A COMPUTATIONAL ACCOUNT OF COHERENCE AS A HEURISTIC FUNCTION FOR TRUTH

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ABSTRACT

A COMPUTATIONAL ACCOUNT OF COHERENCE
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Coherence as a theory of truth claims that truth can be defined as coherence, i.e., a belief is true if and only if it coheres with other beliefs, no matter these beliefs are isolated from the mind-independent external world. In this sense, is it necessary to accept a coherence theory of truth in order to establish that coherence is truth-conducive? Or can this conduciveness be established in another way? To answer these questions, I first attempted to solve the major problem of coherence, namely vagueness, by transforming Bonjour's criterion-based notion of coherence into a computational account of coherence by devising graph-theoretic framework along with quantitative coherence measures. With this way of formalising coherence of belief systems, it also became possible to deal with the problem of isolation objection via the ability to incorporate the cognitively spontaneous beliefs into the framework. By means of various test cases (in terms of rival theories) from history of chemistry, psychology, environmental science, legal reasoning, physiology, geology, astronomy, I put forward results to think that coherence as a heuristic function for truth in the long

run, instead of being a theory of truth, is better suited for establishing a connection between coherence and truth, that is, coherence as a heuristic for truth functions as a device for discovering truth, i.e., securing convergence to truth rather than seeking the absolute truth in the presence of the underconsideration problem.

Keywords: Coherentism, justification, heuristic, truth-conduciveness, computation

ÖZ

UYUMLULUĞA DOĞRULUK İÇİN KEŞİFSEL FONKSİYON OLARAK BERİMSEL BİR BAKIŞ

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Bir doğruluk kuramı olarak uyumluluk, doğruluğun uyumluluk olarak tanımlanabileceğini bir başka ifadeyle bir kanının ancak diğer kanılarla uyumlu olması durumunda (bu kanılar zihin-bağımsız dış dünyadan izole olmuş olsalar da) doğru olabileceğini iddia etmektedir. Bu bağlamda, uyumluluğun doğruluğa sevk edici olduğunu ortaya koymak için doğruluğun uyumluluk kuramını kabul etmek gerekli midir? Ya da bu sevk edicilik başka bir şekilde kurulabilir mi? Bu soruları cevaplamak için, ilk olarak, Bonjour'un kriter bazlı uyumluluk kavramını, niceliksel uyumluluk ölçütleri ile birlikte grafik-kuramsal bir çerçeve geliştirerek ve bu suretle berimsel bir uyumluluk hesabına dönüştürerek uyumluluğun ana problemi olan belirsizliği çözmeye çalıştım. Kanı sistemlerinin uyumluluğunu bu şekilde biçimlendirerek bilişsel spontane kanıları çerçeveye dahil etme kabiliyeti ile izolasyon itirazı sorunuyla da başa çıkmak mümkün hale geldi. Kimya, psikoloji, çevre bilimi, hukuki muhakeme, fizyoloji, jeoloji, astronomi tarihinden çeşitli test senaryoları vasıtasıyla uzun vadede doğruluğun keşifsel bir fonksiyonu olarak uyumluluğun, bir doğruluk kuramı olmak

yerine, uyumluluk ve doğruluk arasında bir bağlantı kurmada daha uygun olduğunu düşünmek için sonuçlar ortaya koydum. Bu bağlamda uyumluluk, doğruluğu keşfetmek için bir araç işlevi görmektedir ve yetersiz hesaba katma problemi varlığında mutlak doğruluğu aramak yerine ona yakınsama sağlamaktadır.

Anahtar Kelimeler: Uyumculuk, gerekçelendirme, keşif, doğruluğa sevk edicilik, berim

To my family…

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My deep gratitude to my university and to the people who believed in me and supported me academically, first and foremost to my supervisors. I feel fortunate for having received not only their guidance but also their understanding.

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CHAPTER 1

INTRODUCTION

1.1 Computational Philosophy

In the mid-20th century, the paths of philosophy and computing had started to converge through the pioneering works of Alan Mathison Turing (Turing Test in Turing's "Computing Machinery and Intelligence") and Simon&Newell's "Logic Theorist" (Turing, 1950; Newell & Simon, 1956). After the appearance of the first personal computers in 1980s, as more and more philosophers had interaction with the computer and involved it in their research activities, the American Philosophical Association was stimulated in creating The Committee on Philosophy and Computers (PAC) that later seized a chance to get transformed into a broader association taking up any aspects of computational turn in the service of philosophy regarding the areas of investigation within artificial intelligence, cognitive science, computer modeling in biology, logic, metaphysics (Formal Ontology, Network Structures, Distributed Processing, etc.), virtual reality, etc., namely, the International Association for Computing and Philosophy (IACAP) in the first decade of 21st century (IACAP, 2002).

In the meantime, the philosophical community had become more aware of the importance of computation and of the value of its methodologies and theories (Hagengruber & Riss, 2014, pp. 5-6; Sequoiah-Grayson & Floridi, 2022; Angius et al., 2021; De Mol, 2018; Immerman, 2021; Rescorla, 2020; Bynum, 2015).

Correspondingly, Floridi (2011) called attention to the fact that computation was no longer seen as esoteric or philosophically irrevelant (p. 5-7), i.e., computational concepts, methods, techniques and theories had become effective metaphors having a role as being hermeneutic devices that can be utilized to interpret the world and guided to The Digital Phoenix with subtitle "How computers are changing philosophy" for the acknowledgement of Bynum and Moor (1998) that computation has emerged as a new force in philosophy:

> From time to time, major movements occur in philosophy. These movements begin with a few simple, but very fertile, ideas - ideas that provide philosophers with a new prism through which to view philosophical issues. Gradually, philosophical methods and problems are refined and understood in terms of these new notions. As novel and interesting philosophical results are obtained, the movement grows into an intellectual wave that travels throughout the discipline. A new philosophical paradigm emerges. […] Computing provides philosophy with such a set of simple, but incredibly fertile notions - new and evolving subject matters, methods, and models for philosophical inquiry. Computing brings new opportunities and challenges to traditional philosophical activities. […] computing is changing the way philosophers understand foundational concepts in philosophy, such as mind, consciousness, experience, reasoning, knowledge, truth, ethics and creativity. This trend in philosophical inquiry that incorporates computing in terms of a subject matter, a method, or a model has been gaining momentum steadily. (p. 1)

In the Symposium on Computational Philosophy (2012) held as part of the AISB/IACAP World Congress 2012 (in Honor of Alan Turing), computational philosophy was given focus for its capability to support traditional philosophical methods in the scope of verification of the philosophical positions throughout almost all branches of philosophy, including epistemology, metaphysics, along with the philosophies of science, mind, technology, etc.

As computation via computers and computer programming is progressively utilized by philosophers over the last two decades, it turns out to be plausible to attempt to benefit from this new means of research to introduce experimenting into philosophy,

i.e., predicting how a philosophical theory will perform in case it is applied in practice for validation by constructing and evaluating corresponding computational models.

1.2 The Need for Computational Modeling of Coherence Theory

The concept of coherence has been a focal point in various areas of philosophy such as epistemic justification and theories of truth. Primarily, coherence can be attributed as a property of sets of beliefs and according to one of the former leading proponents of coherence theory of justification, Laurance Bonjour (1985), it can intuitively be interpreted as the quality of the hanging together of these beliefs:

> Intuitively, coherence is a matter of how well a body of beliefs 'hangs together': how well its component beliefs fit together, agree or dovetail with each other, so as to produce an organized, tightly structured system of beliefs, rather than either a helter-skelter collection or a set of conflicting subsytems. (p. 93)

Since the description of coherence as fitting together well seems to be inexplicit and does not serve to determine a unique notion of coherence, Bonjour (1985), puts forward that this vagueness was disturbing but not corruptive for a theory of epistemic coherence and continued to believe that coherence is virtually a basic component of all rival epistemological theories of justification as well:

> It is important to see, however, that difficulties in this area cannot yield anything like a decisive argument against coherence theories and in favour of their foundationalist rivals. This is so because the concept of coherence, or something so similar to it as to be capable of playing essentially the same role, is also an indispensable ingredient in virtually all foundationalist theories: coherence must seemingly be invoked to account for the relation between the basic or foundational beliefs and other non-foundational or 'superstructure' beliefs, in virtue of which the latter are justified in relation to the former. (Craig, 2005, p. 521)

Later on, after about a decade and a half, Bonjour (2017) concluded that "the precise nature of coherence remains a largely unsolved problem" due to the lack and failure of

a formal explication of the concept of coherence (p. 124). Accordingly, this incompleteness resulted in an exacerbation of variety in interpretation of coherence and inherently increased the vagueness of coherence. At the time Bonjour commenced this view and afterwards, the first proposals, (Shogenji, 1999) as a proponent, i.e., more coherence - according to his own measure of coherence - does imply a higher joint likelihood of truth, and (Olsson, 2002) as an opponent, i.e., there cannot be any measure of coherence that is truth-conducive, related with Bonjour's claim that coherence is truth conducive were put forward by devising probabilistic measures of coherence.

Obviously, there exists a need to reduce this vagueness of coherence and in order to study coherence within the scope of this thesis, it is first required to draw the following principles for allowing the construction of a coherence framework with a more specific and formal interpretation:

- For each belief B, there is a relevant set of beliefs BS of which it is a part.
- BS is coherent to the extent that the elements of BS are inferentially related to each other and consistent, i.e., if BS is an inconsistent set, it is obviously incoherent due to the contradiction existing in BS which causes BS to be conceptually divided.
- The degree to which B is *justified* is proportional to the degree to which BS is *coherent,* i.e., coherence comes in degrees such that some sets of beliefs are more or less coherent than others.
- A measure of coherence is truth conducive if and only if a higher degree of measured coherence eventuates in a higher likelihood of truth.

With the emergence of the first attempts of coherence formalisation in the early 2000s, Paul Thagard (2000) put forward that coherence is the only means that we infer beliefs that correspond to reality, no matter any particular coherent belief turns out to be not true or being at least approximately true:

> So there is a material world independent of our minds' most coherent interpretations of it. The truth of propositions, therefore, and the verisimilitude of other mental representations, such as visual images, is not merely a matter of their coherence with other representations; rather, the truth of a proposition depends on its correspondence to the world. Of course, we have no other means but coherence to infer that a proposition does correspond to the world, and any particular proposition, no matter how coherent, may turn out to be false. But we have ample reason to believe that many bodies of propositions do in fact correspond to reality. People have managed to survive and reproduce for many thousands of years, and in the last few hundred they have been able to use scientific advances to gain an extraordinary physical control over the world. These advances have made possible technologies of transportation, communication, and medicine that are totally mysterious unless such scientific theories as gravity, electromagnetism, and the germ theory of disease are at least approximately true. (pp. 89-90)

For the purpose of modeling coherence, the following questions will initially be investigated to further dissolve the vagueness of coherence:

- Is coherence (of a set of beliefs) a computational entity?
- Can we say that this set of beliefs is more or less coherent than the other in a quantitative manner?

and the following open questions which constitute the inquiry of this study will be attempted to be answered:

- Should coherence of beliefs secure convergence to (at least approximately) to true beliefs?
- Can coherence function as a heuristic?

I will, in the subsequent chapter, present, Bonjour's coherence theory of epistemic justification. In the following chapter, a computationaly connectionist approach for the modeling of coherence which will serve as a basis to devise a number of measures of coherence in a graph theoretic way in order to give a quantitative manner to Bonjour's concept of coherence will be constructed. Next chapter is based on experimental evaluation of various case studies related with history of science, legal reasoning, psychology, etc. Finally, the study is concluded with the epistemic implications of this approach.

CHAPTER 2

BONJOUR ON COHERENCE THEORY OF JUSTIFICATION

2.1 Framing Epistemic Knowledge

Among the coherence theories of contemporary philosophers, the one that I will examine is that of BonJour, as found in his book, The Structure of Empirical Knowledge, since Bonjour's theory puts forward a graded notion of coherence which is more feasible to formalize it in computable terms (Bonjour, 1985).

Bonjour (1985) believes that the traditional conception of knowledge[1] as justified true belief is at least approximately correct and reframes it from point of epistemic subject A's view where P is a proposition: "A knows that P if and only if (1) A must believe confidently that P, (2) P must be true, and (3) A's belief that P must be adequately justified" (pp. 3-4).

According to Bonjour (1985), the kind of justification that is to be used for A's belief that P is epistemic justification whose basic role is being a means to truth and puts forward its distinguishing nature by answering his questions "Why should we, as cognitive beings, care whether our beliefs are epistemically justified? Why is such justification something to be sought and valued":

[1] The issues raising out of Gettier (1963) problem about the tripartite conception of knowledge is ignored by Bonjour (1985): "in the present discussion, however, partly because their exact bearing on the issues which will be discussed is obscure, at least to me, but mainly because there is quite enough to do without them" (p. 5).

> The distinguishing characteristic of epistemic justification is thus its essential or internal relation to the cognitive goal of truth. It follows that one's cognitive endeavors are epistemically justified only if and to the extent that they are aimed at this goal, which means very roughly that one accepts all and only those beliefs which one has good reason to think are true…If epistemic justification were not conducive to truth in this way, if finding epistemically justified beliefs did not substantially increase the likelihood of finding true ones, then epistemic justification would be irrelevant to our main cognitive goal and of dubious worth. It is only if we have some reason for thinking that epistemic justification constitutes a path to truth that we as cognitive beings have any motive for preferring epistemically justified beliefs to epistemically unjustified ones. Epistemic justification is therefore in the final analysis only an instrumental value, not an intrinsic one… It is this essential relation to truth which distinguishes epistemic justification from other species of justification aimed at different goals. (p. 7-8)

In Bonjour's view, A's belief that P is epistemically justified where A has adequate reason to think that P is true. At this point, Bonjour (1985) draws a line between coherence theory of justification and coherence theory of truth:

> In the first place, our concern is with coherence theories of empirical justification and not coherence theories of truth; the latter hold that truth is to be simply identified with coherence (presumably coherence with some specified sort of system). (p. 88)

BonJour (1985) also distinguishes theories regarding the nature of truth and theories regarding the criterion of truth. According to him, the latter theories should be called as coherence theories of justification about the criteria or standards or rules "...which should be appealed to in deciding or judging whether or not something is true..." (p. 88). That is, in his view, a coherence theory of justification is a means that enables one to identify which propositions are more likely to be true. On the other hand, a theory of truth determines what it is to be true for a proposition without a need for such a tool to define these propositions.

A coherence theory of justification does not necessarily imply a coherence theory of truth. Since coherence theory of justification states that it is more likely that the elements of a coherent set of propositions is true, coherence theory of justification is

in no conflict with correspondence theory of truth having the view that what makes a proposition true is its correspondence to the mind-independent external world. In other words, a proposition (truth-bearer) is considered to be true only when it is corresponding to some non-propositional state of affairs (truth-maker), e.g., the proposition that it is raining outside is true just in case it is really raining outside.

Bonjour (1985), as a realist, points to this possibility of coexistence such that "there is no manifest absurdity in combining a coherence theory of justification with a correspondence theory of truth" (p. 88).

Throughout this study, this truth conducive nature of coherence that is certainly not clear and criticized will be taken under the spotlight in accordance with Bonjour's aforementioned interpretation. It will also be argued whether development of scientific theories can be viewed as a series of attempts towards increasing coherence, and the choice between competing theories can based on a comparison of their corresponding coherences.

2.2 Nature of Coherentism

According to the holistic view of coherence, an epistemic subject S is justified in believing P only if belief in P is in a coherence relation with the members of the set to which belief in P belongs. It is the mutual coherence relation which makes the members of that set justified. Here is the explication of this non-linear view by Bonjour:

> The only apparent hope for a coherentist response to this objection, stemming originally from Bosanquet[2], is the suggestion that the objection depends on the plausible but ultimately mistaken idea that relations of justification fundamentally involve a linear, asymmetrical order of epistemic dependence among the beliefs in question. The contrary suggestion is that justification, when properly understood, is ultimately nonlinear or holistic in character, with all of the beliefs in the relevant system of beliefs standing in relations of mutual support, but none being epistemically prior to the others. (Bonjour & Sosa, 2003, pp. 44-45)

The standard argument against coherence theories of justification subsumes the idea that "inferential justification is essentially linear in character, that it involves a one-dimensional sequence of beliefs, ordered by the relation of epistemic priority, along which epistemic justification is passed from the earlier to the later beliefs in the sequence via connections of inference" (Bonjour, 1985, p. 90). Alternatively, BonJour (1985) suggests to accept a non-linear view which holds that "despite its linear appearance, [inferential justification] is essentially systematic or holistic in character: beliefs are justified by being inferentially related to other beliefs in the overall context of a coherent system" (p. 90). BonJour (1985) also points out to the need to distinguish between "local level" and "global level" justification: at the local level, justification appears to be linear:

> One quickly reaches premise-beliefs which are dialectically acceptable in that particular context and which can thus function there rather like the foundationalist's basic beliefs. (But these contextually basic beliefs, as they might be called, are unlikely to be only or even primarily beliefs which would be classified as basic by any plausible version of foundationalism). (p. 91)

In spite of the linear appearance at the local level, BonJour (1985) puts the point that there is no linearity at the global level, but the mutual or reciprocal support. Thus, on Bonjour's account, the view that coherentist justification is viciously circular is misplaced:

[2] (Bosanquet, 1920)

> ...a coherence theory [of justification] will claim, the apparent circle of justification is not in fact vicious because it is not genuinely a circle: the justification of a particular empirical belief finally depends, not on other particular beliefs as the linear conception of justification would have it, but instead on the overall system and its coherence. (p. 92)

Having drawn a distinction between the local justification of 'a single empirical belief' and the global justification of the entire system of which that belief is a member, Bonjour (1985) explains that despite the linear appearance of justification at the local level, the inferential justification of beliefs at the global level is a matter of nonlinear reciprocal support and is "in the final analysis decisive for the determination of empirical justification" (p. 91).

Hence, BonJour's (1985) coherence theory of justification encapsulates four levels for justifying empirical beliefs:

> (1) The inferability of an individual belief from other ones and further interrelations between particular empirical beliefs.
> (2) The coherence of the whole set of empirical beliefs.
> (3) The justification of the whole set of empirical beliefs.
> (4) The justification of the individual belief aforementioned, due to its membership in the whole belief set. (p. 92)

Bonjour's argument for the truth-conduciveness requires that a system of beliefs is likely, to a degree proportional to its degree of coherence, to be true with the suggestion that "coherence is obviously, on any reasonable view, a matter of degree [...] the likelihood that a system of beliefs corresponds to reality varies in proportion to its degree of coherence" (Bonjour, 1985, p. 170). Within this context, when a rational epistemic subject faces two competing sets of beliefs, it seems to be more plausible to give preference to the set that is more coherent. Therefore, the core function in such a coherence theory is expected to be the capability to measure which set is more coherent. In this connection, Bonjour (1985) defines the degree of coherence of a set of beliefs in terms of six criteria that can be used to determine which set of beliefs is more coherent:

1. (BCC-1) A system of beliefs is coherent only if it is logically consistent.
2. (BCC-2) A system of beliefs is coherent in proportion to its degree of probabilistic consistency.
3. (BCC-3) The coherence of a system of beliefs is increased by the presence of inferential connections between its component beliefs and increased in proportion to the number and strength of such connections.
4. (BCC-4) The coherence of a system of beliefs is diminished to the extent to which it is divided into subsystems of beliefs which are relatively unconnected to each other by inferential connections.
5. (BCC-5) The coherence of a system of beliefs is decreased in proportion to the presence of unexplained anomalies in the believed content of the system.
6. (BCC-6) A system of beliefs must satisfy the Observation Requirement. (pp. 97-99, 141-144)

For BCC-1, Bonjour (1985) contends that logical consistency is an absolutely necessary criterion for coherence since logical inconsistency gives rise to the strongest level of incoherence (p. 95). Thus, a must-have and initial feature of a coherent system is that it does not contain any pair of inconsistent propositions.

In the scope of BCC-2, Bonjour points out to a case where a set of beliefs is logically consistent, i.e., non-presence of logical contradiction between any pair of beliefs, but contains the belief that P and also the belief that it is extremely improbable that P. In case an epistemic subject S believes that P ("It will be rainy tomorrow") is 0.9 likely to be true, then she is expected to believe that "It will not be rainy tomorrow" is 0.1 likely to be true. If her degree of confidence in believing not-P is greater than 0.1, such as 0.3, a probabilistic inconsistency takes place. Intuitively, it is explicit that the set of beliefs that is formed by dropping any of these two probabilistically inconsistent beliefs would be more coherent. Therefore, Bonjour (1985) suggests probabilistic consistency as another criterion to be taken into account (pp. 95-96).

For BCC-3, Bonjour (1985) considers the sets of propositions, $S_1 = \{P, Q, R\}$ and $S_2 = \{X, Y, Z\}$, as a challenge where:

P: "All ravens are black."

Q: "This bird is a raven."

R: "This bird is black."

X: "This chair is brown."

Y: "Electrons are negatively charged."

Z: "Today is Thursday." (p. 96)

Although both sets are logically and probabilistically consistent, the propositions in set S_2 are independent, while the propositions in set S_1 are positively related in such a way that mutually support each other, i.e., as Bonjour (1985) poses "fit together and reinforce each other" (p. 96). It thus seems that, by BCC-3 criterion, S_1 should qualify as the more coherent one. In this scope, BCC-3 stands for a requirement "to involve some sort of positive connection among the beliefs in question, not merely the absence of conflict" (Bonjour, 1985, p. 96).

Bonjour's (1985) answer to the question, "What sort of positive connections is required", is that those connections are inference relations:

> …namely, any sort of relation of content which would allow one belief or set of beliefs, if justified, to serve as the premise(s) of a cogent epistemic-justificatory argument for a further belief. The basic requirement for such an inference relation, …, is that it be some degree truth-preserving; any sort of relation [such relations need not be deductive] which meets this requirement will serve as an appropriate positive connection between beliefs, and no other sort of connection is relevant here. (p. 96)

Hence, this constitutes the third criterion of coherence. As Bonjour points out that subsystems of beliefs could be logically and probabilistically consistent, i.e., BCC-1 and BCC2 holds, where within each subsystem, beliefs might mutually support each other, i.e., BCC-3 obtains, but could have nothing to do with another. That is, within the subsystems there exists epistemic support, but the subsystems do not support each other. In this context, BCC-4 points to the fact that the coherence of a system of beliefs

is descreased due to its enclosure of inferentially unconnected subsystems and its being partitioned with such isolated subsystems.

Concerning the justification of scientific theories, Bonjour (1985) points to a kind of inferential relation, namely explanatory relation, between beliefs:

> Explanatory connections are not just additional inferential connections among the beliefs of a system, however; they are inferential connections of a particularly pervasive kind. This is so because the basic goal of scientific explanation is to exhibit events of widely differing kinds as manifestations of a relatively small number of basic explanatory principles. (p. 99)

Bonjour (1985) also defines an anomaly as:

> A fact or event, especially one involving some sort of recurring pattern, which is claimed to obtain by one or more of the beliefs in the system of beliefs, but which is incapable of being explained (or would have been incapable of being predicted) by appeal to the other beliefs in the system. (p. 99)

Thus, it is expected that the lack of explanatory connections between an anomaly and the rest of the system will decrease the coherence of the system. In this connection, Bonjours adds the criterion, BCC-5, for coherence.

The aforementioned coherence criteria on their own do not rule out an isolated system of beliefs from external world. One can consider such a system where there is no logical and probabilistic inconsistency, where beliefs fit together via inferential connections, where there are no relatively unconnected subsystems, and there are no unexplained anomalies, but where experiential beliefs based on observations are isolated from the system. This poses the objection that justification is wholly detached from the world, as Bonjour (1985) describes:

> Coherence is purely a matter of the internal relations between the components of the belief system ...Hence if, as a coherence theory claims, coherence is the sole basis for empirical justification, it follows that a system of empirical beliefs might be adequately justified...in spite of being utterly out of contact with the world that it purports to describe … But this is surely an absurd result. (p. 108)

With this limited interpretation of coherentism depending only on the internal coherence of a belief set, prima facie, such a justification does not necessitate any input from the world external to that belief set, it doesn't matter what the external world is like and what epistemic subjects' experiences are. In case a belief set happens to represent the world correspondingly, then this is considered to be a mere coincidence. Since accidentally true beliefs do not qualify as knowledge, such a view of coherentism is not expected to account for empirical knowledge. Bonjour (1985) considers such a self-enclosed system of beliefs which are entirely immune from any external influence:

> Cannot constitute empirical knowledge of an independent world, because the achievement of even minimal descriptive success in such a situation would have to be either an accident or a miracle, not something which anyone could possibly have any reason to expect — which would mean that the beliefs involved would not be epistemically justified, even if they should somehow happen to be true. (p. 108)

Hence, the input problem is that, where truth is regarded as correspondence with reality, coherentism in an isolated form results in an absurdity that it is possible to have epistemically justified beliefs about a reality that has no input in the justification process, e.g., an epistemic subject might be justified in accepting that pure fiction introduces a true account of real world state of affairs.

In order to circumvent this type of input objection, Bonjour (1985) introduces what he calls the Observation Requirement (OR) by suggesting that the necessary connection between reality and coherentist epistemic justification is constituted through the introduction of non-inferential observational beliefs to rule out such an isolated system: "a cognitive system … must contain laws attributing a high degree of

reliability to a reasonable variety of cognitively spontaneous [experiential] beliefs" (p. 141).

As is known, the main distinction between coherentism and foundationalism lies on the foundationalism's acceptance of basic beliefs which are non-inferentially justified. In this sense, BonJour's view on non-inferential observational beliefs seems to convert his account of coherence into a sort of foundationalism. In this connection, BonJour (1985) claims that the inclusion of these cognitively spontaneous beliefs in his theory of coherentism rests on the distinction between how a belief happens to be epistemically justified and how it is walked into (p. 112). He puts forward that:

> …a belief might occur to a person in some noninferential way which would confer on it no special justificatory status (for instance, as a spontaneous hunch) and only subsequently be seen to cohere with the rest of the system of beliefs in a way which would yield justification. (Bonjour, 1985, p. 113)

Within his view, the epistemic justification of such belief sets is still inferential and remains consistent with coherentism, since the non-inferential provenance of those beliefs has nothing to do with their being justified.
BonJour (1985), as an example, suggests that an observer walking into a well-lit room will usually spontaneously form beliefs that just "strike" her in a coercive, involuntary and noninferential way as follows (pp. 117-118):

- a belief that my belief that there is a red book over there was spontaneously formed;
- a belief that my belief that there is a red book over there was formed via visual perception in normal lighting conditions;
- a belief that beliefs formed spontaneously in normal lighting conditions are generally true.
- Therefore, my belief that there is a red book over there is very likely to be true.
- Therefore, (probably) there is a red book over there (p. 123)

In case this set of beliefs are mutually supported by other beliefs in the observer's belief system, her perceptual spontaneous belief that there is a red book over there can be justified within the nature of coherence. BonJour contends that such an approach allows for "a kind of observational input from the extra-conceptual world that is still recognizably coherentist in its justification" (BonJour & Sosa, 2003, p. 50).

