# Minimal inference

## An inquiry into Navya-Nyāya in quest of nonhuman logic

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Philosophical inquiry has historically centered on human experiences, including cognition. This focus has often led to the assumption that language, specifically human adult language (hL), is a prerequisite for complex reasoning. However, growing evidence suggests that non-human animals (NHAs) and non-linguistic humans exhibit significant inferential abilities, challenging this assumption. This paper explores the implications of these findings by examining the concept of 'minimal inference'—reasoning that may occur independently of hL. It argues that a critical re-evaluation of the relationship between language and thought is necessary. The paper employs a multidisciplinary approach, combining philosophical analysis with insights from the South Asian Nyāya tradition. While Navya-Nyāya philosophy, with its emphasis on human experience and language, might initially seem anthropocentric, its focus on 'relational logic' and the primacy of perception offers a framework for understanding non-human cognition. By expanding Navya-Nyāya in this direction and examining its technicalities through the lens of contemporary research on NHAs' cognition, this paper aims to contribute to a broader understanding of inference, exploring the possibility of non-linguistic or differently linguistic forms of reasoning. This includes investigating the role of counterfactuality, perception-based concepts, and the potential existence of a 'minimal grammar' in NHAs' cognition.

Keywords: Nonhuman inference, relational logic, perception-based configurational concepts, counterfactuality, Navya-Nyāya.

## 1. Introduction[1]

Philosophical inquiry has, in its history, primarily focused on the experiences and capacities of human adults across all domains. This accent extends to the study of cognition, abstraction, and reasoning, often considered the hallmark abilities of the human adult: rational and endowed with language. A

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long-standing and influential tradition has indeed argued for the direct equivalence of thought and language.

> Aren't thought (*diánoia*) and speech (*lógos*) the same, except that what we call thought is speech that occurs without the voice, inside the soul in conversation (*diálogos*) with itself?[2]

Since the lack of language was straightforwardly equated with the absence or severe limitation of thought, this widely held belief has resulted in the neglect of reasoning abilities in nonhuman animals (NHAs) and non-linguistic humans (such as newborns). Nevertheless, compelling scientific evidence now shows that both NHAs and non-linguistic humans exhibit clear logical reasoning abilities, suggesting that language, if conceived as human adult language (hL), may not be a necessary condition (Kaufman 2021). This field of contemporary research is vast and complex. Given the ongoing nature of the debate, even providing a mere glimpse would be beyond the scope of this paper. Instead, this contribution aims to explore the significant implications of these emerging insights through the lens of logic, philosophy, and textual analysis. In the opening, I will attempt to synthesize the issue in a three-sentence inference, a construction that is both verbal and, in this case, self-referential too:

> Making inferences requires language, namely, hL.
> NHAs do not have hL.
> Therefore, NHAs do not make inferences.

Still, as said, NHAs do exhibit inferential abilities. Based on the uncritical acceptance of the equation between language and thought, this syllogism succinctly exposes the flaw inherent in this assumption when the context shifts. Formally valid and previously taken for granted, this syllogism is now undermined because its conclusion (that NHAs lack reasoning) has been widely disproven. It remains to be seen where the error lies. Two logical possibilities exist, though interconnected. (a) The major premise is false: language (as hL) may not be an absolute prerequisite for making inferences, and nonlinguistic inferences are indeed possible. (b) The minor premise is not entirely accurate: NHAs may possess forms of representation that constitute a type of language, albeit different from hL.[3] Clearly,

[2] SP 263e (1997: 287). All translations are my own, unless otherwise noted.

[3] Specifically, this inference is a *modus Camestres* syllogism, where a negative universal is inferred from an affirmative and a negative one; viz., All *x* are *y*; No *z* is *y*; Thus, no *z* is *x*. In Nyāya terminology, this equates to 'Language pervades inferential capacity.' Consequently, the fallacies (*hetvābhāsa*) involved are: (a) *sādhārāṇa-savyabhicāra-hetu* (overly broad deviating *probans*), where the reason (here, inferential capacity) is present where the *probandum* (here, language) is absent; (b)

this logical possibility does not grant NHAs the ability to speak. Even consciousness itself is another issue entirely. This is not the case of the Houyhnhnms, the savant talking horses in Jonathan Swift's *Gulliver's Travels* (1726). The temptation to resist is, nonetheless, exactly that: clinging to an undue anthropomorphism leading to an overly simplistic 'all-or-nothing' dichotomy. This has historically often resulted in either attributing human-like prerogatives to NHAs or, conversely, reducing them to mere automatons, devoid of any genuine cognitive abilities, as in the case of the Cartesian *bête-machine*.

> Et on ne doit pas confondre les paroles avec les mouvements naturels, qui [...] peuvent être imités par des machines aussi bien que par les animaux (Descartes 1637: *5e Partie*).

On the contrary, these two interconnected possibilities could suggest the existence at least of an alternative, basic, or minimal grammar (mG) in NHAs. A sort of representational structure that, while yet to be defined, would likely differ significantly from the fully developed language observed in human adults (e.g., mG ⊂ hL). Indeed, experimental evidence on NHAs suggests that, even in the absence of hL, complex cognitive processes such as pattern detection, concept formation (despite the intricacies of defining what a concept is), generalization, abstraction, and the recognition of identity, sameness, and difference are evident (cf. *infra*). A possibility that I have elsewhere already tentatively called 'perception-based configurational concepts' (see fn. 4). Consider, for a moment, this passage from Plato about humans.

> Aren't we going to say that it takes expertise in dialectic to divide things by kinds and not to think that the same form is a different one or that a different form is the same? [...] So, if a person can do that, he'll be capable of adequately discriminating a single form spread out all through a lot of other things, each of which stands separate from the others (SP 253d, 1997: 276).

