the assets of small samples can be exploited on distant choice tasks whereas large samples can unfold their information advantages on proximal estimation tasks.

CONCLUSIONS

We believe that our three-dimensional cognitive-ecological framework – involving sample size, distance, and valence – has interesting and far-reaching implications for adaptive behavior regulation. The pairwise correlations that can be observed in the three two-dimensional planes of this framework can be considered functional and almost logically necessary. When making judgments and decisions from a large distance, we have to resort to intuitive strategies because larger samples are simply not available. Likewise, the natural tendency to avoid unpleasant stimuli implies, logically, that intuitive strategies are often applied to negative or aversive situations. The same axiomatic assumption – namely, that organisms approach positive and evade negative stimuli – creates a negative correlation between distance and valence.

However, apart from these logical and ecological a-priori constraints, the manner in which intuition – defined as small-sample processing – correlates with valence and distance is functional and likely to increase accuracy and subjective well-being. Cost-benefit considerations within a signal-detection framework suggest that it is ecologically rational to draw quick and intuitive decisions in aversive settings, based on small evidence samples and low thresholds, just to minimize false positives, that is, in order not to overlook dangerous or painful stimuli. Similarly, it is rational to approach an object and to gather large samples of data before making quantitative estimations, while being able to make quick and timely choices from a distance, when only small samples are available.

However, importantly, we have seen it is also rational that the correlations that hold between valence, distance, and intuition or sample size be subject to dialectic regulation. Although positive valence induces approach behavior, reducing distance and increasing stimulus samples, it would be maladaptive if all individuals were increasingly striving for the same positive stimuli (e.g., all men trying to mate the same women; all animals searching for food in the same attractive place). So as we approach and increase the experience samples with attractive objects, there are feasibility constraints that let us discover unforeseen negative aspects in the stimuli, which turn out to be more multi-dimensional and less ideal than expected. In other words, what appeared to be purely positive turns out to be mixed or even negative in valence. Conversely, seemingly negative stimuli that we have been deprived of or that we have avoided long enough, may in the long run raise our curiosity and turn out to be more interesting and attractive than expected. In other words, just as the impact of hunger on eating is regulated by saturation, or just as the increase in attractiveness as a function of repeated exposure finally produces habituation (rendering frequent stimuli less attractive), the impact of valence on distance and sample size is also subject to adaptive regulation.

We believe that the statistical model we have introduced to illustrate the assets of intuitive decisions helps us to go beyond the mere astonishment and the existence proof that intuitive strategies can be quite adaptive. Rather, our model is intended to show why and under what boundary conditions this is the case. Importantly, we have seen that the assets of intuitive processes operating on small samples are confined to choice problems as distinguished from estimation problems. With regard to the causes and origins, the most intriguing implication is that the assets of intuition arise, to a considerable degree, in the environment, rather than in the individual. The very statistical rules by which stimulus samples of decision objects are distributed around their “true values” can explain why intuitive strategies, based on small samples, may inform more accurate choices and decisions than exhaustive strategies based on large information samples.

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Table 1: Illustration of a Two-Person Dilemma Game

		Agent B	
		1 for myself	3 for the other
Agent A	1 for myself	1,1	4,0
	3 for the other	0,4	3,3