Bonjour (1985) also states that the fundamental idea behind his "Observation Requirement" is that, "any claim in the system which is not justified a priori should in principle be capable of being observationally checked, either directly or indirectly, and thereby either confirmed or refuted" (p. 141). He also emphasizes that "whether or not this is so in a given system depends not only on the modes of observation available, but also on the inferential interconnectedness of the system" (p. 141). BonJour argues that it is possible to overcome the Input Objection by appeal to Observation Requirement to connect justification to external world, i.e., constituting a basis for a truth-conducive theory of justification.

In addition, he explains that a belief set is likely, to a degree proportionate to its degree of coherence, to be true by pointing out that "coherence is obviously, on any reasonable view, a matter of degree" (Bonjour, 1985, p. 171).

In the following chapter, Bonjour's aforementioned criteria will be attempted to be computationally modeled in order to be used as a means for comparing coherences and in search of truth-conduciveness.

CHAPTER 3

COMPUTATIONALY MODELING COHERENCE: A GRAPH-THEORETIC APPROACH

The coherence of a belief system is generally described by vague phrases such as sticking/holding/hanging together, mutually supporting, etc. Even if it is challenging for a coherence theorist to provide a precise and absolute measure, she must at least be able to compare the coherence degrees of competing belief systems in order to determine to what degrees they are justified in a relative manner.

In this chapter, with the purpose of serving as a solution to the problem mentioned by Bonjour (2017), "the precise nature of coherence remains a largely unsolved problem" (p. 124), a coherence framework with a graph-theoretic approach is constructed to model coherence for the ultimate purpose of reducing the aforementioned vagueness of coherence by fulfilling Bonjour's criteria, BBC-1 through BCC-6, as mentioned in the previous section.

In this context, beliefs of a rational epistemic subject and the inferential associations between those beliefs are modeled by using structures of Graph Theory, i.e., beliefs as nodes (vertices) and inferential supports between beliefs in terms of links (edges/arcs). Since Bonjour (1985) points out that there is a distinguishment between "local level" and "global level" justification (p. 91), the coherence framework is structured in correspondence to those levels. Firstly, in the local level, coherence measures are computed for each graph node in a relative manner. Subsequently, global coherence measures are mutually built on top of those local coherence values.

In order to more specifically describe the "mutual support" expression in a standard way, the following pattern of (3) will be used given the conditions of (1) and (2) throughout the framework:

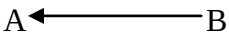
(1) An epistemic subject *S* believes that *A*

(2) *A* is inferentially[3] supported by *B*

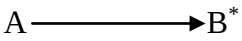
---

(3) S's belief in *A* is inferentially supported by S's belief in *B*.

In graph-theoretic notation, the links (edges) between beliefs denote this presence of inferential support along with the flow of justification.



According to Bonjour, in the scope of Observation Requirement, BCC-6, cognitively spontaneous beliefs, e.g., experiential beliefs, arise without being inferred from any other beliefs, i.e., the external world has an effect on observer's belief system by giving rise to cognitively spontaneous beliefs non-inferentially. They simply *strike* the observer in a way that is both quite coercive and involuntary. Still, these beliefs are justified through an inferential process (Bonjour, 1985, pp. 117, 123). This type of beliefs are distinguished by a mark of '*' in our notation.



At this point, considering a running example will help to illustrate the concepts as they are defined and to see how the coherence measures are gradually computed.

[3] Bonjour (1985) counts explanatory connections in inferential ones: "… explanatory connections are not just additional inferential connections among the beliefs of a system, however; they are inferential connections of a particularly pervasive kind" (p. 99).

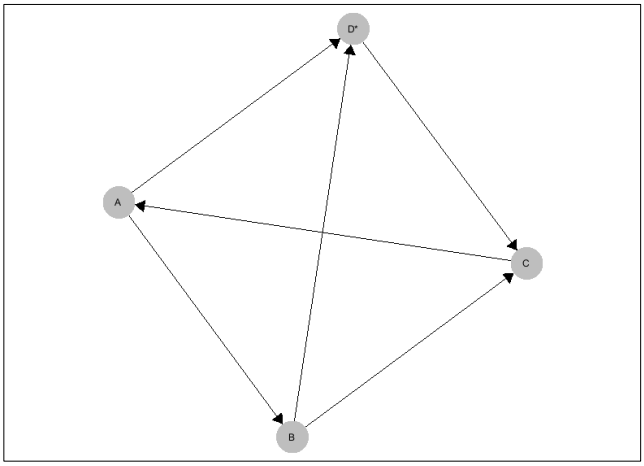


Figure 1 – An example belief network of S

For this purpose, assume an epistemic subject S who is randomly inferencing a network (web/graph) of her beliefs as given in Figure 1. She randomly starts by picking a belief node from her network in accordance with their initial relative probabilities. In case the belief set contains no cognitively spontaneous belief (CSB), random picking takes place with equal probability[4] among the beliefs. Otherwise, leading relative probability (importance) of belief nodes are to vary in degrees in accordance with the Observation Requirement. Here, it is also important to note that none of the beliefs picked by epistemic subject S will be epistemically prior to any other throughout the process of coherence measurements.

In this context, it worths to point out that Bonjour's first and second coherence criterion (BCC-1 & BCC-2) implicitly require a bridge principle between quantitative characteristic of beliefs, i.e., numerical degrees of belief (degree of confidence with which epistemic subject believes) and the qualitative one, i.e., belief simpliciter such as label of belief.

Foley (1992) explicates this principle as follows:

[4] Hereafter the conditon of picking from a set where drawing each element is equally probable is called "uniformly at random".

> To say that we believe a proposition is just to say that we are sufficiently confident of its truth for our attitude to be one of belief. Then it is epistemically rational for us to believe a proposition just in case it is epistemically rational for us to have sufficiently high degree of confidence in it, sufficiently high to make our attitude towards it one of belief. (p. 111)

Foley (1992) attributes this way of bridging to John Locke and calls it "the Lockean thesis" in accordance with Locke's (1823) thought in his work such that a rational epistemic subject's degree of belief in a proposition is expected to be in proportion to the support of evidence the epistemic subject has for it:

> …the mind, if it will proceed rationally, ought to examine all the grounds of probability, and see how they make more or less for or against any proposition, before it assents to or dissents from it; and, upon a due balancing the whole, reject or receive it, with a more or less firm assent, proportionably to the preponderancy of the greater grounds of probability on one side or the other. (pp. 98-99)

Foley (1992) puts forward that rational belief simpliciter corresponds to rational degree of confidence above some threshold level that epistemic subject counts as sufficient for belief:

> What matters, at least for the theory of rational belief, is that some threshold be chosen. For once such a threshold x is stipulated, we can use the Lockean thesis to say what is required for rational belief: it is rational for you to believe p just in case it is rational for you to have degree of confidence y in p, where y>x. (p. 38)

As a common way of formalizing this principle, Lockean Thesis is incorporated into our framework such that a doxastic subject with subjective probability (SPr) believes a proposition P just in case $SPr(P) > 1-\varepsilon$ for some $\varepsilon \in (0,1]$. Within the scope of our framework, due to the interpretation of CSBs, i.e., epistemic subject S's cognitively spontaneous belief that P is very likely to be true (therefore (probably) P) (Bonjour, 1985, p. 123), they are attributed with a value of ε close to 0. For the non-CSBs, the value of 0.5 is preferred for ε:

$$SPr(A) > (1-\varepsilon)\ where \begin{Bmatrix} \varepsilon\ is\ close\ to\ 0, & A\ is\ CSB \\ \varepsilon\ is\ 0.5, & A\ is\ non-CSB \end{Bmatrix}$$

Since in the local level (Bonjour, 1985, p. 91) we are interested in relative importance of S's beliefs, in case S's belief network (graph) contains any CSB, our framework is designed to take into account the necessity of relative normalization of degrees of beliefs. If we assume that the belief graph in Figure 1 did not contain any CSB, then S would pick any belief node with equal probability of 1/(total number of belief nodes) which is 1/3. As in the case of Figure 1, ε_1=0.50 is assumed for non-CSBs, ε_2=0.01 is assumed for CSB and S's subjective probability is reflected in accordance with Lockean Thesis as [0.51, 0.51, 0.51, 0.991], the relative distribution is expected to be approximately calculated in a normalized form (hereafter referred to as *NRD*) as [0.2023, 0.2023, 0.2023, 0.3931] noting that the relative degrees of beliefs remained the same, i.e., the degree ratios of CSBs to non-CSBs, CSBs to CSBs or non CSBs to non-CSBs. Hence, epistemic subject S who is randomly inferencing throughout the graph of her beliefs will start by choosing a belief at random in accordance with a normalized relative distibution like given above if CSBs are also present in her web.

As a next step, S then follows inferential links for a sequence of k steps: in each step, she uniformly at random[5] picks an out-going inferential link from her current belief, and follows it to where this link inferentially points to. Thus, a random path through the belief graph is constructed one belief node at a time. Such an exploration of belief nodes performed by randomly following inferential links is called a random inferential walk on the belief network.

The sequence of random inferential walks provides intuition in terms of measure of *inferential importance*, i.e., the importance of a belief B can be considered as the limiting probability that a random inferential walk throughout inferential links will end up at belief B, as epistemic subject S runs her walk for more and more numbers of steps.

[5] This expression is in accordance with the principle, namely The Principle of Indifference, that, in case of no reason to expect one event rather than another, all the possible events should be assigned the same probability, i.e., the epistemic subject divides her/his credences equally over all possibilities in terms of the uniform distribution.

Assuming that $p_1, p_2, \ldots, p_n$ represent the probabilities of the walk being at belief nodes $B_1, B_2, \ldots, B_n$ respectively in a given step, the probability that the epistemic subject S will be at belief node B_i in the next step can be obtained as follows[6]:

1. For each belief node B_j that is inferentially linked to belief node B_i:

If epistemic subject S's walk is currently at node B_j and the number of links emerging from node B_j is L_j, then there is a $1/L_j$ chance that S moves from B_j to B_i in the next step.

2. Since S's walk is currently at node B_j, node B_j contributes $p_j(1/L_j) = p_j/L_j$ to the probability of being at belief node B_i in the next step.

3. Summing p_j/L_j for each B_j that is linked to B_i gives the probability p_i for S's walk being at B_i in the next step as:

$$p_i = p_1N_{1i} + p_2N_{2i} + \cdots + p_nN_{ni}$$

where for matrix N, $N_{ij} = 0$ if B_i is not linked to B_j, and otherwise N_{ij} is the reciprocal of the number of outgoing links that B_i has, i.e., $1/L_i$. For belief network of S given in Figure 1, N is formed as given in Figure 2 and the corresponding transition graph of N is depicted in Figure 3:

[6] The algorithm described in (Brin & Page, 1998; Miller, 2014) (which is a variant of the eigenvector centrality algorithm (Bonacich, 1987) and is essentially a Markov chain), due to its general structure, can be applied to any network or graph in any domain, i.e., having diverse applications in the domains of social and information network analysis, internet computing, biology, chemistry, neuroscience, physics, etc. (Gleich, 2015) and utilized for modeling our epistemic subject S's random inferential walk in the domain of coherence in accordance with the formalisation in (Easley & Kleinberg, 2010).

N	**A**	**B**	**C**	**D***
A	0	1/2	0	1/2
B	0	0	1/2	1/2
C	1	0	0	0
D*	0	0	1	0

Figure 2 – N for S's belief network

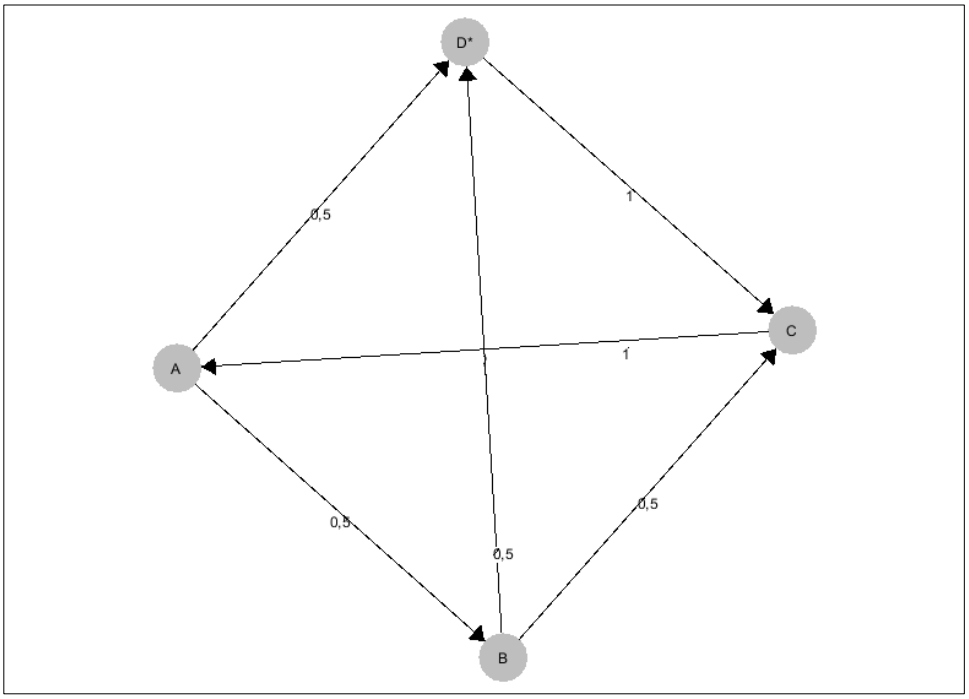


Figure 3 – The transition graph of N for S's belief network

An update rule (hereafter referred to as UR) to compute the probability (p_i) of S's walk at belief node B_i in the form of matrix-vector multiplication (where i-th element of vector p denotes the probability of S's being at node B_i) is as follows:

$$p \leftarrow N^T p$$

$$\mathbf{p}_{1^{st}\text{ iteration}} = \begin{vmatrix} 0 & 0 & 1 & 0 \\ 0.5 & 0 & 0 & 0 \\ 0 & 0.5 & 0 & 1 \\ 0.5 & 0.5 & 0 & 0 \end{vmatrix} \cdot \begin{vmatrix} 0.2023 \\ 0.2023 \\ 0.2023 \\ 0.3931 \end{vmatrix}$$

Intiutively, the probability of being at S's belief node B_i during her random inferential walk gets propagated evenly from B_i's outgoing inferential links to the adjacent belief nodes at the other ends of these links.

Bonjour's fourth criterion (BCC-4) refers to the possibility of relatively unconnected subsystems of beliefs in an epistemic subject's whole belief system. If that subject randomly starts her inferential walk in one of those unconnected belief clusters, she will have no way of getting to the others. The same case applies to the belief nodes with no outgoing links. In order to prevent such deadlocks, there is a need to modify this random walk by adding to the model the following[7]: With probability *s*, S's walk follows a random inferential link as before; and with probability (1 – s) S jumps to a belief node chosen randomly in accordance with NRD.

In this case, the probability of being at node B_i will now be the sum of (sp_j) / L_j , over all belief nodes B_j that link to B_i, to which $(1 - s)NRD_i$ is added.If the matrix N^*_{ij} is defined to be $sNij + (1 - s)\ NRD_i$, then the probability update takes form as:

$$p_i \leftarrow p_1 N^*_{1i} + p_2 N^*_{2i} + \cdots + p_n\ N^*_{ni}$$

[7] Typical values for (1-s) are in the range [0.1, 0.2] according to the algorithm described in (Brin & Page, 1998; Miller, 2014) (where s is 1 for the eigenvector centrality algorithm (Bonacich, 1987)).

or equivalently with the following updated UR*:

$$p \leftarrow (N^{*})^{T} p$$

This model is also capable of handling the Vicious Circularity problem as in Figure 4 via the jumping parameter *s* that is used to prevent the subsystem deadlocks. In case our epistemic subject S gets stuck in such a vicious circular loop (between B7 and B8), *s* will be used to break it and perform a random jump to any other node. Thus the accumulation of local coherence values at B7 and B8 will be prevented accordingly.

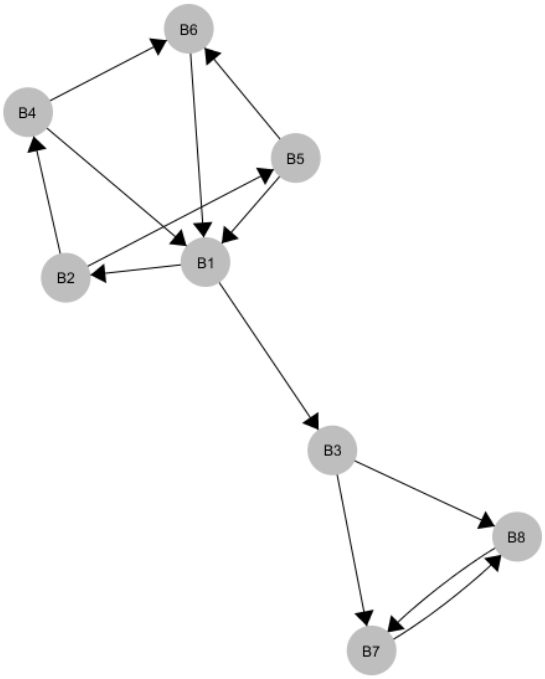


Figure 4 – Vicious circularity example in a belief network

The successive application of UR* makes p converge to a unique[8] stationary probability distribution vector consisting of limiting probability equilibrium values as

[8] Perron's Theorem guarantees that repeated application of the update rule (UR*) to any starting vector I with nonnegative values and any nonnegative matrix M, i.e., $M^{k}I$ and k goes to infinity, will end up with a unique nonnegative stationary limiting probability distribution vector denoting the local coherence values (Miller, 2014).

the number of applications goes to infinity in the long run. These stabilized values represent the *relative inferential importance* of each belief node, i.e., the local coherence measures of beliefs that can be used to measure the cohesion of an epistemic subject's belief system in the global level.

After the application of UR* iteratively, p converges to the relative coherence measures in local level as given in Table 1. The history of iterations until convergence takes place is depicted in Figure 5, correspondingly. Figure 6 describes S's belief graph on which relative coherence measures are visually scaled.

Table 1 – Relative coherence measures in local level for S's belief network

Belief Node	**Relative Coherence Measures in Local Level**
A	0,2911
B	0,1541
C	0,3067
D*	0,2481

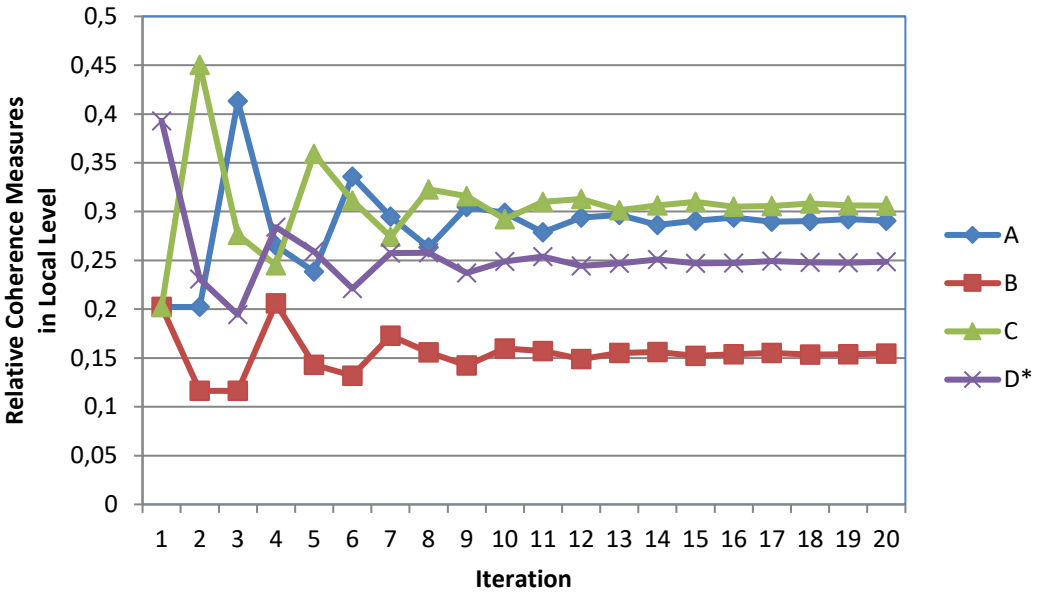


Figure 5 – Relative convergence of *p* for S's belief network

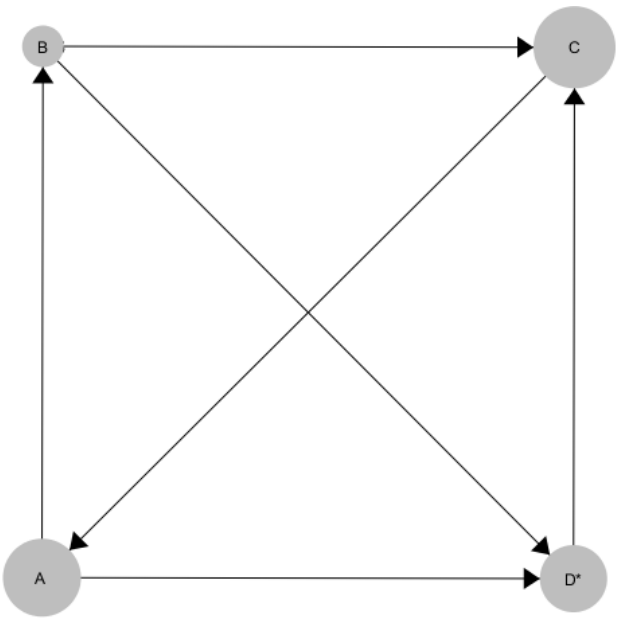


Figure 6 – Local coherence measures visually scaled for S's belief network

At this point, prima facie, accepting Observation Requirement by means of Cognitively Spontaneous Beliefs seems to attribute a kind of epistemic priority to such beliefs. Since it is this notion of priority which is at the core of foundationalism, it is necessary to point out that there is no epistemic priority given to CSBs since they are equally treated as other beliefs without crossing the red line of foundationalism. As given in Table 2 for the belief network depicted in Figure 1, the prior relative inferential importance measure of D* is decreased from 0,3931 to 0,2481, i.e., The change of the initial ordering from ($M_A=M_B=M_C<M_{D*}$) to ($M_B<M_{D*}<M_A<M_C$) shows that the cognitively spontaneous belief, D*, has no final presedence in this computational account of coherentism.

Table 2 – Comparison for relative inferential importance measures in local level for S's belief network

Belief Node	**Initial Relative Inferential Importance Measures (M)**	**Final Relative Inferential Importance Measures**
A	0.2023	0,2911
B	0.2023	0,1541
C	0.2023	0,3067
D*	0.3931	0,2481

Henceforth, the relative coherence measures obtained in the local level can be used to measure the cohesion of S's belief system in the global level with the orientation of the following definitions:

> **Definition 1.** Degree of separation is a function from an inferential link l of graph G to non-negative real numbers s.t.

$$DS_G(l) = |p_i - p_j|$$

where l is the inferential link from belief node B_i to belief node B_j and $|p_i - p_j|$ is the degree of separation measure between B_i and B_j.

Definition 2. Path, P_G, is a relation from a pair of belief nodes (B_i, B_j) of graph G to a set of tuples of inferential links which connect B_i to B_j.

Definition 3. Shortest path length, SPL_G, is a function from a pair of belief nodes (B_i, B_j) of graph G to non-negative real numbers s.t.

$$SPL_G(B_i, B_j) = \begin{cases} \min\{\sum_{l \in p} DS_G(l) \mid p \in P_G(B_i, B_j)\}, & P_G(B_i, B_j) \neq \emptyset \\ \infty, & otherwise \end{cases}$$

Definition 4. Average shortest path length is a function from a belief graph G to non-negative real numbers s.t.

$$ASPL(G) = \frac{\sum_{(B_i, B_j) \in G} SPL_G(B_i, B_j)}{N}$$

where $N = |\{(B_i, B_j) \mid (B_i, B_j) \in G \text{ and } i \neq j\}|$

As BCC-4 points out the possibility of relatively unconnected subsystems of beliefs in an epistemic subject's belief network, a problem with Definition 3 takes place where SPL returns ∞ for a tuple of belief nodes, i.e., ASPL diverges to infinity if there is a disconnected component or an isolated node in the belief graph. A common approach to avoid the divergence is to consider the harmonic mean of shortest path lengths, and to define the Harmonic ASPL of G as:

$$HASPL(G) = \frac{N}{\sum_{(B_i,B_j)\in G} \frac{1}{SPL_G(B_i,B_j)}}$$

$$where\ \frac{1}{\infty}\ is\ assumed\ to\ be\ 0$$

Under the intuition that HASPL and cohesion are inversely proportional, cohesion of belief graph of epistemic subject S can be defined as:

$$C_S(G) = HASPL_S(G)^{-1}$$

In BonJour's coherentist approach, logical consistency is not a sufficient criterion for an epistemic subject's belief set to be coherent, but it is a necessary condition (BCC-1). A set of beliefs, b_1, …. b_n, is coherent only if b_1, …. b_n neither includes, nor logically entails, a contradiction. Both belief sets BS_1 and BS_2 below contain logically contradictory beliefs (BS_1 more explicitly so than BS_2); neither set hangs together and lacks in coherence:

BS_1 {Pandas are herbivorous, Pandas are not herbivorous}

BS_2 {Tomorrow is weekend, Yesterday was Sunday}

Intuitively, an epistemic subject's belief set holding both "the belief that q" and "the belief that it is utmost improbable that q" is less coherent than that belief set would be without them (Bonjour, 1985, p. 95); although the set is logically consistent, it is not probabilistically so. Taking a rational epistemic subject who believes q, "Tomorrow will be rainy", but is not completely confident that q is correct; she believes q to a degree of 0.9. Meanwhile, if she believes "Tomorrow will be sunny" to a degree of 0.3, probabilistic consistency criterion (BCC-2) required by Bonjour is then violated since it is expected for the subject to believe "Tomorrow will be sunny" to a degree of 0.1.

Furthermore, a belief set may be both logically consistent and probabilistically consistent without being coherent. Belief set BS_3 below contains the beliefs which are relatively unrelated to one another whereas the beliefs in BS_4 are inferentially connected (Bonjour, 1985, p. 96). BS_3 avoid conflict by having no inferential connections to one another. But this leads to a case in which they do not hang together. With this connection, BCC-3, "The coherence of a system of beliefs is increased by the presence of inferential connections between its component beliefs and increased in proportion to the number and strength of such connections", requires some sort of positive connection among the beliefs for there to be coherence (Bonjour, 1985):

BS_3:{	BS_4:{
2 is a prime number,	All ravens are black,
There is no 'u' in 'Barack',	This bird is a raven,
Electrons are negatively charged	This bird is black
}	} (p. 98)

BonJour's third criterion partially prescribes that the degree of coherence increases with the number of inferential connections within the belief network of an epistemic subject. Principally, one could suppose such a positive correlation. But in order to consider the cases that include belief graphs in which inferential links are clustered around a batch of belief nodes, it is preferable to interpret "number of inferential connections" as "inferential density" which can serve as a more sensitive measure in terms of the number of inferential connections per beliefs in the epistemic subject's belief graph where V(G) denotes the set of vertices (belief nodes) and L(G) is the set of inferential links between these vertices (Olsson, 2021):

$$D(G) = \frac{|L(G)|}{|V(G)|}$$

By retouching "number of inferential connections" as "number of inferential connections per belief", it enables us to more precisely differentiate between belief

networks in terms of connectedness, that is, a corresponding graph of a belief network with higher density is expected to be more strongly connected.

