Sensitivity and inductive knowledge revisited

Guido Melchior

University of Graz

guido.melchior@uni-graz.at

Orcid ID: 0000-0001-6494-560X

Abstract

The orthodox view about sensitivity and induction has it that beliefs formed via induction are insensitive. Since inductive knowledge is highly plausible, this problem is usually regarded as a reductio argument against sensitivity accounts of knowledge. Some adherents of sensitivity defend sensitivity against this objection, for example by considering backtracking interpretations of counterfactuals. All these extant views about sensitivity and induction have to be revised, since the problem of sensitivity and induction is a different one. Regardless of whether we allow backtracking interpretations of counterfactuals, some instances of induction yield insensitive beliefs whereas others yield sensitive ones. These results are too heterogenous for providing a plausible sensitivity-account of inductive knowledge. Induction remains a serious problem for sensitivity accounts of knowledge.

1 Sensitivity and induction: the discussion so far

Nozick suggests that if S knows that p, then S's belief that p tracks truth. He thinks that subjunctive conditionals can best capture this truth tracking relation. Moreover, he argues that we have to take the belief forming method into account. Nozick (1981, 179) provides the following definition of knowing via a method:

> S knows, via method (or way of believing) M, that p iff
> (1) p is true
> (2) S believes, via method or way of coming to believe M, that p
> (3) In the nearest possible worlds where p is false and where S uses M to arrive at a belief whether (or not) p, S does not believe, via M, that p
> (4) In the nearest possible worlds where p is true and where S uses M to arrive at a belief whether (or not) p, S believes, via M, that p[1]

Condition (3) is the sensitivity condition, which I will focus on here, and condition (4) the adherence condition.[2] Nozick formulates these modal conditions on knowledge as subjunctive conditionals, but he analyzes their truth conditions in terms of possible worlds. For the sake of convenience, and in accordance with the literature, I will

---

[1] Subjects can believe a proposition via various methods. Nozick argues that S knows that p *simpliciter* if the dominant method, the one that outweighs the other methods, fulfills conditions (3) and (4). These subtleties will not concern us here.

[2] Nozick does not provide a clear terminology. He suggests that condition (3) expresses the fact that S's belief is sensitive to the falsity of p, whereas (4) states that S's belief is sensitive to the truth of p. Accordingly, (3) and (4) jointly guarantee the complete sensitivity of S's belief. Hereinafter, I will stick to the terminology dominant in the literature that calls condition (3) the sensitivity condition and condition (4) the adherence condition.

use possible world terminology for formulating conditions (3) and (4). For the purposes of this paper, nothing hinges on this decision, as we acquire the same results for sensitivity and induction when talking in terms of subjunctive conditionals.[3]

Sensitivity accounts of knowledge face several major problems. First, it has been claimed that they preclude us from having inductive knowledge, as Vogel (1987 and 1999) and Sosa (1999) contend. Second, they lead to implausible instances of closure failure as Kripke (2011) argues.[4] Third, Sosa (1999) and Vogel (2000) argued that sensitivity faces severe problems concerning higher-order knowledge about the truth of one's own beliefs. In this paper, I will focus on the first objection.[5] However, we will see in the last section that the problem of inductive knowledge has structural similarities to the problem of higher-order knowledge.

Despite the well-known challenges that sensitivity accounts of knowledge face, the sensitivity principle is intuitively appealing, leading to a 'second wave' of sensitivity accounts, as Becker and Black (2012) label it. These accounts aim at defending a sensitivity-based theory of knowledge that avoids the problems that have been raised for Nozick's (1980) original account.[6] Accordingly, the results about sensitivity and induction are not only relevant for Nozick's original theory but also for these descendants.[7]

Vogel and Sosa argue for the claim that making sensitivity a necessary condition on knowledge rules out inductive knowledge by means of examples; they provide cases where a subject plausibly knows via induction although her belief is insensitive. Here are two cases:

> **CHUTE**
> On his way to the elevator Ernie releases a trash bag down the chute from his high rise condo. Walking along the street Ernie thinks about the trash and forms the belief that the trash is in the basement. Plausibly, Ernie knows that his bag is in the basement. But what if, having been released, it still (incredibly) were not to arrive there? That presumably would be because it had been snagged somehow

---

in the chute on the way down (an incredibly rare occurrence), or some such happenstance. But none of these would affect Ernie's belief, so he would still believe that the bag has arrived in the basement. His belief seems not to be sensitive, therefore, but constitutes knowledge anyhow, and can correctly be said to do so. (See Sosa 1999, 145-146)

HEARTBREAKER
Sixty golfers are entered in the Wealth and Privilege Invitational Tournament. The course has a short but difficult hole, known as the "Heartbreaker." Before the round begins, Jonathan thinks that, surely, not all sixty players will get a hole-in-one on the "Heartbreaker."
(See Vogel 1999, 165)[8]

These are cases of beliefs that are based on inductive reasoning, more specifically, inductive reasoning about particulars, as Vogel puts it.[9] He argues that knowledge about particulars via inductive reasoning is highly plausible. Intuitively, Ernie knows that the trash is in the basement, and Jonathan knows that not all sixty players will get a hole-in-one. However, in each case the target beliefs are insensitive. Consequently, sensitivity is not necessary for knowledge.

Sosa and Vogel argue against sensitivity accounts of knowledge by presenting examples of insensitive inductive beliefs that plausibly constitute knowledge. They need not to argue for the stronger claim that *any* belief formed via induction is insensitive for making their point. The weaker claim that there are some plausible cases of inductive knowledge that involve insensitive beliefs is sufficient for their purpose. Nevertheless, the stronger view that any belief formed via induction is insensitive is the dominant one in the current debate.[10]

Sosa's and Vogel's line of argumentation against sensitivity accounts of knowledge is not unopposed. One standard defense of sensitivity is proposed by Becker (2007). He accepts the view that induction yields insensitive beliefs, but he argues that this does not create a devastating objection to sensitivity accounts of knowledge. He admits that if we know propositions $p_1...p_n$, then we do not have inductive knowledge that p_{n+1} is true. However, we still have knowledge about the *probability* of p_{n+1}.[11] Thus, our view about knowledge via induction rests on a confusion according to Becker. We cannot have knowledge via induction that p_{n+1}; what we do know are propositions in the neighborhood of this proposition. Becker's account not only rejects inductive knowledge but also provides an explanation of our mistaken intuition that we can have this kind of knowledge. However,

---

[8] In conversation, it has been pointed out that HEARTBREAKER is a particularly convincing example. Nevertheless, one might regard its target proposition, that not all players get a hole-in-one, as a lottery proposition, which many think precludes it from being known. However, the problem of sensitivity and induction does not rely on assuming that the target proposition is a lottery proposition, as other cases presented in Vogel (1987 and 1999) and in this paper show. For a discussion of lottery propositions, see Hawthorne (2004).

[9] Sensitivity is, following Nozick (1981), usually defined as a feature of beliefs relative to a particular method. In cases of inductive knowledge, the relevant method is inductive reasoning. Hence, I will assume in the following that inductive reasoning is the relevant belief forming method. Accordingly, for determining the sensitivity of inductive beliefs, we consider possible worlds where the method of inductive reasoning remains constant. In order to acquire the result that CHUTE and HEARTBREAKER are instances of induction, it has to be assumed that the belief-forming bases in these cases are instances of (tacit) inductive reasoning, an assumption that is usually only implicitly made in the literature.

[10] One might object that induction is obviously not always insensitive because beliefs in necessities, which can also be formed via induction, are vacuously sensitive. This is true for orthodox semantics for counterfactuals and counterpossibles. However, it is still worth discussing whether the popular view about the insensitivity of induction holds also for the vast majority of contingent truths. Moreover, there is good reason to think that the orthodox semantics for counterfactuals should be rejected for having the counterintuitive consequence that all counterpossibles are vacuously true. For a discussion of an impossible worlds account of sensitivity, which delivers the result that not all beliefs in necessities are vacuously sensitive, see Melchior (2021b).