However, for many decades already, it has been recognized that generalization of imprinting responses, to cite an example, allows young birds to recognize their social partners despite individual differences and changing appearances (Bateson 1973). Recent studies have been delving even deeper, for instance, assessing the spontaneous capacity of chicks of the domestic fowl to generalize

*vyāptitvāsiddha* (unestablished pervasion), as an intervening variable (*upādhi*) is active (e.g., a different form of representation). With respect to the following, it may be useful to recall that: *modus ponens*: $p \rightarrow q, p \vdash q$; *modus tollens*: $p \rightarrow q, \sim q \vdash \sim p$.

multimodal patterns to novel objects, possibly indicating "an ability to learn an abstract pattern, i.e., a pattern independent of the particular stimuli by which it is instantiated" (Versace *et al.* 2017: 522).[4]

As said, the study of logical inference has been closely intertwined with the analysis of language, often to the extent that the two have been considered essentially the same (namely, inference within and through hL). Despite this historical focus on language, other forms of reasoning that are either non-linguistic or significantly different from those mediated by hL have to be addressed (possibly inference within and through mG). How then to articulate and analyze these nonlinguistic, or differently linguistic, processes? And what could be the implications of this challenge for our understanding of both logic and cognition? This methodological approach will combine philosophical and textual analysis, with a particular focus on the reciprocal illumination between South Asian texts and contemporary philosophical concerns. The choice of texts from the South Asian tradition is not accidental. In the rich and influential tradition that followed in the footsteps of Aristotle and the Stoics, the equivalence between logical and linguistic analysis has been consistently affirmed. Analyzing an inference has traditionally meant resolving the internal structure of an assertion or proposition, as well as the composition of a series of interrelated assertions. The case of the South Asian logicians of the Navya-Nyāya schools is substantially different. Despite its intellectual depth and potential for comprehensiveness, the explicit focus of the Naiyāyikas remains avowedly anthropocentric, yet not inherently so. Navya-Nyāya non-naïve realism is a radical "relational logic" (Guha 1979: 56), strictly non-predictive and grounded in the primacy of perceptual experience. This theoretical account might therefore offer a fruitful lens for understanding and describing non-human, non-verbal inferential processes. This paper thus attempts an exploration into a topic with which Navya-Nyāya texts do not directly and explicitly engage in detail. Nevertheless, their overall theoretical framework may offer unsuspected insights if systematically questioned regarding NHAs' cognition.

## 2. Perceptive premises

Inference presupposes a qualified form of perception, one that involves the recognition and processing of structured perceptual information. Experimental evidence of reasoning in NHAs, therefore, suggests that this definite perception of properties, patterns, or configurations must be processed in a manner that is either nonverbal or independent of the linguistic frameworks typical of adult human cognition.

[4] Regarding the concept of *svarūpa*, which I translate as 'pattern,' 'configuration,' or 'self-configuration,' consider Praśastapāda (ca. 6th c.) and Śrīdhara's subcommentary (10th c.; PB 1984: 189). A more in-depth discussion of this delicate matter, including perception-based concepts and minimal grammar, can be found in Anrò (forth. 1).

In the words of Gaṅgeśa Upādhyāya, leading figure of the Navya-Nyāya and author of the *Tattvacintāmaṇi*, "inference (*anumāna*), as a [reliable] source of knowledge, is to be described after perception (*pratyakṣa*), due to its reliance on perception."[5] But this has much older roots in the school. The *Nyāyasūtra*, attributed to Gautama Akṣapāda, records how "inference has perception as antecedent".[6] In the commentary *Nyāyasūtrabhāṣya*, this role of epistemic antecedent is described as the direct "vision of [both] the inferential mark itself and the relation between this mark and what bears it [i.e., the inferential subject]."[7]

It thus appears that perception is a primary, foundational process. Clearly, its accuracy cannot always be guaranteed, as perceptual errors are always lurking. Nevertheless, perception remains the primary opening of 'presentational experience' (*anubhava*; Phillips 2012: 163). Not only does it not need further and earlier processes to ground it; on the contrary, it itself grounds any subsequent epistemic act. Says Gaṅgeśa:

> We [hold that perception is] a cognition not having [another] cognition as its trigger (*karaṇa*). In a qualified perception, the cognition of the qualifier is not the trigger, as there is no operation (*vyāpāra*) [qualifying the qualifier]. The cognition of the qualifier [e.g., blue] is a cause [only] in the case of the perception of a *qualificandum* [already] qualified [e.g., a pot]. But the cognition of the qualifier of the qualifier [e.g., Blueness qualifying that blue] does not [operate] as a trigger by means of the cognition of that [second-level] qualifier too, since there is no proof [of that].[8]

A blue color qualifies a pot, with blue being the property that qualifies it. But the perception of that shade of color does not depend on another cognition—for example, on a previous categorization according to which to perceive blue, one must first understand the concept of Blueness (that is, the property that defines what it means to be blue). The qualifying function of blue in the perception of a blue pot is, so to speak, direct. Strictly speaking, it is 'non-constructed' or 'indeterminate' (*nirvikalpaka*).

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[5] Navya-Nyāya can be rendered in English as 'New procedure' or 'New logic;' Gaṅgeśa's text, *Tattvacintāmaṇi* (14th c.), as 'Gem of Reflection on the Truth.' The quote is from TCM (1990: 1): *pratyakṣopajīvakatvāt pratyakṣānantaraṃ* [...] *anumānaṃ nirūpyate*.

[6] The *Nyāyasūtra* (2nd-4th c.), 'Procedural' or 'Logical Strings,' is the founding text of classical Nyāya. The quote is from NS 1.1.5 (1997: 12): *atha tat-*[*pratyakṣa*]*-pūrvakam* [...] *anumānam*.

[7] *Nyāyasūtrabhāṣya* (5th c.) or 'Commentary on the NS' by Vātsyāyana. The quote is from NSB (1997: 12): *liṅgaliṅginaḥ sambandhadarśanaṃ liṅgadarśanaṃ ca*.

