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AI, Probability, and Kurt Gödel

JOHN W. MURPHY
University of Miami, Coral, Gables, FL, USA
Email: j.murphy@miami.edu

CARLOS LARGACHA-MARTÍNEZ
Fundación Universitaria del Área Andina, Bogotá, Colombia
Email: clargacha@areandina.edu.co

Probability is central to the functioning of AI. But LLMs tend to regularly hallucinate, or respond to interaction or other inquiries in improbable ways. Nonetheless, through proper training AI can be transformed into an increasingly closed system of options, thereby creating more certainty and improving the decisions made by this technology. Scaling is the process touted regularly to achieve this aim. Nonetheless, the creation of closed systems is in question following the work on logic by Kurt Gödel. Subsequent to Gödel's incompleteness theorem, the creation of any closed is in jeopardy. The impact of this discovery for understanding probability is important, including the functioning of AI. The implications of Godel's work on logic and AI, particularly the ability of AI to more closely mimic human decision-making is examined to make AI more socially relevant.

Keywords: artificial intelligence (AI), Kurt Gödel, incompleteness theory, scaling, hallucinations, closed systems, formalisation

INTRODUCTION

Probability is at the heart of AI. In fact, some writers contend that this technology is mostly stochastic (Bender et al. 2021). For example, in terms of interlocutors, such as chat bots, what is the probability that a particular action is associated with an appropriate response? When putting LLMs (large language models) into practice, the aim is to mimic the everyday interaction of persons. Indeed, successful interaction depends on the ability of persons to anticipate what others are going to say, react reasonably, and elicit additional pertinent responses.

Certain statements are expected to be recognized and followed by a narrow range of responses. Persons enter into interaction with the presumption that this process will proceed as anticipated. When a regular connection occurs between an action and reaction, fruitful interaction is thought to have taken place. The so-called input provided by others is processed and transformed into a situationally relevant output.

What should be recognised is that a lot is happening in any exchange that AI is expected to replicate. That is, persons are not simply responding to behaviours or events, but are in a situation, have a history, and bring along a host of expectations. In other words, they are not mannequins. Nonetheless, AI guided chat bots, along with other modalities, are designed with the hope that they can traverse these conditions like a human. When they do not, and respond inappropriately or simply make things up, they are described as hallucinating (Marcus 2022; Sun et al. 2024).

What is assumed by the term hallucination in this discussion? Particularly important is that a normative expectation exists, and a reaction deviates from this standard. In other words, an LLM responds outside of a normal range of possibilities, and thus an incoherent or irrational message is conveyed (Sun et al. 2024). For every mention of a dog, for example, particular expressions should be forthcoming. Referring to a dog as crude or barbaric would likely be unexpected and lead a discussion astray. Furthermore, a particular rendition of a dog may not be recognised.

Within the confines of AI, what is typically thought to be the reason for such a miscue? The usual answer is faulty training. After all, an LLM responds based on the training that it receives (Ferrer 2024). The usual remedy for hallucinations is to expand the material, or examples, used in training. With a more extensive sample of information, perhaps more literary intensive, barbaric dogs may make sense and fit into the probability structure a routine conversation. Likewise, a wider range of dogs may be recognised.

Scaling up, or scaling, is the term used among AI developers to describe the expansion of a training database (Marcus 2024). The point is that when more examples are used in training, more responses are available. As a result, a stricter isomorphism is possible between input and output. An AI model will thus hallucinate less and behave more like a human.

The thrust of scaling is to create an increasingly closed system where AI can operate. But Luciano Floridi (2025), in his recent 'conjecture', points out that there is a trade-off between scope and certainty. The tighter a system becomes the certainty is increased but the generalisability is reduced. When the work of Kurt Gödel is added to this scenario, no system is ever closed and thus probability must be rethought. Simply put, the usual dichotomy reviewed by Floridi does not hold and other options should be sought.

The point of this paper is to introduce Gödel and the implications of his work for probability, while suggesting that a wider stance be taken on rationality and certainty. While his focus was on logic, and not necessarily probability, he has something important to say on the limitations of decision-making in the application of AI.[*] In the search for completeness, so that LLMs can hone their responses, probability is defined too narrowly. What Gödel does is to illustrate that no system is ever complete, thus shedding new light on how probability should be viewed in interaction if LLMs are going to ever mimic human behaviour.