In graph-theoretic terms, the strength of a belief system pointed out by BCC-3 typifies the difficulty of notionally cutting inferential links. This can be quantified via the minimization of the ratio of the number of inferential links removed to the number of belief clusters created due to the decomposition of the graph triggered by this removal. In other words, it is a measure based on computing partitions of the set of beliefs and detecting zones of high concentration of inferential links crossing over these partitions. Intuitively, as our epistemic subject S performs her random walk throughout her belief graph, a presupposed attacker would use the argument of the minimum effort to choose which inferential links to shatter for maximum deformation, i.e., minimizing over subsets of links (edges) the ratio of the effort to destroy and the benefit (level of fragmentation/scatter) received. Therefore, an epistemic subject walking a belief graph with higher strength is expected to be less vulnerable and has higher resistance to such attacks (Cunningham, 1985).

Let G be the graph representation of an epistemic subject's belief network and L(G) be the set of links in G. For X a subset of links, let G-X be the graph resulting from removing the links in X from G, and let ω(G-X) be the number of connected components in G-X. The strength (link/line-toughness) of G can be computed as follows (Chvátal, 2006):

$$\sigma(G) = \min\{\frac{|X|}{\omega(\mathrm{G}-\mathrm{X})} \mid X \subseteq \mathrm{L(G)}\}$$

In Figure 7, L(G) consists of six links and the corresponding strength is $\frac{3}{2}$ where X can be as given in Table 3:

Table 3 – Sample values for X

X	$\lvert X \rvert$	$\omega(G - X)$
{(B1, B2), (B1, B4), (B3, B1)}	3	2
{(B2, B3), (B2, B4), (B1, B2)}	3	2
{(B3, B1), (B2, B3), (B4, B3)}	3	2
{(B4, B3), (B2, B4), (B1, B4)}	3	2
{(B1, B2), (B1, B4), (B2, B3), (B2, B4), (B3, B1), (B4, B3)}	6	4

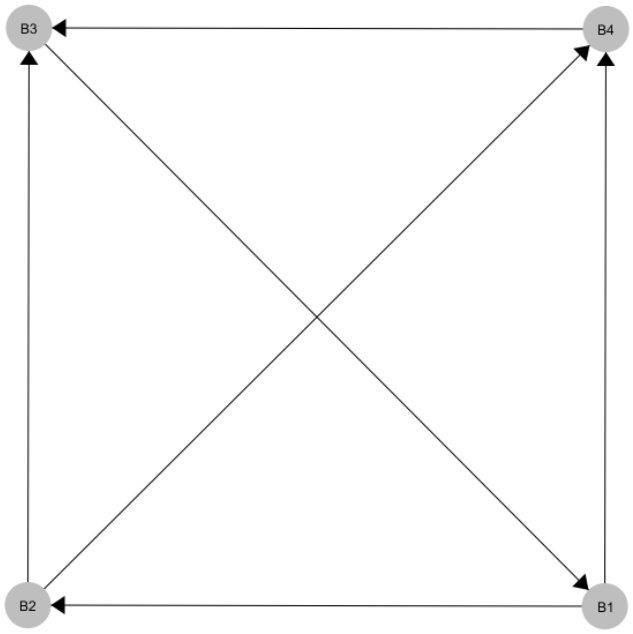


Figure 7 – Example graph for strength measure

According Bonjour, in the context of BCC-4, the coherence of a belief set is lessened to the extent to which it is separated into subsets of beliefs which are relatively disconnected to each other by inferential connections. Such a criterion evokes the concept of fragmentation in terms of clusters in an epistemic subject's belief network.

The measure to capture BCC-4 requires determining the ratio of the number of fragments (sub-systems) which are isolated from each other in the corresponding belief graph to the number of belief nodes of the system:

$$\Phi_1 = \begin{cases} \frac{\omega(\mathrm{G})}{|V(G)|}, & \omega(\mathrm{G}) > 1 \\ 0, & otherwise \end{cases}$$

Heterogeneity as a diversity network measure has been exploited through various indices including Simpson's index in biology, Blau's index in sociology/psychology and Herfindahl-Hirschmann index in economics. By using such a diversity index, the component-level measure of belief network fragmentation can be computed as the transformation of components' (isolated sub-networks a.k.a. clusters) diversity measure (Simpson, 1949):

$$\Phi_2 = 1 - D(G)$$

This generates a single measure of network fragmentation for each belief network that can be interpreted as the probability that any two randomly selected beliefs of a belief network are in different components, i.e., D(G) represents the probability that any two randomly picked beliefs reside in the same component:

$$\mathrm{D(G)} = \frac{|c_1|}{n}.\frac{|c_1 - 1|}{n-1} + \frac{|c_2|}{n}.\frac{|c_2 - 1|}{n-1} + \cdots + \frac{|c_k|}{n}.\frac{|c_k - 1|}{n-1} = \sum_{c \in C(G)} \frac{|\mathrm{c}|.(|\mathrm{c}| - 1)}{n.(n-1)}$$

$$where\ C(G)\ denotes\ the\ set\ of\ G's\ clusters\ and\ |C(G)| = k$$

Bonjour (1985) puts forward that the fifth criterion, BCC-5, is to be only "advisable" and thus presumably not a must-have criterion of his coherence theory of epistemic justification: "…it seems advisable to add one more condition to our list of conditions for coherence: (5) The coherence of a system of beliefs is decreased in proportion to

the presence of unexplained anomalies in the believed content of the system" (p. 99). Obviously, anomalies point to the phenomena which cannot be explained by the mechanism of the belief network which decrease the number and strength of inferential relations between the components of the network, making it less coherent, i.e., being isolates due to the lack of proper inferential links with the rest of the network. Hence, this criterion can naturally be considered to fall in the scope of the criteria, BCC-3 and BCC-4. Thus, there is no requisite to formalise the fifth requirement since it is concomitant with and handled by the criteria that preceded it.

Bonjour (1985) posits that consistency is a necessary criterion for knowledge, i.e., inconsistency is falsity-conducive in that inconsistency implies incoherence: "It is true that consistency is one requirement for coherence, that inconsistency is obviously a very serious sort of incoherence" (p. 95).

Therefore, not being inconsistent is a prerequisite for a belief system for which a degree of coherence is to be measured. After the consistency requirement is satisfied, by using the aforementioned coherence measures, a coherence theorist is able to compare one belief system with another and can then say that a rational subject is epistemically justified in moving from a belief system S_1 to other belief system S_2 only if the coherence scores of S_2 are better than those of S_1.

CHAPTER 4

EXPERIMENTAL COMPUTATIONAL EVALUATION

In the preeceding chapter, I attempted to give an account of formalisation for the coherence theory of justification by defining a computational framework which hereafter will be abbreviated as FBCT (Framework for Bonjour's Coherence Theory), along with certain coherence measures. Sharing the same opinion with Paul Thagard (1998), "At the core of epistemology is the need to understand the structure and growth of scientific knowledge, a project for which computational models can be very useful" (p. 48), throughout this chapter, various case studies are transformed into concrete experimental settings and their corresponding tests are conducted by using FBCT to which an epistemic subject's belief network, as representatively depicted in Figure 8, is fed:

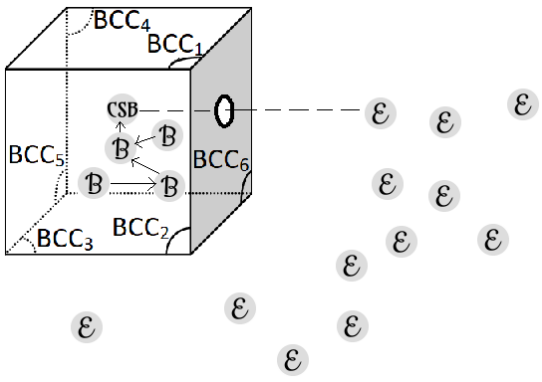


Figure 8 – A representation for an epistemic subject's belief network encapsulated by BCC's and mind-independent external world experiences

4.1 The Sally-Anne (False Belief) Test

In Sally-Anne test scenario as depicted in Figure 9, Sally and Anne are two dolls in a room (Baron-Cohen et al., 1985). Sally has a basket and a marble whereas Anne has only a box. Sally puts the marble into her basket and then goes out the room for a while. Then Anne takes Sally's marble out of the basket and puts it into her own box. After a while, Sally comes back to the room to play with her marble.

In the Baron-Cohen study, 20 autistic children and 27 non-autistic children were asked to answer the following question after Anne, Sally and dolls, were introduced to them and the control question of recalling their names by children were confirmed:

Where will Sally look for the marble (the basket or the box)?

According to the test results, 85% of clinically non-autistic children answered the above question correctly. However, 80% of the autistic children answered it incorrectly with "Anne's Box". Three years later, Leslie and Frith (1988) conducted the experiment with human actors instead of dolls and similar results were obtained.

The test setup (adapted from (O'Laughlin & Thagard, 2000, pp. 389-390)), the corresponding belief graphs and the test results are given in Table 4, Table 5 and Table 6, respectively. In each belief set, there exist no inconsistencies and FBCT computes CASE-B as being superior to CASE-A for each score of the coherence measures.

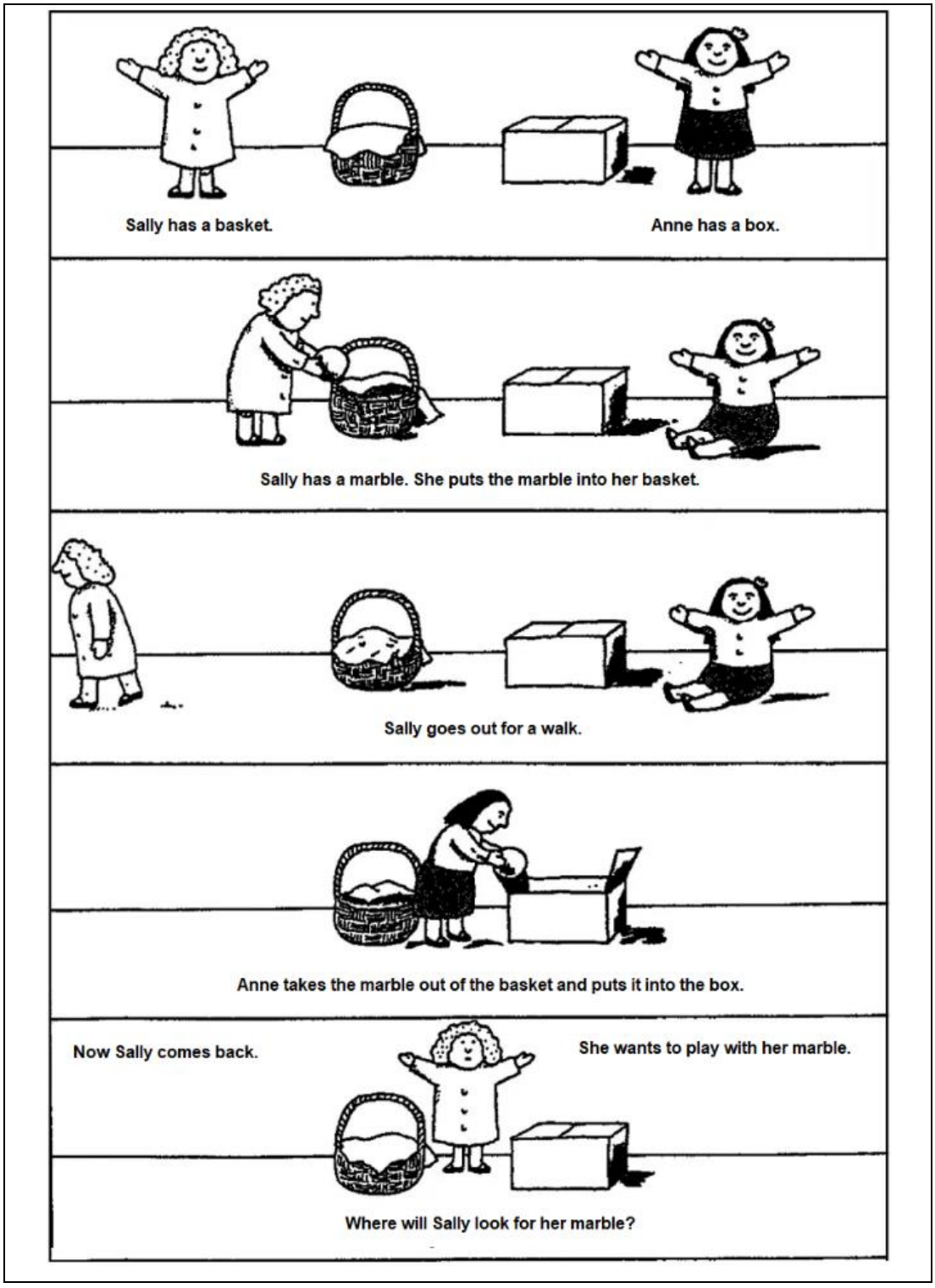


Figure 9 – The Sally-Anne storyboard for the False-Belief test by Baron-Cohen[9]

[9] Adapted from *Autism: Explaining the Enigma* (p. 83), by U. Frith, 1989, Blackwell Publishers. Copyright 1989 by Blackwell Publishers.

Table 4 – Sally-Anne (False Belief) test setup

	CASE A: Autistic Children	**CASE B: Non-Autistic Children**
Belief Sets	E1* E2* E3* E4* RH1	E1* E2* E3* E4* FH1 FH2 FH3
Inferential Connections	E3*, E4* → RH1	E2* → FH1 E1*, FH1 → FH2 FH2, E3* → FH3
Belief Descriptions	E1*: Sally puts the marble in the basket E2*: Anne puts the marble to box while Sally is away E3*: Sally wants the marble E4*: The Marble is in the box FH1: Sally did not see the marble moved to the box FH2: Sally thinks the marble is in the basket FH3: Sally looks in the basket RH1: Sally looks in the box	

Note. Adapted from "Autism and coherence: A computational model" by C. O'Laughlin & P. Thagard, 2000, Mind and Language, 15(4), 389-390, Copyright 2000 by Blackwell Publishers Ltd.

Table 5 – Belief graphs for Sally-Anne (False Belief) test cases

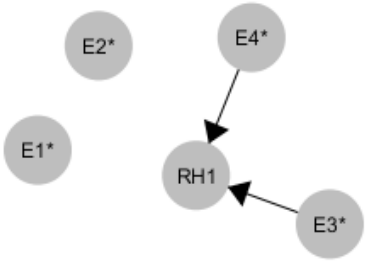
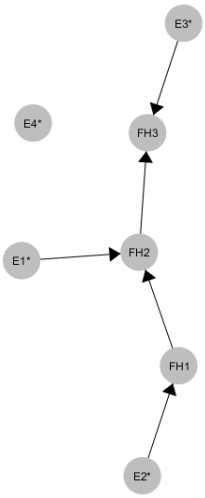
CASE A: Autistic Children	**CASE B: Non-Autistic Children**
	

Table 6 – Results for Sally-Anne (False Belief) test cases

	Cohesion	**Link Density**	**Strength**	**Fragmentation-I**	**Fragmentation-II**
CASE-A	0,2483	0,56	0,75	-1	-1
CASE-B	1	1	1	-0,4762	-0,4082
SUPERIORITY	B	B	B	B	B

4.2 The Combustion (Phlogiston Theory vs Oxygen Theory) Test

The change from Stahl's phlogiston theory in which most of the chemists were believers to the oxygen theory of Lavoisier is a noteworthy example from the history of science.

Stahl's phlogiston theory had very significant explanatory coherence, providing explanations of processes such as rusting and combustion, which are now collectively known as oxidation, that had directed chemistry for most of the 18th century. It was clearly the foremost explanation of the evidence until it was superseded by Lavoisier's oxygen theory in the 1780s. Stahl's view of phlogiston can briefly be described as:

> To Stahl, metals were compounds containing phlogiston in combination with metallic oxides (calces); on ignition the phlogiston was freed from the metal leaving the oxide behind. When the oxide was heated with a substance rich in phlogiston, such as charcoal, the calx again took up phlogiston and regenerated the metal. Phlogiston was a definite substance, the same in all its combinations. (Leicester & Klickstein, 1952, p. 59)

According to Stahl's theory, phlogiston was assumed to be given off when a body is burned. On the other hand, Lavoisier discovered an anomaly with phlogiston theory such that phosphorus and sulfur are expected to lighten when burned in experiments, but on the contrary, they have become heavier. Lavoisier describes this case as follows:

> This discovery which I have proved by experiments that I regard as decisive, has made me think that what was observed in the combustion of sulphur and phosphorous might take place in regard to all bodies which acquire weight in combustion or calcination, and I felt sure (‘je me suis persuudk) that the increase in weight of the metallic cakes was due to the same cause. My conjecture was completely confirmed by experiment. I reduced litharge (lead oxide) in closed vessels, with the apparatus of Hales and I observed that at the moment of the passage of calx (calcium oxide) into metal a considerable quantity of air was given off and that the volume of this air was at least a thousand times as great as that of the litharge used. As this discovery seemed to me one of the most interesting made since the work of Stahl, I have thought it right to make certain that my claim to it by depositing the present note in the hands of the Secretary of the Academy to remain secret till the moment when I publish my experiments. Paris 1, November 1772. (Hartog, 1941)

The test setup (adapted from (Thagard, 1993, pp. 83-84)), the corresponding belief graphs and the test results are given in Table 7, Table 8 and Table 9, respectively. In each belief set, there exist no inconsistencies and the computation of FBCT resolves the oxygen-phlogiston controversy by assigning CASE-B as being superior to CASE-A for each score of the coherence measures.

Table 7 – The combustion test setup

	CASE A: **Phlogiston Theory**	**CASE B:** **Oxygen Theory**
Belief Sets	PH1, PH2, PH3, PH4, PH5, PH6 E1*, E2*, E3*, E4*, E5*, E6*, E7*, E8*	OH1, OH2, OH3 OH4, OH5, OH6 E1*, E2*, E3*, E4*, E5*, E6*, E7*, E8*
Inferential Connections	PH1, PH2, PH3→E1* PH1, PH3, PH4→E2* PH5, PH6→E5*	OH1, OH2, OH3→E1* OH1, OH3→E3* OH1, OH3, OH4→E4* OH1, OH5→E5* OH1, OH4, OH5→E6* OH1, OH5→E7* OH1, OH6→E8*

Note. Adapted from Conceptual Revolutions (pp. 83-84), by P. Thagard, 1993, Princeton University Press. Copyright 1993 by Princeton University Press.

Table 7 (continued)

	CASE A: Phlogiston Theory	**CASE B: Oxygen Theory**
Belief Descriptions	E1*: In combustion, heat and light are given off. E2*: Inflammability is transmittable from one body to another. E3*: Combustion only occurs in the presence of pure air. E4*: Increase in weight of a burned body is exactly equal to weight of air absorbed. E5*: Metals undergo calcination. E6*: In calcination, bodies increase weight. E7*: In calcination, volume of air diminishes. E8*: In reduction, effervescence appears. OH1: Pure air contains oxygen principle. OH2: Pure air contains matter of fire and heat. OH3: In combustion, oxygen from the air combines with the burning body. OH4: Oxygen has weight. OH5: In calcination, metals add oxygen to become calxes. OH6: In reduction, oxygen is given off. PH1: Combustible bodies contain phlogiston. PH2: Combustible bodies contain matter of heat. PH3: In combustion, phlogiston is given off. PH4: Phlogiston can pass from one body to another. PH5: Metals contain phlogiston. PH6: In calcination, phlogiston is given off	

Note. Adapted from Conceptual revolutions (pp. 83-84), by P. Thagard, 1993, Princeton University Press.

Table 8 – Belief graphs for the combustion test cases

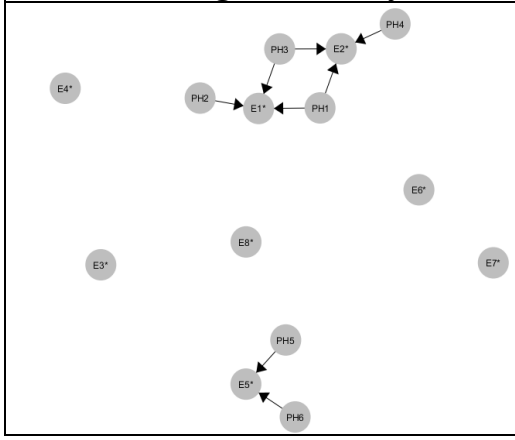
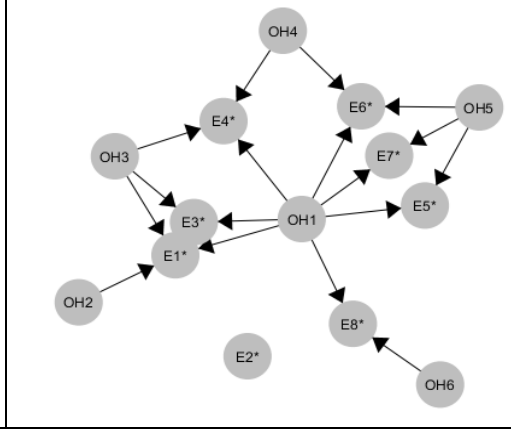
CASE A: Phlogiston Theory	CASE B: Oxygen Theory
	

Table 9 – Results for the combustion test cases

	Cohesion	**Link Density**	**Strength**	**Fragmentation-I**	**Fragmentation-II**
CASE-A	0,2954	0,4706	0,375	-1	-1
CASE-B	1	1	1	-0,2857	-0,1781
SUPERIORITY	CASE-B	CASE-B	CASE-B	CASE-B	CASE-B

4.3 The Astronomy (Ptolemaic Geocentrism Theory vs Copernican Heliocentrism Theory) Test

In the 2nd century, the main contribution of Ptolemy's solar system model and heavenly sphere was that his view was able to explain the motions of heavenly bodies (sufficiently accurate to describe and predict the motions of the celestial bodies for almost 1400 years). Ptolemy thought that all celestial objects, including the planets, the sun, the stars and the moon, orbited the earth, that is, the earth was stationary and

was both the center of the solar system and the entire universe. His model was also based upon the concept of "perfect circles", i.e., by assuming that each planet was moving on its own small circle, simultaneously having a motion on a larger circle, called, epicycle and deferent, respectively.

As observations improved starting with the 14th century, continuous refinements to Ptolemy's model were mandatory. Consequently, by the 16th century, the corrected Ptolemaic model had become very complex. At this point, Copernicus proposed his heliocentric model as a *simpler* one which would produce the same observed results, but with fewer circles. In his model, Moon orbits Earth, there is a much easier explanation of retrograde motion and the planets orbit stationary Sun which is located in the center of the universe:

> Finally, we shall place the Sun himself at the center of the Universe. All this is suggested by the systematic procession of events and the harmony of the whole Universe, if only we face the facts, as they say, 'with both eyes open? (Copernikus, 1959)

Later on in 1600s, it was found that the Ptolemaic model and the Copernican model made different predictions about the shadows on Venus. Meanwhile, new telescope technology allowed Galileo to make observations of the phases of Venus and his results adopted by scientific community indicated that Venus *must* orbit Sun and this was the end for Ptolemy's geocentric model of the solar system.

The test setup (adapted from (Nowak et al., 1992, pp. 274-309)), the corresponding belief graphs and the test results are given in Table 10, Table 11 and Table 12, respectively. In each belief set, there exist no inconsistencies and FBCT finalizes the computation for geocentric and heliocentric theories by attributing superiority to CASE-B for each score of the coherence measures.

Table 10 – The astronomy test setup

	CASE A: Ptolemaic Geocentrism Theory	**CASE B: Copernican Heliocentrism Theory**
Belief Sets	PC1, PC2, PC3, PC4, PC5, PC6, PC7, PC8, PC9, PC10, PC11, PC12, P2, P3, P5, P6, P7, P9, P12, P14, P16, P17, P18, P19, P20, P22, P23, P24, P25, P26, P27, P28, P28E, P28V, P29, P29E, P29I, P29V, P30, P30E, P30I, P30V, P33, P33E, P33S, P34, P35, P36, P37, P38, P39, P40, E1*, E2*, E3*, E4*, E5*, E6*, E7*, E8*, E9*, E10*, E11*, E12*, E13*, E14*, E15*, E16*, E18*, E19*, E20*, E21*, E22*, E24*, E25*, E26*, E27*, E28*, E30*, E31*, E33*, E35*, E36*, E40*, E43*, E45*, E46*, E48*, E49*, E50*, E51*, E52*, E53*, E54*, E55*, E56*, E57*, E58*, E59*, E60*, E64*, E66*, E67M*, E67V*, E68J*, E68M*, E68S*, E69*, E73J*, E73M*, E73S*, NE41*, NE42*	PC1, PC2, PC3, PC4, PC5, PC6, PC7, PC8, PC9, PC10, PC11, PC12, C4, C5, C7, C8, C9, C10, C11, C12, C13, C14, C15, C19, C20, C21, C22, C23, C26, C27, C28, C29, C31, C32, C32V, C33, C34, C35, C39, C40, C41, E1*, E2*, E3*, E4*, E5*, E6*, E7*, E8*, E9*, E10*, E11*, E12*, E13*, E14*, E15*, E16*, E18*, E19*, E20*, E21*, E22*, E24*, E25*, E26*, E27*, E28*, E30*, E31*, E33*, E35*, E36*, E40*, E41*, E42*, E43*, E45*, E46*, E48*, E49*, E50*, E51*, E52*, E53*, E54*, E55*, E56*, E57*, E58*, E59*, E60*, E64*, E66*, E67M*, E67V*, E68J*, E68M*, E68S*, E69*, E73J*, E73M*, E73S*
Inferential Connections	P2 P3 → E1* P6 P12 PC2 → E2* P6 P22 P24 PC2 → E3* P2 P3 P7 → E4* P14 P12 → E5* P9 P6 P5 → E6* PC3 P12 P17 PC11 → E7* PC1 P2 P3 P5 PC3 → E8*	C4 C8 → E1* C9 PC2 C12 → E2* C9 PC2 C12 C19 → E3* C4 C5 C8 → E4* C9 C10 → E5* C7 C9 C12 → E6* PC3 C12 C13 PC11 → E7* PC1 PC3 C4 C8 → E8*

Note. Adapted from Cognitive Models of Science (pp. 302-309), by G. Nowak, P. Thagard, 1992, University of Minnesota Press. Copyright 1992 by the Regents of the University of Minnesota.

