

Chapter 2

Theoretical and Practical Justifications for Popper's Non-justificationism

2.1 Introduction

This chapter starts the first part of the argument of the present book. It aims to lay the groundwork for developing a Popperian theory and practice of education (in Chap. 3) by providing theoretical and practical justifications for Popper's falsificationist epistemology. It is important in that while a distinctive characteristic of Popper's philosophy is the unification of his thought (particularly his political and educational thoughts) by a focal concern with the growth of knowledge, there is much controversy not only in the philosophical literature over the legitimacy of his falsificationist epistemology, but also in the psychological literature over the feasibility and utility of his falsificationism as a heuristic.

Based on a rather simple thesis that we can learn from our mistakes despite our fallibility, Karl Popper develops a *non-justificationist* theory of knowledge and of its growth. According to Popper (1989), knowledge, especially scientific knowledge, grows through unjustified conjectures (i.e. tentative solutions to our problems) which are controlled by criticism, or attempted refutations (including severely critical tests). While these conjectures may survive the criticism and be accepted tentatively, they can never be positively justified: they cannot be established either as certainly true or even as probable in the sense of the probability calculus. As he puts it,

Criticism of our conjectures is of decisive importance: by bringing out our mistakes it makes us understand the difficulties of the problem which we are trying to solve. This is how we become better acquainted with our problem, and able to propose more mature solutions: the very refutation of a theory ... is always a step forward that takes us *nearer to the truth* [italics added]. And this is how we can learn from our mistakes. (Ibid., p. vii)

Indeed, many scholars, like R. Bailey (2000) and Notturmo (2000), regard this non-justificationist or falsificationist epistemology as the most distinctive feature of Popper's philosophy. Yet, Popper's non-justificationism is also what makes his philosophy so unpopular: many of the epistemologists with whom he is contemporary, Popper (1989) maintains, are justificationists or verificationists who demand

that we should accept only those beliefs which can be verified or probabilistically confirmed. This partly accounts for Bartley's (1976) seemingly exaggerated assertion that "If he [Popper] is on the right track, then the majority of professional philosophers the world over have wasted or are wasting their intellectual careers" (p. 463). Is Popper on the right track? If so, why do so many philosophers reject his teachings? In the following discussion, I start with the problem of the bounds of reason which, arising from justificationism, disputes Popper's non-justificationist epistemology. After considering three views of rationality that are intended to solve this problem – viz. comprehensive rationalism, critical rationalism, and comprehensively critical rationalism – in turn, I then turn to the practical side of the issue and explore some possible ways of implementing the Popperian approach. Finally, I consider Popper's influence on scientific practice, and whether falsification is an effective strategy for solving scientific problems.

2.2 The Problem of the Bounds of Reason

Although Gettier's (1963) polemical but persuasive counter-examples have showed that one can have *justified true belief that p* without *knowing that p*, where *p* is a sentence, Haack (1993) claims that mainstream epistemologists still see knowledge as justified true belief: one knows that *p*, if and only if one believes that *p*, *p* is true, and one has good grounds for the belief. It is within this justificationist context that the problem of the bounds of reason emerges. To put it in a nutshell, the problem is that we are unable to verify or justify our beliefs rationally. In fact, this problem had been widely discussed by sceptical philosophers as early as the Hellenistic period. For example, Pyrrho of Elis, regarded as the founder of the sceptical tradition, suggests suspending judgement in order to achieve tranquillity, since good grounds can be found not only for any belief but also against it (Annas & Barnes, 1994). However, just as A. Bailey (2002) maintains that "an examination of Sextus' Pyrrhonism will be an examination of the original source of most of the disjointed arguments and recommendations that pass for scepticism today" (p. 20), it seems sensible to turn to the influential arguments of Sextus Empiricus for a sceptical understanding of the problem.

According to Sextus (1994), there are at least three modes of suspension of judgement which derive from infinite regress, hypothesis and reciprocity:

[166] In the mode deriving from infinite regress, we say that what is brought forward as a source of conviction for the matter proposed itself needs another such source, which itself needs another, and so *ad infinitum*, so that we have no point from which to begin to establish anything, and suspension of judgement follows.... [168] We have the mode from hypothesis when the Dogmatists [the philosophers with positive beliefs], being thrown back *ad infinitum*, begin from something which they do not establish but claim to assume simply and without proof in virtue of a concession. [169] The reciprocal mode occurs when what ought to be confirmatory of the object under investigation needs to be made convincing by the object under investigation; then, being unable to take either in order to establish the other, we suspend judgement about both. (p. 41)

While the infinite regress mode shows the logical impossibility of verifying or justifying anything, both the hypothetical and reciprocal modes are intended to rule out the possibility of circumventing the problem of infinite regress. More specifically, Sextus' objection to the hypothetical mode is that if the dogmatist is convincing when s/he makes a hypothesis, then the sceptic will be no more unconvincing when s/he hypothesizes the opposite. As for the reciprocal mode, it is in reality a more complicated case of the hypothetical mode since, in such a circular mode, the argument intended to establish the dogmatist's claim rests for its effect on the hypothesis that the claim in question can already be established (A. Bailey, 2002). Taken together, Sextus' three modes (or arguments) deny our claims to rationally justified true belief and thus to knowledge.

Persuasive as Sextus' sceptical arguments are, their implication that we should suspend judgement about everything can hardly be accepted, because what follows is suspension of all beliefs: Sextus (1994) asserts that "Suspension of judgement is a standstill of the intellect, owing to which we neither reject nor posit anything" (p. 5); yet one who believes that *p* is clearly one who mentally posits that *p*. Accordingly, the fideists, for instance, who affirm that knowledge of religious matters can be obtained only through faith and cannot be established by rational means, do not follow the counsel of Sextus. Instead, without recourse to reason due to its limitation, they suggest making a subjective commitment to or a choice of what to believe. However, this kind of subjective irrationalism renders not only the choice between competing beliefs arbitrary but also the irrationalist immune from criticism. Bartley (1982) explains the latter in terms of a *tu quoque* (you as well) argument: "To any critic, the irrationalist can reply: 'tu quoque', reminding him that people whose rationality is similarly limited should not berate others for admitting to and acting on the limitation" (p. 135). As the *tu quoque* argument can be used by everybody – including the irrationalist's opponent, no rational criticism of subjective commitments is possible if this argument is not defeated.

Indeed, apart from demonstrating the problem of the bounds of reason that we are unable to verify or justify our beliefs rationally so any choice between competing ideas is arbitrary and irrational, the sceptical and fideistic arguments challenge the possibility of Popper's conception of rationality: they imply the impossibility of the *progress* of knowledge and the *criticism* of theories respectively. Yet, according to Popper (1989), "it is essentially their [scientific theories'] critical and progressive character – the fact that we can *argue* about their claim to solve our problems better than their competitors – which constitutes the rationality of science" (p. vii). Obviously, as long as the above-mentioned arguments go undefeated, Popper's assertion can hardly be defended.

2.3 Solution One: Comprehensive Rationalism

2.3.1 Two Dogmatic Approaches

To stop the infinite regress of justifications, dogmatists argue for the possibility of achieving certain basic beliefs, which do not require further justification but can be

used to justify other beliefs, because their truth can be comprehended immediately – immediate knowledge of basic propositions or first principles. The attempt to identify the source of this immediate knowledge divides the dogmatists: while empiricists appeal to experience as a source of immediate knowledge, rationalists or intellectualists appeal to reason or intellectual intuition. However, just as Van Fraassen (2002) holds that the criteria of use of the term “empiricism” are not very strict or extensive, the meanings of the terms “reason” and “rationalism”, which can be used in opposition to “irrationalism” or “empiricism”, are not distinct. Following Popper (1966), “reason” and “rationalism” will be used here in a wide sense to cover not only intellectual activity (intellectualism) but also observation and experiment (empiricism). In other words, the terms “rationalism” and “intellectualism” will be used in opposition to “irrationalism” and “empiricism” respectively.

In response to the claim of empiricism that our senses enable us to know immediately the truth of certain propositions, or observation statements, the sceptics have long asserted that such observation statements as “The boat is stationary” and “The oar is straight” do not provide a secure basis for knowledge. The reason is that our senses often offer us conflicting appearances – for example, “The same boat appears from a distance small and stationary, but from close at hand large and in motion. . . . The same oar appears bent in water but straight when out of it” (Sextus, 1994, p. 31) – without telling us which appearance should be taken for reality. As we can never, according to Sextus, ascertain whether the real world is as it appears to be, we can never assume any observation statement to be true on the basis of our experience. Ironically, it is Hume, a Scottish empiricist philosopher himself, who influentially develops and strengthens such sceptical argument against empiricism in the history of modern philosophy. As Bartley (1982) puts it,

Hume's own arguments showed that – apart from the question of the reliability and dubitability of sense experience itself – the empiricist criterion was inadequate: it excluded not only claims about God and angels but also scientific laws, causality, memory, and claims about other people. None of these could be reduced to sense experience; empiricism in effect [was] reduced to solipsism – to a variety of radical subjectivism. (p. 140)

Accordingly, what renders empiricism untenable is its exclusion of numerous obviously tenable laws, principles, concepts and views, including the popularly held belief that other people exist and have minds.