This discussion of probability and Gödel will first deal with the usual solution to hallucinations, that is, scaling. Following this presentation, and building on the critique of scaling, the prospects of developing closed probability systems will be examined. Gödel, however, expands on the usual limitations of such systems, and proposes that closed, or complete, systems are fictional. The final two sections of this paper deal with Gödel's incompleteness thesis and the impact of this position for thinking about probability in AI.

[*] John W. Dawson, Jr. (1983) has published an annotated bibliography of Gödel's work. A reader who wants to consult some of Godel's original papers should consult this paper.

PROBLEMS WITH SCALING

Although scaling has a widespread support as a remedy for hallucinations, this strategy has some critics. Gary Marcus (2022), for example, does not think highly of scaling. He concluded recently that this process had reached a dead end. Increased scaling, he contends, will result merely in incremental improvements in AI. Proponents of scaling have wrongly linked this process to natural laws, whereas Marcus argues that this activity produces limited results with a minimal generalisability. Rather than a law, his position is that scaling produces merely empirical findings that need a thorough verification and are not necessarily universally accepted.

In technical critiques of scaling, sampling issues come to the forefront (Diaz, Madaio 2024). How certain elements are actually distributed in a population may be missed by merely increasing the size of a sample. For example, perhaps some behaviours or events related to subpopulations are not randomly distributed. Probabilities would be way off unless any scaling is sensitive to this anomaly. The increased sample size does not necessarily resolve this issue; more targeted sampling would be necessary.

But does anyone know the location of these targets? How should the sampling be focused? The problem is that if this knowledge were available, amassing more data through scaling would be unnecessary. A conundrum seems to be reached at this point – increase the sample size and hope for the best. As Marcus points out, this methodology hardly leads to a relevant and socially responsible AI.

Additionally, Marcus (2024) maintains that the level of development necessary to reflect accurately the population making decisions will be very costly, and a point of diminishing returns may be reached quickly. In fact, in a recent MIT report, 95% of organisations currently using AI report receiving zero return (Challapally et al. 2025). And the so-called general AI is not on the horizon. Therefore, a reasonable question is: how long will such unproductive investments continue?

Marcus (2024: 68–73), along with some other critics (Crawford 2021), note that the increased computing required by expanded scaling has negative ecological implications. That is, the required scaling of LLM's will be accompanied by unsustainable energy consumption and pollution. For example, Elon Musk's AI supercomputer centre in Memphis, Tennessee has raised ecological concerns (Brabenec 2025). Resources are going to be used that can never be replaced, or could be devoted elsewhere and used more efficiently and responsibly. The headlong pursuit of AI seems to have blinded many advocates to this ecological downside.

On the other hand, there is a philosophy operating that will limit the impact of scaling and deserves more attention. Melanie Mitchell (2023) begins this critique by asserting that more data does not provide any insight into reasoning; what matters most in creating relevant AI is the world model that is in play. Specifically important is how persons frame and execute knowledge when they make decisions? This question leads beyond the typical pragmatic or situational application of the frame problem to the world created by the population where probabilities are calculated.

Scaling assumes that an increasing net can be cast across the space where a population resides, so that the probability of an event or behaviour occurring can be calculated. The more data that are available, more about this space is known and more accurate calculations are possible.

This way of envisioning the parameters of a population resembles the Cartesian space, named after Descartes. Based on the Cartesian dualism, this space is thought to be closed, like a box, and have several unambiguous dimensions (Bordo 1987). Additionally, this space is neatly circumscribed because the boundaries of this box are treated as objective and readily identifiable. In a manner of speaking, a world is neatly outlined where all decisions take place.

Because this space is neatly deployed, this domain can be filled by data and, gradually, totally covered. Accordingly, the distribution of events can be quickly identified, along with the relevant normative expectations. With knowledge of these two factors, the calculation of probabilities is not difficult. Therefore, scaling makes sense.