[11] For a similar take, see Roush (2005, 65f).

knowledge via induction is widely accepted. Accordingly, most philosophers are presumably not willing to bite the bullet of rejecting inductive knowledge for the gain of acquiring a sensitivity-based account of knowledge. We will take up Becker's account later and see that his solution faces additional problems.

Vogel, Sosa, and Becker agree that the subjects' beliefs in cases like CHUTE and HEARTBREAKER are insensitive, but draw conflicting conclusions as to whether this claim creates a serious problem for sensitivity accounts of knowledge. Until recently, the view that induction yields insensitive beliefs has remained unchallenged. Wallbridge (2018) takes up this objection to sensitivity accounts of knowledge and argues that, properly understood, the purported counterexamples fail to succeed because the beliefs formed via induction are actually sensitive, not insensitive. Focusing on Sosa's chute case, Wallbridge argues that Ernie sensitively believes that the rubbish is in the basement. He claims that in some cases, in order to avoid 'miracles', i.e. events that would not easily have happened, counterfactuals have to be interpreted as backtracking. According to a backtracking interpretation, counterfactual conditionals can be evaluated without keeping the past fixed until the time at which the counterfactual antecedent obtains. Wallbridge argues that, according to this backtracking analysis, Ernie's belief is sensitive.[12] He suggests that other examples presented by Vogel (1987 and 1999) and Pritchard (2012) can be analyzed analogously. Wallbridge is not particularly clear about his conclusion. In the abstract, he claims to show that inductive knowledge is sensitive. In the conclusion, Wallbridge (2018, 8) makes the weaker claim that "there are cases of sensitive inductive knowledge" and leaves the reader with a challenge, concluding that "if there are cases of insensitive inductive knowledge then they have yet to be pointed out."

In Section 2, I will show that the situation concerning induction and sensitivity is more subtle than opponents and defenders of sensitivity accounts of knowledge claim it to be. Some inductive processes yield sensitive beliefs, others yield insensitive beliefs, regardless of whether we opt for a backtracking or a non-backtracking interpretation of counterfactual conditionals. In Section 3, I will argue that this is problematic since the subjects in the cases presented are concerning inductive reasoning intuitively in similarly good epistemic situations. Hence, sensitivity accounts of knowledge are committed to making implausibly heterogenous predictions about the knowledge status of subjects who believe via induction.

2   Sensitive and insensitive induction

In this section, I will discuss instances of enumerative and temporal induction and backtracking and non-backtracking interpretations of counterfactual conditionals. First let me make some preliminary remarks about backtracking and non-backtracking counterfactuals. Lewis (1973) distinguishes between backtracking and non-backtracking counterfactuals. Non-backtracking counterfactuals keep the past fixed until the time at which the counterfactual antecedent obtains, whereas backtracking counterfactuals do not.[13] He argues that only non-backtracking counterfactuals can be used for analyzing causal dependencies. For example, in order to determine

---

[12] In fact, Wallbridge's argumentation is more subtle. He distinguishes between a weak and a strong reading of sensitivity, analogously to weak and strong safety. For avoiding miracles, the strong reading requires a backtracking interpretation according to which Ernie's belief turns out to be strongly sensitive. A weak reading of sensitivity does not require backtracking for avoiding miracles, but Ernie's belief fulfills weak sensitivity even according to a non-backtracking analysis. Hence, Ernie's belief is sensitive under both readings of sensitivity. However, these subtleties are not crucial for the following argumentation.