Note: The first payoff in each pair refers to Agent A, the second payoff to B

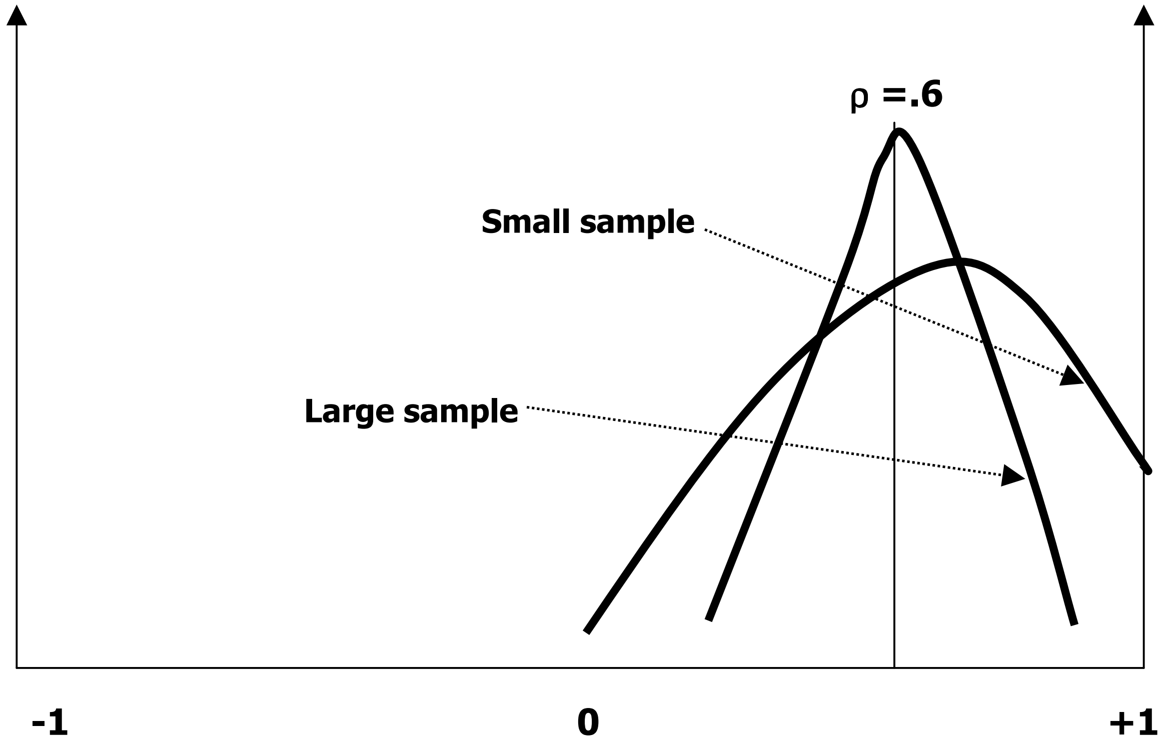
Figure Captions

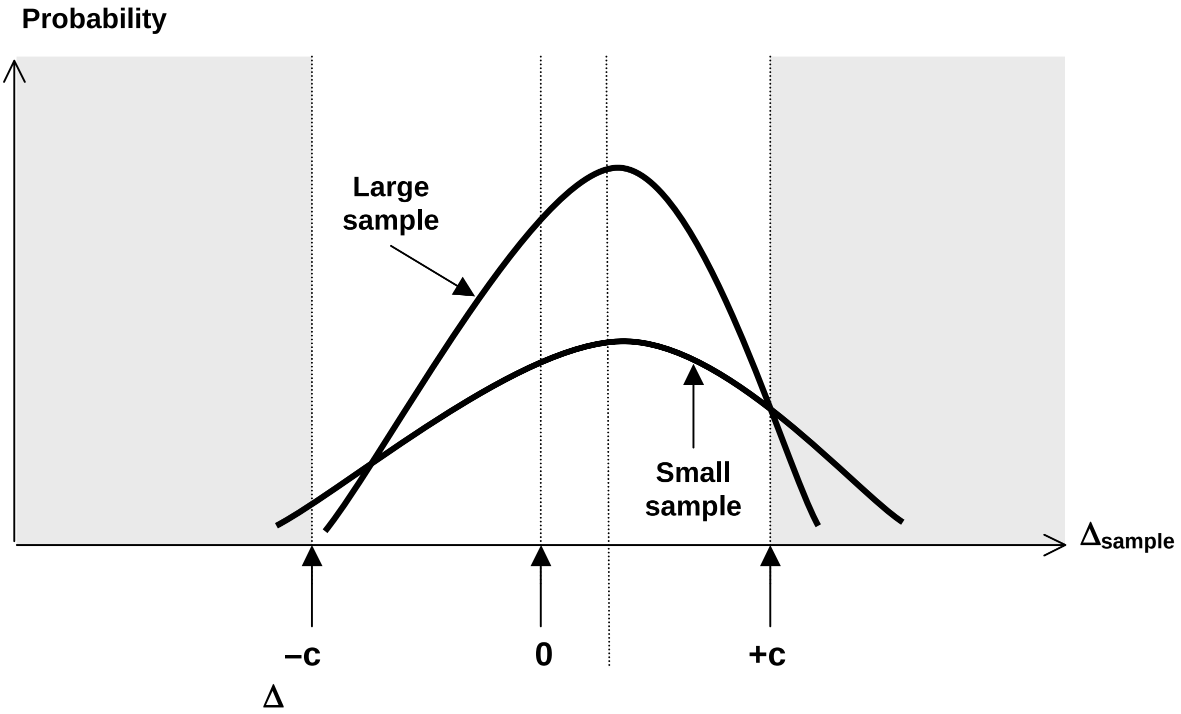
Figure 1: Skew of sampling distribution increases with decreasing sample size, according to a model proposed by Kareev (1995).