The problem is that persons do not live in such an artificial environment. This issue is what Marcus is referring to when he writes that scaling does not provide any insight into how persons reason. Due to the Cartesianism at the root of scaling, decision-making is portrayed as following rules with a wide application that are unaffected by the human presence. Persons simply adhere to the logic that is presumed to be universal, rather than interacting and interferring with reality.

At this point in this discussion, an important question is the following: Do persons merely follow rules when making decisions or are they inventive? In the context of dualism, persons are confined to rules. But in the absence of dualism, persons infect the world of probabilities through their presence, even the version that underpins scaling. Most recently, constructionists have challenged this objective space of probability and open the door to recognising the personal and collective creation of reality that leads to the prospect of multiple realities and disparate worlds (Gergen 2009).

CLOSED SYSTEMS?

Presupposed by scaling is a closed system where decisions are made, either economic, cultural, or social. As mentioned earlier, the aim of scaling is to provide a broader coverage of a social system with the addition of more data. And because systems can be thoroughly circumscribed when conceived dualistically, the ability to calculate probabilities improves. Both the characteristics of a population and the distribution of behaviours and events becomes clearer, with prediction becoming more precise.

When sustained by dualism, the parameters of a system are treated as objective and reliable. Errors may occur on the margins where the coverage provided by the expansion of data is fuzzier. But for the most part, distributions and probabilities are clear and stable, and thus easily to determine. With a foundation this certain, calculations become routine.

Several writers, in both the sciences and humanities, have challenged this Cartesian portrayal of reality (Gebser 1986). Under the general heading of constructionism, these critics contend that persons mediate whatever is known (Gergen 2009). That is, persons intervene in and carve up reality in various ways through their actions, particularly their use of language (Merleau-Ponty 1973). As persons weave narratives about themselves, places, and others, for example, these storylines provide reality with a unique shape and meaning. Reality is thus an invention that gradually becomes a convention, including any world that is presupposed when assessing probabilities.

These narrative realities are now known to have biographies rather than natural properties, such as parameters and norms (Berger, Luckmann 1966). And as biographies, these narrative worlds are contingent due to their limited nature. Because they are situated, as phenomenologists say, these narratives have 'horizons' (Husserl 2013). Specifically, the meaning and relevance of these stories are limited and open to other narrative domains. What is important is that these constructions are finite; in fact, limitless constructions could not even be identified (Gödel 1931: 174).

The impact of these narratives for probability is noteworthy – the nature of reality can change dramatically. Especially important is that narratively constructed realities reveal their limits, thereby exposing the other side of these boundaries. Like a threshold, both sides of an entrance are revealed. In terms of thinking about probabilities, the prospect of various realities, or worlds, becomes real.

The significance of this realisation for scaling is crucial. First, the worlds of probability are not closed. Because of the limited nature of parameters, due to their constructed character, boundaries can shrink or expand, depending on a shift in definitions and viewpoints. And second, the possibility of multiple worlds comes into play, based on the horizons of the narratives that are valued. Each of these changes affects probability and the utility of scaling (Schutz 1945).

Since the parameters of the population and normative expectations may change, relying on scaling to improve probability calculations may be short sighted. Indeed, both of these facets of predictability may be misidentified in the Cartesian orientation of a single reality, or world. What may be more important than precision in identifying these factors, and covering this area with more data, is world sensitivity. What may be more important than scaling and identifying probabilities, and making generally logical decisions, is paying attention to the world that exists, that is, the reality that persons and communities have interpreted and continue to enact.

GÖDEL'S CONTRIBUTION

Although Gödel never dealt explicitly with probability, his work has relevance to this discussion. This claim may seem controversial, since Gödel was neither a constructionist nor an advocate of the multiple reality thesis (except, perhaps, related to time). To the contrary, he was a Platonist and was searching for a uniform foundation for logic (Wang 1987). And while he was not a Cartesian, and never tried to address dualism, his search for objective knowledge never abated.

Central to this discussion is that he offered a critique of formal systems that adds to this argument about the limits of probability (Gödel 1931). Basically, he contends that no matter how formalised a system becomes, such a complex is never complete. Although formalisation is designed to create the image of completeness, this state can never be achieved. Why is this condition of incompleteness true?