With respect to the claim of intellectualism that our intellectual intuition enables us to see immediately – by thinking alone – the truth of certain first principles, or self-evident propositions, an exemplar of such truths is mathematical knowledge. For one thing, intellectualists believe that substantial a priori knowledge (i.e. knowledge of a reality independent of our beliefs and experience) exists and that the truths of mathematics relate to an objective reality which is independent of our minds (Carruthers, 2004). Indeed, the remarkable achievement of Euclidean geometry, in which the truth of theorems is proved by self-evident processes of reasoning from self-evident axioms, has inspired the composition of several important philosophical works in the geometrical manner – with axioms, theorems, and proofs (Musgrave, 1993). Examples include Hobbes' *Leviathan*, Descartes' *Principles of Philosophy* and Spinoza's *Ethics*. Yet, the sceptical response to intellectualism, despite the

Euclidean achievement, is entirely negative. Apart from the hypothetical argument mentioned in Sect. 2.2, the sceptics object that self-evidence cannot guarantee truth for two main reasons. First, there are many propositions our ancestors thought self-evident but we think false: “The earth is flat”, for instance. Second, self-evident truths cannot exist at all: since “standards of truth having appeared perplexing, it is no longer possible to make strong assertions, so far as what is said by the Dogmatists goes, either about what seems to be evident or about what is unclear” (Sextus, 1994, p. 91). More importantly, the invention of non-Euclidean geometries reveals that the question of whether space is Euclidean or not is a question of physics to be settled ultimately by observation and experiment,¹ and thus that Euclidean geometry does not give us a priori knowledge of the structure of space (Musgrave, 1993). In other words, even Euclidean geometry – the intellectualist exemplar of knowledge – fails to establish the existence of substantial a priori knowledge.

2.3.2 *Popper’s Critique*

Paradoxically enough, Popper’s (1989) comment on empiricism and intellectualism is that “they are mistaken although I am myself an empiricist and a rationalist [intellectualist] of sorts” (p. 4). What he really means here is that although both sensory experience and intellectual intuition have an important role to play in the growth of knowledge, these roles hardly resemble those their respective advocates ascribe to them. Experience (including experimental and observational experience), as stated by Popper (1966), does not consist of pure sense data, but “a web of guesses – of conjectures, expectations, hypotheses, with which there are interwoven accepted, traditional, scientific, and unscientific, lore and prejudice” (p. 388): it is the result of usually mistaken guesses, of testing them, and of learning from our mistakes (rather than a source of authoritative knowledge as conceived by empiricists); and the resort for criticizing our theories. With regard to intellectual intuition, Popper, acknowledging its importance to scientific discovery, explains that

Everybody who “understands” an idea, or a point of view, or an arithmetical method, for instance, multiplication, in the sense that he has “got the feel of it”, might be said to understand that thing intuitively; and there are countless intellectual experiences of that kind. (p. 15)

However, he denies the capability of these experiences to establish the truth of any idea or theory (as conceived by intellectualists), no matter how intensely and intuitively we may feel that it must be true. For one thing, somebody else may have an equally intense intuition that the same theory is false. In that case, the choice between such contrary intuitions will become arbitrary. Accordingly, Popper maintains that

¹ This empiricist view of geometry is not without its difficulties, a grave one of which is that it is impossible to find geometric objects, like points and lines, in experience exactly as geometry conceives them (Torretti, 1984).

neither experience nor intuition can serve as an authoritative source of immediate knowledge. The reason why they are thought they can do so is that both empiricism and intellectualism are epistemologically *optimistic* and *authoritarian*.

According to Popper (1989), the doctrine that underlies the optimistic epistemology inherent in the teaching of Bacon and Descartes (representatives of empiricists and intellectualists respectively), is that truth is manifest: truth can always be recognized as truth by our power of perception or intuition if it is nakedly put before us. Indeed, while Bacon's doctrine of manifest truth is based on the notion of the *veracitas naturae* (the truthfulness of Nature), that Nature is seen as an open book which can be understood by people with an unprejudiced mind, Descartes' is built on the theory of the *veracitas dei* (the truthfulness of God), that what we clearly and distinctly see to be true must be true because God would not deceive us. Although this optimistic view of human power to discern truth has inspired the birth of modern science and the hope of a free society, Popper asserts that the optimistic epistemologies of both Bacon and Descartes are false:

For the simple truth is that truth is often hard to come by, and that once found it may easily be lost again. Erroneous beliefs may have an astonishing power to survive, for thousands of years, in defiance of experience, with or without the aid of any conspiracy. (Ibid., p. 8)

An epistemology that holds that truth is manifest also leads to fanaticism in that those who fail to see the manifest truth are often considered either to refuse wickedly to see it themselves or to harbour prejudices inculcated by evil powers which conspire to suppress it. Considering that both Bacon and Descartes require us to eliminate all prejudices from our mind – so as to enable it to recognize the manifest truth – and to discard all beliefs except those whose truth has been perceived by us, their approach is anti-authoritarian in the sense that we do not need authorities since we can perceive and pursue the truth ourselves. However, Popper (ibid.) discovers a deeper form of authoritarianism in this apparent anti-authoritarian approach: Bacon appeals to the authority of the senses, whilst Descartes appeals to the authority of the intellect. Popper argues further that Bacon and Descartes, in establishing senses and intellect as authorities within each individual, split the individual into a higher part (having authority with respect to truth) and a lower part (making up our ordinary selves and being responsible for our prejudices, our errors and our ignorance). In fact, the authoritarian character of the epistemology of such dogmatists as Bacon and Descartes is also reflected in the traditional questions “How do you know?” and “What is the source of your assertion?” that they ask. These questions, as Popper says, are authoritarian and completely misconceived because they assume that knowledge derives its validity from its source and is valid only if the source is authoritative. But this assumption of dogmatists fails to distinguish clearly enough the question of origin from the question of validity:

[I]n general the two questions are different; and in general [apart from the validity of an historical assertion] we do not test the validity of an assertion or information by tracing its sources or its origin, but we test it, much more directly, by a critical examination of what has been asserted – of the asserted facts themselves. (Ibid., pp. 24–25)

Basically, the traditional questions raised by dogmatists about the sources of our knowledge are a reflection of what Popper (1966) calls “comprehensive rationalism”,

which can be expressed in the form of the justificationist principle that “any assumption which cannot be supported either by argument or by experience is to be discarded” (p. 230). Yet, Popper claims that this principle of comprehensive rationalism is logically untenable, since it cannot be supported by argument or experience and thus should itself be discarded. To extricate himself from the justificationist predicament of dogmatists, Popper proposes – in contrast with comprehensive rationalism – a non-justificationist view of rationality called critical rationalism.

2.4 Solution Two: Critical Rationalism

2.4.1 Popper’s Original Version

Formulated fundamentally by Popper (1966) as an attitude of admitting that “*I may be wrong and you may be right, and by an effort, we may get nearer to the truth*” (p. 225), critical rationalism is an attitude of readiness to listen to critical arguments and to learn from our mistakes. Near the end of his life, Popper (1996) reveals that the idea of this formulation is owed to what a young Carinthian member of the National Socialist Party, not long before the year 1933 (the year Hitler came to power in Germany), said to him: “What, you want to argue? I don’t argue: I shoot!” (p. xiii). Indeed, the young man’s readiness to shoot rather than to argue may have planted the seed of three core concepts of Popper’s critical rationalism, viz. *fallibilism* (“I may be wrong”), *criticism* (the required “effort”), and *verisimilitude* (“we may get nearer to the truth”).

By “fallibilism” Popper (1966) means the view that we are fallible and that the quest for certainty is mistaken. Here, while the former view can be substantiated, historically, by the fact that what we once thought to be well-established may later turn out to be false, the latter can be understood, theoretically, by the problem that what we can explain or know is limited. One such limitation concerns the power of our brain to explain: according to Hayek (1952), any apparatus of classification must possess a structure of a higher degree of complexity than that possessed by the objects which it classifies; it implies that no explaining agent can ever explain objects of its own kind or own degree of complexity, and thus that the human brain can never fully explain its own operations. Another limitation arises from our incapability of predicting the future course of history due to our incapability of predicting the future growth of human knowledge: as Popper (2002a) puts it, “*if there is such a thing as growing human knowledge, then we cannot anticipate today what we shall know only tomorrow*” (p. xii). Accordingly, Popper’s fallibilism denies the possibility of certain knowledge and of authoritative sources of knowledge. Instead, he asserts that nothing is secure and that our knowledge remains conjectural and fallible.

However, fallibilism need in no way cause any sceptical or relativist conclusions in that we can learn from our mistakes. And criticism, Popper (1966) claims, “is the

only way we have of detecting our mistakes, and of learning from them in a systematic way" (p. 376). It includes criticizing the theories or conjectures not only of others but of our own. Since, for Popper (1989), criticism invariably consists in pointing out some contradiction (within the theory criticized, or between the theory and another theory which we have some reason to accept, or between the theory and certain statements of facts), deductive logical reasoning is suggested as *the* method of criticism: only by purely deductive reasoning can we discover what our theories imply, and thus where contradictions lie. More specifically, the importance of deductive or formal logic to criticism lies in the fact that it adopts the rules by which truth is transmitted from premises to conclusions while falsity is re-transmitted from conclusions to premises. It is this re-transmission of falsity that "makes formal logic the *Organon of rational criticism* – that is, of refutation" (ibid., p. 64). In fact, rejecting all attempts at the justification of theories, Popper (2002b) replaces justification with criticism in his non-justificationist or falsificationist view of rationality: "Previously, most philosophers had thought that any claim to rationality meant rational *justification* (of one's beliefs); my thesis was, at least since my *Open Society*, that rationality meant rational *criticism* (of one's own theory and of competing theories)" (p. 173). Yet, considering a theory may stand up to criticism better than its competitors, he concedes that we can sometimes "justify" our *preference* for a theory in the *negative* sense that a theory receives some kind of support if it has, rather than secured positive evidence, withstood severe criticism.