[8] TCM (2009: 334): *jñānākaraṇakam jñānam iti tu vayam | viśiṣṭapratyakṣe ca viśeṣaṇajñānaṃ na karaṇaṃ vyāpārābhāvāt | viśiṣṭavaiśiṣṭyapratyakṣe ca viśeṣaṇajñānaṃ hetur na tu viśeṣaṇaviśeṣaṇadhīr api viśeṣaṇadhīdvārā karaṇam, mānābhāvat |*. Regarding *karaṇa*, consider also the following translational choices: 'trigger, chief instrumental cause' (Phillips 2012: 166); 'instrumental cause' (Jha 2001: 129). Regarding *vyāpāra*: "operation, employment in causal operation, which is said to be required of 'triggers' in relation to effects" (Phillips 2012: 171); 'intermediate causal link' (Jha 2001: 375). Consider the abstract *vaiśiṣṭya*: 'the condition of possessing a qualification' or 'the property of being qualified'—thus, *qualificandum* in my translation.

This is not due to vagueness, but because, in the process of determination—termed 'determinate cognition' (*viśiṣṭa-jñāna*) in Navya-Nyāya, involving a qualified subject (*viśeṣya*) and a qualifying property (*viśeṣaṇa*)—it occupies the role of the qualifier, not of the qualified. In other words, in this context, indeterminate refers to 'that which determines by qualifying, while itself remaining unqualified.' Thus, it is a 'pure' or 'primary qualifier.' In a blue pot, the blue is not cognized as the intentional object (*viṣaya*) to be qualified (*viśeṣya*); only 'Pot' is intentionally cognized, and this as blue. Consequently, the blue qualifying a pot is grasped without Blueness, qualifying that blue, being grasped. If, and only if, we were discussing 'Blue' (as we indeed are, in this moment), it would be cognized as an intentional object (*viṣaya*) to be qualified (*viśeṣya*). The epistemic subject cognizes a singly qualified percept—a 'pattern' or a 'self-referential configuration' (*svarūpa*; cf. fn. 4)—with no need to attribute any second-level qualifier to it. To phrase it differently, there is a sort of direct 'cognitive availability' (cf. Phillips in TCM 2009: 628) of the qualifying percept within the context of the determined cognition it helps to constitute. As Gaṅgeśa states, 'Cow' is cognized without the cognition of Cow-ness, and even less so of Cow-ness-hood qualifying Cow-ness.

> Perception is twofold: indeterminate and determinate. In this regard, indeterminate [perception] is never associated with names, classes, etc. It lacks built-in distinctions, and it is devoid of presentation modality [as it would have if it were defined by any qualifier].[9]

> [When a cow has never been seen before], the very first perceptual [qualified] cognition 'Cow' is produced through an [indeterminate] cognition of the qualifier. [This is a cognition that must itself] be formed, since a qualified cognition, like an inference, must be generated [through the attribution of a property to a subject: e.g., 'This is a cow' or 'This is qualified by Cow-ness']. In this case, memory is not involved [by definition], due to the [perceiver's] lack of experience with Cow-ness in his life.[10]

Regarding the highly problematic and widely debated question of the possibility and mutual roles of determinate and indeterminate perceptions, Gaṅgeśa argues the latter serves a crucial epistemic function, the purpose of which is primarily causal, effectively interrupting a potential infinite regress

[9] TCM (2009: 609): *tac ca pratyakṣaṃ dvividhaṃ nirvikalpakaṃ savikalpakañ ceti | tatra nāmajātyādiyojanārahitaṃ vaiśiṣṭyānavagāhi niṣprakārakaṃ nirvikalpakam |*. Regarding *prakāra:* 'predication content, way' (Phillips 2012: 167). Consider also Banjeree (1972: 96): "Indian thinkers [i.e., Nyāya exponents] did not consider knowledge as a case of predication, and their concepts of *viśeṣa* and *prakāra* do not correspond to the Western concepts of subject and predicate." I conceive of *prakāra* accordingly as the 'presentation' or 'appearing modality' of a content in the context of its cognition. Regarding *vaiśiṣṭyānavagāhin*: "not grasping a qualificative relationality" (Phillips in TCM 2009: 609). Note that the term, through the prefix *an-*, negates *ava√gāh* 'to plunge into.'

[10] TCM (2009: 627): *prāthamikaṃ gaur iti pratyakṣaṃ jñānaṃ janyaviśeṣaṇajñānajanyaṃ janyaviśiṣṭajñānatvāt anumitivat | na ca smaraṇaṃ tatra saṃbhavati | tajjanmani tena gotvasyānanubhavāt |*.

(from Cow to Cow-ness, to Cow-ness-hood, etc.). Actual epistemic acts consist of nothing but determinate cognitions. What determines cognition about an object is the attribution of a qualifier to that object, for example, the qualifying color with respect to the pot. Thus, this is no longer just a pot; it is also blue. But this qualifier in turn derives from what? Necessarily, the determinate perception 'Blue pot' (i.e., 'A pot qualified as blue') must arise from an indeterminate one—that is, the perception of a qualifier whose own qualification is not considered within that specific cognitive act, lest infinite regress. In sum, to perceive blue, it is not necessary to know what the being blue of blue means.

But this is not all. Beyond the crucial immediate availability of primary qualifiers, even determinate cognition itself does not appear to be reliant on hL but may be grounded in more fundamental forms of epistemic frames (which I have tentatively called 'minimal grammar'). Recognizing color in an object, the specific individuality of social partners in birds (cf. *supra*, Bateson 1973), or, in general, complex patterns of stimuli do not seem to depend on linguistic faculties in the manner of hL. Fowl chicks not only recognize identities and differences but also generalize them multimodally (cf. *supra*, Versace *et al.* 2017).

## 3. One example among many

Setting aside the cognitive abilities of complex organisms such as cetaceans, primates, and even fowl chicks, a much simpler model, the *Polistes* paper wasp, could prove more useful in this context. Considering the range of cognitive abilities within the phylogenetic differentiation of the species, its cognitive capacities may represent a point sufficiently distinct from those of a verbally competent adult human. Nonetheless, with a brain volume of approximately 0.125 cubic millimeters (cf. Gandia 2022), this invertebrate demonstrates logical reasoning abilities in transitive inference.