Formalisation is an example of deduction (Devlin 2002). The problem with formalisation is that a starting point of a logical chain is assumed to be valid (Gödel 1931: 174). As a result, these foundational claims cannot be examined or explained by the resulting system. The reason for this fault is quite simple: these initial assumptions are presupposed by the system and cannot be proved by the system. In a word, the system is an extension of these presuppositions, and thus these initial propositions cannot be confirmed by the formalised system.

The result is that these systems are never completely formalised. Why? They are based on assertions that can be verified but not by a system that depends on them for its existence. As Max Horkheimer (2002: 188–243) suggested, formalised systems are based on undecidable claims that such a project is designed to obscure; that is, the fact that the initial claims could have been different must be concealed. Completeness is thus an illusion that Gödel exposed. The key ingredient here is that initial claims are contingent, and that disparate propositions lead to different conclusions, i.e. realities or worlds.

In contrast to the thinking at the time, Gödel exposed that formalisation rests on claims backed by intuition. The point of formalisation, however, is to squeeze out any remnant of this source of ambivalence (Goldstein 2005: 185). This unpredictable element continues to linger at the base of any formalised system. Therefore, those who champion formalisation as a strategy to establish unambiguous foundations will not be happy with intuition lingering at the base of this process.

In the field logic, Gödel's claims were startling. Most logical systems are based on axioms. These initial statements, the building blocks of syllogisms, for example, are presumed to be foundational. That is, they are thought to recapitulate accurately reality. And through formalisation, this status is illustrated and reinforced. An example of this strategy is supplied by the symbolism invented by Gottlob Frege (1997). In this regard, Frege was striving to create a universal calculus that thoroughly circumscribed the rationality that permeated reality, so that logic statements could be accurate and reliable.

As Gödel pointed out, every formal system is limited, and thus is incomplete. But systems may be incomplete in other, technical, ways. For example, the math may not be known to reach closure. Measurement devices may be imprecise. And logical connections may not be recognised; all the rules may not be followed. Each of these shortcomings, however, suggest that solutions are at hand. With respect to Gödel's incompleteness thesis, even the tightest system is incomplete, limited by the original propositions that cannot be examined within the system. All formalisms are thus truncated. Any system that may claim universality is 'undecidable', that is, other premises could have been selected, and could also compete for universality.

While Gödel did not deal directly with probability, the implications of his incompleteness thesis for this issue seem to be quite clear. That is, calculating probability is not simply a technical matter of seeking precision and clarity. Adding more data does not address what Gödel has uncovered – formal systems start from assumptions that specify different realities, or worlds, where unique distributions of events or behaviours are present, along with particular normative expectations. Accordingly, logical outcomes may be very different in each world.

Whereas Husserl recognised that every world has a horizon and has parameters that can be examined, Gödel's work went further. Specifically, Gödel goes beyond showing the connections between worlds to illustrating that no world can ever be finalised. No claims about the totality of a world are legitimate. And because the parameters of any world can be redefined, the normative expectations necessary to calculate probability are unstable and subject to change.

POTENTIAL IMPACT OF GÖDEL'S THESIS

The relationship between Gödel's work and Turing's is intriguing (Goldstein 2005). Who influenced whom seems to be the most pressing question to historians. How Gödel's work relates to the origin of computerisation is debatable. His numbering scheme may have been helpful to Turing, but the incompleteness theorem is speculative in this regard. Nonetheless, this thesis seems to have relevance to AI, specifically the goal of having this technology grounded closer to the everyday activities of persons to reduce hallucinations.

What Gödel's theorem suggests is that probability should not be viewed primarily as a technical matter. How persons make decisions should be recognised to have a philosophical dimension, rather than focusing mostly on increasing the precision of logic through increased data. Seeking technical solutions to hallucinations ignores how the interpretive worlds of persons affect the distribution of events and behaviours and the likelihood of their appearance. In effect, scaling tends to be a one-world strategy.

What Gödel does is to attack systems from their inside rather than outside, and thus exposes their contingent stature. Their newly discovered limits, accordingly, reveal the prospect of different worlds with specific probability functions. Although not necessarily his aim, Gödel is exposing the semantic aspect of logic, whereas formalisation deals with the pragmatic side. The stark conclusion is that formalisation does not overcome interpretation, and the accompanying perspectives and uncertainty, but rests on interpretations (intuitions) that are neither autonomous nor universal. And because these narratives are never completely settled, and could be substituted for others, formalisation does not culminate in closed or complete systems.