Tablo 10 (continued)

	CASE A: Ptolemaic Geocentrism Theory	**CASE B: Copernican Heliocentrism Theory**
Inferential Connections	PC1 PC3 P5 → E9* PC1 P2 P6 P7 P12 → E10* PC1 P6 P9 → E11* PC1 P2 P3 P6 P9 → E12* P2 P3 P6 P7 P12 → E13* P6 P12 P17 PC11 → E14* PC1 P5 P6 P9 → E15* P2 P3 P5 → E16* P12 PC2 P14 → E18* P2 P3 P5 P17 → E19* P16 P17 P18 P19 P20 P12 → E20* P16 P17 P18 P19 P20 P12 → E21* PC4 P16 P17 P19 PC8 → E22* PC4 P16 P17 PC8 P19 → E24* P16 P17 P18 P19 P20 P12 → E25* P2 P5 → E26* P12 P17 PC9 PC12 → E27* P33 P33E PC2 P33S P34 P35 P36 → E30* P33 P33E P33S PC2 P34 → E31* P22 P23 P24 P25 PC2 → E35* P22 P23 P24 P25 P26 PC2 → E36* P24 PC2 P27 P28 P28E → E40* P16 P17 P18 P19 P20 → NE41* P16 P17 P18 P19 P20 → NE42* P33 P34 P37 PC2 → E43* P6 P24 → E45* P6 P34 → E46* P33 P34 P37 P38 P39 P40 → E48*	PC1 PC3 C4 → E9* C9 C5 C8 → E10* PC1 C7 C9 C12 → E11* PC1 C4 C7 C8 C9 C12 → E12* C5 C8 C9 C11 → E13* C9 C12 C13 PC11 → E14* C7 C9 C12 → E15* C4 C8 C11 → E16* C9 PC2 C10 → E18* C4 C13 → E19* C13 C14 C15 → E20* C13 C14 C15 PC8 → E21* C13 C14 C15 PC4 PC8 → E22* PC8 C13 PC4 → E24* C13 C14 C15 C9 → E25* C4 C8 C11 → E26* C9 C12 C13 PC12 → E27* C9 C12 C19 C39 → E28* C12 C22 C23 C9 PC2 → E30* C9 C12 C22 PC2 C39 → E31* C9 PC2 C12 C19 C39 → E33* C19 C20 C21 PC2 → E35* C19 C20 C21 PC2 → E36* C19 C29 C31 C32 PC2 → E40* C13 C14 C15 PC2 → E41* C13 C14 C15 PC2 → E42* C22 C26 PC2 → E43* C9 C12 C19 → E45* C9 C12 C22 → E46* C9 C22 C26 C27 C28 → E48* C19 C33 C34 C35 → E49* C19 C33 C34 C35 → E50* C19 C33 C34 C35 → E51* C19 C33 C34 C35 → E52* C19 C33 C34 C35 → E53* C19 C33 C34 C35 → E54* C19 C29 C31 C32 C32V → E55* C19 C29 C31 C32 C32V → E56*

Note. Adapted from Cognitive Models of Science (pp. 302-309), by G. Nowak, P. Thagard, 1992, University of Minnesota Press. Copyright 1992 by the Regents of the University of Minnesota.

Tablo 10 (continued)

	CASE A: Ptolemaic Geocentrism Theory	**CASE B: Copernican Heliocentrism Theory**
Inferential Connections	P22 P24 P29 P29I P29E → E49* P22 P24 P29 P29I P29E P29V → E50* P22 P24 P29 P29I P29E P29V → E51* P22 P24 P30 P30I P30E → E52* P22 P24 P30 P30I P30E P30V → E53* P22 P24 P30 P30I P30E P30V → E54* P22 P24 P27 P28 P28E P28V → E55* P22 P24 P27 P28 P28E P28V → E56* P33 P34 P36 P35 P37 → E57* P34 P38 P36 P39 P40 → E58* P34 P36 P37 P38 P39 P40 → E59* P12 P16 P17 → E60* PC10 P34 → PC5 PC10 PC5 P34 → PC6 PC10 PC5 PC6 P34 → PC7 P2 P3 P5 P6 P12 → E66* P6 P12 P34 → E68S* P6 P12 P34 → E68J* P6 P12 P34 → E68M* PC9 → E64*	C22 C23 C26 C27 → E57* C22 C26 C27 C28 → E58* C22 C26 C27 C28 C9 → E59* C13 C9 → E60* C22 C9 C12 → PC5 C12 C22 C9 → PC6 C12 C22 C9 → PC7 C13 C19 C22 → PC9 C9 C19 C22 → PC10 PC10 C19 C9 C12 → C40 PC10 C19 C9 C12 → C41 C4 C9 C12 → E66* PC5 PC6 PC7 PC10 C40 C41 → C39 C40 C41 C9 C12 C19 → E67M* C40 C9 C12 C19 → E67V* C22 C39 C9 → E68S* C22 C39 C9 → E68J* C22 C39 C9 → E68M* C9 C19 C40 C41 → E69* C22 C12 C39 C9 → E73S* C22 C12 C39 C9 → E73J* C22 C12 C39 C9 → E73M* PC9 → E64*
Belief Descriptions	See Appendix A.	

Note. Adapted from Cognitive Models of Science (pp. 302-309), by G. Nowak, P. Thagard, 1992, University of Minnesota Press. Copyright 1992 by the Regents of the University of Minnesota.

Table 11 – Belief graphs for the astronomy test cases

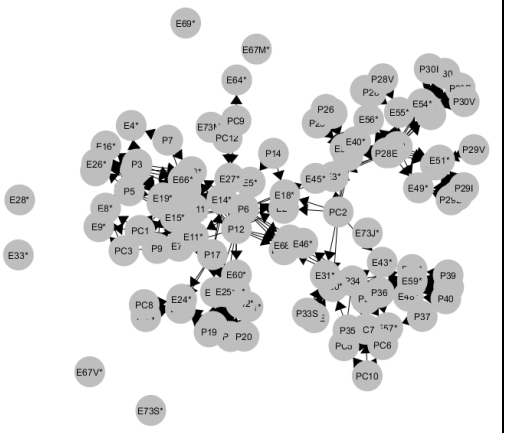
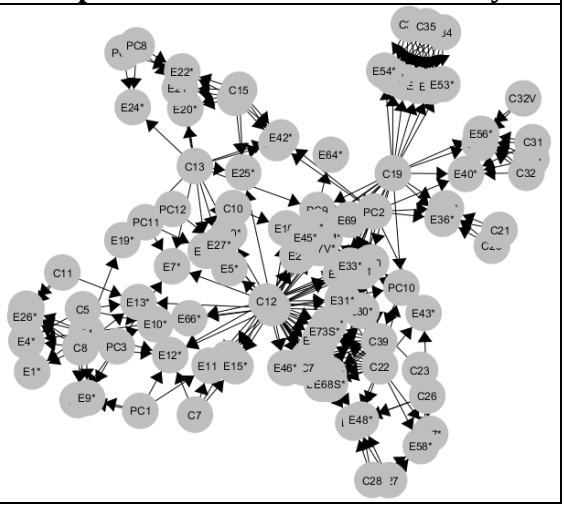
CASE A: Ptolemaic Geocentrism Theory	CASE B: Copernican Heliocentrism Theory
	

Table 12 – Results for the astronomy test cases

	Cohesion	Link Density	Strength	Fragmentation-I	Fragmentation-II
CASE-A	0,384	0,8462	0,6773[10]	-1	-1
CASE-B	1	1	1	0	0
SUPERIORITY	CASE-B	CASE-B	CASE-B	CASE-B	CASE-B

4.4 The Global Warming (Naturalistic Theory vs Anthropogenic Theory) Test

Global climate changes in the late-20th century point out a obvious anomaly in the historical climate records. The rise in surface air temperature of 0.6 ± 0.2 °C observed

[10] In case the number of links of a belief graph is high, i.e., time complexity grows faster, FBCT switches to the greedy algorithm approach for the *strength* measure computation and the median of a parametrized number of successively repeated scores is taken.

since the end of the 19th century has happened at an extraordinary rate in the last ten centuries (Houghton et al., 2001). Such a rise at a quite high rate during the last four decades in global temperatures has prompted considerable discussion in the global scientific community as pointed out by the Intergovernmental Panel on Climate Change (IPCC) in order to comprehend the changes that are currently being observed in the global climate system as depicted in Figure 10 (Pachauri & Meyer, 2015).

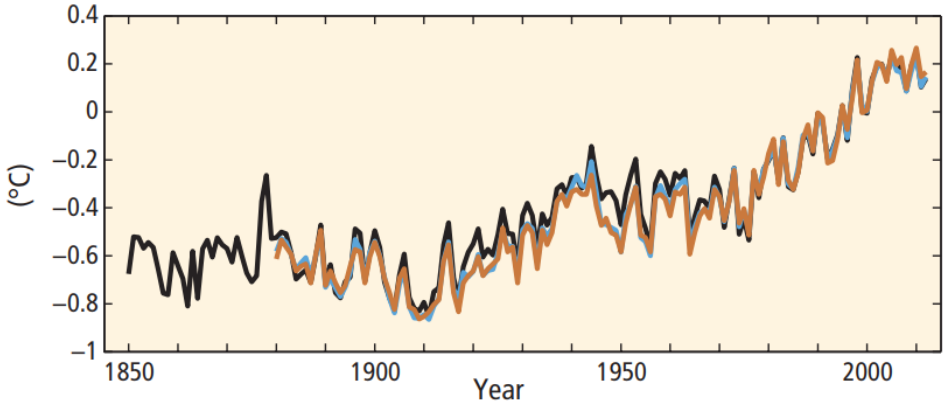


Figure 10 – Globally averaged combined land and ocean surface temperature anomalies relative to the average over 1986 to 2005[11]

Since established in 1988 as an organization of 195 governments that are members of the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO), the mission of the IPCC which is contributed by thousand of scientists from all over the world is to assess the science related to climate change in terms of scientific results shared each year and to give an overall summary of what is learned about the triggers of climate change, its long term effects along with future risks and how those risks can be mitigated by developing climate policies by governments before they turn into issues (IPCC, 2018).

[11] From Climate change 2014: Synthesis report: Contribution of Working Groups I, II and III to the Fifth Assessment Report of the intergovernmental panel on climate change (p. 3), by R. K. Pachauri, L. A. Meyer, 2015, IPCC. Copyright 2015 by Intergovernmental Panel on Climate Change.

The IPCC releases assessment reports at regular intervals, which also serve as a substantial input into negotiations of international climate change, with the current evaluation, based mainly on application of climate models along with comparisons of field observations with simulations.

The forcing agents that influence global warming are mainly classified as natural and anthropogenic. Natural effects are due to solar irradiance and volcanic eruptions. Anthropogenic agents which are effective since about 1850s, with the growth of industrialisation, mainly consist of greenhouse gases (GHG), e.g., ozone (stratospheric and tropospheric), carbon dioxide, water vapor, nitrous oxide, methane as given in Figure 11 (IPCC, 2018; Matthews et al., 2004; Myhre et al., 2014).

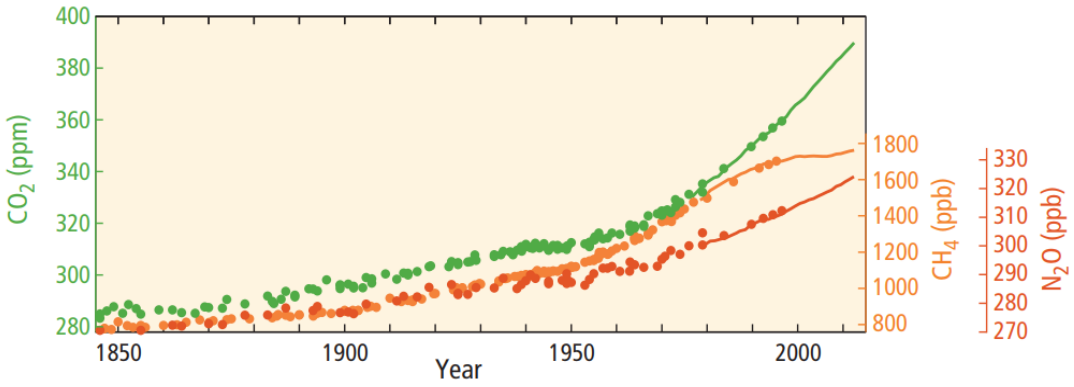


Figure 11 – Globally averaged greenhouse gas concentrations[12]

IPCC's fifth assessment report (AR5) has stated that the globally averaged surface temperature data indicate a warming of about 0.85 °C [0.65°C - 1.06°C], over the anthropogenic period 1880 to 2012. These assessments attribute over 90% of the global warming since the end of 19th century, and a higher percentage of the global

[12] From Climate change 2014: Synthesis report: Contribution of Working Groups I, II and III to the Fifth Assessment Report of the intergovernmental panel on climate change (p. 3), by R. K. Pachauri, L. A. Meyer, 2015, IPCC. Copyright 2015 by Intergovernmental Panel on Climate Change.

warming since 1970s, to anthropogenic factors, particularly. IPCC primarily attributes this rise to the increased level of atmospheric CO_2 since 1750 (Myhre et al., 2014).

The controversy between anthropogenic forcing due to GHG and natural forcing of solar-volcanic heating can simply be modeled with the test setup (adapted from (Thagard & Findlay, 2010)), the corresponding belief graphs and the test results given in Table 13, Table 14 and Table 15, respectively. In each belief set, there exist no inconsistencies and the computation of FBCT attributes superiority to CASE-B for each score of the coherence measures indicating that anthropogenic activities are mainly responsible for the global climate changes.

Table 13 – The global warming test setup

	CASE A: Naturalistic Theory	**CASE B: Anthropogenic Theory**
Belief Sets	E1*, E2*, E3", E4", E5", N1, N2, N3, N4, N5	E1*, E2*, E3*, E4*, E5*, IPCC1, IPCC2, IPCC3, IPCC4, IPCC5, IPCC6, IPCC7, IPCC8
Inferential Connections	N1, N2 → N4 N1, N2, N4 → E1* N1, N2, N3, N4 →E4*	IPCC1, IPCC2 → IPCC4 IPCC4, IPCC7 → IPCC5 IPCC5, IPCC3, IPCC8 → IPCC6 IPCC5, IPCC6 → E1* IPCC5, IPCC6 → E2* IPCC5, IPCC6, IPCC7, IPCC3 → E3* IPCC5, IPCC6, IPCC8 → E4* IPCC5, IPCC6, IPCC7, IPCC3 →E5*
Belief Descriptions	E1*: Average global temperatures have risen significantly since 1880. E2*: The rate of warming is rapidly increasing. E3*: The recent warming is more extreme than any other warming period as far back as the record shows to 1000 AD. E4*: Arctic ice is rapidly melting and glaciers around the world are retreating. E5*: Global temperature shows strong correlation with carbon dioxide levels throughout history. IPCC1: Carbon dioxide, methane gas, and water vapour are greenhouse gasses. IPCC2: Greenhouse gasses absorb infrared radiation, some of which is reemitted back to the Earth's surface. IPCC3: Carbon dioxide levels in the atmosphere have been increasing since the beginning of the industrial revolution.	

Note. Adapted from Belief Revision Meets Philosophy of Science (pp. 343-345), by E.J. Olsson, S. Enqvist (eds.), P. Thagard, S. Findlay, 2010, Springer. Copyright 2010 by Springer.

Table 13 (continued)

	CASE A: Naturalistic Theory	**CASE B: Anthropogenic Theory**
Belief Descriptions	IPCC4: There is a greenhouse effect that warms the planet. IPCC5: The greenhouse effect has the potential to be enhanced. IPCC6: Global warming is a human caused crisis. IPCC7: Increasing the concentration of greenhouse gasses in the atmosphere directly increases the warming of the Earth. IPCC8: Small changes in global temperature have the potential to drastically upset a variety of climate systems through causal interactions. N1: Long term cycling of Earth's orbital parameters, solar activity and volcanism and associated aerosols are natural causes that can warm the globe. N2: The impact of natural factors on global temperature dwarfs the enhanced greenhouse effect. N3: Climate systems will be affected by natural cycles and fluctuations. N4: Global warming is natural and not a concern. N5: Small changes in temperature will not have significant negative effects on global climate.	

Note. Adapted from Belief Revision Meets Philosophy of Science (pp. 343-345), by E.J. Olsson, S. Enqvist (eds.), P. Thagard, S. Findlay, 2010, Springer. Copyright 2010 by Springer.

Table 14 – Belief graphs for the global warming test cases

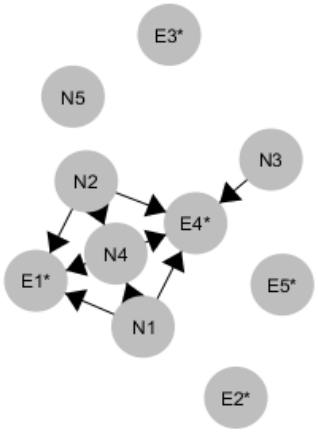
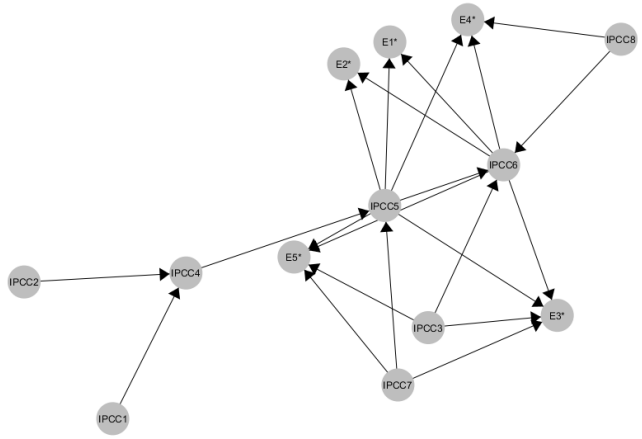
CASE A: Naturalistic Theory	**CASE B: Anthropogenic Theory**
	

Table 15 – Results for the global warming test cases

	Cohesion	**Link Density**	**Strength**	**Fragmentation-I**	**Fragmentation-II**
CASE-A	0,1649	0,5318	0,3333	-1	-1
CASE-B	1	1	1	0	0
SUPERIORITY	CASE-B	CASE-B	CASE-B	CASE-B	CASE-B

4.5 The Chambers Trial (Innocence Theory vs Guiltiness Theory) Test

The test case outlined in this section is a case from the domain of legal reasoning. On August 26, 1986, Robert Chambers was convicted of killing his friend, Jennifer Levin, in New York City's Central Park. Prosecutor Linda Fairstein stated: "Robert and Jennifer left Dorrian's, by all accounts, the bar on 2nd Avenue, around four or 4:30 in the morning. At 6:20, a cyclist in the park found her body, her lifeless body under a tree." After the police arrived at Chambers' house, "He came out of the bedroom and the minute the two detectives - homicide detectives - saw him, they saw deep, fresh, bloody scratches on both sides of his face. And in their minds without saying anything their immediate thought was this guy has to explain those scratches" she continued (CBS Interactive, 2016). Chambers' initial statement that his cat had scratched him was rapidly discredited after the police brought him in for questioning. At the end of the trial that went on for two years, he confessed his guilt and claimed it was an accident that he reflexively hit his friend after she injured him during rough sex.

The test setup given in Table 16 is adapted from (Thagard, 1989) in which the theories of innocence and guiltiness for Chambers case is modeled based on the New York Times daily reports. The corresponding belief graphs and the test results are given in Table 17 and Table 18, respectively. In each belief set, there exist no inconsistencies[13]

[13] Since G6 and G7 do not directly rule out each other, their subjective probabilities are assumed to be consistent with Lockean Thesis.

and the computation of FBCT assigns superiority to CASE-B for each score of the coherence measures pointing out that Robert Chambers is guilty.

Table 16 – The chambers trial test setup

	CASE A: Innocence Theory	**CASE B: Guiltiness Theory**
Belief Sets	E0*, E1*, E2*, E3*, E4*, E5*, E6*, E7*, E8*, E9*, E10*, E11*, E12*, E13*, E14*, E15*, E16*, I1, I2, I3, I4, I5, I6, I7, I8	E0*, E1*, E2*, E3*, E4*, E5*, E6*, E7*, E8*, E9*, E10*, E11*, E12*, E13*, E14*, E15*, E16*, G1, G2, G3, G4, G5, G6, G7
Inferential Connections	I1, I8 → E0* I2 → E1* I3 → I4 I4 → I1 I3, I5 → E4* I6 → E8* I7 → E12* I3 → E15* I1 → E16*	G2 → G1 G2 → E3* G2 → E4* G2 → E7* G2 → E12* G1 → G4 G1 → E0* G1 → E1* G2 → E10* G2 → E11* G4 → E13* G2 → E14* G2 → E15* G5 → E8* G5 → E9* G3 → E16* G3 → E6* G6 → G1 G7 → G1 G2 → G7
Belief Descriptions	**Evidences:** E0*: Jennifer died. E1*: Jennifer had wounds on her neck. E2*: Jennifer said she liked sex with Chambers. E3*: Jennifer's blouse was around her neck. E4*: Jennifer's panties were not found near her. E5*: The police were careless about evidence.	

*Note.*Adapted from Behavioral and Brain Sciences 12(3) (pp. 453-454), by P. Thagard, 1989, Cambridge University Press. Copyright 1989 by Cambridge University Press.

Table 16 (continued)

	CASE A: Innocence Theory	CASE B: Guiltiness Theory
Belief Descriptions	E6*: Chambers lied to Jennifer's friend about not having seen Jennifer. E7*: Chambers had scratches on his face and cuts on his hands. E8*: Chambers had a broken hand. E9*: The skin on Chambers' hand was not broken. E10*: Jennifer's left eye was swollen and her mouth was cut. E11*: Jennifer's face was dirty. E12*: Jennifer had pinpoint hemorrhages in eye tissue. E13*: Jennifer's neck had severe hemorrhages. E14*: Bloodstains of Chambers' type were found on Jennifer's jacket. E15*: Chambers' fingers were bitten. E16*: Chambers' video said he had hit her once. **Hypotheses that Chambers is guilty:** G1: Chambers strangled Jennifer. G2: Chambers and Jennifer struggled. G3: Chambers lied about what happened. G4: Jennifer's neck was held for at least 20 seconds. G5: Chambers broke his hand punching Jennifer. G6: Chambers intended to kill Jennifer. G7: Chambers intended to hurt Jennifer. **Hypotheses that Chambers is innocent:** I1: Chambers killed Jennifer with a single blow. I2: The marks on Jennifer's neck were a scrape from Chambers' watchband. I3: Jennifer was having rough sex with Chambers. I4: Jennifer grabbed painfully Chambers' genitals. I5: The police moved Jennifer's panties. I6: Chambers broke his hand falling on a rock. I7: Chambers threw Jennifer over his shoulder. I8: Chambers' blow triggered the carotid sinus reflex.	

Note. Adapted from Behavioral and Brain Sciences 12(3) (pp. 453-454), by P. Thagard, 1989, Cambridge University Press. Copyright 1989 by Cambridge University Press.

Table 17 – Belief graphs for the Chambers trial test cases

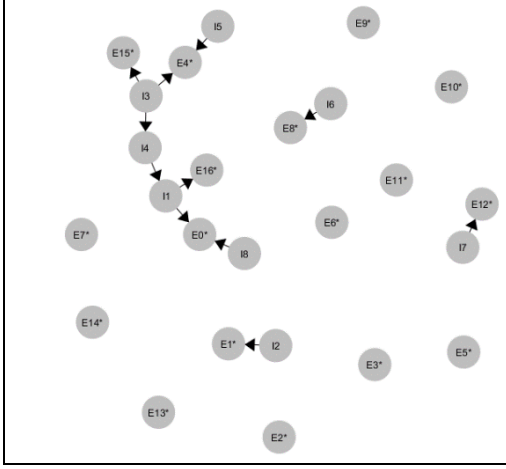
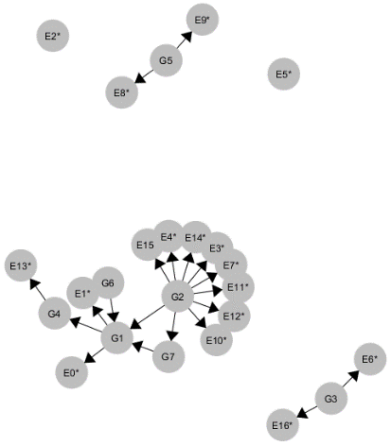
CASE A: Innocence Theory	CASE B: Guiltiness Theory
	

Table 18 – Results for the Chambers trial test cases

	Cohesion	**Link Density**	**Strength**	**Fragmentation-I**	**Fragmentation-II**
CASE-A	0,2515	0,528	0,4	-1	-1
CASE-B	1	1	1	-0,372	-0,6247
SUPERIORITY	CASE-B	CASE-B	CASE-B	CASE-B	CASE-B

4.6 The Earth Tectonics (Contracting Earth Theory vs Sea-floor Spreading Theory) Test

By the mid-19th century, global cooling theory, namely, Contracting Earth Theory, formulated by the American geologist James Dwight Dana, had gained widespread acceptance by attempting to explain mountains (wrinkles) and basins (fissures) as results of a cooling and shrinking process of Earth which was formerly in a molten state like a drying grape turning into a crumpled raisin. The pressure produced by the

contraction which is triggered by cooling caused some portions of the crust to buckle upwards generating mountains and other regions to buckle downwards creating ocean basins. Calculations had led to a declaration that the cooling of the Earth from a molten state over a period of about one hundred million years induced the Earth's circumference to be contracted by hundreds of kilometers. Despite some problems, Contracting Earth Theory satisfied most geologists including a leading Austrian geologist Eduard Suess expressing in 1885: "What we are witnessing is the collapse of the world" (Frankel, 2012, p. 39).

The Contracting Earth Theory had been questioned and like many scientists of the time, Alfred Lothar Wegener realized that it can in fact not stand up to some observational data. One flaw was about the age of the mountains. From both radioactive dating measurements and fossil evidences, it was known that mountains varied enormously in age, e.g., The Caledonians of Scotland had been much, much older than the European Alpine system. Were the Contracting Earth Theory true, all mountains were expected to be nearly at the same age. Another flaw was concerned with the pattern of mountain ranges aligned at the edges of continents in the form of curvilinear and narrow belts. In case the Earth was actually contracting, such belts would not be expected. Instead, it would be plausable to imagine mountains randomly scattered on the Earth's surface. After Wegener's death, the scientific community continued to believe that the contracting Earth theory was correct and that the locations of the continents were fixed., i.e., although they can submerge, they could neither depart nor be created from scratch. This view had survived for more than three decades until, Harry Hammond Hess, had come up with a stimulating hypothesis that the ocean floors were not stationary. They were more like conveyor belts transporting the continents over them. In his paper, entitled "The History of Ocean Basins", he mentioned:

> The birth of the oceans is a matter of conjecture, the subsequent history is obscure, and the present structure is just beginning to be understood. Fascinating speculation on these subjects has been plentiful, but not much of it predating the last decade holds water. … *I shall consider this paper an*

> *essay in geopoetry*. In order not to travel any further into the realm of fantasy than is absolutely necessary I shall hold as closely as possible to a uniformitarian approach; even so, at least one great catastrophe will be required early in the Earth's history. (Hess et al., 1962, pp. 599-600)

Hess used the term "geopoetry" to describe his (at the time) eccentric ideas because he wanted scientific community to suspend their disbelief and allow him to speculate imaginatively, as if writing poetry.