The idea of getting nearer to the truth or achieving greater verisimilitude is crucial to Popper's concept of critical rationalism. For it is only the idea of truth that allows us to speak sensibly of fallibilism and criticism: the purpose of searching for mistakes and eliminating as many of them as we possibly can through critical discussion is to get nearer to the truth. Criticizing subjective theories of truth for conceiving truth as something we are justified in believing or in accepting in accordance with some criterion of well-foundedness, Popper (1989) adopts Tarski's correspondence theory of objective truth that a statement is true if and only if it corresponds to the facts. For one thing, Tarski's objective theory of truth allows us to make certain assertions that appear obviously correct to Popper but self-contradictory within those subjective theories of truth. The following are examples of these assertions: a theory may be true even if nobody believes it, and even if we have no reason to think it true; another theory may be false even if we have comparatively good reasons for accepting it; we search for truth, but may not know when we have found it; and we have no criterion of truth, but are guided by the idea of truth as a regulative principle. To allay suspicions about the idea of getting nearer to the truth, or of the growth of knowledge, Popper (1979) introduces a logical idea of verisimilitude by combining two notions from Tarski, viz. truth and content. Defining the class of all true statements and false statements following from a statement *a* as the truth content and falsity content of *a* respectively, Popper explains that

Intuitively speaking, a theory T_1 has less verisimilitude than a theory T_2 if and only if (a) their truth contents and falsity contents (or their measures) are comparable, and either (b) the truth content, but not the falsity content, of T_1 is smaller than that of T_2 , or else (c) the truth content of T_1 is not greater than that of T_2 , but its falsity content is greater. (Ibid., p. 52)

And he regards the search for verisimilitude rather than truth as a more realistic aim of science in that while we can never have sufficiently good arguments for claiming that we have actually attained the truth, we can have reasonably good arguments for claiming that we may have made progress towards the truth (i.e. that the theory T_2 is nearer to the truth and thus preferable to its predecessor T_1).

2.4.2 *A Whiff of Justificationism*

Notwithstanding an emphasis on anti-authoritarianism and non-justificationism – where justification is understood in the usual sense of holding positive reasons that establish a theory – in his conception of rationality, Popper's explicit defence of critical rationalism in *moral* terms leaves a trace of justificationism. For whilst explicating why critical rationalism is morally superior to irrationalism which, Popper (1966) maintains, due to its stress on emotions and passions, leads to crime and anti-equalitarianism, he admits repeatedly in his works that his rationalism is limited and depends on an irrational faith in reason:

... whoever adopts the rationalist attitude does so because he has adopted, consciously or unconsciously, some proposal, or decision, or belief, or behaviour; an adoption which may be called 'irrational'. Whether this adoption is tentative or leads to a settled habit, we may describe it as an irrational *faith in reason*. So rationalism is necessarily far from comprehensive or self-contained. (Ibid., p. 231)

Here is another example of such an admission:

I frankly confess that I choose rationalism because I hate violence, and I do not deceive myself into believing that this hatred has any rational grounds [M]y rationalism is not self-contained, but rests on an irrational faith in the attitude of reasonableness. (Popper, 1989, p. 357)

This kind of fideistic confession made by Popper is problematic in two respects, no matter how morally admirable his sentiments may be. First, Popper seems to resort to justificationism, since he assumes a foundation – a faith in reason – on which rational arguments are based. Second, by admitting that the foundation of his rationalism is irrational, Popper lays himself open to the *tu quoque* argument of irrationalists and thus has no grounds to criticize the irrational commitments of others (see Sect. 2.2).

As a former student and colleague of Popper, Bartley (1987b) accuses Popper of fideism too. He asserts that Popper's fideistic remarks are not in line with the main thrust and intent of his non-justificationist methodology, but superfluous remnants carried over from the dominant tradition of limited rationalism – a tradition that assumes the impossibility of comprehensive rationalism. Bartley (1982) attributes this tradition, common in much British and American epistemology, to certain assumptions and doctrines of justificationist philosophy that have the effect of preventing the problem of the limits of reason from being solved within its framework. One such influential assumption is that criticism is necessarily fused with

justification: to criticize a position, one must show either that it cannot be derived from (i.e. justified by), or that its denial can be derived from, (the) rational authority, which is itself not open to criticism. Indeed, it is this assumption, Bartley argues, that causes an authoritarian structure to have been retained and gone unnoticed in modern philosophies that have been designedly anti-authoritarian and critical in spirit. And he suggests that the solution to the problem of the bounds of reason lies in the separation of criticism and justification.

2.5 Solution Three: Comprehensively Critical Rationalism

2.5.1 *Bartley's Boundless Version*

To achieve a comprehensive concept of rationality that can provide a complete defence against irrationalist attacks, Bartley (1982) proposes a non-justificationist theory of criticism wherein criticism is not based on something that is taken for granted as justified or beyond criticism. According to Bartley, there are four important kinds of such non-justificational criticism, viz. testing a theory against experience, comparing it against other theories, pushing it against whatever problems it is intended to solve, and testing it logically for consistency. Locating rationality in criticism rather than justification (as Popper does) yet abandoning all justification (including the irrational justification for adoption of the rationalist attitude Popper seems to concede), he characterizes a rationalist as

... one who holds *all* his positions, including his standards, goals, decisions, etc., and his basic philosophical position itself, open to criticism; one who protects nothing from criticism by justifying it irrationally; one who is committed, attached, addicted, to no position ...; one who is willing to *entertain* any position, but who *holds* (tentatively) only those positions which have been subjected to and have survived intense criticism. (Ibid., pp. 157–158)

This characterization, which Bartley calls “comprehensively critical” or “pancritical” rationalism, is *boundless* in two senses. First, in contrast with locating rationality in justification wherein eventual irrational justification or commitment would be inevitable, locating rationality in criticism and subjecting everything – including the rationalist position itself or the very practice of critical argument – to criticism would not lead to infinite regress, circularity or the need for justifying or committing to anything. This, accordingly, renders rationality unlimited and spells defeat for the *tu quoque* argument: a comprehensively critical rationalist, who accuses her/his opponent of protecting some position from criticism through irrational commitment to it, is not open to the charge that s/he is committed likewise. Second, the process of criticism is potentially infinite – one can criticize criticisms indefinitely – provided that when one position is subjected to criticism, others are taken for granted, not as justified or beyond criticism, but as unproblematical at the moment. Indeed, such a process comes to a halt only when we reach, rather than uncriticizable authorities, positions against

which we can find no criticisms. However, when a concrete argument is produced later to challenge these positions and thus renders them problematical, the critical process resumes. In other words, “there is no theoretical limit to criticizability – and to rationality” (ibid., p. 160).

Considering Bartley’s solution follows directly from Popper’s general philosophical position and strengthens his critical rationalism by making it boundless and hence comprehensive, it can be regarded as “a Popperian advance upon Popper’s own work” (R. Bailey, 2000, p. 145). In fact, even Popper himself recognizes the contribution of Bartley’s theory of non-justificational criticism to his rationalism: he (1966) acknowledges “Bartley’s incisive criticism” (p. 369), which inspires him to alter the terminology of Chapter 24 of *The Open Society and Its Enemies* (a crucial place to explain his critical rationalism) so as to tone down its fideism, accepting that

Bartley’s simple formulation – that *justification* can be replaced by *non-justificational criticism* – and his emphasis on the change of focus involved in the transition from the various *justificationist philosophies* to a *critical philosophy which does not aim at justification* is most illuminating. (Popper, 1983, p. 27)

Yet, curiously, Popper does not seem determined to eradicate his fideistic approach in that he has only corrected it in a patchy manner all along – dropping some of the old notions but retaining the old terminology (e.g. “critical rationalism”) and old slogans (e.g. “irrational faith in reason”) – since his discussion with Bartley about it in April 1960 (Bartley, 1982). Popper does not clarify this puzzling situation until 1992, when he expresses for the first time how he really feels about Bartley’s interpretation of his critical rationalism as fideism at a seminar in Kyoto: in contrast to Bartley (1987b), who repeatedly claims that his *theory* of rationality “attempts to build on, to interpret, to correct, and to generalize Popper’s *theory* [italics added]” (p. 205), Popper (1999) emphasizes that his critical rationalism is not a thesis or theory at all but an *attitude* of critical discussion which is neither true nor false; accordingly, it cannot be replaced by a theory of rationality (e.g. Bartley’s comprehensively critical rationalism) which can be true or false, and is in essence different from fideism which is a philosophical thesis that all our theories must be ultimately based on faith.

According to Artigas (1999), Bartley’s underlying reason for accusing Popper of fideism is that Popper’s critical rationalism fails to solve his problem, which is centred on demolishing the argument of those relativists, sceptics, and fideists who reproach the rationalist with the *tu quoque* argument. Unfortunately, however, Bartley’s problem is not the concern of Popper which is centred on the growth of knowledge (in epistemology) and the improvement of society and its institutions (in social theory). In other words, Bartley’s comprehensively critical rationalism – even though it is often presented as a complement to Popper’s critical rationalism – really changes Popper’s problem and complicates his solution. In fact, when Popper describes his critical rationalism as being based on a “faith in reason” that implies a “moral decision”, on the one hand, he is using the term “faith” in a very special sense to refer to, rather than the blind faith of fideism, the adoption of positions when it is impossible to provide a conclusive logical proof of their adequacy; on the

other, he is referring to the attitude of reasonableness that promotes such social values as the respect for freedom, justice, equality, and peace. Therefore, Bartley's accusation of fideism against Popper, which seems entirely drawn from logic without paying due regard to the profound ethical nature of Popper's decision or clarifying Popper's special use of the term "faith", is unjust and unfounded.