Gödel revealed that no system escapes from contingency; thus, no universal foundation is available to sustain logic. Pinning down probability outcomes, therefore, is not necessarily improved by accumulating more data. What may give more insight into decision-making is nothing technological. Indeed, the various issues related to the creation of everyday worlds may be more significant (Heidegger 1962; Dreyfus 2007). How persons interpret themselves, their situations, and others, that is their worlds, may be more helpful. Melvin Pollner (1987), for example, refers to this world creating process as 'mundane reasoning'.

Clearly, Gödel is not thinking in these terms. However, his incompleteness theorem could lead in this direction and contribute to a more socially relevant AI. After all, in everyday life is where a logic is created that informs a world and, if used in AI, could make this technology more situationally or socially grounded.

CONCLUSIONS

In the absence of Cartesianism, probability moves beyond a technical exercise. With the elimination of dualism, interpretive narratives emerge in importance in understanding the likelihood of events or behaviours occurring. What this shift in orientation means is that those who build AI platforms should introduce reading into this process. The problem is that multiple storylines may be operating in daily life, and therefore the proper reading of these narratives is necessary to discover the world that is in play. Which narrative is the frame for a particular person or community becomes an important concern.

When AI systems are formalised, the logic that is operative is thought to be standard across persons or communities. In this way, uniformity is pursued, with the aim of having a widespread relevance. The problem, however, is that this strategy overlooks the everyday, or mundane reasoning that persons use to make decisions and direct their lives (Pollner 1987). When this situation exists, AI begins to drift away and behave in ways that are unrecognisable, irrelevant or, possibly, harmful. The key issue is how to retrieve and make this technology more relevant in distinct worlds.

Where does Gödel fit into this multiple world scenario? Without a doubt, he did not aim to let reality proliferate in this manner. Nonetheless, he challenged the existence of closed systems and untied mathematics and logic from a single, universal anchor. And as a sidebar, he opened the possibility that multiple systems could exist, even simultaneously. In this sense, the traditional frame problem is raised in a more radical manner. Specifically, framing is not merely an add-on, an analytic tool, but calls into question the utility of formalisation. Framing is now inextricably linked to creation of worlds.

As a result of this insight, AI development would be sent in a new direction. Instead of attempting to mimic reality through scaling, the point would be to recognise the range of realities, or worlds, that can be an outgrowth of different narratives. Pursuing world relevance would thus become a priority, instead of technical refinements designed to mimic reality. By becoming good readers of worlds, AI platforms may come closer to repeating how humans make decisions in their daily affairs. Rather than simply an analytical and abstract enterprise, logic would be brought closer to the daily behaviours of individuals and communities.

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JOHN W. MURPHY, CARLOS LARGACHA-MARTÍNEZ

Dirbtinis intelektas, tikimybė ir Kurtas Gödelis

Santrauka

Tikimybė yra esminis dalykas veikiant dirbtiniam intelektui (DI). Tinkamai jį apmokant, DI galima paversti vis labiau uždara galimybių sistema, taip sukuriant daugiau tikrumo ir pagerinant šios technologijos priimamus sprendimus. Mastelio keitimas nuolat reklamuojamas siekiant šio tikslo. Nepaisant to, kuriant uždaras sistemas kyla abejonių dėl Kurto Gödelio logikos darbų. Po K. Gödelio nepilnumo teoremos bet kokia uždara sistema yra abejotina. Šio atradimo poveikis tikimybės supratimui yra svarbus, įskaitant DI veikimą. Straipsnyje nagrinėjamos K. Gödelio logikos implikacijos DI, ypač imituojant žmogaus sprendimų priėmimą. Taip pat parodomi DI socialiniai klausimai.

Reikšminiai žodžiai: dirbtinis intelektas (DI), Kurtas Gödelis, nepilnumo teorema, mastelio keitimas, haliucinacijos, uždaros sistemos, formalizavimas