Transitive Inference (TI) is a complex form of reasoning previously thought to be limited to vertebrates. It involves the ability of "animals to use known relationships to deduce unknown relationships" (Vasconcelos 2008). In their experiments with wasps, Tibbetts and colleagues (2019) metaphorically describe TI through the relation of "greater than"—that is, TI = $(A>B) \wedge (B>C) \rightarrow (A>C)$ (If A is greater than B and B is greater than C, then A is greater than C). The study shows that paper wasps perform TI by their ability to learn to discriminate between elements within a series and then successfully apply this knowledge to novel, untrained items. In particular, wasps were first trained to discriminate pairs of colors (here labeled with a letter) in association with an adverse stimulus, according to the following pattern: $A_0B_1$, $B_0C_1$, $C_0D_1$, and $D_0E_1$, where '1' means the association of the color with an electric shock, whereas '0' its absence. Then, individuals were tested on novel pairs without training (viz., B versus D, A versus E). Tested individuals choose B more frequently than D and

A more frequently than E, showing they organize the trained stimuli into the implicit hierarchy A > B > C > D > E and use TI to choose between untrained pairs. The outcome clearly shows that Polistes wasps consistently avoid the element that is logically 'greater,' so to speak, demonstrating their ability to form a mental hierarchy while applying TI proficiently.

## 4. How could a non-language-based inference look like?

The stock example used in Navya-Nyāya to describe inference evokes the image of smoke and fire, according to what could be expressed through *modus ponens* (cf. fn. 3) as:

> [1] Smoke → Fire, Smoke ⊢ Fire
> If Smoke, then Fire; and Smoke, then Fire

In its simplest expression: *yatra yatra dhūmas tatra tatra vahniḥ* 'Wherever there is smoke, there is fire.' The reliability of this relation is more than robust, and its significance offers even deeper insights.[11]

Confirming its essentially non-predicative and non-hL-based nature, Navya-Nyāya logic is not formalistic, although potentially formalizable. The validity of the inference is not derivable from its internal structure (as in the case of the syllogism, for example) but from the exogenous relation of the properties involved. Indeed, Navya-Nyāya analyzes "the process of inference as a process of knowing and is invariably talking about objects of knowledge and not about words or sentences" (Bhattacharyya 2001: 169). In the inference 'If smoke, then fire,' nothing grounds the conclusion except for the actual observed relation between smoke and fire. This inference is first founded upon the relation 'Fire is the locus of smoke.' Although smoke is associated with fire loci, there can be fire without smoke, as exemplified by a glowing metal lump (*tapta-ayaḥpiṇḍa*). Consequently, for reasons of quantification, it is necessary to define the inverse relation of 'Being the locus of,' namely, 'Smoke is the *superstratum* with respect to fire' (cf. Anrò 2022: 18-20). In the jargon of Navya-Nyāya, which, while rooted in natural language, develops into a highly structured technical language (Bhattacharya 2007), this relationship between smoke and fire could then be described as: *yā dhūmatva-avacchedaka-avacchinna-ādheyatā sā vahnitva-nirūpitā*, or '*Superstratumness*, limited by the limitor *smoke-hood*, is conditioned by *fire-hood*,' that is, 'Every smoke is on some fire.' Nonetheless, fire too has a locus. Hence, observing smoke in the distance on a mountain allows for the inference of an underlying fire. The inferential subject (*pakṣa*)

[11] Regarding the relation between fire (as combustion, that is, rapid oxidation) and smoke (as the eventual colloidal dispersion of particulate matter produced by combustion), see Anrò (forth. 2) and Turns (2000: 3-6).

exhibits one property that is invariably connected with another. The former is thus the inferential reason or *probans* (*hetu*) whereby the latter can be inferred as *probandum* (*sādhya*). The mountain exhibits smoke, which invariably co-occurs with fire. Within the theoretical framework of Navya-Nyāya, the logical structure of formula [1] can thus be rephrased in general terms as:

> [2] *yadi sahetupakṣaḥ sādhyavyāpyahetuś ca, tarhi sādhyavatpakṣaḥ*
> If the inferential subject exhibits the *probans* and the *probans* is pervaded by the *probandum*, then the inferential subject possesses the *probandum*

In light of [2], the theory of inference in Navya-Nyāya appears as a "theory of substitution, where one property, by virtue of its logical relation with another property, forces the substitution of the latter in its place" (Matilal 1998: 22–24). The entire inferential process is grounded on *vyāpti*, an 'invariable concomitance' (Goekoop 1967) or 'pervasion' (Ingalls 1951), a relationship between two properties whereby one is never found without the other and is therefore 'pervaded' by it, but not necessarily vice versa. Gaṅgeśa wonders:

> Regarding the cognition of pervasion as the *reason* (*hetu*) for inferential knowledge, what is this pervasion?[12]

His answer is not immediate. In a first approximation, it can be said that:

> [Pervasion] is a non-deviation, being the non-occurrence [of the *probans*] in what possesses the absence of the *probandum*.[13]

However, as reasonable as this may sound, this is still an insufficient formulation for quantification reasons. It has to be noted that "instead of quantification, Naiyāyikas use double negatives and abstract substantives to accomplish the same result" (Matilal 1964: 88). The highly technical, and at first sight even convoluted, 'conclusive definition of pervasion' (*vyāpti-siddhānta-lakṣaṇa*) can be thus articulated as follows:

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[12] TCM (1990: 27): *nanv anumiti-hetu-vyāpti-jñāne kā vyāptiḥ?* Consequently, freely rearranging this question, we can get the positive definition: *hetu-vyāpti-jñānam ity anumitiḥ*; 'Inferential knowledge is the cognition of the pervasion of the *probans* [by the *probandum*].'

[13] TCM (1990: 27): *... (na) avyabhicaritatvaṃ, tad dhi (na) sādhyābhāvavad-avṛttitvaṃ*. I provisionally omit here the negations (*na*) present in the original text. This passage is part of the so-called *vyāpti-pañcaka-lakṣaṇī*, Gaṅgeśa's refutation of five insufficient definitions of *vyāpti*. Subsequent paragraphs will clarify that these definitions are not entirely false, but rather useful provisional approximations that will ultimately be refuted—hence, Gaṅgeśa's *na*.