After all, the process of criticism not only requires certain non-epistemic values, like respect for truth, people, and their arguments, but also entails responsibility, for example, to offer or accept criticism or to learn to participate effectively in a critical discussion (Gattei, 2002). Obviously, such a critical or rationalist attitude cannot be the simple result of logical arguments and requires a moral decision to adopt it: as Popper (1966) puts it, "neither logical argument nor experience can establish the rationalist attitude; for only those who are ready to consider argument or experience, and who have therefore adopted this attitude already, will be impressed by them" (p. 230). Yet, since it is possible to argue in favour of its adoption (as Popper does himself), the moral decision can be considered "rational" rather than an irrational faith that Popper concedes unnecessarily.

2.5.2 *A Challenge to Its Boundlessness*

As regards Bartley's comprehensively critical rationalism, even from a *theoretical* or *logical* point of view, there is much controversy over its adequacy: as Popper (1996) explains it, "because this attempt bore the character of a definition, it led to endless philosophical arguments about its adequacy" (p. xii). Indeed, the boundlessness of comprehensively critical rationalism, which is embodied in the statement (S) that all statements (or positions) are criticizable, is subjected to three main criticisms. To start with, not only are logical truths (e.g. "Either it is raining or it is not raining"), analytic truths (e.g. "All bachelors are unmarried") and arithmetic identities (e.g. " $2+2=4$ ") uncriticizable in principle, but also are many synthetic statements that are trivially true, such as "I am more than three years old" and Watkins' (1971) "There exists at least one sentence written in English prior to nineteen eighty that consists of precisely nineteen words" (p. 59). One way of answering this objection is to note that we have developed methods for checking the correctness of – and thus, in a sense, criticizing – these truths and identities, although we seldom need to perform the check (Miller, 1994). Admittedly, no criticism of these true statements will be successful; yet, S does not require that all statements be successfully criticizable. In fact, whether the decision to problematize a particular statement in a particular problem situation is rational depends not upon its criticizability simply – which is seen by comprehensively critical rationalists as a property shared by every statement – but upon whether sensible criticisms of it are feasible at the moment, and hence upon both the problem situation and the background knowledge (Radnitzky, 1987). Consider the statement " $2+2=4$ " as an illustration. While in the context of a calculus with mathematical interpretation no sensible criticisms of it are feasible, in the context of the application of arithmetic the issue cannot be

decided unless we have information about the domain: for instance, suppose the plus is construed as the operation of physically putting together, then the statement is false if it is made to refer to a population of mercury drops (*ibid.*).

Another objection to S is that comprehensively critical rationalism is committed to deductive logic, which is uncriticizable. Accordingly, the challenge to Bartley, as Derksen (1980) asks, is “whether, given his view that ‘logic’ is a necessary presupposition for any critical, rational argument, it is possible for a CCR-ist [comprehensively critical rationalist] to be *rationally* argued out of his tentative belief in logic” (p. 63). In reply to this challenge, Bartley (1980) reiterates a point made by Popper (see Sect. 2.4.1) that criticism presupposes the notion of deducibility (i.e. the idea of the transmission of truth from premises to conclusions and the retransmission of falsity from conclusions to premises) so that when the conclusion of a valid argument is found to be false, that falsity is retransmitted to the premises whence it came, at least one of which must then be re-evaluated and corrected. And Bartley concedes that deducibility presupposes a minimal logic which he believes to be the law of non-contradiction (one of the three laws of thought, which states that a proposition cannot be both true and not true), for if contradictions were allowed, falsity could not be retransmitted and criticism in the intended sense would be impossible. Echoing Bartley’s defence that a minimal logic is presupposed in the argument or revision situation, Baghramian (2004) asserts that several core rules of logic – including the law of non-contradiction – are “preconditions of intelligibility of thought; they are minimum requirements for any coherent language-use” (p. 166). However, given Bartley’s insistence that everything, including the practice of critical argument and using logic, is open to criticism and rejection, how could he argue himself out of such practice while presupposing logic in that argument necessarily? This question can be answered in two ways. First, although logic is criticizable in principle, not all logic could be criticized at the same time: “certain logical systems or parts of such systems may be criticized, but only with the help of some other parts of logic” (Radnitzky, 1987, p. 305). Second, a large part of the philosophical tradition evidences the possibility of being argued logically out of the practice of rational argument and using logic. One good example is the existence of such logical paradoxes as the liar paradox² and Grelling’s paradox³ that are reached in the course of

² The liar paradox is generated by a sentence that, directly or indirectly, asserts its own falsity. A typical example is: (L) *This sentence is false*. In this case, the argument runs as follows: if (L) is true, then what it asserts is so; but what it asserts is that (L) is false, hence (L) is false. Yet, if (L) is false, then what it asserts is not so; but what it asserts is that (L) is false, hence (L) is true. In other words, the paradox arises because it seems possible to prove that (L) is true if and only if it is false, and vice versa.

³ Grelling’s paradox is concerned with the fact that some words are self-describing, or *autological* (e.g. “short” is a short word, “English” is an English word) while other words are non-self-describing, or *heterological* (e.g. “long” is not a long word, “Chinese” is not a Chinese word). It arises when we consider whether the word “heterological” is heterological: on one hand, if “heterological” is a heterological word, then it is clearly autological (by definition), yet heterological (by assumption); on the other hand, if “heterological” is not a heterological word, then it is clearly heterological (by definition), yet autological (by assumption). In either case, a contradiction results.

rigorously logical argument: using logic, and presupposing logic, we reach illogic (Bartley, 1980). If these paradoxes could not be shunned, then we would have strong reasons to mistrust logic and rational argumentation.

Interestingly, comprehensively critical rationalism is also criticized by both Watkins (1987) and Post (1987) for producing something like the liar paradox and generating an uncriticizable statement. The crux of the problem is not that S is uncriticizable, but that the statement "S is criticizable" is uncriticizable. To understand how this problem arises, we can consider the following two claims – A and B – that Bartley (1987a) accepts, wherein A is an alternative formulation of S.

A. All positions are open to criticism.

B. A is open to criticism.

Given A implies B, if we were to show that B is false and thus to criticize B, then we should have shown that A is false too. In other words, we should have criticized A. However, since this possibility is what B envisages, B would be true. Accordingly, "Any attempt to criticize B demonstrates B; thus B is uncriticizable, and A is false" (Bartley, 1987a, p. 320). In response to this objection, Bartley emphasizes that he is well aware of its possibility before Watkins and Post. Following Tarski's analysis, Bartley attributes the inevitability of such a paradoxical result to three characteristics A or S possesses: it refers to itself as criticizable, interprets criticizability in terms of possible falsity and thus involves the semantical concepts of truth and falsity, and is expressed in natural language. And Bartley believes that this kind of semantical paradox can be dealt with through such means as Russell's theory of types and Tarski's distinction between object-language and metalanguage so that the criticizability of B can be restored.⁴ Yet, this response seems not persuasive in that criticizability "depends on such things as the knowledge and technique available at the time ... which are *not purely semantic matters* [italics added] but pragmatic-temporal, or material" (Post, 1987, p. 262); therefore, the resort to Russell's or Tarski's solution to the semantical paradox appears not to the point. Perhaps the point is that the paradoxical argument is not valid at all. According to Miller (1994), although A, which talks about positions rather than statements, is rationally acceptable, B does not follow from A because B is not in the ordinary way what we call a position but a statement. As B is not a consequence of A, the paradox is defeated. In fact, the result does not change even if the word "positions" is replaced by the word "statements" in A. For comprehensively critical rationalists, Miller claims, must not be understood to hold that every statement they count as true (i.e. rationally accept) is on its own criticizable. Therefore, if A is changed to "All statements are open to criticism" while B remains unchanged, then A has to be rejected as a false and rationally unacceptable statement. In other words, B is not a consequence of A, which defeats the paradox similarly.

⁴ Apart from Russell's and Tarski's approaches to such semantical paradox, various strategies, like Kripke's concept of grounding, Van Fraassen's device of supervaluations, and Gupta's theory of revision rule, have been developed in recent decades to resolve it (Martin, 1984).

Considering these main criticisms against S turn out to be innocuous to its credibility, Bartley's assertion that comprehensively critical rationalism is boundless can be taken as tenable. Accordingly, Bartley's comprehensively critical rationalism can be regarded as *theoretically* or *logically* superior to Popper's critical rationalism in the sense that it is capable of demolishing the sceptical and fideistic arguments effectively and thus solving the problem of the bounds of reason completely.