Hess put forward his outstanding theory that is currently recognized as a fundamental support of plate tectonics such that the sea floor is mobile and continually being regenerated. He theorized that oceanic ridges lie above rising convection cells in the mantle, where fluidic material from the underlying mantle is constantly swelling and spreading outward, producing about half an inch of new lithosphere per year at both sides of mid-ocean ridges.

As new oceanic crust was created along mid-ocean ridges, Hess conjectured that because the Earth was not expanding, an equal amount of old crust must have been destroyed at the same time, and he correctly predicted that this happens in deep ocean trenches that run close to the margins of the continents. This process, in which the ancient ocean floor retreated into deep trenches, was then called 'subduction', that is, old materials are being recycled back into the mantle. In his own words:

> The ocean basins are impermanent features and the continents are permanent, although they may be torn apart or welded together and their margins deformed. The continents are carried passively on the mantle with convection and do not plough through the oceanic crust. (Hess et al., 1962, p. 618)

During this process which was later termed as sea-floor spreading, with the aforementioned mantle convection rate, the ocean floors would have been expected to be generated during the last 200 to 300 million years which is about one-tweentieth of the age of the Earth.

Currently, the theory of seafloor spreading has gained wide acceptance and it is known that the expansion is caused by convection currents in the ductile asthenosphere and fragile lithosphere (Elsasser, 1971). On the other hand, Contracting Earth Theory is now disproven and considered obsolete.

The contention between Contracting Earth Theory and Seafloor Spreading Theory can be modeled with the test setup (adapted from (Thagard, 1993, pp. 157-190)), the corresponding belief graphs and the test results given in Table 19, Table 20 and Table 21, respectively. In each belief set, there exist no inconsistencies and the computation of FBCT attributes superiority to CASE-B for each score of the coherence measures pointing out to the fact that Contracting Earth Theory is no longer valid.

Table 19 – The earth tectonics test setup

	CASE A: **Contracting Earth Theory**	**CASE B:** **Seafloor Spreading Theory**
Belief Sets	E1*, E2*, E3*, E4*, E5*, E6*, E7*, E9*, E10*, E11*, E12*, E13*, E14*, E15*, E16*, E17*, E18*, E19*, E20*, E21*, E22*, E23*, E24*, E25*, NE14, NE17, NE18, NE20, NE21, CS1, CS2, C1, C2, C3, C4, C8, C9, C10, C11, C12, C13, C14, C15, C16, C17, C18, C19, C20	E1*, E2*, E3*, E4*, E5*, E6*, E7*, E9*, E10*, E11*, E12*, E13*, E14*, E15*, E16*, E17*, E18*, E19*, E20*, E21*, E22*, E23*, E24*, E25*, CS1, CS2, S2, S4, S7, S8, S10, S11, S14, S15, S16, S17, S18, S19, S20, S21, S22
Inferential Connections	C1 → C2 C1 → NE20 C1 → NE14 C2, C3, C11, C14, C17 → E2* C2, C3, C14 → E3* C1, C3, C14, C15, C16, C17, C18 → E4* C2, C3, C4, C17 → E7* C2, C3, C4, C11, C14, C16, C17 → E9*	S4, S7, S10 → E1* S2, S4, S11 → E2* S2, S15, S18, S22 → E3* S2, S4, S11, S21 → E4* S2, S4, S7, S10 → E5* S2, S4, S7, S10 → E6* S2, S4, S11 → E9* S2, S4, S11 → E10* S2, S14, S15, S16, S17 → E11* S2, S22 → E12* S2, S21, S22 → E13*

Note. Adapted from Conceptual Revolutions (pp. 187-190), by P. Thagard, 1993, Princeton University Press. Copyright 1993 by Princeton University Press.

Tablo 19 (continued)

	CASE A: Contracting Earth Theory	**CASE B: Seafloor Spreading Theory**
Inferential Connections	C11, C14, C16, C17, C18 → E10* C9, C10 → E11* C2, C3, C4, C14, C15, C20 → E12* C11, C13, C14 → E13* C9, C10, C12, C13 → E16* C12, C13 → NE17 C9, C10 → NE18 C8 → E19* C19 → E20* C9, C10 → NE21 C8 → E22* C2, C3, C12 → E23* CS2, CS1 → E7*	S2, S22 → E14* S2, S15 → E15* S2, S15, S19 → E16* S2, S15, S16, S20 → E17* S2, S15, S16, S20 → E18* S4, S7, S8, S10 → E19* S2, CS1, S15 → E20* S2, S15, S16, S20 → E21* S4, S7, S8, S10 → E22* S2, S10, S15 → E23* S2, S15, S16, S18 → E24* S2, S15, S16, S18 → E25* CS2, CS1 → E7*
Belief Descriptions	**Evidences:** E1*: Many fossil species are divided by water. E2*: There are sedimentary strata at high elevations. E3*: Oceanic earthquakes produce steeply dipping faults. E4*: There are nearly horizontal faults in mountain ranges. E5*: The geology of opposite sides of die Atlantic is similar. E6*: Transoceanic continental margins are congruent. E7*: Scandinavia is rising 1 cm./yr. E9*: Existence of mountains. E10*: Structure of Alps requires major compession. E11*: Seismic refraction indicates that oceanic crust is very uniform. E12*: There are gravity deficiencies at oceanic trenches. E13*: Deep earthquakes occur near oceanic trenches, at an angle to surface. E14*: Trenches are colder than the rest of the ocean floor. E15*: Mid-ocean ridges have high heatflow. E16*: There is a mid-Pacific Mesozoic ridge. E17*: There are relatively few volcanic seamounts on the ocean floor. E18*: There are no pre-Cretaceous rocks on the ocean floor. E19*: Apparent polar wander paths indicate that the north magnetic pole was not always where it is today.	

Note. Adapted from Conceptual Revolutions (pp. 187-190), by P. Thagard, 1993, Princeton University Press.

Tablo 19 (continued)

	CASE A: Contracting Earth Theory	CASE B: Seafloor Spreading Theory
Belief Descriptions	E20*: Average heatflow in oceans about same as that of continents, despite radioactive rock. E21*: There is a relatively thin veneer of sediments on tbe ocean floor. E22*: Apparent polar wander paths differ between continents, but are consistent within continents. E23*: There is a worldwide system of mid-ocean ridges. E24*: Most oceanic earthquakes occur on central rift. E25*: Seismic velocities under the crests of ridges are lower than normal, but become normal again on ridge flanks. **Contractionist hypotheses:** C1: The upper mantle of the earth has been gradually cooling. C2: The earth has been contracting since birth. C3: The crust is compressed and fractures into blocks. C4: Blocks subside and become elevated. C8: Earth's magnetic pole has wandered over time. C9: Ocean basins are older than continents. C10: Ocean basins are parts of the original crust that have been least altered. C11: Continents grow over former ocean floors, starting with accretion of deltas. C12: Topography of ocean floors is complex, more rugged than that of continents. C13: There are large number of islands and seamounts on the ocean basin that originated as volcanoes. C14: After shelf accretion, a conical fracture zone forms further offshore than the shelf, located by earthquake foci. C15: Volcanism starts as a result of the fracturing and produces a volcanic arc. C16: Continental material accumulates from volcanic residue and erosion of the continents, creating shallow inland seas. C17: Further depression, compression, and uplift convert inland seas to land and volcanic arcs into mountain arcs. C18: Primary arcs of mountain building meeting at an acute angle create a short mountain range of great height. C19: Measures of the earth's radioactivity are too high. C20: Ocean trenches are due to overriding by inner blocks of arcs. NE14: Trenches over a cooling mantle should be as warm as the rest of the ocean floor.	

Note. Adapted from Conceptual Revolutions (pp. 187-190), by P. Thagard, 1993, Princeton University Press.

Tablo 19 (continued)

	CASE A: Contracting Earth Theory	CASE B: Seafloor Spreading Theory
Belief Descriptions	NE17: An ancient ocean floor should display many volcanic seamounts. NE18: An ancient ocean floor should include rocks of all epochs. NE20: A cooling mantle would leave the ocean floor cooler than the continents. NE21: An ancient ocean floor should be covered with a thick layer of sediment. **Seafloor spreading hypotheses:** CS1: Mantle is viscous. CS2: Ice sheets are heavy enough to depress continental marginss. S2: The mantle is convecting at the rate of 1 cm./yr. S4: The continents are carried passively on the mantle at a uniform rate by convection and do not plow through oceanic crust. S7: Continents were once all connected. S8: The earth's pole of rotation has moved with respect to the crust. S10: Rising limbs coming up under continental areas fracture them and move the fragmented parts away from one another. S11: Mountains form on the leading edges of continents underthrusting one another. S14: Continental and oceanic crust are very different. S15: The mantle's convection cells have rising limbs under mid-ocean ridges. S16: Mantle material comes to the surface at the crest of mid-ocean ridges and becomes oceanic crust. S17: The uniform thickness of the oceanic crust results from the maximum height that the 500 degree C. isotherm can rach under the mid-oceanic ridge. S18: Higher temperatures and intense fractures under ridge crests explain lower seismic velocities there. S19: Mid-ocean ridges are ephemeral features having a life of 200 to 300 million years, the life of a convecting cell. S20: The whole ocean is virtually swept clean (replaced by new mantle material) every 300 to 400 million years. S21: The leading edges of continents are strongly deformed when they impinge upon the downward moving limbs of convecting mantle. S22: The oceanic crust, buckling down into the descending limb, is heated and loses its water to the oceans.	

Note. Adapted from Conceptual Revolutions (pp. 187-190), by P. Thagard, 1993, Princeton University Press.

Table 20 – Belief graphs for the earth tectonics test cases

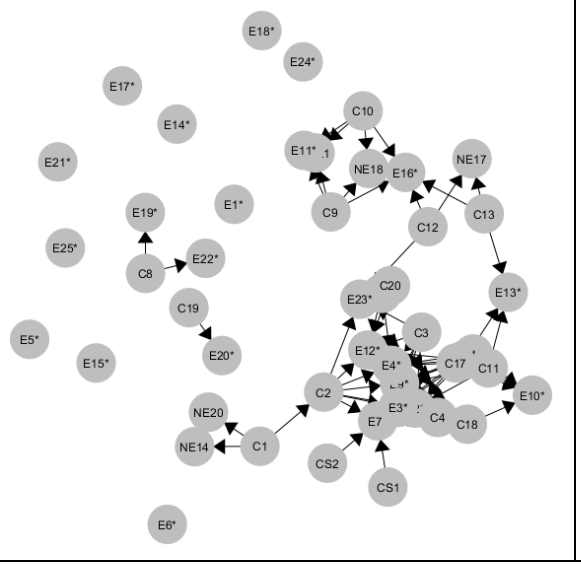
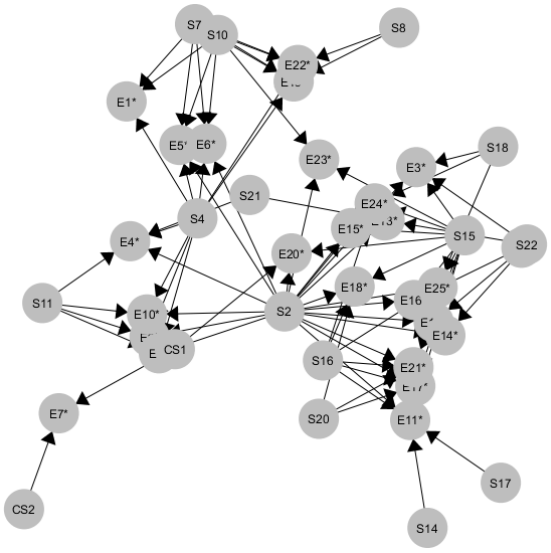
CASE A: **Contracting Earth Theory**	**CASE B:** **Seafloor Spreading Theory**
	

Table 21 – Results for the earth tectonics test cases

	Cohesion	**Link Density**	**Strength**	**Fragmentation-I**	**Fragmentation-II**
CASE-A	0,6431	0,6644	0,1398	-1,0	-1,0
CASE-B	1,0	1,0	1,0	0,0	0,0
SUPERIORITY	CASE-B	CASE-B	CASE-B	CASE-B	CASE-B

4.7 The Ulcer (Acidity Theory vs Bacterial Theory) Test

In the early-20th century, ulcers were believed to be caused by stress and dietary factors. The therapy was based on hospitalization, bed rest and special diets. In 1910,

Dr. Karl Schwarz put forward the excess acid theory of ulcer, announcing the phrase "no acid, no ulcer" (Gustafson & Welling, 2010). Within the practice of this view, antacids had been used to prevent acid production as standard therapy. In the course of time, the recurrence rate of the disease had been observed to be unexpectedly high.

For the first time, in 1982, Dr. J. Robin Warren and Dr. Barry J. Marshall succeeded to isolate the spiral-shaped bacteria in cultures of endoscopic biopsy specimens from patients having peptic ulcer disease (PUD) and gastritis. By this finding, despite the medical community's consensus that bacteria could not survive in the acidic stomach, the link between Helicobacter pylori (H. pylori) and ulcers was first identified (Warren & Marshall, 1983). McNulty and Watson (1984) succeeded to reproduce findings of Marshall and Warren's study. In the meantime, this accomplishment was approved by the Gastroenterological Society of Australia to be presented. In June 1984, Marshall intentionally injected H. pylori to himself and became infected. By taking antibiotics, he was successful to show that it is possible to get relieved of this disease. At this time, Dr. Lawrence K. Altman, the medical correspondent of The Newyork Times, wrote an article on the relation between ulcer disease and H. Pylori. Later in 2002, he surprisingly stated that "I have never seen the medical community more defensive or more critical" since 1969 (Humphrey, 2002). Contemporaneously, the treatment involving antibiotics and bismuth developed in 1984 by Dr. Thomas Borody was able to successfully treat H. pylori with an eradication rate greater than 90%, which later became commercialized in 1994 (Borody et al., 1992). Followingly, Dr. David Graham's study succeeded to heal his patients' ulcers in 1992 by using antibiotics therapy (Graham et al., 1992).

Nevertheless, the theory has remained in dispute, with the role of H. pylori still debated, up until the evidence for bacterial infection hypothesis piled up to such a level so that National Institute of Health (USA) accepted H. pylori as the cause of PUD and recommended that antibotics be used for the treatment of duedenal ulcers. In 1994, The World Health Organization's International Agency for Research on Cancer recognized H. pylori a Group 1 (definite) cause of cancer (Møller et al., 1994). In

1995, the consumer research by the American Digestive Health Foundation found that nearly 90 percent of ulcer sufferers were unaware that H. pylori is the root cause of ulcers so that they believed their ulcers were caused by stress, and 60 percent attributed to diet (Centers for Disease Control and Prevention, 2006). Eventually, the dispute is closed by fundemantally changing the understanding of ulcer disease and its treatment when The Nobel Prize in Physiology or Medicine 2005 was awarded jointly to Marshall and Warren "for their discovery of the bacterium Helicobacter pylori and its role in gastritis and peptic ulcer disease (PUD)" (Nobel Prize Organization, 2005).

The excess acidity and the bacterial theories can be modeled with the test setup (adapted from (Thagard, 2000, pp. 232-233)) and the corresponding belief graphs given in Table 22 and Table 23, respectively. In Table 24, FBCT points out the superiority of CASE-B for each score of the coherence measures yielding the fact that acidity theory is obselete.

Table 22 – The ulcer test setup

	CASE A: **Acidity Theory**	**CASE B:** **Bacteria Theory**
Belief Sets	E1*, E2*, E3*, E4*, E5*, E6*, E7*, E8*, A1	E1*, E2*, E3*, E4*, E5*, E6*, E7*, E8*, B1, B2, B3, B4
Inferential Connections	A1 → E3* A1 → E4*	B1, B2 → E1* B2 → E2* B1, B2 → E3* B1, B2 → B4* B1, B3 → E4* B3 → E8* B4 → E5* B4 → E6* B4 → E7*

Table 22 (continued)

	CASE A: Acidity Theory	CASE B: Bacteria Theory
Belief Descriptions	**Evidences:** E1*: Association between bacteria and ulcers E2*: Many have observed stomach bacteria E3*: Some people have stomach ulcers E4*: Antacids heal ulcers E5*: Marshall's 1988 study that antibiotics cure ulcers E6*: Graham's 1992 study that antibiotics cure ulcers E7*: Several other cure studies E8*: Bacteria/acid study **Acidity hypotheses:** A1: Excess acidity causes ulcers **Bacteria hypotheses:** B1: Bacteria cause ulcers B2: Stomach contains bacteria B3: Bacteria produce acid B4: Eradicating bacteria cures ulcers	

Table 23 – Belief graphs for the ulcer test cases

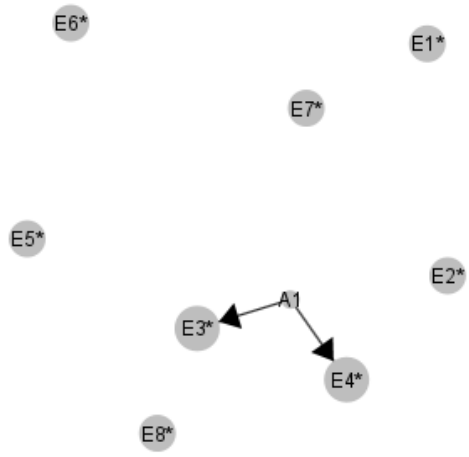
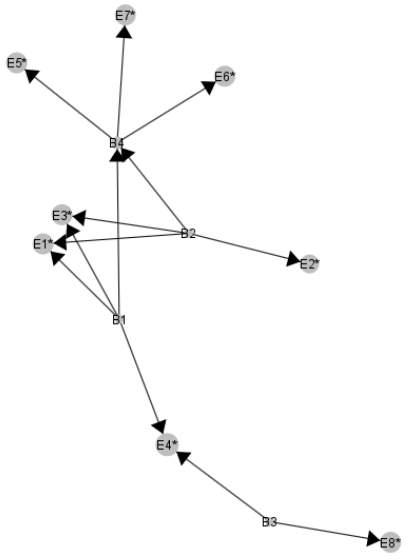
CASE A: Excess Acidity Theory	CASE B: Bacteria Theory
	

Table 24 – Results for the ulcer test cases

	Cohesion	**Link Density**	**Strength**	**Fragmentation-I**	**Fragmentation-II**
CASE-A	0,1099	0,2051	0,25	-1,0	-1,0
CASE-B	1,0	1,0	1,0	0,0	0,0
SUPERIORITY	CASE-B	CASE-B	CASE-B	CASE-B	CASE-B

4.8 Truth-Conduciveness Analysis of the Experimental Results

In all of the experiments conducted above, the contact with the external world is established via the cognitively spontaneous beliefs. Without them, Isolation Problem would take place and associated belief sets of theories would remain solely as epistemic subjects' mental representations consisting of isolated beliefs. In this context, FBCT implements BCC-6 by incorporating CSBs to the computation in terms of evidences which are considered to be highly reliable, i.e., very likely to be true. Thus, it is ensured that evidences are integrated into systems of belief with this computational account of coherence providing such a sort of truth connection.

In each case study, a pair of competing theories are measured for their coherences via five metrics devised, namely, cohesion, link density, strength, fragmentation I and II. Coherence measures are said to be truth-conducive if and only if a higher degree of measured coherence eventuates in a higher likelihood of truth. It should be emphasized that this is not a strong view of truth-conduciveness such that coherence implies a high probability of truth, but rather a weaker one as a *greater (relatively high)* likelihood of truth. In this sense, probability specifies the degree to which hypotheses (belief set) of epistemic subject cohere with, i.e., are inferentially supported by, evidences in terms of CSBs.

Within this context, we can assume two rival theories such that their belief sets are denoted by BS_1 and BS_2, respectively and both of them are subject to the same set of evidences in terms of cognitively spontaneous beliefs which is denoted by CSBS. Coherence measure in the scope of this computational account is truth-conducive if and only if the following holds, i.e., given the common evidence set of CSBS and the measured relative coherence of BS_2 is being greater than that of BS_1, the set of hypotheses of BS_2 (excluding CSBS) is more likely to be true, i.e., truer, than that of BS_1:

$$Pr(BS_2 \setminus CSBS \mid (RC(BS_2) > RC(BS_1)) \,\&\, CSBS) > Pr(BS_1 \setminus CSBS)$$

where RC(X) represents the *relatively* measured coherence of X

In order to exemplify this sort of truth-conduciveness, the case study of combustion can be illustrative:

BS_1 = {PH1…PH6, E1…E8} for Phlogiston Theory
BS_2 = {OH1…OH6, E1…E8} for Oxygen Theory
CSBS = {E1…E8}
$BS_1 \setminus CSBS$ = {PH1…PH6}
$BS_2 \setminus CSBS$ = {OH1…OH6}

Prior probabilities of CSBS elements (evidences) are assigned in accordance with Lockean interpretation taking ε close to 0 as 0.01 so that their probability is approximately 1, i.e., very likely to be true. In the same manner, hypotheses of belief sets' initial probabilities are assigned by taking ε as 0.5, yielding:

$Pr(e) = 0.991$ where $e \in CSBS$
$Pr(h) = 0.51$ where $h \in BS_1 \setminus CSBS$ or $h \in BS_2 \setminus CSBS$

Subsequently, FBCT takes this initial probability distribution of a belief set and normalizes it relatively:

NRD_{BS1} = [0.0464…0.0464, 0,0902…0,0902]

The random inferential walk of epistemic subjects on the corresponding belief graphs for BS_1 and BS_2 is then triggered. After equilibrium state probabilities are reached throughout the graphs yielding local coherences, *cohesion* measure of coherence is computed for each set in the global level:

$$\text{COHESION}_{BS1} = 0.44311 \qquad \text{COHESION}_{BS2} = 1.49991$$

Cohesion measurements of BS_1 and BS_2 are subjected to normalization:

$$\text{COHESION}_{BS1} = 0.2954 \qquad \text{COHESION}_{BS2} = 1.0$$

This process is followed by the other coherence measurements for link density, strength, fragmentation I and II along with their normalizations:

$\text{LINKDENSITY}_{BS1} = 0.4706$	$\text{LINKDENSITY}_{BS2} = 1.0$
$\text{STRENGTH}_{BS1} = 0.375$	$\text{STRENGTH}_{BS2} = 1.0$
$\text{FRAGMENTATION-I}_{BS1} = -1$	$\text{FRAGMENTATION-I}_{BS2} = -0.2857$
$\text{FRAGMENTATION-II}_{BS1} = -1$	$\text{FRAGMENTATION-II}_{BS2} = -0.1781$

A relatively higher value for cohesion, link density, strength and a relatively lower value for fragmentation measurements result in a higher degree of coherence. Since all relative coherence measurement values of oxygen theory are superior to those of phlogiston theory in this sense, it is plausible to conclude:

$$RC(BS_2) > RC(BS_1)$$

In the scope of BS_1, phlogiston was assumed to be given off when a body is burned. However, the precise experiments of Lavoisier encountered an anomaly (E6) with phlogiston theory such that metals were gaining, rather than losing, weight when they

were burned. Within time, phlogiston theory also failed to explain other evidences (E3, E4, E6, E7, E8) and it is ruled out by the scientific community with a *no longer valid* label. Thus, it is superseded by more likely to be true, i.e., truer, Lavoisier's oxygen theory such that

$$Pr(BS_2 \setminus CSBS) > Pr(BS_1 \setminus CSBS)$$

Additionally, since any belief set is subject to be superseded by future sets due to the problem of underconsideration, i.e., in the long run, there may be other belief sets not considered yet, it is important to recall that the aforementioned weaker view of truth-conduciveness is included in the scope of this study in order to prevent prematurely ascribing absolute truth to the singled-out belief set. The above explicated interpretation of truth-conduciveness similarly applies to the other case studies given in this chapter.

CHAPTER 5

CONCLUSION

Most epistemologists believed that there is a close relationship between truth and epistemic justification. Is it that if a set of beliefs are justified, then in virtue of what makes them justified it is highly likely (or secured) that they are true? In the scope of the coherence theory of justification, such a relation is certainly not apparent. This is the major criticism of coherentism for which no satisfactory resolution for the problem of truth-conduciveness has been provided.

The isolation and alternate system objection (ASO) can be seen as escalated forms of truth-connection problem. The view that epistemic justification depends merely on the internal coherence of a belief set seems to imply that such justification does not necessitate any input from the world external to that belief set. Moreover, it is possible to create alternative coherent sets of beliefs, one containing belief B, and an equally coherent system including its negated form ¬B. In the presence of these problems, coherentist views of justification seem inadequate to lead us search for truth.

With ASO raising the possibility that there can be two mutually incompatible coherent systems that are equally coherent, Bonjour (1985) states such a commonly expressed objection to coherentism as follows:

> According to a coherence theory of empirical justification […] the system of beliefs which constitutes empirical knowledge is epistemically justified solely by virtue of its internal coherence. But such an appeal to coherence will never even begin to pick out one uniquely justified system of beliefs, since on any plausible conception of coherence, there will always be many,

> probably infinitely many, different and incompatible systems of belief which are equally coherent. (p. 107)

Prima facie, it seems that coherentism is too permissive letting an epistemic subject believe, with justification, whatever she wants to believe. Richard Feldman (2003) exemplifies this more clearly:

> Consider the proposition that Abraham Lincoln was assassinated. If, as the objectors contend, there are many different, and incompatible, coherent systems of beliefs, there will be some systems that include this belief and others that include its negation. If that belief is part of your actual system, you can imagine a system that replaces everything supporting it or following from it with different propositions. By carefully constructing the new system, you could get one just as coherent as your current system, but including the proposition that Lincoln was not assassinated. Thus, if there are all these different coherent systems, then you can make any belief you want justified simply by picking and choosing the rest of your beliefs appropriately. That cannot be right. (p. 67)

Bonjour argues that this objection becomes invalid once BCC-6 is satisfied via the Observation Requirement. While coherentism seems to provide no solution to the problem for a particular instance of time at which such equally coherent systems of beliefs are competing, he points out, in the long run, with the continuous introduction of cognitively spontaneous beliefs, one system is bound to be more coherent than the other and corresponds closer (in the long run and approximately) to reality (Bonjour, 1985, p. 144): "This is neither alarming nor particularly surprising. The most that it seems reasonable to expect of an epistemological account is that it make it possible for such ties to be broken in the *long* run."

In this respect, let us assume that two belief systems, BS_1 of rational epistemic subject S_1, and BS_2 of rational epistemic subject S_2, are competing at a particular time and each belief of BS_2 is the negation of the corresponding belief of BS_1, as depicted in Table 25 and Table 26.