> Pervasion is the coreference of that [property in the role of pervaded *probans*] with what is [never] defined as the limitor of the counterpositivity of a constant absence in [that] coreference with that [*probans*] that is not coreferred with the counterpositive [of that absence].[14]

The pervaded property cannot coexist with the absence of the pervading property, for this latter is itself precluded under those conditions. In other words, "pervasion of *x* [e.g., smoke] with *y* [fire] is *x*'s concurrence with such a *y* as is not the counterpositive of an absence that occurs in the locus of *x*" (Matilal 1968: 80). Notably, in this form of inference, no separate middle term is necessary. The key point is instead to combine the two premises into a comprehensive *parāmarśa*, a 'complex judgment,' a 'consideration,' or a sort of 'cognitive putting together.'[15] What is essential is cognizing 'The mountain possessing smoke as pervaded by fire.' In general terms, and as an abridged form of [2], [2a] follows:

> [2a] *sādhyavyāpyahetumān pakṣaḥ*
> The inferential subject [*pakṣa*] possesses the *probans* [*hetu*] as pervaded by the *probandum* [*sādhya*] (cf. also Bhattacharya 2001: 22).

## 5. Nonlinguistic grasps

In order to possibly describe nonhuman inference, it becomes crucial at this point to better define the cognitive processes underlying that complex consideration that apprehends the pervasion between two properties. The author of the *Tattvacintāmaṇi* devotes a section to the 'means of apprehending pervasion' (*vyāpti-grahopāya*), beginning with a series of critical remarks:

> Repeated observation is doubtful. Suppositional reasoning is flawed by infinite regress. Then, how is pervasion grasped?[16]

From Russell's turkey to black swans and red herrings, induction fallacies prevent us from concluding with certainty. Gaṅgeśa seems to be aware that repeated observation is insufficient. Moreover, repeated exposure to stimuli, their retention, association, and composition in complex architectures

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[14] TCM (1990: 100): *pratiyogy-asamānādhikaraṇa-yat-samānādhikaraṇa-atyantābhāva-pratiyogitā-avacchedaka-avacchinnaṃ yan na bhavati tena samaṃ tasya sāmānādhikaraṇyaṃ vyāptiḥ*. Cf. Goekoop (1967: 109-111): "Pervasion is the fact that that which constant absence shares a locus with, without sharing the locus with its counterpositive, shares a locus with that which is not what is determined by a limitor of the counterpositiveness to that absence."

[15] Quotes are respectively from: Bhattacharyya (2001: 178-182), Jha (2001: 257), and Phillips (2012: 167).

[16] TCM (1990: 209): *evaṃ bhūyodarśanam api saṃśāyakam, tarkas tv anavasthāgrasta eveti kathaṃ vyāptigrahaḥ?*

of reflexes appears to be exactly what contemporary experimental evidence is overcoming in nonhuman cognition. Secondly, 'hypothetical' or 'suppositional reasoning' (*tarka*) is also logically flawed in grounding pervasion. It suffers from 'infinite regress, for *tarka* itself is rooted in a grasp of pervasion.'[17] In light of the above, Gaṅgeśa argues that:

> Pervasion grasping is the observation of co-occurrence [of pervaded and pervader], together with no cognition of any deviation.[18]

In other terms, it consists of perceptual observation plus a cognitive surplus that cannot be reduced to the mere association of stimuli. Inference is different from mere association or simple belief because it is characterized by the certainty of its conclusion. The question concerning that cognitive surplus that underpins inferential certainty has thus evolved into the 'doubt of *non sequitur*' (*aprayojaka-śaṅkā*), which can be summarized in the stock formula: *hetur astu sādhyam māstu*, 'Given the *probans*, *probandum* could not be.'

> Doubt can arise from the suspicion regarding [the intervention of] additional conditions (*upādhi*) or from the observation of common properties accompanied by non-observed particulars. This [doubt] can sometimes be dispelled through suppositional reasoning that obliterates counter-instances; sometimes, [its resolution] can be self-evident. If [it is argued that] the rooting of pervasion appraisal in suppositional reasoning [implies] infinite regress, it is not so insofar as suppositional reasoning follows doubting. When doubt does not appear, due to [patent] contradiction, pervasion is grasped without suppositional reasoning.[19]

One type of compelling evidence—that likely does not occasion the arising of any doubt and, hence, no suppositional reasoning—could involve the systematic administration of adverse stimuli (AS). Typically, AS lead individuals to consistent avoidance behavior. This constitutes a form of 'if–then' so

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[17] TCM (1990: 212): *tarka-vyāptigraha-mūlakatvena anavastheti*. Note *mūla-ka-tva*: the 'condition of having roots in.'

[18] TCM (1990: 210): *vyabhicāra-jñāna-viraha-sahakṛtaṃ sahacāradarśanaṃ vyāptigrāhakam*.

[19] TCM (1990: 211–2): [*śaṅkā*] *kvacid upādhisaṃdehāt kvacid viśeṣādarśana-sahita-sādhāraṇa-dharma-darśanāt | tadvirahaś ca kvacid vipakṣa-bādhaka-tarkāt, kvacit svataḥ siddha eva | tarkasya vyāptigrahamūlakatvānavastheti cen na yāvad āśaṅkāṃ tarkānusaraṇāt | yatra ca vyāghātena śaṅkaiva nāvatarati tatra tarkaṃ vinaiva vyāptigrahaḥ |*. Regarding *upādhi*, consider also the following translation choices: 'imposed property' (Ingalls 1951: 140; Matilal 1968: 33; Jha 2001: 127); 'condition' (Sarma in MK 1960: 37; Matilal 1968: 84); 'accident' (Goekoop 1967: 14); 'inferential undercutting condition' (Phillips 2002); 'additional condition' (Phillips 2022). See also TCM (1990: 293–294), where *upādhi* is defined as pervading the *probandum*, but not the *probans*. For example, while 'There is fire, because there is smoke' is true, the inverse inference, 'There is smoke, because there is fire,' is false. This is because the intervening condition 'wet fuel' (*ārdra-indhana*) pervades the *probandum* (here, smoke), but not the *probans* (here, fire). For a concise overview of Gaṅgeśa's contributions to *tarka*, refer to Bagchi (1953: 32–38). Consider also Anrò (forth. 2).