2.6 From Theory to Practice

2.6.1 *Stratagems Opposed to Criticism*

Yet, to put such a non-justificationist theory into practice, it is necessary to identify and combat a nest of philosophical presuppositions that work against criticism and confine individuals to the justificationist framework. And, just as the Chinese proverb says that "It is easy to dodge an open spear thrust but difficult to guard against an arrow shot from behind", it is unlikely to circumvent or eliminate the effects of these anti-criticism presuppositions unless various hidden stratagems that reduce and eschew criticism are exposed to criticism. Here, it may be said that both Popper and Bartley, as advocates of non-justificationism, spare no pains to reveal such protective or evasive stratagems. For example, in explaining why justification and criticism are fused in the way described in Sect. 2.4.2 (the view to be criticized is examined for whether it can be derived from or justified by the uncriticizable authority), Bartley (1982) reveals the underlying assumption of justificational criticism to be that the view being examined inherits logically whatever merit it possesses from the justifying authority where it is derived: "if the justifying authority is true, the view being examined, if derivable from it, is true" (p. 153). The hidden philosophical dogma whence this assumption comes Bartley calls the "transmissibility assumption", which states that *all* measures and tokens of intellectual value (e.g. truth), as properties of statements, are transmitted from premises to conclusion through the relationship of logical deducibility. Admittedly, if all measures of intellectual value resembled truth in being transmissible, all criticism would certainly be justificational. However, while truth is just one of the *very few* properties that are transmissible, Bartley maintains, most other properties of statements (e.g. the properties of "being written in English" and "empirical character") are non-transmissible. This fact, together with the possibility of non-justificational criticism (see Sect. 2.5.1), shows that it is not necessary for criticism to be bound by the justificational transmissibility assumption.

As for Popper, being a long-standing critic of justificationist presuppositions, he has always been keen on exposing those anti-criticism stratagems. To begin with, Popper (1989) points out that the doctrine that truth is manifest, apart from leading to fanaticism and authoritarianism (see Sect. 2.3.2), runs counter to the

doctrine of fallibility and thus of tolerance: if truth was manifest, we would be unlikely to make mistakes, and thus would not need to tolerate or pardon others for their mistakes which were regarded as the result of their prejudices. Since criticism involves searching for errors of our own and of others, which assumes that we are prone to errors and consequently should be tolerant of others, the doctrine that truth is manifest is diametrically opposed to it. Another stratagem Popper combats is the demand for precision in concepts as a prerequisite for criticism or problem-solving. Affirming the non-existence of “precise” concepts, or concepts with “sharp boundary lines”, Popper (*ibid.*) emphasizes that words are significant only as tools for formulating theories and don't need to be more precise than our problems demand. To deal with the problem that our problems may sometimes demand that we make new distinctions for the sake of clarity or precision, he suggests an *ad hoc* approach:

If because of lack of clarity a misunderstanding arises, do not try to lay new and more solid foundations on which to build a more precise ‘conceptual framework’, but reformulate your formulations *ad hoc*, with a view to avoiding those misunderstandings which have arisen or which you can foresee. And always remember that *it is impossible to speak in such a way that you cannot be misunderstood*: there will always be some who misunderstand you. (Popper, 2002b, p. 29)

Besides, Popper identifies three isms that work against criticism, namely essentialism, instrumentalism, and conventionalism. First, concerning the essentialist doctrine that science aims at *ultimate explanations* which describe the “essences” of things – the realities that lie behind the appearances – and therefore are neither in need nor susceptible of further explanation, Popper (1989) criticizes it as obscurantist in the sense that it prevents fruitful questions or further criticisms from being raised. Second, Popper (*ibid.*) also condemns as obscurantist the instrumentalist view of theories as mere instruments for prediction, because it stresses application but neglects falsification or criticism: for instrumental purposes of practical application, a theory may continue to be used within the limits of its applicability even after its refutation; in other words, a theory cannot be falsified insofar as it is interpreted as a simple instrument, for it can always be said that different theories have different ranges of application. Third, although Popper (1980) admits that the conventionalist philosophy, which regards laws of nature as our own creations and arbitrary conventions rather than representations of nature, deserves great credit for clarifying the relations between theory and experiment, or rather for recognizing “the importance ... of the part played by our actions and operations, planned in accordance with conventions and deductive reasoning, in conducting and interpreting our scientific experiments” (p. 80), he rejects its methods of protecting the theoretical systems of the natural sciences against criticism; indeed, Popper asserts, there are at least four conventionalist stratagems – introducing *ad hoc* hypotheses, modifying ostensive definitions, adopting a sceptical attitude as to the reliability of the experimenter, and casting doubt on the acumen of the theoretician – which make it impossible to falsify these systems.

2.6.2 *A Bias Towards Confirmation*

2.6.2.1 *Its Pervasiveness and Various Guises*

To achieve personal and institutional implementation of Popper's non-justificationism, however, apart from exposing to criticism various hidden stratagems that work against criticism as mentioned above, it is also necessary to combat what seems a common psychological tendency of humans to be biased towards confirmation, or against disconfirmation. Unfortunately, neither Popper nor Bartley gave much of their attention to such an anti-criticism tendency, which reflects markedly a conflict between falsificationism and deep-rooted psychological mechanisms. According to Nickerson (1998), *confirmation bias*, as the term is generally used in the psychological literature, connotes an unwitting process of seeking or interpreting evidence in ways that are partial to existing beliefs or hypotheses. A great deal of empirical evidence supports the view that the confirmation bias not only is extensive and strong but also appears in various guises: it is reflected in the tendency of people, for example, to demand less hypothesis-consistent evidence for accepting a hypothesis than hypothesis-inconsistent information for rejecting a hypothesis (Pyszczynski & Greenberg, 1987); to recall or produce reasons supporting the side they favour rather than the other side on a controversial issue (Baron, 1995); and, when assessing the validity of a conditional "if p then q ", to seek for the presence of p and q so as to confirm the conditional rather than for the presence of p and *not- q* so as to disconfirm the conditional (Wason, 1966).

In the context of science, although Polya (1954) has argued that what distinguishes scientists from ordinary people is their disposition to seek disconfirmatory evidence for their hypotheses, instances of confirmation bias still abound in the history of science. This can be illustrated at two – personal and institutional – levels. At personal level, Michael Faraday advocated ignoring disconfirmatory evidence when dealing with a novel hypothesis until the hypothesis was well-confirmed (Tweney, 1989), while Robert Millikan reported only those observations that fitted his hypothesis when publishing the experimental work on determining the electric charge of a single electron (Henrion & Fischhoff, 1986). At institutional level, just as Newton's concept of universal gravity was rejected by Huygens and Leibniz due to their resistance to the idea of a force extending throughout space not reducible to matter and motion, scientific discoveries have often met with resistance from scientists themselves, especially from those whose theoretical positions were challenged by the discoveries; in fact, the typical reaction of scientists to the challenge of anomalous data to the existing theory is to challenge the data first and, if the data prove reliable, then to complicate the theory just enough to accommodate the anomalous result (Nickerson, 1998). Perhaps Polya's characterization of individual scientists as being inclined to disconfirm their own hypotheses is half correct at most: they are eager to criticize or disconfirm other scientists' hypotheses rather than theirs.

2.6.2.2 Several Theoretical Explanations for It

With regard to the question of how to account for the confirmation bias, apart from what Matlin and Stang (1978) dub the Pollyanna principle, which explains in a commonsensical way that people tend to be partial towards pleasant thoughts and memories rather than unpleasant ones and thus to believe propositions they would like to be true rather than those they would prefer to be false, there are at least four other theoretical explanations that various researchers have proposed. First, according to Nickerson (1998), people are basically limited to consideration of only one thing – and inclined to gather information about only one hypothesis – at a time. However, restricting the attention to a single hypothesis might strengthen that hypothesis even if it is false:

An incorrect hypothesis can be sufficiently close to being correct that it receives a considerable amount of positive reinforcement, which may be taken as further evidence of the correctness of the hypothesis in hand and inhibit continued search for an alternative. (Ibid., p. 198)

Hence the confirmation bias.

Second, discounting the possibility that people deliberately seek to confirm rather than disconfirm their hypotheses, J. St. B. T. Evans (1989) attributes the confirmation bias to, not their motivation to confirm, but their failure to think in explicitly disconfirmatory terms. His argument accords with much evidence that people find it more difficult to deal with negative information than with positive one. For example, it is more difficult to decide the truth or falsity of negative sentences than of positive ones (Wason, 1961); and inferences from negative premises need more time to evaluate and are more likely to be evaluated wrongly than those from positive premises (Fodor, Fodor, & Garrett, 1975).

Third, just as Friedrich (1993) asserts that “our inference processes are first and foremost pragmatic, survival mechanisms and only secondarily truth detection strategies” (p. 298), the judgements people make in many real-life situations are motivated more by a desire to achieve success and survival – and thus to balance potential rewards against perceived risks – than by the objective of determining the truth or falsity of hypotheses. This explains why confirmation bias may result when the undesirable consequences of considering a true hypothesis as false are greater than those of considering a false hypothesis as true.

Last, stressing the importance of being able to *justify* what one believes at all levels of education can establish or strengthen a tendency to seek confirmatory evidence selectively: if one is always stimulated to adduce reasons for opinions that one holds and is not urged also to articulate reasons that could be given against them, one is being trained to exercise a confirmation bias (Nickerson, 1998). To make matters worse, some educational practices fail to distinguish explicitly between case-building (i.e. seeking selectively or giving undue weight to evidence that supports one's position while neglecting to seek or discounting evidence that would tell against it) and evidence-weighing (i.e. seeking evidence on all sides and evaluating it as objectively as one can) so that what is in reality case-building passes

for the impartial evaluation of evidence; hence the ubiquity and strength of the confirmation bias among educated adults. A typical example of such case-building educational practices is debate, in which debaters give their primary attention to arguments that support the positions they are defending – even if they might advance counter-arguments, their intention is only to reveal the shortcomings of these counter-arguments. After all, the debaters' aim is to win and the way to do so is to make the strongest possible case for their own position while countering, discounting, or simply ignoring any evidence that might be brought against it.