After this test setup (short-run version) is evaluated in FBCT, it is observed that the test results given in Table 27 are consistent with the alternative systems objection, i.e., the alternatively constructed rival belief system yielded the same coherence measure scores so that *neither* system is considered superior to the other.

Table 25 – ASO (short-run) test setup

SHORT-RUN	**BS_1**	**BS_2**
Belief Sets	B1, B2, B3, B4	¬B1, ¬B2, ¬B3, ¬B4
Inferential Connections	B1 → B2 B2 → B3 B3 → B4	¬B4 → ¬B3 ¬B3 → ¬B2 ¬B2 → ¬B1

Table 26 – Belief graphs for ASO (short-run) test cases

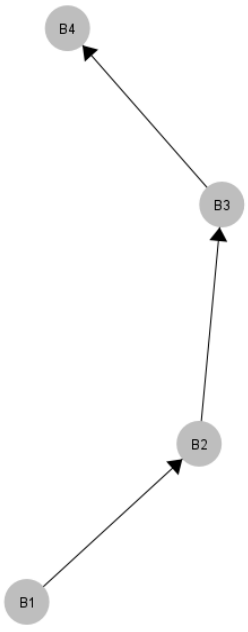
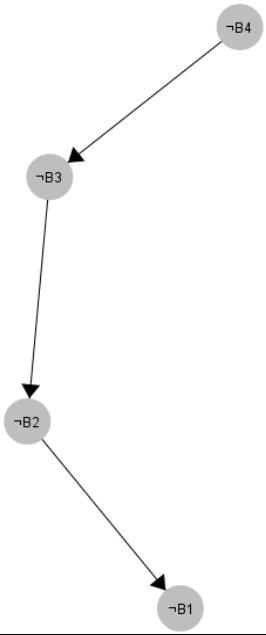
CASE A: **I**	**CASE B:** **II**
	

Table 27 – Results for ASO (short-run) test cases

	Cohesion	**Link Density**	**Strength**	**Fragmentation-I**	**Fragmentation-II**
CASE-A	1	1	1	-1	-1
CASE-B	1	1	1	-1	-1
SUPERIORITY	Neither	Neither	Neither	Neither	Neither

The second test setup (long-run version) can be formed by the incorporation of a cognitively spontaneous belief CSB to both of the rational epistemic subjects' belief sets as given in Table 28 and Table 29. The remarkable point here is that S_2 cannot create any inferential connections between the newly added CSB which is attributed as 'very likely to be true' and its belief set elements coming from the short-run version. Consequently, FBCT computes BS_1 as being *superior* to BS_2 for each score of the coherence measures given in Table 30. This supports Bonjour's long-run argument such that the equality of coherence being observed at a particular time gets broken over time via the introduction of the very likely to be true CSB(s) to belief sets.

Table 28 – ASO (long-run) test setup

LONG-RUN	**BS_1**	**BS_2**
Belief Sets	B1, B2, B3, B4, CSB*	¬B1, ¬B2, ¬B3, ¬B4, CSB*
Inferential Connections	B1 → B2 B2 → B3 B3 → B4 B1, B4 → CSB*	¬B4 → ¬B3 ¬B3 → ¬B2 ¬B2 → ¬B1

Table 29 – Belief graphs for ASO (long-run) test cases

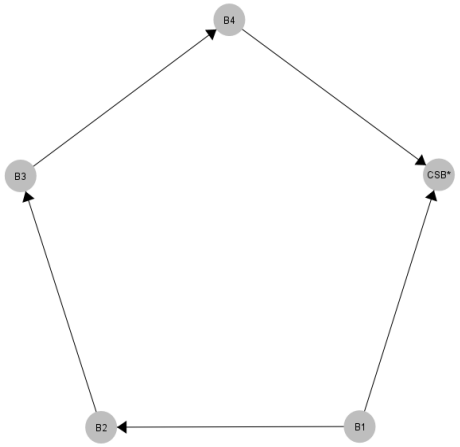
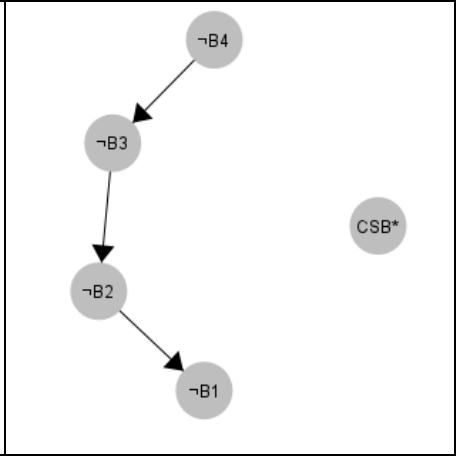
BS_1	**BS_2**
	

Table 30 – Results for ASO (long-run) test cases

	Cohesion	**Link Density**	**Strength**	**Fragmentation-I**	**Fragmentation-II**
BS_1	1	1	1	0	0
BS_2	0.5984	0.6	0.3333	-1	-1
SUPERIORITY	BS_1	BS_1	BS_1	BS_1	BS_1

Accordingly, Rescher (1973) argue that the role of the coherence theory is to provide a rationale for thinking that an epistemic subject whose beliefs are justified according to the standards of the coherence theory is likely to arrive at truth (pp. 23-24, 39-40). Further, Rescher suggests that truth is on a par with ideal coherence (Rescher, 1987). However, in such a coherence theory of truth (without taking into consideration the observation requirement BCC-6), the alternative coherence systems objection points out that it is always possible that a belief system BS can be false no matter how strong a warrant we have that BS is true. Shogenji (1999) also argues that coherence can in fact be truth conducive if it involves at least one belief that is known to be true.

Moreover, Thagard (2012) points out that coherence with currently available (best) evidence supports the view that reality is independent of mental representation of it, i.e., truth is not a solely mental matter and coherence is not irrelevant to truth (as in the case of BCC-6):

> Scientific evidence strongly suggests that the universe is more than 10 billion years old, but that representations constructed by humans have existed for less than a million. Thus we can infer that there was a world existing independent of any human representation for billions of years. This inference does not in itself show that truth cannot consist in a relation only among representations, because a proponent of the coherence theory could simply maintain that there were no representations and hence no true representations until intelligent beings evolved. But if there is a world independent of representation of it, as historical evidence suggests, then the aim of representation should be to describe the world, not just to relate to other representations. […] Hence truth must consist of some sort of relation between the representations that occur in human minds or artifacts and the world. Truth is not a purely mental matter, because our best evidence suggests that minds and their representations have not been around all that long. […] there is ample evidence from contemporary psychology and neuroscience that people employ mental representations, which therefore qualify as potential bearers of truth. […] Of course, the fact that, as far as we know, there were no mental representations 10 billion years ago does not undermine the correspondence theory of truth, because we can consider the fit, or lack of fit, between current representations and the state of reality at that time. (pp. 82-83)

Bonjour rejects the coherence theory of truth which has the claim that a belief is true if and only if it coheres with other beliefs. He responds to the truth-connection objection by advancing the following argument that allows the coupling of a coherence theory of justification, i.e., claiming that a belief is justified iff it is a part of coherent system, with a correspondence theory of truth, i.e., it is its correspondence with reality what makes a belief true:

> A system of beliefs which (a) remains coherent (and stable) over the long run and (b) continues to satisfy the Observation Requirement is likely, to a degree which is proportional to the degree of coherence (and stability) and the longness of the run, to correspond closely to independent reality. (Bonjour, 1985, p. 171)

Cross (1999) also emphasizes that "the truth conduciveness of [coherentist] justification on Bonjour's theory is not refuted … in general, by the fact that a coherent set of beliefs will often turn out to be more likely to contain a falsehood than some of its less coherent subsets" (p. 193). He also emphasizes that "since this latter fact does not constitute a reason to reject Bonjour's theory, it does not constitute a reason to reject the very idea of a coherence theory of justification" (p. 193).

Olsson (2005) suggests to inspect whether coherence is conducive to truth-likeness, instead of being conducive to absolute truth:

> Does coherence imply truth? This is our central problem, and one could in principle imagine many possible ways of attacking it. While it may be implausible to think that a system that is coherent is thereby guaranteed to contain only true propositions, it is conceivable that coherence could imply verisimilitude, so that a system, in virtue of being coherent, is at least close to the truth. (p. 1)

In scope of the aforementioned interpretations considering truth as an essential ingredient of knowledge, for coherence to be taken as an account for epistemic justification, it is anticipated to be truth-conducive. Otherwise, knowing that a belief set is more coherent than another does not provide us with any epistemically useful information. In order to discover whether coherence is a truth-conducive notion, this study devised coherence measures for Bonjour's coherence criteria, BCC-1 through BCC-6, via FBCT in a computational manner. Thus, by reframing Bonjour's coherence criteria in such a quantitatively measurable way, it became possible to tackle the vagueness problem of coherence and apply them to rival theories in order to judge which one is superior to another. Within this context, by means of various test cases from history of geology, physiology, astronomy, chemistry, psychology, environmental science and legal reasoning, Bonjour's criteria are tested by using FBCT whether they can be utilized to argue that competing theories can be accepted or rejected on the basis of an evaluation of their degree of coherence. It can also be considered as an attempt to discover any connection between truth and this

computation based specific sort of coherence, i.e., might such a computationally reinforced coherence be truth conducive? Whether more coherent web of beliefs tend to be more likely to be (at least approximately) true.

Even if coherence does not provide an infallible guide to truth, that is, a more coherent belief set is not always more likely to be true than a less coherent one, due to the inductive behaviour in the sense that an increase in coherence is mostly hang together with an increase in likelihood of truth, it can provide an indication thereof and can be considered as a heuristic[14] device in the form of justification, which guides cognitive agents in their theory choices. In this sense, a heuristic is an approach which can be utilized for finding an approximate solution when we are not able to find the exact solution at the moment. With this view, truth can be interpreted as a heuristic function of coherence to rank alternatives even if it fails to be absolutely truth-conducive. Such a heuristic function can be used as a way to inform the search about the direction to truth, i.e., progressively (in the long run) limiting the field of search for truth and providing an informed way to guess which belief set will lead to the goal of truth. The evaluation of this heuristic function yields an estimation to become closer to truth by ranking belief sets with respect to their coherence measures:

$$t_{approx.} \approx h(c)$$

Hence, I attempted to show that the quantitative cognitive-computational way of ruling out inadequate belief sets via coherence is (at least partially) truth-conducive in the long-run perspective based on the test cases exemplified in Section 4 where each test can be considered as a marker test used to predict the more promising carriers of truth. The findings of these tests seem to support rather than undermine the truth-conduciveness of coherence and show that most cases of higher coherence are also cases of higher likelihood of truth in most scenarios, that is, there exist a correlation in between them, eventhough it falls short of doing it in ASO (short-run) case. Besides,

[14] The etymological origin of the word *heuristic* comes from the Greek *heuriskein* (Εύρίσκω) with a definition of "to discover / to find out".

due to the problem of underconsideration, we do not know whether the initial pool of belief sets is complete, i.e., there may be other belief sets not considered yet, it is premature to ascribe certain truth to the singled out set after the heuristic testing. With every set ruled out by providing quantified justification via coherence, the remaining sets gain higher probability of being true, however, we never know how probable a belief set actually is. Nevertheless, it can be epistemically useful even if coherence does not provide absolute truth-conduciveness and may be better to aim at whether our belief sets are becoming truer or not by taking into account coherence as a heuristic device.

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APPENDICES

A. THE ASTRONOMY TEST BELIEF SET

Evidence relating to hypotheses about the heavens:[15]

E1 There is a regular diurnal rotation of the sky along the celestial equator.

E2 The normal motion of the sun is to the east.

E4 The stationary point of the daily rotation of the stars is about 67 degrees from the ecliptic.

E5 The seasons are of slightly unequal length.

E6 The relative distances of the stars are fixed during revolution.

E7 Lunar eclipses happen later further to the east.

E8 The stars rise gradually later for those slightly further west.

E9 Someone traveling northward gradually loses sight of southern stars.

E10 Equinoxes always occur midway between the solstices.

E11 The heavens are always divided in half by the horizon.

E12 Six zodiacal signs are always visible.

E13 At equinoxes, the sun rises due east and sets due west.

E14 Lunar eclipses occur only when the sun and moon are in opposition.

E15 The relative position of the stars is independent of the location of the observer.

E16 There is a fixed pole star for the diurnal rotation throughout the course of a year.

E18 The sun moves from apogee to point of mean motion faster than from point of mean motion to perigee.

E26 The celestial pole moves in a slow circle around the pole of the ecliptic once every 26,000 years.

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[15] Retrieved from Cognitive Models of Science (pp. 302), by G. Nowak, P. Thagard, 1992, University of Minnesota Press. Copyright 1992 by the Regents of the University of Minnesota.

E66 The sun moves through all the signs of the zodiac in one year.

Evidence relating to hypotheses about the moon:[16]

E19 The moon moves eastward each day in its orbit.

E20 The moon's angular velocity varies from 10 to 14 degrees per day in a onemonth cycle (the first anomaly).

E21 The moon's maximum velocity can occur at any point in the ecliptic.

E22 The moon's maximum or mean latitude can occur anywhere on the ecliptic.

E24 The moon does not follow the ecliptic, but varies in latitude to 5 degrees.

E25 The moon exhibits a second anomaly called evection, which is maximum at the quadratures and 0 twice a month.

E27 The moon eclipses the sun.

NE41 The moon varies in apparent size by a factor of 4.

E41 The moon does not vary in apparent size to a large degree.

NE42 The moon's parallax increases greatly at the quadratures.

E42 The moon's parallax does not change.

E60 The moon is seen in opposition to the sun.

E64 The moon has an observable parallax.

Evidence relating to hypotheses about the superior planets: [16]

E46 The normal motion of the superior planets is to the east.

E43 The superior planets' maximum latitudes occur at a fixed longitude.

E30 The superior planets' motion is nonuniform.

E31 The superior planets exhibit retrograde motion.

E48 The superior planets' latitudes are greater at the perigees of epicycles than at apogees.

E57 The superior planets reach their maximum northern latitude in the vicinity of the apogee of the eccentric and their maximum southern latitude in the vicinity of the perigee.

[16] Retrieved from Cognitive Models of Science (pp. 302-303), by G. Nowak, P. Thagard, 1992, University of Minnesota Press. Copyright 1992 by the Regents of the University of Minnesota.

E59 When the center of the epicycle is near the apogee and perigee of the eccentric, and thus near the northern and southern limits of latitude, the planet appears farther from the ecliptic at opposition in the perigee of the epicycle than near conjunction near the apogee.

E68M Mars often appears in opposition.

E68J Jupiter often appears in opposition.

E68S Saturn often appears in opposition.

E73M Mars appears in opposition only during retrograde motion.

E73J Jupiter appears in opposition only during retrograde motion.

E73S Saturn appears in opposition only during retrograde motion.

Evidence relating to hypotheses about the inferior planets:[17]

E3 The inferior planets occasionally retrograde to the west.

E45 The normal motion of the inferior planets is to the east.

E40 The inferior planets' maximum latitudes occur at a fixed longitude.

E28 Mercury and Venus never appear in opposition.

E33 The inferior planets have mean motion in longitude equal to that of the sun.

E35 The inferior planets' motion in longitude is nonuniform.

E36 Mercury experiences two perigees and one apogee.

E49 When the centers of the epicycles of the inferior planets are +/-90 degrees from the apsidal line as seen from earth (true eccentric anomaly), the maximum latitudes above or below the ecliptic occur near the inferior and superior conjunctions, the larger latitude near the inferior conjunction.

E50 When the center ofVenus's epicycle is at +90 degrees from the apsidalline, the latitude of Venus at inferior conjunction is south and at superior conjunction north, and at -90 degrees the reverse.

E51 When the center of Mercury's epicycle is at +90 degrees from the apsidal line, the latitude of Mercury at inferior conjunction is north and at superior conjunction south, and at -90 degrees the reverse.

[17] Retrieved from Cognitive Models of Science (pp. 303-304), by G. Nowak, P. Thagard, 1992, University of Minnesota Press. Copyright 1992 by the Regents of the University of Minnesota.

E52 When the centers of the epicycles of the inferior planets are on the apsidallines, they reach equal maximum latitudes on either side of the ecliptic at opposite greatest elongations.

E53 At apogee, the evening elongation of Venus is north and the morning elongation is south, and at perigee, the reverse is true.

E54 At apogee, the evening elongation of Mercury is south and the morning elongation is north, and at perigee, the reverse is true.

E55 When the center of Venus's epicycle is in the apsidalline and the planet is near inferior or superior conjunction, Venus always has a small northern latitude.

E56 When the center of Mercury's epicycle is in the apsidal line and the planet is near inferior or superior conjunction, Mercury always has a small southern latitude.

E67M Mercury is never seen in opposition.

E67V Venus is never seen in opposition.

E69 Venus's greatest elongation is larger than Mercury's.

Hypotheses about the heavens:[18]

PC1 The heavens are shaped like a sphere.

P2 There is a ninth heavenly sphere, the primum mobile, experiencing only diurnal rotation.

P3 The eight innermost spheres are all carried along by the primum mobile in its daily rotation.

PC2 Motions of heavenly bodies are uniform, eternal, and circular or compound-circular about the center of the universe.

P5 The stars are fixed in position on the eighth sphere, which rotates once every 26,000 years.

C4 The sphere of stars is immobile.

Hypotheses about the earth: [18]

P6 The earth is always at the center of the heavenly sphere.

P7 The axis of the celestial diurnal rotation is inclined about 23 degrees to the ecliptic.

P9 The earth has the ratio of a point to the heavens.

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[18] Retrieved from Cognitive Models of Science (pp. 304-305), by G. Nowak, P. Thagard, 1992, University of Minnesota Press. Copyright 1992 by the Regents of the University of Minnesota.

PC3 The earth is spherical.

C5 The earth's axis of rotation is inclined about 23 degrees to the perpendicular to the ecliptic.

C7 The earth's orbit has the ratio of a point to the heavens.

C8 The earth rotates on its axis once a day.

C9 The earth revolves around the sun once a year, uniformly in a circle.

C10 The orbit of the earth is eccentric to the center of the sun.

C11 The earth's axis rotates with a conical motion slightly less than once a year.

Hypotheses about the sun: [19]

P12 The sun moves eastward along a circle about the earth in one year.

P14 The sun's orbit is eccentric.

C12 The sun is immobile at the center of the universe.

PC12 Solar eclipses are caused by the moon passing between the earth and the sun.

Hypotheses about the moon: [19]

PC4 The nodal line of the lunar orbit rotates around the center of the deferent 3 minutes of arc per day.

P16 The moon moves along an epicycle.

P17 The moon's epicycle moves eastward along a deferent about the earth.

P18 The moon's deferent is eccentric.

P19 The center of the moon's eccentric deferent revolves around the earth.

P20 The center of the moon's eccentric deferent revolves around the earth in synchronization with the sun.

PC11 Lunar eclipses are caused by the earth's shadow falling on the moon.

C13 The moon moves eastward on a deferent about the earth's center once a month.

C14 The moon's deferent is the path of its first epicycle.

C15 The first epicycle carries the moon along on a second epicycle.

PC8 The moon's deferent is inclined to the ecliptic by about 5 degrees.

Hypotheses about the inferior planets (Mercury and Venus):[19]

P22 The inferior planets each move along an epicycle.

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[19] Retrieved from Cognitive Models of Science (pp. 305-306), by G. Nowak, P. Thagard, 1992, University of Minnesota Press. Copyright 1992 by the Regents of the University of Minnesota.

P23 The inferior planets travel in epicycles whose centers have the same longitude as the "mean sun".

P24 The epicycles of the inferior planets travel eastward about the earth along eccentric deferents about the earth, uniformly as seen from the center of another eccentric circle called the equant.

P25 The centers of the epicycles of the inferior planets move uniformly with respect to an equant point along the apsidal line.

P26 The center of Mercury's deferent moves in a small circle about a point on the apsidal line.

P27 The deferents of the inferior planets are inclined (deflection) to the ecliptic along a fixed nodal line.

P28 The angle of deflection of the deferents of the inferior planets varies along the nodal line.

P28E The angle of deflection of the deferents of the inferior planets varies in phase with the motion of the epicycle center on the deferent, being 0 at the nodes and maximum at the apses.

P28V The deflection of the deferent of Venus is always above the ecliptic is always below.

P29 The epicycles of the inferior planets have an angle of inclination (angle of first diameter) with respect to the deferent.

P29I The epicycles of the inferior planets have a varying angle of inclination.

P29E The varying angle of inclination of the inferior planets is maximum at the nodes, and 0 at the apses.

P29V The maximum of the inclination of the inferior planets is positive for Venus and negative for Mercury.

P30 The second diameter of the epicycles of the inferior planets makes an angle (slant) with their deferents.

P30I The slant of the inferior planets varies.

P30E The slant of the inferior planets varies in phase with the motion of the epicycle center, being 0 at the nodes and maximum at the apses.

P30V The maximum angle of the second diameter of the epicycles of Venus is positive for Venus and negative for Mercury.

C19 The inferior planets have one major longitudinal motion, eastward along a deferent about the sun.

C20 The centers of the deferents of the inferior planets move in small circles about the sun.

C21 The small circles carrying the orbits of the inferior planets are eccentric to the sun.

C29 The deferents of the inferior planets are deflected to the ecliptic.

C31 The nodal line of the deflection of the inferior planets' deferents rotates about the sun.

C32 The deflections of the inferior planets' deferents vary in such a way that they are 0 whenever the planets cross their nodal lines.

C32V The deflection of Venus is always to the north and the deflection of Mercury is always to the south.

C33 The inferior planets are inclined along their apsidallines.

C34 The inclination of the inferior planets along their apsidal lines varies.

C35 The inclination of the inferior planets along their apsidal lines varies from a fixed minimum at the apses to a fixed maximum at the nodes.

Hypotheses about the superior planets (Mars, Jupiter, and Saturn):[20]

P33 The superior planets move along epicycles.

P33E The superior planets move along their epicycles at rates keyed to the sun.

P33S The superior planets move along their epicycles faster than the epicycles move along the deferents.

P34 The epicycles of superior planets travel eastward along circular deferents about the earth, uniformly as seen from the center of another eccentric circle called the equant.

P35 The deferents of the superior planets are eccentric.

[20] Retrieved from Cognitive Models of Science (pp. 306-307), by G. Nowak, P. Thagard, 1992, University of Minnesota Press. Copyright 1992 by the Regents of the University of Minnesota.

P37 The deferents of the superior planets have a fixed inclination to the ecliptic, with the apogee being inclined to the north.

P38 The epicycles of the superior planets are inclined to their deferents.

P39 The inclination of the epicycles of the superior planets to their deferents varies.

P40 The inclination of the epicycles of the superior planets varies so that it is maximum at the apses and minimum at the nodes, where they are parallel to the ecliptic.

C22 The superior planets have one major longitudinal motion, eastward on deferents about the sun.

C23 The deferents of the superior planets are eccentric.

C26 The deferents of the superior planets are inclined to the ecliptic.

C27 The inclination of the superior planets' deferents varies within a range of positive inclination.

C28 The inclination of the superior planets' deferents varies from maximum to minimum inclination between each true opposition and conjunction of the planet with the mean sun.

Hypotheses about the order of the planets:[21]

PC5 Saturn is the outermost planet.

PC6 Jupiter is the next planet inward after Saturn.

PC7 Mars is the next planet inward after Jupiter.

PC9 The moon is the closest planet to the earth.

C39 Earth is inside the orbits of Mars, Jupiter, and Saturn, and outside the orbits of Mercury and Venus.

C40 Venus is the next planet out from the sun after Mercury.

C41 Mercury is the first planet counting out from the sun.

PC10 Longer planetary periods require larger orbits.

[21] Retrieved from Cognitive Models of Science (p. 307), by G. Nowak, P. Thagard, 1992, University of Minnesota Press. Copyright 1992 by the Regents of the University of Minnesota.

B. CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Yolaçan, Burak
Nationality: Turkish

EDUCATION

Degree	Institution	Year of Graduation
MS	METU Computer Engineering	2004
BS	METU Computer Engineering	2001

WORK EXPERIENCE

Year	Place	Enrollment
2005-Present	HAVELSAN A.Ş.	Team Leader

FOREIGN LANGUAGES

English

HONORS

Recognizing exceptional performance, BOEING, September 2015

C. TURKISH SUMMARY / TÜRKÇE ÖZET

20. yüzyılın ortalarında, felsefe ve berimin yolları, Alan Mathison Turing'in "Turing Test" ve Simon&Newell'ın "Logic Theorist" öncü çalışmaları ile kesişmeye başladı (Turing, 1950; Newell & Simon, 1956). 1980'lerde ilk kişisel bilgisayarların ortaya çıkmasından sonra, daha fazla filozofun bilgisayarla etkileşime girmesi ve bilgisayarları araştırma faaliyetlerine dahil etmeleriyle beraber, Amerikan Felsefe Derneği, daha sonra daha geniş bir derneğe (International Association for Computing and Philosophy) dönüşme fırsatını yakalayan ve yapay zeka, bilişsel bilim, biyolojide bilgisayar modelleme, mantık, formel ontoloji, sanal gerçeklik gibi alanlarda berimsel araştırmalarla ilintili olarak felsefenin hizmetine sunma amacıyla Felsefe ve Bilgisayar Komitesi'nin (PAC) kurulmasını teşvik etmiştir.

Bu süreçte felsefe camiası, berimleme ile beraber metodolojilerinin ve kuramlarının değerinin daha fazla farkına vardı (Hagengruber & Riss, 2014, s. 5-6; Sequoiah-Grayson & Floridi, 2022; Angius et al., 2021; De Mol, 2018; Immerman, 2021; Rescorla, 2020; Bynum, 2015).

Buna bağlı olarak, Floridi (2011), berimlemenin artık ezoterik ya da felsefi açıdan alakasız olarak görülmediğine (s. 5-7); berimsel kavramların, metotların, tekniklerin ve kuramların hermenötik araçlar olarak rol alarak etkili metaforlara dönüştüklerine dikkat çekmiş ve berimlemenin felsefede yeni bir güç olarak ortaya çıktığına işaret etmiştir (Dijital Feniks – Bilgisayarlar felsefeyi nasıl değişikliğe uğratıyor):

> Zaman zaman felsefede büyük hareketler meydana gelir. Bu hareketler, filozoflara felsefi konuları ele almak için yeni bir bakış açısı sağlayan birkaç basit ama çok verimli fikirle başlar. Yavaş yavaş, felsefi yöntemler ve problemler bu yeni kavramlar açısından rafine edilir ve anlaşılır. Yeni ve ilginç felsefi sonuçlar elde edildiğinde, hareket disiplin içinde ilerleyen entelektüel bir dalgaya dönüşür. Yeni bir felsefi paradigma ortaya çıkar.