direct and immediate as to risk being mistaken as a simple conditioning, unless specifically investigated through experimental protocols, such as those employed by Tibbetts and colleagues (cf. *supra*). This is an issue that I will return to shortly. For the time being, if there is no such compelling evidence, doubt arises. According to Gaṅgeśa, this doubt can only be dispelled through hypothetical reasoning and never by the mere repetition of experience. Then, what constitutes hypothetical reasoning? To a first approximation, *tarka* is neither knowledge (*pramā*) nor an independent means of knowledge (*pramāṇa*) in the proper sense, but a useful, sometimes necessary, auxiliary process. *Nyāyasūtra* states in this regard:

> [Applied] to an object whose features [remain] undiscerned, hypothetical reasoning [involves] postulating a potential cause in order to know those features.[20]

In the same vein, the anonymous *Gem Sliver* (*Maṇikaṇa*; ca. 16th c.), a widely circulated compendium of the *Tattvacintāmaṇi*, describes in summary the technicalities of *tarka* as follows:

> Hypothetical reasoning is the assumption of the pervader through the assumption of the pervaded. [...] It is performed through the conjecture named 'accessory assumption of the pervaded' and through the 'ascertainment of the deviation of what is [supposed] to occur.'[21]

For the sake of clarity, let us recall the *modus ponens* inference already expressed in [1]:

> [1] Smoke → Fire, Smoke ⊢ Fire
> If Smoke (as pervaded), then Fire (as pervader). And Smoke, then Fire

This certainty is now undermined by a lingering doubt: Is it not the case that smoke can exist even in the absence of fire? If applying *tarka* entails assuming by hypothesis the conclusion to be proved through the inversion of pervaded and pervader, then formula [2] is derived (in this case, assuming the

[20] NS 1.1.40 (1997: 36): *avijñātatattve 'rthe kāraṇopapattitas tattvajñānārtham ūhas tarkaḥ*. I translate *ūha* with 'postulating' or assuming a possibility as a basis of reasoning. While translating *tarka* and *ūha* respectively as 'deliberation' and 'reflection,' Kang (2010: 3, 5) notes along similar lines: "*ūha*, taken as the content of *tarka*, is generated by consideration of the reasons postulated for each possibility. [Thus], the reason for each assumption is, at least epistemologically, furnished before the *tarka* process begins, and, secondly, that the reasons (*kāraṇa*) relating to any concrete case are considered only after dealing with hypothetical cases. In this way we come to understand Jhā's translation for *tarka* as 'hypothetical reasoning' [cf. Gaṅgānāṭha Jhā's English translations of the *Nyāya-sūtra*, 1912-1919]."

[21] MK (1960: 34–35): *tarko nāma vyāpyāropeṇa vyāpakāropaḥ | [...] tarke vyāpyasyāhāryāropo nāma tarkaṇam āpādya-vyātireka-nirṇayaś ca kāraṇam iti dik ||*. Regarding *āpādya-vyātireka-nirṇaya*: 'accomplishment of what is not to be caused' (Jha 2001: 88); 'decisive knowledge of the opposite of the deduced' (Sarma in MK 1960: 37).

absence of smoke by assuming the absence of fire). This formula is perfectly equivalent to [1], through *modus tollens* (cf. fn. 3).

> [2] ~Fire → ~Smoke, ~~Smoke ⊢ ~~Fire
> If there is no fire (as pervaded), then there is no smoke (as pervader). Yet, it is false that there is no smoke (since there is). Thus, it is false that there is no fire (since there is).

But doubt arises precisely about the certainty of formula [2]. May there be instances where smoke is produced even in the absence of fire? To express this doubt, formula [2] is modified into a new, hypothetical pervasion:

> [3] ~Fire → Smoke
> If there is no fire, then there is smoke.

The second step of *tarka* involves identifying a possible 'deviation of what is supposed to occur' (here, the presence of smoke in the absence of fire). Empirical evidence must therefore be gathered to support or refute this new hypothesis. Identifying a relation of pervasion involves observing the co-occurrence of the two properties in question while also accounting for potential deviations (cf. fn. 19). Stock Navya-Nyāya counterexamples, such as those involving the kitchen hearth and the lake, respectively, illustrate the actual presence and absence of smoke under the conditions imposed by [3]. Counterfactual formulae [4] and [5] then follow, along with their confutations.

> [4] ((~Fire → Smoke, ~Fire ⊢ Smoke) ∧ Lake) ⊢ ~ (~Fire → Smoke)
> If there is no fire, then there is smoke. There is no fire. Thus, by *modus ponens*, there is smoke.
> BUT, in the case of a lake, both smoke and fire are absent. Consequently, the lake counterexample falsifies the pervasion stated in [3].

> [5] ((~Fire → Smoke, ~Smoke ⊢ ~~Fire) ∧ Hearth) ⊢ ~(~Fire → Smoke)
> If there is no fire, then there is smoke. There is no smoke. Thus, by *modus tollens*, the absence of fire is absent.
> BUT, in the case of the kitchen hearth, while fire is present (or its absence is absent), smoke is also present. Therefore, the hearth counterexample falsifies the pervasion stated in [3], which, under the conditions outlined in [5], erroneously allows for the inference of fire from the absence of smoke.

In the wasp experiment—since *yatra yatra kramottararūpaṃ tatra tatra duḥkham* 'Wherever, in a sequence, there is a higher-ranked color (HRC), there is pain'—the color rank functions as the inferential mark (*hetu*), being the property pervaded by the aversive stimulus (AS). AS, in turn, is the

pervader (*vyāpaka*) to be deduced (*sādhya*) and so avoided. To see that rank implies the anticipation of pain, achieved through transitive inference rather than mere association, as definitively established by Tibbetts et al. Formally:

[6] HRC → AS, HRC ⊢ AS
If HRC (as pervaded), then AS (as pervader). And HRC, then AS

In this instance, applying suppositional reasoning and questioning the occurrence of HRC without AS will initially generate the equivalent formula [7], followed by the derivation of the two contradictions [8] and [9], erroneously suggesting the possibility of HRC without AS.