2.6.2.3 Teachers' Role in Undermining Its Strength and Spread

Although it can be argued that the confirmation bias helps to protect our ego by rendering our preferred beliefs less vulnerable than they otherwise would be (Greenwald, 1980) and to guard science against indiscriminate acceptance of alleged new discoveries which fail to stand the test of time (Price, 1963), the bias is still generally regarded, with reason, as a human failing: it can contribute to the formation of various delusions, the development and survival of superstitions, and the perpetuation of hostility and strife between people with conflicting views of the world (Nickerson, 1998). However, as the saying goes, "The child is father of the man". It is necessary to start with the education of children if the strength and spread of the confirmation bias are to be undermined and checked respectively among adults. So, what are the implications of the above paragraphs for educational practices? First of all, since a crucial move to deal with any kind of bias is recognizing its existence, teachers themselves should be well aware of the confirmation bias – its pervasiveness and the various guises in which it appears – and then help their students to acquire this awareness. Such awareness can help students to be somewhat more cautious with hasty decisions on important issues and more open to opinions that differ from their own than they might otherwise be.

Moreover, considering that the confirmation bias is partly attributed to the tendency of people to consider only one hypothesis at a time, teachers should also train their students to think of several alternative hypotheses simultaneously in explanation of phenomena. Yet, the discovery by Tweney et al. (1980) that individuals cannot employ this thinking strategy successfully – for they prefer "to evaluate several pieces of data against a single hypothesis, rather than one datum against several hypotheses" (p. 119) – demonstrates the superiority of working in groups over acting individually in avoidance of the bias: having each individual work on a different hypothesis, groups can keep track of several hypotheses at the same time.

Further, teachers should realize the significance of making explicit the distinction between case-building and evidence-weighing, and encourage their students to evaluate evidence objectively in the formation and evaluation of hypotheses. Here, it is vital to cultivate in students a critical mindset that prompts them to think of reasons both for and (especially) against any judgement that is to be made. And they should be made aware that the motivation to find support for preferred beliefs

“often leads a person to overlook even glaring faults in the data, because it is difficult to find what is not sought” (Dawson, Gilovich, & Regan, 2002, p. 1386).

Finally, despite the inclination of scientists to discount data inconsistent with their theory, Fugelsang, Stein, Green, and Dunbar (2004) found that scientists began to modify their original theory when *repeated* observations of inconsistent data occurred. Indeed, the initial reluctance of scientists to accept inconsistent data and their subsequent re-theorization through repeated experimentation can be considered as a practical heuristic device: it prevents them from prematurely accepting findings that may be spurious while permitting the revision of theories and thus the growth of knowledge. In the realm of science teaching, this heuristic device should be introduced to students, particularly for fostering a proper attitude towards inconsistent data.

2.7 The Problem of Practicality

2.7.1 *Is Popper a Philosopher of Influence?*

Yet, if Popper's non-justificationism is to be justified, apart from pondering how to put it into practice through combatting both the philosophical presuppositions and confirmation bias that work against criticism, two other practical questions need to be considered, viz. the question of Popper's influence on scientific practice, and whether falsification is an effective strategy for solving scientific problems. With regard to the former question, whatever the answer, Popper himself indicates that he intends to have a practical influence on scientific practice. As he puts it, “I shall try to establish the rules, or if you will the norms, by which the scientist is guided when he is engaged in research or in discovery” (Popper, 1980, p. 50). More specifically, in accordance with Popper's rules of scientific method, scientists should ensure that their theories are falsifiable and that only those theories which have withstood rigorous attempts to falsify them are accepted. In fact, quite a lot of scientists have publicly acknowledged the significance of these rules and thus his influence on their work. For example, John Eccles (1974), the winner of the Nobel Prize in medicine in 1963, has repeatedly declared that his scientific life since 1945 owes a great deal to his conversion to Popper's teachings, the most important of which, he claims, is that it is “not disgraceful to have one's own favourite hypotheses falsified” (p. 350). Persuaded by Popper to formulate his favourite hypothesis with sufficient precision and rigour to invite strict experimental falsification, Eccles finally defeated it – the brain-child he had nurtured for nearly two decades – in the early 1950s, but made a breakthrough in neurobiological research later on. Another more recent example comes from Federspil and Vettor (2000), also in the field of medicine. They assert that various alternative medical practices such as homeopathic medicine and urotherapy do not represent authentic scientific disciplines, because these practices violate Popper's rules of scientific method, especially the principle of falsifiability

he uses to separate science from pseudo-science: “only if one can say in what way a theory is refutable [i.e. falsifiable] is it possible to accept the assertion that the theory is scientific” (ibid., p. 243).

However, many scientists don’t seem to recognize Popper as a philosopher of influence. For instance, after interviewing 34 members of a research network in biochemistry, Mulkay and Gilbert (1981) found that although most agreed with Popper’s message for practising scientists, almost all were doubtful about his influence on scientists’ research activities; and that although some portrayed themselves as Popper’s followers, very few were actually acknowledged by their fellows as following his methodological rules faithfully. Accordingly, it appears that Popper’s prescriptive methodology cannot be regarded as an accurate description of scientific practice. This point is echoed by Munro (2002), who contends that Popper is “attempting to *prescribe* not *describe* science since scientists themselves do talk of theories being more or less probable, of being supported by the evidence” (p. 466). Yet, it can be argued that what Mulkay, Gilbert, and Munro are in fact portraying is how some scientists talk about what they believe they are doing when they are doing science rather than how scientific knowledge really grows, while Popper – in presenting his falsificationist method – is putting forward his hypothesis of what method is logically and empirically better at attaining scientific explanations and is not referring to the perceived fallible opinions of experts about that process (Gomory, 2002). As Einstein (1982) puts it so aptly, “If you want to find out anything from the theoretical physicists about the methods they use, I advise you to stick closely to one principle: don’t listen to their words, fix your attention on their deeds” (p. 270). One such deed is that individual scientists have been highly motivated to demonstrate the falsity of hypotheses held by other scientists, not by themselves, due to the confirmation bias (see Sect. 2.6.2). In other words, although individual scientists are not likely to direct falsification against their own hypotheses, they have a strong tendency to falsify other scientists’ hypotheses; hence the application of Popper’s falsificationist methodology. Indeed, the firm demand of science, as an institution, for its practitioners to observe the rule that “only such statements may be introduced in science as are inter-subjectively testable” (Popper, 1980, p. 56) has ensured its relative freedom from their biases.

More importantly, the history of science abounds in evidence that when confronted with crisis and change scientists have turned to Popper’s philosophy for direction. A typical illustration of this can be found in the field of astronomy. According to Sovacool (2005), astronomers use Popper’s methodology to confront three interrelated crises in modern astronomy which are driven primarily by advances in instrumentation, viz. the crises of methodology, legitimacy, and testability. Corresponding examples are as follows: Carl Sagan lays out explicitly the grounds of how his theory of Venusian atmosphere can be falsified by different observations from *Mariner 2*; Ken Freeman and Joss Bland-Hawthorn question contemporary theories of globular clusters and argue that the inability of these theories to be falsified makes them fatally flawed; and Michael Turner, after tracing the developments of cosmology throughout the last century, finds that falsification has been the driving force in the evaluation of cosmological theories and asserts that new theories

should be bold and testable (ibid.). Another illustration is concerned with the work of Frederick Hopkins (a Nobel laureate in medicine), which is generally accepted as providing the final convincing evidence that led to the adoption of the vitamin theory, as far back as 1912, at which time “a large amount of factual evidence had been produced which supported the viewpoint of the protagonists of theory 5 [the vitamin theory] without however reducing the credibility of theories 1–4 [other competing theories]” (Akeroyd, 1985, pp. 224–225). Hopkins’ cogency lies not in his publication of even more evidence in support of the vitamin theory but in his attempt, yet failure, to falsify this theory by subjecting it to the severest possible tests (ibid.). Interestingly enough, in 1912, Popper was only about ten and certainly had not published anything on philosophy yet. In other words, Hopkins used Popper’s methodology to resolve the crisis well before Popper constructed it: Popper thus not only prescribes but also describes scientific practice. Admittedly, more work needs to be done to depict completely the influence of Popper on scientists. Nevertheless, considering that such a diverse community of scientists turn to the ideas of Popper to direct and strengthen their practice over such a long span of time, Popper deserves to be called a philosopher of influence.

2.7.2 Does the Popperian Method Work?

2.7.2.1 Can Students Be Taught to Falsify?

Influential as Popper is in the practice of science, a question can still be raised about the effectiveness of his methodology, for there is much controversy in the psychological literature over the feasibility and utility of falsification as a strategy for solving scientific problems. To start with, many psychological studies show that many scientists have difficulty in disconfirmatory reasoning. For instance, in a survey conducted by Mahoney and Kimper (1976), a sample of physicists, biologists, sociologists, and psychologists were asked to rate the validity of four forms of material implication (i.e. to judge whether it is valid, assuming that p materially implies q , to infer q from p , $not-q$ from $not-p$, p from q , and $not-p$ from $not-q$) and to identify the logically critical experiments that could test the validity of a hypothesis of the form “if p then q ”. It was found that over half of these scientists failed to recognize *modus tollens* (i.e. the inference from $not-q$ to $not-p$) as logically valid, and that fewer than 10% of them were able to select correctly the experiments which had the critical potential of falsifying the sample hypothesis. Perhaps more surprisingly, similar difficulty in recognizing the logical validity of falsification was found in a sample of statisticians who had been formally trained in testing statistical (null) hypotheses and thus in examining possible disconfirming evidence (Einhorn & Hogarth, 1978).