> […] Berim, felsefeye böyle basit ama inanılmaz derecede verimli kavramları felsefi sorgulama için yeni ve gelişen özel alan konuları, yöntemler ve modeller vasıtasıyla sunar. Berim, geleneksel felsefi faaliyetlere yeni fırsatlar ve zorluklar getirir. […] Berim, filozofların felsefede zihin, bilinç, deneyim, akıl yürütme, bilgi, gerçek, etik ve yaratıcılık gibi temel kavramları anlama biçimini değiştirmektedir. Bir konu, bir yöntem veya bir model açısından berim içeren felsefi sorgulamadaki bu eğilim sürekli olarak ivme kazanmaktadır. (Bynum & Moor, 1998, s. 1)

AISB/IACAP Dünya Kongresi'nin 2012 (Alan Turing'in onuruna) bir parçası olarak düzenlenen Berimsel Felsefe Sempozyumu'nda (Symposium on Computational Philosophy), epistemoloji, metafizik, zihin ve bilim felsefesi gibi alanlarda takip edilen geleneksel yöntemleri destekleyici rolüyle berimsel felsefeye odaklanılmıştır.

Bilgisayarlar ve bilgisayar programcılığı yoluyla berimleme, son yirmi yılda filozoflar tarafından aşamalı olarak kullanıldığından, bu kapsamda deneylemeyi felsefeye dahil etmek için bu yeni araştırma yönteminden yararlanmaya çalışmak makul görünmektedir. Bu bağlamda, bir felsefi kuramın doğrulanması için, ilgili berimsel modellerini oluşturarak ve değerlendirerek pratikte uygulanması durumunda nasıl bir performans göstereceği tahmin edilebilir.

Uyumluluk kavramı, epistemik gerekçelendirme ve doğruluk kuramları gibi felsefenin çeşitli alanlarında odak noktası olmuştur. Esasen, uyumluluk kanı kümelerinin bir özelliği olarak atfedilebilir. Gerekçelendirmenin uyumluluk kuramının ilk önde gelen savunucularından Laurance Bonjour'a (1985) göre uyumluluk, sezgisel olarak bu kanıların birbiri ile birlik olmalarının kalitesi olarak yorumlanmaktadır.

Harmoni içinde olmak olarak uyumluluğun tariflenmesinin yeterince açık olmaması nedeniyle, Bonjour, bu belirsizliğin epistemik bir uyumluluk kuramı için rahatsız edici ama yozlaştırıcı olmadığını ileri sürmektedir:

> Bununla birlikte, bu alandaki zorlukların, uyumluluk kuramlarına karşı ve temelci rakipleri lehine belirleyici bir argüman türünden bir şey ortaya koyamayacağını görmek önemlidir. Bu böyledir çünkü uyumluluk kavramı

> ya da esasen aynı rolü oynayabilecek kadar benzer bir şey, aynı zamanda neredeyse tüm temelci kuramların vazgeçilmez bir bileşenidir: Görünen o ki uyumluluğa basit veya temel kanılar ile temel olmayan veya 'üstyapı' kanıları arasındaki ilişkiyi hesaba katmak için başvurulmalıdır (ikinci tipteki kanıların birinci tiptekilerle olan ilişkisi vasıtasıyla). (Craig, 2005, s. 521)

Takip eden yaklaşık on beş yıllık süreçte, Bonjour (2017), "uyumluluk kavramının formel açıklama eksikliği ve başarısızlığı nedeniyle uyumluluğun belirgin bir yapıya sahip olup olmadığı büyük ölçüde çözülmemiş bir sorun olarak durmaktadır" sonucuna varmıştır (s. 124). Bu doğrultuda, söz konusu eksiklik, uyumluluğun yorumlanmasında çeşitliliğin alevlenmesine neden olarak belirsizliğinin artmasına neden olmuştur. Bonjour bu görüşünü belirttiğinde ve sonrasında ilk savlar, uyumluluğun olasılıksal ölçümlerini tasarlama yoluyla Shogenji (1999) (daha fazla uyumluluğun daha yüksek doğruluk olasılığına işaret etmesi) ve Olsson (2002) (doğruluğa sevk edici herhangi bir uyumluluk ölçümü olamayacağı) tarafından öne sürülmüştür.

Ortaya çıkmaktadır ki uyumluluk tarifindeki bu bulanıklığı azaltma hedefiyle bu tez kapsamında uyumluluk kavramını incelemek için bir ihtiyaç vardır. Bu bağlamda ilk aşamada aşağıdaki kabulleri içeren bir uyumluluk çerçevesi çizmek gerekmektedir:

- Her K kanısı için parçası olduğu ilintili bir KK kanı kümesi vardır.
- Bir KK, içerdiği K öğelerinin çıkarımsal olarak birbiriyle ilişkili ve tutarlı olduğu ölçüde uyumludur.
- K'nin gerekçelendirilme derecesi KK'nın uyumluluk derecesi ile doğru orantılıdır.
- Ölçümlenen daha yüksek bir uyumluluk derecesi daha yüksek bir doğruluk olasılığına işaret ediyorsa bu uyumluluk ölçüsü doğruluğa sevk edicidir.

2000'lerin başlarında uyumluluğun biçimselleştirilmesi kapsamındaki ilk girişimlerinin ortaya çıkmasıyla beraber Paul Thagard (2000) uyumluluğun gerçekliğe karşılık gelen kanıları tespit etmenin tek yolu olduğunu (uyumlu bir kanı doğru çıkmasa ya da en azından doğruluğa yakınsasa dahi) öne sürmektedir:

> Böylece zihnimizin en tutarlı yorumlarından bağımsız duyulur bir dünya var. Bu nedenle, önermelerin doğruluğu ve görsel imgeler gibi diğer zihinsel temsillerin doğruluğu, sadece diğer temsillerle uyumluluk meselesi değildir; daha ziyade, bir önermenin doğruluğu, onun dünya ile karşılılığına bağlıdır. Tabii ki, bir önermenin dünya ile karşılılığa sahip olması ve ne kadar uyumlu olursa olsun, herhangi bir önermenin yanlış olabileceği sonucuna varmak için uyumluluktan başka bir yolumuz bulunmamaktadır. Ancak, birçok önermenin aslında gerçekliğe karşılık geldiğine inanmak için yeterli nedenimiz var. İnsanlar binlerce yıldır hayatta kalmayı ve üremeyi başardılar ve son birkaç yüz yılda dünya üzerinde olağanüstü bir fiziksel kontrol elde etmek için bilimsel gelişmeleri kullanabildiler. Yerçekimi, elektromanyetizma, hastalık yapıcı mikrop gibi bilimsel kuramların en azından yaklaşık olarak doğru olmamaları durumunda tamamen gizemli olacak olan tıp, ulaşım ve iletişim teknolojileri bu gelişmelerle mümkün hale gelmiştir. (s. 89-90)

Bu bağlamda, bu çalışmanın konusu ‘Kanıların uyumluluğu (en azından yaklaşık olarak) doğru kanılara yakınsamayı sağlamaktadır mı’ sorusuna aranan cevap ile şekillenmektedir.

Çağdaş felsefecilerin uyumluluk kuramları arasından derecelendirilmiş ve hesaplanabilir terimler aracılığıyla biçimselleştirilmeye daha uygun olması nedeniyle Bonjour’un yaklaşımı bu çalışmada temel alınmıştır.

Bonjour (1985), üç taraflı bilgi tanımının (gerekçelendirilmiş doğru kanı) en azından yaklaşık olarak doğru olduğunu belirtmektedir ve epistemik özne A’nın bakış açısına göre yeniden çerçevelemektedir: "A’nın, P’yi bilmesi ancak ve ancak şu koşulların sağlanması ile mümkündür: (1) A emin şekilde P’ye inanmalıdır, (2) P doğru olmalıdır, (3) A, P’nin yeterince gerekçelendirilmiş olması gerektiğine dair kanıya sahip olmalıdır" (s. 3-4).

(3) için kullanılacak gerekçelendirmenin tipi, temel rolü doğruluğa aracılık etmek olan ve ayırt edici özelliğinin Bonjour’un (1985) sorduğu şu sorulara verilecek olan cevaplarla belirlendiği bir epistemik gerekçilendirmedir: "Bilişsel varlıklar olarak, kanılarımızın epistemik açıdan gerekçelendirilip gerekçelendirilmediğini neden önemsemeliyiz? Neden böyle bir gerekçelendirme aranacak ve değerli bir şeydir?":

> … epistemik gerekçelendirmenin ayırt edici özelliği, doğruluğun bilişsel hedefiyle olan temel veya içsel ilişkisidir. Sonuç olarak, kişinin bilişsel çabaları, ancak bu hedefe yönelik oldukları ölçüde epistemik olarak gerekçelendirilir, bu da kabaca kişinin sadece ve sadece doğru olduğunu düşünmek için iyi bir nedeni olan kanıları kabul ettiği anlamına gelir... Epistemik gerekçelendirmenin bu şekilde doğruluğa sevk edici olmaması durumunda epistemik olarak gerekçelendirilmiş kanıları bulmak, gerçek olanları bulma olasılığını önemli ölçüde arttırmıyorsa o zaman epistemik gerekçelendirme ana bilişsel hedefimizle alakasız ve şüpheli olurdu. Epistemik gerekçelendirmenin doğruluğa giden bir yol oluşturduğunu düşünmek için bir nedenimiz olduğu sürece, bilişsel varlıklar olarak, epistemik olarak gerekçelendirilmiş kanıları epistemik olarak gerekçelendirilmemiş olanlara tercih etmek için bir nedene sahip olabiliriz. Bu nedenle epistemik gerekçelendirme, nihai analizde içsel değil, yalnızca enstrümantal bir değerdir… Farklı hedeflere yönelik diğer gerekçe türlerinden epistemik gerekçelendirmeyi ayıran doğrulukla olan bu temel ilişkidir. (s. 7-8)

Bonjour (1985), gerekçelendirmenin uyumluluk kuramı ile doğruluğun uyumluluk kuramı arasına bir çizgi çekmektedir:

> Bizi öncelikle ilgilendirmesi gereken doğruluğun uyumluluk kuramları değil ampirik gerekçelendirmenin uyumluluk kuramlarıdır. Doğruluğun uyumluluk kuramları doğruluğun basitçe uyumluluk ile tanımlanabileceğini ileri sürmektedir (muhtemelen belirli bir tür sistemle uyumluluk). (s. 88)

Bonjour'un (1985) görüşüne göre gerekçelendirmenin uyumluluk kuramı, epistemik öznenin hangi önermelerinin doğru olma olasılığının daha yüksek olduğunu belirlemeyi sağlayacak bir araçtır (s. 88).

Gerekçelendirmenin uyumluluk kuramı mutlaka doğruluğun uyumluluğu kuramına işaret etmez. Gerekçelendirmenin uyumluluk kuramı, uyumlu bir önermeler kümesinin elemanlarının doğru olma olasılığının daha yüksek olduğunu belirttiğinden, bir önermeyi doğru kılanın o önermenin zihin-bağımsız dış dünya ile karşılılığa sahip olması gerektiğini belirten doğruluğun karşılıklılık kuramı (DKK) ile çelişmemektedir. Bir başka ifadeyle, bir önerme (doğruluk-taşıyıcısı) önermesel olmayan bir bilfiil-olgu-durumuna (doğruluk-yapıcı) tekabül ediyorsa o önerme doğru

olarak addedilmektedir. Bu duruma, "Dışarıda yağmur yağıyor" önermesinin dışarıda yağan yağmurun deneyimlenmesi durumunda doğru olması örnek olarak verilebilir.

Bu bağlamda Bonjour bir realist olarak, gerekçelendirmenin uyumluluk kuramı ile doğruluğun karşılıklılık kuramının birlikteliğinin belirgin bir absürtlük oluşturmadığına işaret etmektedir.

Bu çalışmada, uyumluluğun kesin bir şekilde açık olmayan ve eleştirilen bu doğruluğa-sevk-edici karakteri Bonjour'un yorumlaması eşliğinde mercek altına alınacaktır. Aynı zamanda bilimsel kuramların gelişiminin uyumluluğun artırılmasına yönelik bir dizi girişim olarak görülmesi ve rekabet halindeki bu kuramlar arasında seçim yapmada uyumluluklarının karşılaştırmasının kullanılması tartışılacaktır.

Uyumluluğun holistik görüşüne göre, epistemik bir özne olan S, P'nin ait olduğu kanı kümesinin diğer elemanlarıyla uyumluluk ilişkisi içinde olması kaydıyla P'ye olan kanısını gerekçelendirmiş olur. Kanı kümesinin elemanlarını gerekçelendirilmiş yapan şey karşılıklı uyumluluk ilişkisidir. Bonjour, bu karşılıklı ilişkide bir elemanın kümenin diğer elemanlarına herhangi bir epistemik üstünlüğünün olmadığını belirtmektedir (BonJour & Sosa, 2003, s. 44-45).

Gerekçelendirmenin uyumluluk kuramına karşı getirilen standart argüman "çıkarımsal gerekçelendirme esasen karakteristik olarak doğrusaldır ve elemanları epistemik önceliklerine göre sıralanmış tek boyutlu bir kanı dizisi içermektedir. Bu yapıda epistemik gerekçelendirme dizide ön sıradaki elemanlardan takip eden gerideki elemanlara doğru çıkarım bağlantıları yoluyla geçmektedir" (Bonjour, 1985, s. 90).

Bonjour (1985), alternatif olarak doğrusal olmayan bir görüş içerebileceğini belirtmektedir: "… doğrusal görünümüne rağmen, [çıkarımsal gerekçelendirme] temelde sistematik veya holistik bir özelliğe sahiptir: Kanılar, uyumlu bir kanı sisteminin genel bağlamında diğer kanılara çıkarımsal olarak ilintili olduklarında gerekçelendirilmiş olmaktadırlar" (s. 90).

Bonjour (1985), "lokal seviye" ve "global seviye" arasında bir ayrıma ihtiyaç olduğuna da dikkat çekmektedir: Bu kapsamda, lokal seviyede gerekçelendirmenin doğrusal görünümlü olduğuna işaret etmektedir: "… bu belirli bağlamda diyalektik olarak kabul edilebilir olan öncül-kanılara hızlıca ulaşmak mümkün olmaktadır ve böylece temelcilikteki temel kanılar gibi işlev görebilmektedirler" (s. 91).

Lokal seviyedeki doğrusal görünüme karşın, Bonjour (1985), global seviyenin bu şekilde bir yapıda olmadığını ve fakat karşılıklı destek içerdiğini ifade etmektedir:

> Gerekçelendirmenin uyumluluk kuramı, gerçekten bir çember olmadığı için gerekçelendirmenin görünen döngüsünün aslında kısır olmadığını iddia etmektedir: bir ampirik kanının gerekçelendirmesi nihai olarak doğrusal gerekçelendirme görüşünde olduğu gibi tek tek kanılar üzerinden değil sistemin geneline ve uyumluluğuna bağlıdır. (s. 92)

Bu kapsamda, Bonjour'un (1985) gerekçelendirmenin uyumluluk kuramı ampirik kanıların gerekçelendirmesi için 4 aşama içermektedir:

> (1) Bir kanının diğer kanılardan ve ampirik kanılar arasındaki ilişkilerden çıkarımı
> (2) Ampirik kanılardan oluşan sistemin uyumluluğu
> (3) Ampirik kanılardan oluşan sistemin gerekçelendirmesi
> (4) Söz konusu olan kanının sisteme olan aidiyeti nedeniyle gerekçelendirmesi (s. 92)

Bonjour'un (1985) doğruluğa-sevk-edici argümanı, bir kanı kümesinin uyumluluğu ile doğruluk olasılığının orantılı olduğuna işaret etmektedir: "uyumluluk açıkça, herhangi bir makul görüşte, bir derece meselesidir […] bir kanı sisteminin gerçekliğe karşılık gelmesi uyumluluk derecesi ile orantılı olarak değişiklik göstermektedir" (s. 170). Bu bağlamda rasyonel epistemik bir özne birbirine rakip iki kanı kümesi ile karşı karşıya geldiğinde daha uyumlu olan kümeyi tercih etmesi daha makul görünmektedir. Buradan hareketle, bir uyumluluk kuramındaki çekirdek işlev, hangi kanı kümesinin daha uyumlu olduğunu ölçme yeteneği olması olarak düşünülebilir. Bu bağlamda

Bonjour (1985), bir kanı kümesinin uyumluluk derecesini ve hangi kümenin daha uyumlu olduğunun belirlenmesinde altı kriter ortaya koymaktadır:

1. (BUK-1) Bir kanı sistemi mantıksal olarak tutarlı olması kaydıyla uyumludur.
2. (BUK-2) Bir kanı sistemi olasılıksal olarak tutarlı olduğu ölçüde uyumludur.
3. (BUK-3) Bir kanı sisteminin uyumluluğu, içerdiği kanılar arasındaki çıkarımsal bağlantıların sayısı ve bu bağlantıların mukavemeti ile artar.
4. (BUK-4) Bir kanı sisteminin uyumluluğu, içerdiği birbirleriyle çıkarımsal bağlantıları olmayan alt sistemleri arttığı oranda azalır.
5. (BUK-5) Bir kanı sisteminin uyumluluğu, o sistemdeki açıklanmamış anomaliler arttığı oranda azalır.
6. (BUK-6) Bir kanı sistemi Gözlem Gereksinimini sağlamalıdır. (s. 97-99, 141-144)

Bonjour, mantıksal tutarsızlığın en yüksek seviyede uyumsuzluğa sebep olması bağlamında BUK-1'i olmazsa olmaz ilk koşul olarak değerlendirmektedir. BUK-2'de Bonjour, içinde mantıksal çelişki içeren kanıların olmadığı ve fakat P kanısı ve P'nin son derece olası olmadığına işaret eden başka bir kanı içeren bir kümenin olduğu duruma değinmektedir. Epistemik bir özne olan S'nin "Yarın yağmur yağacak" P kanısının doğru olma olasılığının 0.9 olması durumunda S'nin "Yarın yağmur yağamayacak" kanısının (değil-P) doğru olma olasılığının 0.1 olması beklenir. S'nin değil-P kanısındaki güven derecesinin 0.1'den büyük olması durumunda (0.3 gibi) olasılıksal tutarsızlık ortaya çıkmaktadır. Olasılıksal olarak tutarsızlık yaratan bu iki önermeden herhangi birinin bağlı oldukları kanı sisteminden düşürülmesi ile oluşacak yeni kanı sisteminin daha uyumlu olacağı açıktır.

Bonjour (1985), BCC-3 kapsamını S_1 = {P, Q, R} and S_2 = {X, Y, Z} önerme kümeleri ile örneklendirmektedir:

P: "Tüm kuzgunlar siyahtır."

Q: "Bu kuş bir kuzgundur."

R: "Bu kuş siyahtır."

X: "Bu sandalye kahverengidir."

Y: "Elektronlar negatif yüklüdür."

Z: "Bugün perşembedir." (s. 96)

Her ne kadar her iki küme mantıksal ve olasılıksal olarak tutarlı olsa da, S_2'deki önermeler birbirinden bağımsız iken S_1'dekiler birbirlerini karşılıklı olarak destekleyecek şekilde pozitif ilişkililerdir. BUK-3 kriteri kapsamında, S_1 daha uyumlu olma değeri taşımaktadır. Bu bağlamda BUK-3, "sadece mantıksal çakışma içermeme değil aynı zamanda bir çeşit pozitif bağlantı içerme" gereksinimi olarak ortaya çıkmaktadır (Bonjour, 1985, s. 96).

Bonjour (1985), "Ne çeşit pozitif bağlantılar gerekmektedir" sorusuna bu bağlantıların çıkarımsal ilişkiler olduğunu belirterek cevap vermektedir:

> Şöyle ki bir kanı ya da kanı kümesi gerekçelendirildiğinde başka bir kanı için ikna edici epistemik-gerekçelendirici bir argümanın öncülü olarak bu kanı ya da kanı kümesinin hizmet etmesini sağlayacak herhangi çeşit içerik ilişkisi. Bu çeşit bir çıkarım ilişkisi için temel gereksinim, … bir dereceye kadar doğruluk-koruyucu olmasıdır; bu gereksinimi sağlayan herhangi çeşit ilişki [bu ilişki tümdengelimli olmak zorunda değil] kanılar arasında uygun pozitif bağlantı olarak hizmet edecektir ve başka hiçbir bağlantı türü burada alakalı değildir. (s. 96)

Bir kanı sisteminin içindeki alt sistemlerin kendi içinde epistemik destek mevcut olabilir fakat bu alt sistemler birbirlerini desteklemiyor olabilirler. BUK-4, bu tür izole alt sistemlerle bölümlenmiş olmanın ilgili kanı sisteminin uyumluluğunu azaltacağına işaret etmektedir.

Bilimsel kuramların gerekçelendirmesi ile ilgili olarak, Bonjour (1985), bir tür çıkarımsal ilişkiye, kanılar arasındaki açıklayıcı ilişkiye işaret etmektedir:

> Açıklayıcı bağlantılar sadece sistemin kanıları arasındaki ilave çıkarımsal bağlantılar değildir aynı zamanda bunlar özellikle yaygın bir türün çıkarımsal bağlantılarıdır. Bunun nedeni, bilimsel açıklamanın temel amacının, nispeten az sayıda temel açıklayıcı ilkenin tezahürü olarak çok farklı türde olayları sergilemesi olmasıdır. (s. 99)

Bonjour (1985), bir anomaliyi "özellikle bir çeşit yenilenen örüntü içeren ve sistemdeki diğer kanılara başvurarak açıklanamayan bir olgu veya olay" olarak tanımlamaktadır (s. 99). Bu bağlamda, BUK-5, bir anomali ve anomalinin ait olduğu sistemin geri kalanı arasındaki açıklayıcı bağlantıların eksikliğinin sistemin uyumluluğunu düşüreceğini belirtmektedir.

Yukarıda belirtilen uyumluluk kriterleri tek başlarına dış dünyadan izole edilmiş bir kanı sistemini dışlamaz. Mantıksal ve olasılıksal tutarsızlığın olmadığı, kanıların çıkarımsal bağlantılar yoluyla bir araya geldiği, nispeten bağlantısız alt sistemlerin olmadığı ve açıklanamayan anomalilerin olmadığı, ancak gözlemlere dayanan deneyimsel kanıların sistemden izole edildiği böyle bir sistem düşünülebilir. Bu durum, Bonjour'un (1985) da işaret ettiği gibi gerekçelendirmenin dünyadan tamamen koptuğu itirazını doğurur:

> Uyumluluk tamamen kanı sisteminin bileşenleri arasındaki iç bağıntılar meselesidir… Dolayısıyla, uyumluluk kuramının iddia ettiği gibi, uyumluluk ampirik gerekçelendirmenin tek temelini oluşturuyorsa, açıklamak istediği dünyayla tamamen temas etmemesine rağmen ampirik inançlar sisteminin yeterince gerekçelendirilebileceği sonucuna varır… Ancak bu kesinlikle saçma bir sonuçtur. (s. 108)

Sadece bir kanı sisteminin iç uyumluluğuna bağlı olan bir uyumculuğun bu sınırlı yorumuyla bu tür bir gerekçelendirme, bu kanı sistemi dışındaki dünyadan herhangi bir temas veya girdi gerekmediği, dış dünyanın nasıl olduğu ve epistemik öznelerin deneyimlerinin ne olduğunun önemli olmadığı izlenimini oluşturmaktadır. Böyle bir kanı sisteminin dünyayı doğru bir şekilde temsil etmesi durumunda, bu sadece bir tesadüf olarak kabul edilir. Tesadüfi olarak doğru olan kanılar bilgi olarak nitelendirilmediğinden, böyle bir uyumluluk görüşünün ampirik bilgiyi açıklaması beklenmez. Bonjour, böylesine kendi içine kapalı ve herhangi bir dış etkiden tamamen

bağışık olan bir kanı sisteminin, bağımsız bir dünya hakkında ampirik bilgi oluşturamayacağını öne sürmektedir. Çünkü böyle bir durumda en az betimleyici bir başarı elde etmenin bile, kimsenin herhangi bir sebeple umacağı türden bir şey olmadığını ancak tesadüfi ya da mucizevi olabileceğini belirtmektedir (Bonjour, 1985, s. 108).

Dolayısıyla, girdi problemi, doğruluğun gerçeklikle karşılıklılık arz etme olarak kabul edilmesi durumunda, uyumculuktaki bu izolasyonun, gerekçelendirme sürecinde hiçbir girişi olmayan bir gerçeklik hakkında epistemik olarak gerekçelendirilmiş kanılara sahip olmanın mümkün olduğu bir absürtlüğe sebep olması şeklinde kendini gösterir.

Bu tür bir giriş itirazını cevaplamak için Bonjour (1985), gözlem gereksinimini, uyumlu epistemik gerekçelendirme ve gerçeklik arasındaki gerekli bağlantının, çıkarımsal olmayan gözlemsel kanıların oluşumu yoluyla yapıldığını belirterek ileri sürer: "Bilişsel bir sistem, makul çeşitlilikteki bilişsel spontane [deneyimsel] kanılara yüksek derecede güvenilirlik atfeden yasalar içermelidir" (s. 141).

Bilindiği üzere, uyumculuk ve temelcilik arasındaki temel ayrım, temelciliğin çıkarsama yapılmadan gerekçelendirilmiş temel kanıları kabul etmesinde yatmaktadır. Bu anlamda, Bonjour'un çıkarımsal olmayan gözlemsel kanılar hakkındaki görüşü, uyumluluk yaklaşımını bir tür temelciliğe dönüştürüyor gibi görünmektedir. Bu bağlamda, BonJour (1985), bu bilişsel spontan kanıların uyumluluk kuramına dahil edilmesinin, bir kanıya nasıl ulaşıldığı ve epistemik olarak o kanının nasıl gerekçelendirildiği arasındaki ayrıma dayandığını iddia etmektedir:

> Bir kanı, bir kişide, herhangi gerekçelendirici bir durumdan kaynaklanmadan (örneğin, kendiliğinden bir önsezi olarak) ortaya çıkabilir ve ancak daha sonra bu kanının, gerekçelendirme oluşturacak şekilde sisteminin geri kalanıyla uyumlu olduğu görülebilir. (s. 112)

Bonjour'un bu bakışı kapsamında, kanıların epistemik gerekçelendirmesi çıkarımsal kalmakla beraber bu spontane kanıların çıkarımsal olmayan kökeninin kendilerinin gerekçelendirilmeleriyle hiçbir ilgisi olmaması nedeniyle uyumluluk ile tutarlılık arz etmektedir.

BonJour (1985), örnek olarak, iyi aydınlatılmış bir odada yürüyen bir gözlemcinin genellikle spontane bir şekilde kendisine istemsiz, zorlayıcı ve çıkarımsal olmayan bir şekilde "vuran" kanılar oluşturacağını şu şekilde öne sürmektedir (s. 117-118):

> • Orada kırmızı bir kitap olduğuna inandığıma dair kanı;
> • Orada kırmızı bir kitap olduğuna inandığıma dair kanının normal aydınlatma koşullarında görsel algılama aracılığıyla oluşmuş olması;
> • Normal aydınlatma koşullarında görsel algılama yoluyla spontane bir şekilde oluşan kanıların genellikle doğru olduğuna dair olan kanı;
> • Bu nedenle, orada kırmızı bir kitap olduğuna dair olan kanımın doğru olması çok muhtemeldir.
> • Bu nedenle, (muhtemelen) orada kırmızı bir kitap var (s. 123).