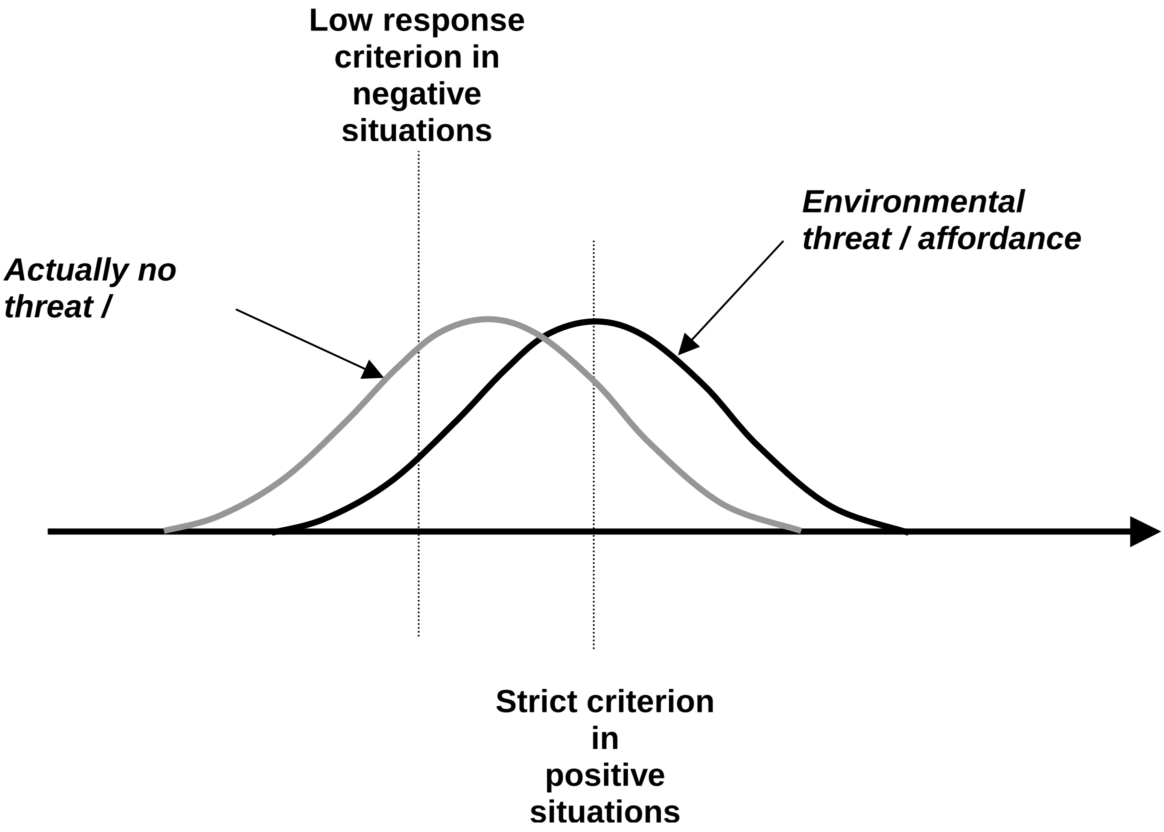
Figure 2: Dispersion of sampling distribution increases with decreasing sample size, according to a model proposed by Fiedler and Kareev (2006).

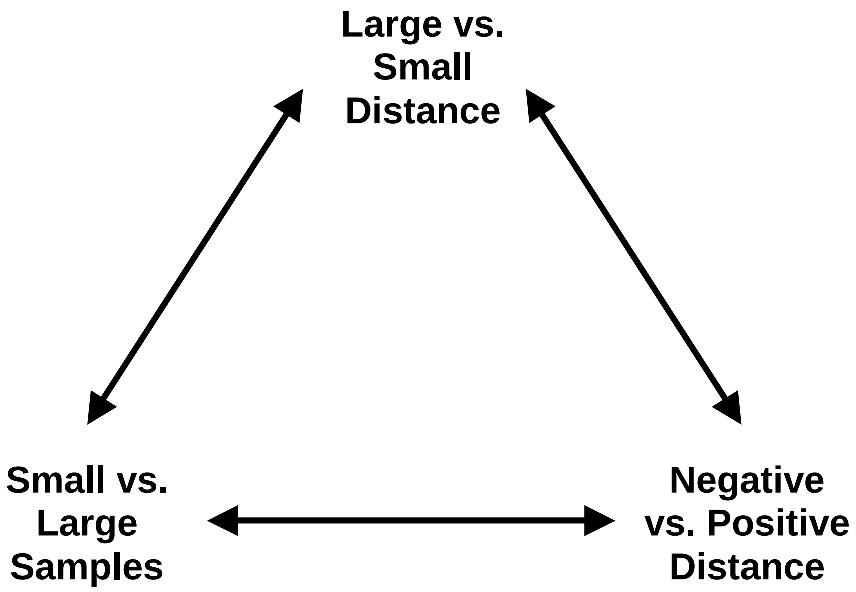
Figure 3: Lower response criterion, warranting more hits (larger proportion of area under the black curve exceeding the criterion) but also allowing for more false alarms (larger proportion of area under the grey curve exceeding the criterion) in negative as compared to positive settings.

Figure 4: Triadic relation between sample size, valence, and distance.


ρ =.6
Small sample
Large sample
-1
0
+1


Probability
Large sample
Small sample
Δ_{sample}
–c
0
+c
Δ


Low response criterion in negative situations
Environmental threat / affordance
Actually no threat /
Strict criterion in positive situations


Large vs. Small Distance
Small vs. Large Samples
Negative vs. Positive Distance

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