However, having difficulty in using disconfirmatory reasoning does not mean a lack of ability to do so. Indeed, some researchers have successfully taught college students to employ disconfirmatory strategies to solve such reasoning problems as Wason’s (1960) 2-4-6 problem and Gardner’s (1977) “New Eleusis”. Wason

advanced the 2-4-6 problem as a test of inductive reasoning: subjects were told that the sequence of three numbers “2-4-6” was an instance of a rule which the experimenter had in mind (The rule was “Any three numbers in ascending order”.); they were required to discover the rule by generating their own test sequences of three numbers which the experimenter would describe to them as correct or incorrect instances of the rule. Considering Wason’s subjects displayed a strong confirmation bias and tended to generate test sequences consistent with their tentative hypotheses, Tweney et al. (1980), using the same 2-4-6 task, made an attempt to teach disconfirmatory strategies to their subjects, that is, to ask their subjects to try generating disconfirmatory instances. They found that the mean number of confirmatory and disconfirmatory instances generated by subjects in the disconfirmatory group was 1.5 and 6.6 respectively (in Experiment 1). This result indicates that Tweney et al. were successful in eliminating most attempts at confirmation and thus in changing the inquiry strategy of those subjects in the disconfirmatory group.

“New Eleusis” is a card game explicitly designed to simulate the inductive search for truth. Gorman, Gorman, Latta, and Cunningham (1984) adapted it to create a task for studying scientific reasoning: subjects were asked to guess what the underlying rule behind a sequence of cards was by playing cards one at a time (One of the rules, for instance, was “A difference of 1 must separate adjacent cards”.); they would be informed by the experimenter about whether their cards were right or wrong (Correct cards continued in a straight line while incorrect cards went off at right angles and were placed beneath the card after which they were played.) but would not receive any feedback from the experimenter on whether their guesses were right or wrong until the end of the experiment. Using this task to study how confirmatory, disconfirmatory, and combined strategies affected group problem solving (in Experiment 2), they instructed their subjects to concentrate respectively on getting as many cards right as possible, on getting as many cards wrong as possible, and on getting cards right until they had a guess which was then tested by playing cards that would be wrong. They found that disconfirmatory groups played incorrect cards 41% of the time, combined groups 33% of the time, and confirmatory groups only 20% of the time. Again, the result shows that the instructional manipulation was successful; hence the feasibility of inducing the use of disconfirmation.

Two Contributory Factors in Eliciting Disconfirmation

Here, two contributory factors in the higher use of disconfirmation – collaborative reasoning and lower normativity – need attention if disconfirmatory strategies are to be promoted in the classroom. To illustrate how group processes often facilitated disconfirmation, Gorman et al. (1984) provided the following brief exchange between two subjects in one disconfirmatory group:

One subject complained to the other group members: ‘I have a hard time guessing wrong’. Another subject tried to tell her how to disconfirm: ‘If you think the series goes like this (pointing to a sequence of cards ascending by ones), try to prove it wrong by putting down a card that doesn’t go with the series.’ (p. 75)

The second subject soon induced not only the first subject but also other group members to falsify more and more guesses. Such beneficial effect of peer interaction is echoed in the study of Moshman and Geil (1998), who found that while 75% of the subjects in interactive groups could apply correctly a disconfirmatory strategy in testing a hypothesis, only 9% of the individual subjects working in isolation could do so. As close examination of the videotaped group discussions revealed little evidence of passive conformity to majority views or to the views of an apparent expert but a usual attempt to co-construct a consensus solution – a structure of arguments qualitatively more sophisticated than that generated by most individuals – by sharing perspectives and reasons, they attributed the superior performance of the groups to collaborative reasoning rather than to peer pressure or imitation. Accordingly, useful insights into the logic of falsification appear to be more readily achieved in collaborative reasoning than in individual reasoning.

The question whether disconfirmation is used during collaborative hypothesis testing might, however, depend upon the type of relation reasoners have with their partners and with the experimenter: the study of Butera, Caverni, and Rossi (2005) showed that while confrontation with a low-competence partner rendered subjects able to learn to use disconfirmation, confrontation with a high-competence partner induced them to use confirmation, even when the partner used disconfirmation. A possible explanation is that confrontation with a high-competence partner can threaten the subjects' competence, thereby leading them to test their own hypotheses through confirmation as a defensive strategy that seems to support their hypotheses and thus to protect their competence; in contrast, a low-competence partner is less likely to threaten the subjects' competence, thereby allowing them the opportunity to test the limits of the validity of their own hypotheses through disconfirmation (*ibid.*). Moreover, Butera et al. (2005) showed that subjects who were confronted with the violation of a conversational rule – i.e. were told by the experimenter in solving Wason's (1960) 2-4-6 problem that 2-4-6 was *not* a good example of the rule and had been chosen only to show them what was a number triad – used a high proportion of disconfirmation, whatever the competence of the partner. They explained that disconfirmation stemmed from the possibility of diverging from not only social norms in the case of interaction and social influence (e.g. the constraining power of competence), but also conversational norms in the case of language (e.g. the constraining power of the example given by the experimenter): considering the high-status experimenter might lead subjects through conversation to focus on the given triad, to formulate a hypothesis that captured all the salient features of the triad, and to try to confirm it, telling them that 2-4-6 was not a good example of the rule might break the focused processing of the task and lead them to use disconfirmation. It appears therefore that people use confirmation in constraining reasoning situations but that “the use of disconfirmation can be increased by lowering the normativity of the situation, either by a less threatening source or by less constraining conversational rules” (*ibid.*, p. 186).

In other words, if disconfirmation is to be taught effectively to students, merely creating the opportunity for them to collaborate with each other is not enough. The teacher should also attempt to lower the normativity of the learning environment by

such means as ensuring that students interacting within the group are not threatening or dominating, and avoiding proposing as an authority a model solution to them during problem solving. The latter is particularly noteworthy in that many teachers really see themselves as an authority in the classroom who, they think, should know the answer to every question. Such an authoritative image teachers have of their role is detrimental to the adoption of disconfirmation in two ways: first, it makes the interaction between the teacher and students more normative; and second, it makes the classroom less likely to satisfy the basic requirement for implementing falsificationism in education, that is, to become a place that values mistakes made by both teachers and students (Sankey, 1999).

The Influence of the Complexity of the Problem

Despite the foregoing evidence in support of the argument that people can be taught to falsify their hypotheses, some studies have shown that instructional manipulations might fail to elicit falsification when the inference problem turns complex. For example, to achieve a more realistic simulation of science in their study, Mynatt, Doherty, and Tweney (1977) designed a rather complex inference task: after observing a set of computer displays made up of stationary geometric figures and moving particles whose motion was influenced by the figures, subjects were asked to discover the laws that governed the motion of particles by first generating a hypothesis and then choosing the appropriate experiments to test that hypothesis. They found that their manipulation failed to induce the disconfirmatory group to seek disconfirmation. In a follow-up study, Mynatt, Doherty, and Tweney (1978) gave subjects more extensive instructions to falsify and rendered the task even more complex yet more realistic by allowing them to explore it in a less constrained manner (e.g. allowing them to design their own experiments instead of forcing them to choose from the potential ones). As in Mynatt et al. (1977), however, they found that instructions to disconfirm produced little or no effect on the disconfirmatory group; indeed, “there was ... almost no indication whatsoever that they [both the disconfirmatory and control groups] intentionally sought disconfirmation” (Mynatt et al., 1978, p. 400). A possible explanation, they suggest, is that a disconfirmatory strategy might simply overload the cognitive capacity of most people – hence the difficulty in eliciting it from them – when they are groping for a means of dealing with complex inference problems. Accordingly, the feasibility of teaching people to falsify seems to depend on whether or not the task is complex.

To complicate matters still further, sometimes it is difficult to judge from the testing behaviour of people whether they have actually followed the falsificatory instruction. For it can be argued that the falsificatory instruction is not carried out successfully if people who are instructed to falsify perform what Wetherick (1962) calls negative tests – i.e. testing their hypothesis by means of test items that it predicts to be false – but at the same time expect the hypothesis to be confirmed rather than falsified by the test result. This argument is echoed and supported by the study of Poletiek (1996) who found that although 60% of subjects in the falsificatory

group adopted negative tests, only 10% of them expected a hypothesis-falsifying result, concluding that

when subjects are asked to behave as falsifiers in a hypothesis-testing task, their behaviour expresses the paradoxical character of this requirement by showing a preference for negative tests on the one hand, but nonetheless expecting this strategy to fail with regard to the production of hypothesis-inconsistent data on the other. (p. 456)

In other words, it seems “paradoxical” to regard those who simultaneously use negative tests and expect confirmation of their hypotheses as following the falsificatory instruction. Leaving aside the problem of how to deal with such paradoxical situations which may arise when people are instructed to falsify, an interesting question is: why don't they think and act in the same way? That is, why don't they expect to falsify their hypotheses when performing negative tests? Does it reveal a disbelief at heart in the utility of falsificatory strategies? At any rate, do these strategies work in reality?