Bu kanılar kümesinin gözlemcinin kanı sistemindeki diğer kanılar tarafından karşılıklı olarak desteklenmesi durumunda, gözlemcinin orada kırmızı bir kitap olduğuna dair spontane algısal kanısı uyumluluğun doğası içinde gerekçelendirilebilir. BonJour, bu tür bir yaklaşımın, kavramsal dünyadan, gerekçelendirmesinde halen tanınabilir bir şekilde uyumcu olan bir tür gözlemsel girdiye izin verdiğini iddia etmektedir (BonJour & Sosa, 2003, s. 50). Bonjour (1985), ayrıca Gözlem Gereksiniminin ardındaki temel düşüncenin şu olduğunu açıklar:

> Sistemdeki önsel olarak gerekçelendirilmemiş herhangi bir iddia, prensip olarak doğrudan ya da dolaylı bir şekilde gözlemsel olarak kontrol edilebilir olmalıdır; böylece ya onaylanmış ya da çürütülmüş olur. Ancak, bunun belirli bir sistemde böyle olup olmadığı, sadece mevcut gözlem modlarına değil, aynı zamanda sistemin çıkarımsal birbirine bağlılığına da bağlıdır. (s. 141)

BonJour, gerekçelendirmeyi dış dünyaya bağlamak için Gözlem Gereksinimine başvurarak Girdi İtirazının üstesinden gelmenin mümkün olduğunu ve epistemik gerekçelendirmenin doğruluğa sevk edicilik kuramı için bir temel oluşturulabileceğini savunmaktadır. Ayrıca Bonjour (1985), bir kanı sisteminin, uyumluluk derecesiyle orantılı olduğu dereceye kadar doğru olduğunu iddia etmektedir: "…uyumluluk açıkça, herhangi bir makul görüşte, bir derece meselesidir" (s. 171).

Buradan hareketle bu çalışmada Bonjour'un yukarıda belirtilen kriterleri, uyumlulukları karşılaştırmak ve doğruluğa sevk edicilik arayışında bir araç olarak kullanılmak üzere berimsel olarak modellenmeye çalışılmıştır.

Bir kanı sisteminin uyumluluğu, genellikle birbirine destek olma / bir arada tutma / birbirinden ayrılmama, karşılıklı olarak destekleme gibi belirsiz ifadelerle betimlenmektedir. Bir uyumluluk kuramcısının kesin ve mutlak bir ölçü sağlaması zor olsa bile, en azından göreceli olarak hangi derecelerde gerekçelendirildiklerini belirlemek için rakip kanı sistemlerinin tutarlılık derecelerini karşılaştırabilmelidir.
Bu amaçla, Bonjour (2017) tarafından bahsedilen probleme, "uyumluluğun kesin doğası, büyük ölçüde çözülmemiş bir problem olmaya devam etmektedir" (s. 124), bir çözüm olarak hizmet etmek amacıyla grafik-kuramsal yaklaşıma sahip bir uyumluluk çerçevesi, Bonjour'un kriterlerini (BUK-1 - BUK-6) yerine getirerek bahsi geçen uyumluluğun belirsizliğini azaltmak amacıyla uyumluluğu modelleyerek yapılandırılmıştır.

Bu bağlamda, rasyonel bir epistemik öznenin kanıları ve bu kanılar arasındaki çıkarımsal bağıntılar, grafik kuramının yapıları (kanıların düğüm / köşe ve kanılar arasındaki çıkarımsal desteklerin link / kenar / yay formunda) kullanılarak modellenmiştir. Bonjour (1985) "lokal düzey" ve "global düzey" gerekçelendirmesi arasında bir ayrım olduğuna dikkat çektiğinden, uyumluluk çerçevesi bu düzeyler gözetilerek yapılandırılmıştır (s. 91). İlk olarak, lokal düzeyde, her bir grafik düğümü için uyumluluk ölçümleri göreceli olarak hesaplanır. Daha sonra, global uyumluluk ölçümleri bu lokal uyumluluk değerlerinin üzerine karşılıklı olarak inşa edilir.

"Karşılıklı destek" ifadesini standart bir şekilde daha spesifik olarak tanımlamak için, çerçeve boyunca (1) ve (2) 'nin koşulları göz önüne alındığında, aşağıdaki (3) kalıbı kullanılacaktır.

(1) Bir epistemik özne S, A'ya inanmaktadır.

(2) A çıkarımsal olarak B tarafından desteklenmektedir.

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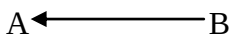
(3) S'nin A'ya dair kanısı S'nin B'ye dair kanısı tarafından çıkarımsal olarak desteklenmektedir.

Grafik-kuramsal notasyonda, kanılar arasındaki linkler (kenarlar), gerekçelendirme akışıyla birlikte bu çıkarımsal desteğin varlığını temsil etmektedir.



Bonjour'a göre, Gözlem Gereksinimi (BUK-6) kapsamında, bilişsel spontane kanılar, örneğin deneyimsel kanılar, başka kanılardan çıkarım yapılmadan ortaya çıkar; bir diğer ifadeyle dış dünya, çıkarımsal olmayan şekilde bilişsel spontane kanılara yol açarak gözlemcinin kanı sistemi üzerinde bir etkiye sahiptir. Bu türden kanılar, gözlemciyi hem istemsiz hem de oldukça zorlayıcı bir şekilde vururlar. Yine de bu kanılar çıkarımsal bir süreçle gerekçelendirilmektedir (Bonjour, 1985, s. 117, 123). Bu tür kanılar, çerçeve gösterimimizde ' * ' işareti ile ayırt edilmektedir.

Bu noktada, çalışan bir örneğin göz önüne alınması, kavramları tanımladıkça açıklamaya ve uyumluluk ölçümlerinin kademeli olarak nasıl hesaplandığını görmeye yardımcı olacaktır.

Bu amaçla, Şekil 1'de verildiği gibi kanılarının bir ağında rastgele çıkarım yapan epistemik bir özneyi (S) varsayalım. S, ilk göreceli olasılıklarına göre ağından bir kanı düğümünü rastgele seçerek başlar. Kanı setinin bilişsel spontane bir kanı içermemesi durumunda, kanılar arasında eşit olasılıkla rastgele seçim yapılır. Aksi takdirde, kanı

düğümlerinin ilk göreceli olasılığı (önemi) Gözlem Gereksinimine göre derece olarak değişecektir. Burada, epistemik öznenin seçtiği kanıların hiçbirinin bir diğerine uyumluluk ölçümleri sürecinde epistemik olarak üstünlük arz etmediği altı çizilmesi gereken bir durumdur.

Bu bağlamda, Bonjour'un birinci ve ikinci uyumluluk ölçütünün (BUK-1 ve BUK-2) dolaylı olarak kanıların nicel (epistemik öznenin inandığı güven derecesi) ve nitel (kanı etiketi gibi kanı genelleyici) karakteristikleri arasında bir köprü ilkesi gerektirdiğini belirtmek gerekir.

Foley (1992) bu prensibi şu şekilde açıklamaktadır: "Bir önermeye inandığımızı söylemek aslında onun doğruluğundan bir kanı olarak yeterince eminiz demektir" (s. 111).

Foley (1992) bu köprüleme yöntemini John Locke'a atıfta bulunarak ilişkilendirir ve Locke'un rasyonel bir epistemik öznenin bir önermeye dair kanı derecesinin, öznenin o kanı için sahip olduğu kanıt desteğiyle orantılı olması gerektiği fikriyle uyumlu olarak Lockean kuramı olarak adlandırır:

> …zihin, rasyonel olarak ilerleyecekse, tüm olasılık esaslarını incelemeli ve herhangi bir önermeyi onaylamadan ya da ona karşı çıkmadan önce o önerme için söz konusu olasılık esasları az ya da çok neler yapabilir görmelidir; bu esaslar, bütünün dengelenmesi üzerine, bir ya da diğer taraftaki daha büyük olasılık gerekçelerinin baskınlığıyla orantılı olarak, az ya da çok kesin bir onayla o önermeyi reddeder ya da alırlar. (s. 98-99)

Foley (1992), rasyonel inanç genelleştiricisinin, epistemik öznenin sahip olduğu kanı için yeterli gördüğü eşik seviyesinin üzerindeki rasyonel güven derecesine karşılık geldiğini ileri sürmektedir:

> Önemli olan (en azından rasyonel kanı kuramı için), bir eşiğin seçilmesidir. Bir kez böyle bir x eşiği belirlendiğinde, rasyonel kanı için neyin gerekli olduğunu söylemek için Lockean kuramını kullanabiliriz: p'ye dair kanınızın olması, p için olan güven dereceniz y değerindeyse ve y>x olması durumunda rasyoneldir. (s. 38)

Lockean kuramının berimsel çerçevemize dahil edilmesiyle beraber BUK-1 – BUK-6 uyumluluk koşulları grafik-kuramsal olarak modellenmiştir. Bu model içinde geliştirilen uyumluluk ölçütleri aracılığıyla, bir uyumluluk kuramcısı bir kanı sistemini diğer bir kanı sistemiyle karşılaştırabilmektedir ve böylece rasyonel bir öznenin bir kanı sisteminden (S_1) diğerine (S_2) geçişinde epistemik olarak gerekçelendirmesinin ancak S_2'nin uyumluluk skorlarının S_1'inkinden daha iyi olması durumunda mümkün olabileceğini belirtebilmektedir.

Paul Thagard'ın (1998) "Epistemolojinin özünde, berimsel modellerin çok yararlı olabileceği bir proje olan bilimsel bilginin yapısını ve büyümesini anlama ihtiyacı vardır" görüşünü Bonjour'un uyumluluk kuramı için geliştirdiğimiz berimsel çerçevemizde doğrulama olanağı da sağlanmış durumdadır (s. 48). Bu ve daha geniş bağlamda çeşitli vaka çalışmaları somut deney ortamlarına dönüştürülmüştür ve bunlara karşılık gelen epistemik öznelerin kanı ağlarının beslendiği testler (Yanlış Kanı, Filojiston – Oksijen, Jeosentrik – Heliosentrik, Naturalistik – Antropojenik, Masumiyet – Suçluluk, Büzüşen Yerküre – Deniz Tabanı Yayılımı, Asit - Bakteri) icra edilmiştir.

Çoğu epistemolojist, doğruluk ve epistemik gerekçelendirme arasında yakın bir ilişki olduğuna inanmaktadır. Eğer bir dizi kanı gerekçelendirilirse, o zaman onları gerekçelendirilmiş kılan şey nedeniyle, onların doğru olmaları muhtemel (veya güvence altına alınmış) mıdır? Gerekçelendirmenin uyumluluk kuramı kapsamında, böyle bir ilişki kesinlikle belirgin değildir. Bu, doğruluğa sevk edicilik problemi için tatmin edici bir çözümün sağlanmadığı uyumculuğun en önemli eleştirisidir.

İzolasyon ve alternatif sistem itirazları (ASİ), doğruluk-bağlantı probleminin daha da şiddetli biçimleri olarak görülebilir. Epistemik gerekçelendirmenin bir kanı sisteminin

sadece iç uyumluluğuna bağlı olduğu görüşü, bu tür bir gerekçelendirmenin bu kanı sistemi dışındaki dünyadan herhangi bir girdi veya temas gerektirmediği anlamına gelmektedir. Ayrıca, biri B kanısını, diğeri onun değillemesini (¬B) içeren ve birbirleriyle eşit derecede uyumluluk seviyesine sahip olan alternatif uyumlu kanı sistemleri oluşturmak mümkündür. Bu problemlerin varlığında, gerekçelendirmenin uyumluluk görüşleri, doğruluğu aramamıza rehberlik etmek için yetersiz görünmektedir.

ASİ, kendi içlerinde eşit derecede uyumlu olan ama karşılıklı olarak uyuşmayan iki kanı sistemi olabileceğini ortaya koyarken, Bonjour (1985), uyumluluğa bu kadar yaygın olarak ifade edilen bir itirazı şöyle belirtir:

> Ampirik gerekçelendirmenin uyumluluk kuramına göre […], ampirik bilgiyi oluşturan kanı sistemi yalnızca içsel uyumluluğu nedeniyle epistemik olarak gerekçelendirilmiştir. Ancak uyumluluğa bu şekilde başvurmak, tekil bir şekilde gerekçelendirilmiş bir kanı sistemini seçmeye bile başlamayacaktır. Çünkü, herhangi bir makul uyumluluk görüşünde, her zaman eşit derecede tutarlı olan birçok, muhtemelen sonsuz sayıda, farklı ve uyumsuz kanı sistemleri olacaktır. (s. 107)

İlk bakışta, uyumculuk, bir özneye gerekçelendirmesi ile beraber inanmak istediği şeye inanması için çok müsamahakar davrandığı yönünde bir izlenim bırakmaktadır. Richard Feldman (2003) bu durumu şu şekilde açıklamaktadır:

> Abraham Lincoln'un suikaste uğradığı önermesini düşünün. Karşıt görüştekilerin iddia ettiği gibi, birçok farklı ve uyumsuz, [kendi içinde] uyumlu kanı sistemi varsa, öznenin bu önermeye dair kanısını içeren bazı sistemler ve değillemesini içeren başka sistemler olacaktır. Eğer bu kanı edimsel sisteminizin bir parçasıysa, onu destekleyen veya ondan çıkarım yapılan her şeyin yerini alan bir sistemi farklı önermelerle hayal edebilirsiniz. Yeni sistemi dikkatli bir şekilde inşa ederek, mevcut sisteminiz kadar uyumlu bir şekilde oluşturabilirsiniz, ancak Lincoln'ün suikaste uğramadığı önerisi de dahil olmak üzere. Böylece, tüm bu birbirinden farklı ve uyumlu sistemler olabiliyorsa istediğiniz herhangi bir kanıyı, basitçe sistemin geri kalanındaki kanıları uygun bir şekilde seçerek gerekçelendirebilirsiniz. Bu doğru olamaz. (s. 67)

Bonjour, BCC-6'nın Gözlem Gereksinimi ile sağlandığında bu itirazın geçersiz hale geldiğini savunuyor. Uyumculuk, bu tür eşit derecede uyumlu kanı sistemlerinin rekabet ettiği belirli bir zaman kesiti için probleme bir çözüm sağlamasa da, Bonjour (1985), bilişsel spontane kanıların sürekli olarak sisteme dahil edilmesiyle, bu sistemin diğerinden daha uyumlu olması gerektiğine ve (uzun vadede yakınsayarak) dış dünyaya karşılık geldiğine işaret etmektedir: "Bu ne endişe verici ne de özellikle şaşırtıcıdır. Epistemolojik bir görüşten beklenen ve en mantıklı görünen şey, bu tür bağların uzun vadede kırılmasını mümkün kılmasıdır." (s. 144)

Bu bağlamda, iki kanı sisteminin (biri rasyonel epistemik özne S_1'in BS_1'i ve diğeri rasyonel epistemik özne S_2'nin BS_2'si) belirli bir zamanda rekabet ettiğini ve BS_2'nin her bir kanısının, Tablo 25 ve Tablo 26'da gösterildiği gibi, BS_1'in ilgili kanısının değillemesi olduğunu varsayalım.

Bu test düzeneği (kısa vadeli versiyon) FBCT'de değerlendirildikten sonra, Tablo 27'de verilen test sonuçlarının alternatif sistem itirazı ile tutarlı olduğu görülmektedir. Bir diğer ifadeyle, alternatif olarak inşa edilen rakip kanı sistemi, aynı uyumluluk ölçüm skorlarını vermiştir, böylece her iki sistem de birbirine üstün addedilememiştir.

İkinci test düzeneği (uzun vadeli versiyon), Tablo-28 ve Tablo-29'da verildiği gibi, her iki rasyonel epistemik öznenin kanı kümelerine aynı bilişsel spontane kanının (BSK) eklenmesiyle güncellenmiştir. Burada dikkat çeken nokta, S_2'nin kısa vadeli versiyondaki kanı kümesi ile doğru olma olasılığı çok yüksek olan BSK arasında çıkarımsal bağlantı oluşturamamasıdır. Sonuç olarak, FBCT, Tablo 30'da verilen uyumluluk ölçümlerinin her skoru için BS_1'i BS_2'den üstün olarak hesaplamaktadır. Bu, Bonjour'un belirli bir zamanda gözlemlenen uyumluluk eşitliğinin, kanı kümelerine doğru olma olasılığı çok yüksek olan bilişsel spontane kanıların dahil olmasıyla zaman içinde kırılacağı uzun vadeli argümanını desteklemektedir.

Bu doğrultuda Rescher (1973), uyumluluk kuramının rolünün, kanıları uyumluluk kuramının standartlarına göre gerekçelendirilen epistemik bir öznenin doğruluğa

ulaşmasının muhtemel olduğunu düşünmek için mantıksal bir açıklama sağlamak olduğunu savunmaktadır (s. 23-24, 39-40). Ayrıca, Rescher (1987) doğruluğun ideal uyumluluğa eşdeğer olduğunu öne sürmektedir. Bununla birlikte, böyle bir doğruluğun uyumluluk kuramında (BCC-6 gözlem gereksinimini dikkate almadan), alternatif uyumluluk sistemleri itirazı, bu kanı sisteminin doğru olduğuna dair ne kadar güçlü gerekçemiz olursa olsun, bir kanı sisteminin yanlış olabileceğinin her zaman mümkün olduğuna işaret etmektedir. Shogenji (1999) ayrıca, doğru olduğu bilinen en az bir kanı içeriyorsa, uyumluluğun aslında doğru olabileceğini ileri sürmektedir.

Diğer taraftan, Thagard (2012) şu anda mevcut (en iyi) kanıtlarla uyumluluğun, doğruluğun zihinsel temsilinden bağımsız olduğu görüşünü desteklediğine dikkat çekiyor. Bir başka ifadeyle doğruluk sadece zihinsel bir husus değildir ve uyumluluk doğrulukla alakasız değildir:

> Bilimsel kanıtlar, evrenin 10 milyar yıldan daha eski olduğunu, ancak insanlar tarafından yapılan zihinsel temsillerin bir milyon yıldan az süredir var olduğunu kuvvetle göstermektedir. Böylece milyarlarca yıldır herhangi bir insan temsilinden bağımsız olarak var olan bir dünya olduğu sonucuna varabiliriz. Bu çıkarım, doğruluğun yalnızca temsiller arasındaki bir ilişkiden ibaret olamayacağını kendi içinde göstermez, çünkü uyumluluk kuramının bir savunucusu, akıllı varlıklar evrimleşene kadar hiçbir temsilin olmadığını ve dolayısıyla gerçek bir temsilin olmadığını savunabilir. Ancak, tarihsel kanıtların da belirttiği gibi, kendi temsilinden bağımsız bir dünya varsa, temsilin amacı sadece diğer temsillerle ilişkilendirilmek değil, dünyayı tanımlamak olmalıdır. […] dolayısıyla doğruluk, insan zihninde veya yapıtlarında meydana gelen temsiller ile dünya arasında bir tür ilişkiden oluşmalıdır. Doğruluk tamamen zihinsel bir husus değildir, çünkü en iyi kanıtlarımız zihinlerin ve onların temsillerinin bu kadar uzun süredir var olmadığını göstermektedir. […] Çağdaş psikoloji ve sinirbilimden, insanların zihinsel temsilleri kullandıklarına dair yeterli kanıt vardır, bu nedenle potansiyel doğruluk-taşıyıcıları olarak nitelendirilirler. Tabii ki, bildiğimiz kadarıyla, 10 milyar yıl önce hiçbir zihinsel temsilin olmadığı gerçeği, doğruluğun karşılıklılık kuramını zayıflatmaz, çünkü mevcut temsiller ile o zamanki gerçekliğin durumu arasındaki uyumu veya uyumsuzluğu değerlendirebiliriz. (s. 82-83)

Bonjour (1985), bir kanının ancak diğer kanılarla uyumlu olması durumunda doğru olduğunu iddia eden doğruluğun uyumluluk kuramını reddetmektedir. Doğruluk-bağlantı itirazına, doğruluğun karşılıklılık kuramı ile gerekçelendirmenin uyumluluk kuramının bir kombinasyonunu sağlayan aşağıdaki argümanı ileri sürerek yanıt verir:

> (a) uzun vadede tutarlı (ve stabil) kalan ve (b) gözlem gereksinimini karşılamaya devam eden bir kanı sistemi, uyumluluk (ve stabilizasyon) derecesi ve vadenin uzunluğu ile orantılı olan bir dereceye kadar, bağımsız gerçekliğe yakınsayan bir şekilde karşılık gelir. (s. 171)

Cross (1999) da bu bağlamda şu noktaya dikkat çekmektedir:

> Bonjour'un kuramındaki [uyumculuk] gerekçelendirmesinin doğruluğa sevk ediciliği çürütülmüş değildir … genel olarak, uyumlu bir kanı setinin daha az uyumlu alt kümelerine kıyasla yanlışlık içerme olasılığının daha yüksek olması Bonjour'un kuramını reddetmek için bir neden teşkil etmediğinden gerekçelendirmenin uyumluluk kuramı fikrini reddetmek için bir neden oluşturmaz. (s. 193)

Olsson (2005), uyumluluğun mutlak doğruluğa sevk edici olması yerine doğruluğa yakınsayıp yakınsamadığını incelemeyi önermektedir:

> Uyumluluğun sağlanması doğruluğu da sağlar mı? Bu bizim temel problemimizdir ve prensip olarak bu problemi ele almanın birçok olası yolu düşünülebilir. Uyumlu bir sistemin sadece doğru önermeleri içerdiğinin garanti edildiğini düşünmek mantıksız olsa da, uyumluluğun doğruluğa yakınlık anlamına gelebileceği düşünülebilir, böylece uyumlu olması nedeniyle bir sistemin en azından doğruluğa yakın olması mümkündür. (s. 1)

Doğruluğu bilginin önemli bir bileşeni olarak gören yukarıda belirtilen yorumlar kapsamında, uyumluluğun bir epistemik gerekçelendirme görüşü olarak dikkate alınması için doğruluğa sevk edici olması beklenmektedir. Diğer türlü, bir kanı kümesinin diğerinden daha uyumlu olduğunu bilmek, bize epistemik olarak faydalı herhangi bir bilgi sağlamaz. Uyumluluğun doğruluğa sevk edici bir kavram olup olmadığını araştırmak için bu çalışmada, Bonjour'un BCC-1 ila BCC-6 arasındaki uyumluluk kriterleri için FBCT üzerinden berimsel bir şekilde uyumluluk ölçütleri

geliştirildi. Böylece, Bonjour'un uyumluluk kriterlerini niceliksel olarak ölçülebilir bir şekilde yeniden çerçeveleyerek, uyumluluk konusundaki belirsizlik problemini çözmek ve hangisinin diğerine üstün olduğuna karar vermek için bunları rakip kuramlara uygulamak mümkün hale gelmiştir. Bu bağlamda, kimya, psikoloji, çevre bilimi, hukuki muhakeme, fizyoloji, jeoloji, astronomi tarihinden çeşitli test senaryoları aracılığıyla, Bonjour'un kriterleri, uyumluluk derecelerinin değerlendirilmesi temelinde rakip kuramların kabul edilme ya da reddedilme iddiası kapsamında kullanıp kullanamayacakları FBCT kullanılarak test edilebilmiştir. Ayrıca bu, berime dayalı uyumluluk ile doğruluk arasındaki herhangi bir bağlantıyı keşfetme girişimi olarak da addedilebilir. Bir başka ifadeyle şu sorulara cevap verme denemesi olarak değerlendirilebilir: Bu türden bir berim ile desteklenmiş uyumluluk doğruluğa sevkedici olabilir mi? Daha uyumlu kanı ağlarının (en azından yaklaşık olarak) doğru olma olasılığı daha yüksek olabilir mi?

Uyumluluk doğruluk için yanılmaz bir rehber olmasa da (daha uyumlu bir kanı kümesinin daha az uyumlu olandan daha doğru olma olasılığının her zaman daha yüksek olmaması) uyumluluktaki artışın çoğunlukla doğru olma olasılığındaki artışla birlikte olması yönündeki tümevarımsal davranış nedeniyle doğruluğun bir göstergesi olabilir ve bilişsel özneleri kuram seçimlerinde yönlendiren gerekçelendirme biçiminde keşifsel bir araç olarak düşünülebilir. Bu anlamda keşifsel bir yaklaşım, şu anda tam çözüm bulmanın mümkün olmadığı durumda yaklaşık bir çözüm bulmak için kullanılabilir. Bu şekilde, doğruluk, kesinlikle doğruluğa sevk edici olmasa bile alternatifleri sıralamak için uyumluluğun keşifsel bir işlevi olarak yorumlanabilir. Böyle bir keşifsel fonksiyon, aramayı doğruluğa yönlendirme hakkında bilgilendirmenin bir yolu olarak kullanılabilir. Bir anlamda doğruluk arayış alanını aşamalı olarak (uzun vadede) sınırlama ve hangi kanı kümesinin doğruluk hedefine götüreceğini tahmin etmek için bilinçli bir yol sağlama işlevi gütmektedir. Bu keşifsel fonksiyonun değerlemesi, kanı kümelerinin uyumluluk ölçütlerine göre sıralanarak doğruluğa hangisinin daha yakın olabileceği yönünde bir tahmin vermektedir.

Yetersiz kanı kümelerini uyumluluk yoluyla dışlamak için niceliksel bilişsel-berimsel yolun uzun dönem perspektifinde (en azından kısmen) doğruluğa sevk edici olduğunu 4. Bölümde örnek verilen test vakaları (burada her test, doğruluğun daha olası taşıyıcılarını tahmin etmek için kullanılan bir markör testi olarak düşünülebilir) üzerinden göstermeye çalıştım. Bu testlerin bulguları, uyumluluğun doğruluğa sevk ediciliği zayıflatmak yerine desteklediğini, çoğu yüksek uyumluluk vakasının daha yüksek doğruluk olasılığı vakaları olduğunu ve her ne kadar kısa vadede yetersiz kalınsa da uzun vadede aralarında bir korelasyon olduğunu göstermektedir. Ayrıca, yetersiz hesaba katma problemi nedeniyle kanı kümelerinin ilk havuzunun eksiksiz olup olmadığını bilememekteyiz. Başka bir deyişle, henüz dikkate alınmayan başka kanı kümeleri olabileceğinden keşifsel testten sonra teke indirgenmiş kümeye doğruluk atfedilmesi için erken olabilmektedir. Uyumluluk vasıtasıyla nicel gerekçelendirme sağlayarak ekarte edilen her kümeyle, geri kalan kümelerin doğru olma olasılığı artmaktadır. Ancak, bir kanı kümesinin gerçekte ne kadar olası olduğunu bilemediğimizden tam olarak doğruluğa sevk edici olamasa da uyumluluğun epistemik açıdan yararlı olduğunu ve keşifsel bir araç olarak kanı kümelerimizin uzun vadede nispeten daha doğru olup olmadığını anlamak için kullanılabileceğini söyleyebiliriz.

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