[7] ~AS → ~HRC, ~~HRC ⊢ ~~AS
If there is no AS (as pervaded), then there is no HRC (as pervader). Yet, it is false that there is no HRC (since there is). Thus, it is false that there is no AS (since there is).

[8] ((~AS → HRC, ~AS ⊢ HRC) ∧ ~HRC) ⊢ ~ (~AS → HRC)
If there is no AS, then there is HRC. There is no AS. Thus, by *modus ponens*, there is HRC.
BUT, in the experimental setting, the absence of AS always corresponds to the absence of HRC. Consequently, the generated contradiction falsifies the claims made in [8] and its underlying assumption.

[9] ((~AS → HRC, ~HRC ⊢ ~~AS) ∧ ~AS) ⊢ ~(~AS → HRC)
If there is no AS, then there is HRC. There is no HRC. Thus, by *modus tollens*, the absence of AS is absent.
BUT, there is no case of HRC absence and AS presence. Consequently, this contradiction falsifies [9] and its assumption.

Given the experimental constraints, which limit behavior to rigid patterns ('Choose and move toward one of the two colors'), formulae [8] and [9] exemplify an otiose *tarka*, generating what Gaṅgeśa would consider a 'patent contradiction' (cf. fn. 19), rather than a genuine suppositional reasoning in the presence of a doubt. From a logical perspective and disregarding the practical challenges (or even the impossibility) of implementing such an experiment with wasps, testing *tarka* would have required breaking dull repetitions while concealing the colors and allowing subjects to counterprove or disprove their rank based on the presence or absence of the painful stimuli. In this event, formula [8] would describe the previous experience of AS absence and confirm the subsequent HRC absence, disproving the counterfactual hypothesis of its presence. The same holds true for formula [9], where the presence of AS in covered colors would predict the absence of HRC, thereby refuting the contrary doubt.

While pragmatically unfeasible within this experimental setting, this application of *tarka* nonetheless retains significant logical value. Indeed, it not only has falsified the dubious hypothesis ~AS → HRC but has also revealed the genuine pervasion HRC → AS to be in truth a 'mutual pervasion' (*samavyāptitva*), as expressed by the biconditional HRC ↔ AS. Indeed, the counterevidence now ensures that there is no HRC without AS, and conversely, no AS without HRC, within a previously unassessed epistemic increment.

## 6. A three-step pyramid

In the words of the *Gem Sliver*, "Inferential knowledge is a cognition produced by the assessment of a property in the inferential subject, as qualified by a pervasion."[22] Still, further insights can be gleaned: three epistemic levels take shape within this inferential account.

As said, inference is grounded in pervasion. In turn, this latter necessitates prior and iterated empirical observations (*bhūyodarśana*) of co-occurrences (*sahacāra-darśana*). It is thus a matter involving stimuli assessment, retention, and recognition, which are all epistemic acts far from trivial but appear to be qualified by complex pattern discrimination (which I connect to the notion of *svarūpa-ālocana*; cf. Anrò, forth.1). The significance of perception in these processes cannot be overstated. Discriminating implies the ability to manage identity and difference (*tādātmya* and *bheda*, or *anyonyābhāva*), generality and particularity (*sāmānya* and *viśeṣa*) in a manner that exhibits some of the key features of concept formation, although not hL-like. This onset level of appraisal can, furthermore, be considered analogous to logical conjunction ('And') and closely aligned with psychological association ('This and that,' roughly speaking).[23]

Building upon that, a second phase emerges. Characterized by a deeper level of cognitive processing, this phase involves the formulation of relations that approach the sophistication of fully-fledged inference. The second step thus suggests a cognitive increment, as expressed by the material implication 'If–Then.' Co-occurrence observation is now defined as the 'non-deviation' (*avyabhicāra*) between two properties. This leads to the emergence of an implicit inductive pseudo-rule, analogous to a generalized 'That's so' statement, if that were expressed linguistically. However, at this stage of refinement, mere non-deviation can be an inexhaustible source of biases, susceptible to undue generalizations and to the influence of parasite intervening variables (*upādhi*).

[22] MK (1960: 30): *vyāptiviśiṣṭapakṣadharmatājñānajanyaṃ jñānam anumitiḥ.*

[23] For a critical rethinking of classical conditioning, emphasizing its functional role in an ecological perspective and its capacity to represent the environment as event relations, see Rescorla (1988) and Honey *et al.* (2020, 2022).

A third step contrasts the pair of co-occurrence and non-deviation with the doubt of *non sequitur* (*aprayojaka-śaṅkā*), prompting critical examination: 'This and that. Then, that's so. But what if not?' The counterproving procedure, through suppositional reasoning (*tarka*), modulates logical quantification and incorporates multiple refutations, as in formulae [2] to [5]. The material conditional 'If Smoke, then Fire' is reformulated as the double negation 'Fire can never be the counterpositive of an absence where Smoke occurs.' This signifies a transition from an inductive pseudo-rule to a counterfactual proper rule, linguistically expressible as 'It can't be different.' At this juncture, the inferential process unfolds incrementally in three stages: perceptual co-occurrence, non-deviation, and hypothetical counterproof. According to Gaṅgeśa, only the third stage, involving the grasping of pervasion through hypothetical counterproof, constitutes a rigorous inference. This signifies that inference acquires its distinctive characteristic (*lakṣaṇa*) through this hypothetical turn, which inherently involves negation and counterfactuality.

## 7. Conundrum of mice and men, rethought

Inference hinges on the assessment of a property's pervasiveness. This procedurally reduces to a unique cognitive act, *parāmarśa* (cf. §4): 'a cognitive putting together' that simultaneously perceives a property and apprehends its inherent link with another. In the case of *Polistes* wasps, the aversive stimulus (AS) is not directly associated with a particular color. Instead, AS pervades all colors 'greater' in the hierarchy (according to Navya-Nyāya jargon and Tibbetts *et al.*'s metaphor). According to that specific transitive inference, seeing a higher-ranked color (HRC) within the series implies seeing it as pervaded (*vyāpya*) by the pervading (*vyāpaka*) AS. This experiment constructs the inferential rule from the straightforward material conditional HRC → AS, without puzzling variables, detours, or risks of undue generalization. Under this condition, wasps exhibit a proficient grasp of that pervasion (*vyāpti*) at the second level of the inferential pyramid (as outlined in my interpretation of Gaṅgeśa's texts). As mentioned, the second level involves the repeated (*bhūyas*) observation of a co-occurrence (*sahacāra-darśana*) plus its 'non-deviation' (*avyabhicāra*), without entertaining any *non sequitur* doubt (*aprayojaka-śaṅkā*). In other words, perception-based pervasion entails non-deviation between properties, essentially being conceived as consistent co-occurrence. Still, there is no evidence suggesting they can reach even the third one, involving negation and counterfactuality.