2.7.2.2 Should Students Be Taught to Falsify?

Judging from the results of several studies conducted by Michael Gorman and his colleagues in the 1980s, there appear to be grounds for cautious optimism about the utility of falsification. To begin with, in the above-mentioned study on how different strategies affect the performance of groups in the task adapted from “New Eleusis” (in Experiment 2), Gorman et al. (1984) found that disconfirmatory groups solved significantly more rules (72%) than combined (50%) and confirmatory (25%) groups. Together with the findings that disconfirmatory groups played the highest percentage of incorrect cards (41%) while combined and confirmatory groups played the middle (33%) and the lowest (20%) percentage respectively, and that the percentage of incorrect cards played by these three different groups was highly correlated with their success in solving the rules, this indicates that the strategy instructions were carried out successfully and indeed accounted for the differences in performance; hence the effectiveness of disconfirmation in problem solving.

Considering that scientists do not work in an error-free environment, in order to model the role of disconfirmation in scientific inference more authentically, Gorman (1986) added the possibility of error to the “New Eleusis” experiment in another study (with a design virtually identical to the preceding study): subjects were told that 0–20% of the feedback on their trials from the experimenter might be in error, that is, a card that should be correct would be classified as incorrect and vice versa. He found that disconfirmatory groups did not perform significantly better than confirmatory or control (i.e. no-strategy) groups, because the possibility of error interfered with the ability of disconfirmatory groups to obtain and use disconfirmatory information in the senses that it allowed them to immunize their hypotheses against disconfirmation by classifying disconfirmatory information as error, and that it made them spend so much time checking potential errors that they failed to test their hypotheses adequately. However, this result does not mean

the futility of disconfirmation under possible-error conditions. Given that the few successful groups used a strategy which combined disconfirmation with replication (i.e. replicating situations in which they thought an error might have occurred), it means that disconfirmation becomes even more important as a necessary, though not sufficient, strategy (*ibid.*).

A Favourable Condition for Disconfirmation to Be Effective

Further, Gorman and Gorman (1984) showed that the positive effect of disconfirmatory instructions found by Gorman et al. (1984) could be replicated on Wason's (1960) 2-4-6 task with individual subjects. Specifically, they found that a significantly larger number of disconfirmatory subjects (95%) than confirmatory (48%) and control (53%) subjects solved the original rule (i.e. "Any three numbers in ascending order") of the task. Curiously enough, such positive effects of disconfirmation on performance did not appear in the aforesaid Tweney et al.'s (1980) study, the Experiment 1 of which used a design very similar to Gorman and Gorman's and found that "while subjects did learn to seek disconfirmatory data, the possession of such strategies led neither to faster solutions, nor to a greater proportion of subjects with correct solutions" (p. 112). Later on, Gorman and his colleagues discovered that the difference between their results and Tweney et al.'s was probably caused by the fact that their subjects were given no feedback on the correctness of their guesses until the experiment was over, but Tweney et al.'s subjects were informed of whether or not each of their guesses about the rule was correct and thus could rely on the experimenter for confirmation or disconfirmation (Gorman, 1992). Therefore, it appears that disconfirmation might be an effective heuristic when people cannot appeal to an outside authority to find out whether they are making progress towards a discovery.

Yet, if disconfirmation is less useful when people can appeal to such an authority, then it has little value in the case of laboratory exercises done in many high-school and college classes. For, according to Gorman (1995), the objective of most of these exercises is to get the correct answer rather than explore a novel phenomenon, and frequent appeals to authority in the form of the laboratory assistant or the instructor are not only possible but likely to be helpful. The educational implication is that another more open-ended and exploratory kind of exercise might provide better training in the use of disconfirmation for future scientists who typically cannot appeal to any authority to test their hypotheses.

The Limits of Disconfirmation

However, disconfirmation seems not to be a universally effective strategy for solving reasoning problems. This is substantiated by the results of some 2-4-6 studies (e.g. Gorman & Gorman, 1984; Gorman, Stafford, & Gorman, 1987) that it does not work on very general, or more difficult, rules such as "No two numbers can be the same". Moreover, disconfirmation seems not to be self-sufficient either, because

sometimes its utility is dependent upon confirmation in two senses. First, strategically, confirmation acts as a necessary complement to disconfirmation, especially in the early stages of a complex inference task. Here are two illustrative examples: Mynatt et al. (1978) found that although no subjects solved their demanding task, the most successful one initially concentrated on accumulating confirmatory evidence for his hypothesis without regard to disconfirmatory evidence and only sought to establish whether disconfirmatory instances could be found after a relatively well-confirmed hypothesis had been developed; and Karmiloff-Smith and Inhelder (1975) found that young children presented with difficult reasoning problems were incapable of using disconfirmatory evidence – i.e. recognizing counterexamples – until after their hypotheses had been sufficiently confirmed. Echoing the findings of these two studies, Vartanian, Martindale, and Kwiatkowski (2003) showed that reliance on a mixed strategy of confirmation and disconfirmation in the early and later stages of hypothesis testing respectively appeared to be quite advantageous. In fact, in order to defend Faraday against the charge that his deliberate neglect of the disconfirmatory experiments (conducted in 1831 as part of his discovery of electromagnetic induction) reflected a confirmation bias on his part, Tweney and Chitwood (1995) argue instead that what Faraday had done simply manifested a sophisticated use of such a “confirm early, disconfirm late” strategy, and explained in detail that

Nature is chaotic in its character and will frequently provide false feedback to the inquirer ... many of the experiments tried by Faraday were in fact producing the expected effects but the effects were small and could not be detected with Faraday's insensitive apparatus. The task of the scientist in such an environment is to impose order on the apparent disorder ... one of the necessary functions of a confirmation heuristic ... [is that] it filters out some of the noise and may allow a signal to be detected. This is not a sure thing, which is why a disconfirmatory strategy is a necessary supplement later on. (p. 255)

Second, essentially, a confirmatory strategy not only does not necessarily contradict the goal of seeking disconfirmation, but may be the only way to achieve it in some circumstances. To understand this, according to Klayman and Ha (1987), a confirmatory strategy is better interpreted as a *positive test strategy*, which means testing a hypothesis by examining instances where the target property is hypothesized to be present or is known to be present. Further, it is crucial to distinguish between two different senses of “seeking disconfirmation”. One sense, which is the focus of empirical investigations, is to examine instances that are predicted not to have the target property, or to conduct negative tests. The other sense, which is emphasized by Popper, is to examine instances that are most expected to falsify the hypothesis. Using Wason's (1960) 2-4-6 task as an example, Klayman and Ha demonstrate graphically that although a positive test strategy cannot produce falsifications in the Popperian sense when the hypothesized rule (e.g. “increasing by 2”) is embedded within the correct rule (e.g. “increasing numbers”, as in Wason's original task), it can do so when the hypothesized rule (e.g. “increasing by 2”) overlaps the correct rule (e.g. “three even numbers”). More importantly, indeed paradoxically, it is the sole strategy that can reveal conclusive falsifications – even negative tests cannot do so – when the hypothesized rule (e.g. “increasing by 2”) surrounds the correct rule (e.g. “consecutive even numbers”). Therefore, it can be seen that it is impossible to

judge the effectiveness of a confirmatory or positive test strategy in the absence of information about the nature of the task at hand.

2.8 Conclusion

To sum up: Popper's non-justificationism is justified on the grounds that it not only solves, theoretically, the problem of the bounds of reason in the form of comprehensively critical rationalism, but also influences, practically, the research work of scientists from diverse fields over a long span of time. With regard to the feasibility and utility of falsification as a strategy for solving scientific problems, although there is cause for cautious optimism about them, the psychological interpretation and application of Popper's falsificationist philosophy in the relevant literature are not completely free from problems. One illuminating example of such problems is that Popper strongly relates falsification to properties of the hypothesis rather than to properties of testing behaviour as psychologists in studying reasoning do (Poletiek, 1996). Another is that psychologists who work on Wason's (1966) influential experimental task for studying deductive reasoning are criticized for virtually ignoring the difficulties inherent in ascribing material conditional interpretations to natural language conditionals (Stenning & van Lambalgen, 2004). However, this does not mean that it is injudicious for philosophers of science to draw on published reports of psychological research to gain insight into the feasibility and utility of falsification as a heuristic. For one thing, psychological studies of falsification can force recognition of the breadth and depth of the problems inherent in understanding it (Tweney & Doherty, 1983). For another, the experimental simulations involved in psychological studies can test the potential normative value of falsification under a variety of controlled conditions and determine when a falsificatory strategy might be effective in changing the way people approach a problem (Gorman, 1995). In fact, the emergence of such practical problems confronting psychologists can be seen as a sign of progress in the process of solving the problem of the bounds of reason. After all, according to Popper's (1979) evolutionary approach to epistemology, those practical problems can be conceived as the new problems (P_2) discovered and created as products of the evolution by the error-elimination (EE) of tentative solutions (TS, including solutions one, two, and three in Sects. 2.3, 2.4, and 2.5 respectively) of an old problem (P_1 , that is the problem of the bounds of reason), which can be represented by his oft-used tetradic schema as follows:

$$P_1 \rightarrow TS \rightarrow EE \rightarrow P_2.$$

And, as he puts it, "the growth of knowledge proceeds from old problems to new problems, by means of conjectures and refutations" (ibid., p. 258). Strange as it may seem, the provision of a justification for Popper's non-justificationism through the solution to P_1 here is itself a clear demonstration of how his non-justificationist epistemology works.

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