In wasp experiments, tests are repeatable *ad libitum* without significant changes: selecting the HRC results in a shock, while selecting the other color avoids it. Due to the contingent constraints imposed by the experimental design, the pseudo-rule at the second level (HRC → AS) *de facto* overlaps with the genuine rule at the third level (HRC ↔ AS; cf. §5). Given Gaṅgeśa's analytical framework, the

pervasiveness is evident and renders any doubt of spurious correlation pragmatically superfluous. In general, a second-level pseudo-rule is fallacious not because it fails in practice, but rather due to its inherent logical imperfection: the potential for erroneous conclusions in specific instances, if any. Introducing counterfactual reasoning in wasps' second-level deduction refines the inference, logically securing its conclusion, yet without any practical effect (cf. [8]-[9]). If NHAs can perform transitive inferences, as paper wasps demonstrate, one might be tempted to conclude that at least the third level of the inferential pyramid is a uniquely human capacity. This would require the ability to deal not only with perception-based configurational concepts in a minimal grammar but also with hypothetical and counterfactual states of affairs, involving suppositions, negations, and absences, supposedly only manageable in hL. This is an angle of observation that may open up some avenues for further insights.

First, what if a group of humans were subjected to an experiment similar to that conducted with *Polistes*? Human counterfactual abilities would not emerge. In hostile environments, prioritizing self-preservation over adherence to strict logical truth by adopting broad pseudo-rules to avoid adverse stimuli might be a prudent solution, even for proven counterfactual intelligences. Moreover, counterfactual validation was not even feasible in that specific experimental setting, as only a straightforward answer was possible. While it remains uncertain whether NHAs possess a full capacity for counterfactual reasoning, explicitly testing them to determine the presence, extent, and nature of their potential counterfactual abilities could reveal unexpected cognitive resources. Experimental design is crucial, as experimenters are well aware.[24]

Furthermore, it is a well-established fact that humans exhibit behaviors that significantly deviate from strictly rational and optimal decision-making, especially when faced with challenging situations or limited epistemic foundations (cf., e.g., Bicchieri 2016 and Spiegelhalter 2024). Humans do not prove themselves to be impeccable reasoners even in controlled environments with epistemically favorable conditions if only the variables involved are less readily apparent. In a now-classic experiment, cognitive psychologist Peter Wason showed that people often struggle with logical thinking, leaning towards confirmation biases and 'positive tests' over counterfactual validation. In Wason's selection task (1966, 1968), participants were presented with four cards, each displaying a letter on one side and a number on the other. The visible sides of the cards showed, for example, 'A,' 'K,' '4,' and '7,' while the rule to be tested was 'If Vowel, then Even.' When asked to tell which cards they must turn over to definitively test the rule, participants tried to confirm the condition and tended to choose the cards with 'A' and '4.' In Navya-Nyāya jargon, most subjects thus demonstrated reasoning at the level of

[24] As a mere title of reference, consider, among the many, Bohn *et al.* (2020) and Dautriche *et al.* (2022).

*sahacāra* plus *avyabhicāra*, while neglecting *tarka*. Only a small minority made use of the falsification tool and chose the right cards, namely, 'A' and '7.' Results underscore that card '7' is the source of the issue. If individuals who failed the test had applied *tarka*, the hypothetical state of affairs 'If not Even, then Vowel' would have been generated through the 'accessory assumption of the pervaded' (*vyāpyasya āhāryāropa*). At this point, selecting the card with '7' would have been evident, with a counterfactual expectation of a vowel. The 'ascertainment of the deviation of what is supposed to occur' (*āpādya-vyātireka-nirṇaya*) would have ultimately disproven this hypothetical expectation (see formulae [2] to [5], discussed above in section 5). Counterfactuals prove to be challenging, while humans do not seem to inherently exercise this capacity in all circumstances. Facing outcomes of this sort, a more dialectical approach is needed to redefine the boundaries of human and nonhuman inferential capabilities within a spectrum, rather than relying on rigid yes-or-no dichotomies.

In light of the above tentative exploration, the Navya-Nyāya epistemological account of inference proves to be a potentially powerful heuristic tool for inquiring into logical reasoning, especially from a nonlinguistic or differently linguistic perspective. As described, inference, conceived as perceiving the pervasiveness of a property, can be effectively modeled using perception-based configurational concepts within a minimal grammar. When reinterpreted as the perceptual grasp of interrelated complex patterns, the complexity of the inferential process can consequently be seen as a capacity potentially shared by both humans and non-humans. This initial investigation into non-human inference, grounded in the Navya-Nyāya framework, clearly necessitates in-depth analysis of relevant texts and further interdisciplinary inquiry, encompassing scientific, philosophical, and philological approaches. Contemporary evidence offers a novel perspective on classical texts, illuminating them from a different angle. Rigorous philological investigation remains crucial when texts are viewed through the new lens of non-linguistic or differently linguistic cognition. Nonetheless, shifts in context can unlock revived avenues for understanding within established philosophical traditions while remaining faithful to the originals. In contrast, these classical texts, with their highly sophisticated theoretical frameworks, might contribute to illuminating both contemporary experimental and philosophical inquiry.

## Abbreviations and symbols

| | | | |
|---|---|---|---|
| AS | aversive stimulus | → | if, then |
| hL | human language | ↔ | if and only if, then |
| HRC | higher-ranked color | ⊢ | therefore |

| | | | |
|---|---|---|---|
| NHA | nonhuman animal | ~ | not |
| TI | transitive inference | Λ | and |

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