[13] See Menzies (2014). For a discussion of backtracking counterfactuals, see Khoo (2017).

whether event *c* caused event *e*, we consider those possible worlds that are identical with the actual world until the time where *c* does not obtain.[14]

In this paper, I will remain neutral about whether counterfactuals are correctly interpreted as backtracking or non-backtracking. Rather, I will investigate the consequences of these two interpretations for sensitivity accounts of knowledge. Let me emphasize the point of considering backtracking counterfactuals. We can say that whether S's induction-based belief is sensitive depends on whether "the minimal 'change' from truth to falsity of *p* keeps the inductive evidence for *p* intact."[15] In terms of possible worlds, the sensitivity of S's belief depends on whether the inductive evidence is available to S in the nearest possible worlds where *p* is false. If we interpret counterfactuals exclusively as non-backtracking, then we only consider possible worlds that do not differ from the actual world until the point at which the counterfactual antecedent obtains. If we allow for backtracking interpretations of counterfactuals, then we need not keep the past fixed until that point. Hence, backtracking or non-backtracking interpretations make a difference concerning which nearest possible worlds are considered and consequently whether a belief is judged to be sensitive or not.

In the following, I will present and analyze further cases of induction. We will see that some cases yield insensitive beliefs whereas others yield sensitive beliefs, regardless of whether counterfactuals can be backtracking or not. I will distinguish between enumerative induction where we draw an inference from objects o_1-o_n to o_{n+1} and temporal induction where we draw an inference about object *o* from time t_1-t_n to t_{n+1}.[16] In each of these cases, the method of belief formation in question is induction.[17] Moreover, the cases have to be understood in a way such that the subjects are intuitively in equally good epistemic positions concerning the inductive conclusion in that (1) the evidence for believing the premises is equally strong; (2) the numbers of cases *n* observed is equally large (or the time interval observed is equally long); (3) the relevant similarity between the induced case c_{n+1} and observed cases c_1 to c_n is equally strong (or the similarity between the basic conditions for *o* of the induced time point *t* and the observed interval *i*); (4) there are no rebutting or undercutting defeaters available to the subjects; and (5) the predicates involved are equally projectible. Take, first, the following example of enumerative induction that yields an insensitive belief:

---

[14] We must distinguish two different claims about backtracking counterfactuals, a more specific claim that a particular counterfactual is backtracking and a general claim that there can be backtracking counterfactuals. Accordingly, we can distinguish two different dependence relations between backtracking counterfactuals and possible worlds. Given that we accept in general that there can be backtracking counterfactuals, whether a particular counterfactual is backtracking or not depends on what the nearest possible worlds are where the antecedent is false. In this case, the nearest possible worlds determine whether a counterfactual is backtracking. However, when backtracking counterfactuals in general are questioned, it is rather the other way around. Whether counterfactuals can be backtracking determines which of the nearest possible worlds where the antecedent is false we have to consider.

[15] I am indebted to an anonymous reviewer for this formulation.

[16] This distinction is not meant to be exhaustive as there might be instances of induction that cannot be clearly classified either as enumerative or as temporal. Moreover, like the contemporary discussion on induction and sensitivity, I will focus on inductive knowledge about particulars. Thus, generalizations of the form 'All x are F' are not the conclusions of the inductive reasonings considered. For a discussion of inductive generalizations and sensitivity, see Roush (2005, 65f).

[17] However, I do not mean that the subjects in these cases explicitly draw inductive inferences. Rather they can be drawn implicitly and automatically. Nozick already developed an account of inferential knowledge. See Nozick (1981, 233f) and Baumann (2012). Since I do not understand induction here as an explicit process of drawing inferences, I will ignore this account. However, Nozick's account of inferential knowledge provides the same results as to whether the inductive processes investigated here are sensitive or insensitive.

RAVEN (enumerative induction)
Carl observes that $raven_1$–$raven_n$ is black and infers that $raven_{n+1}$, which he has not observed, is black. Ravens are typically black, though not necessarily, since there also exist rare mutations like albino ravens. In the nearest possible worlds where $raven_{n+1}$ is not black, it is such a rare mutation. However, $raven_1$-$raven_n$ is black in these nearest possible worlds and Carl believes via observation of $raven_1$-$raven_n$ and induction that $raven_{n+1}$ is black. Thus, his belief that $raven_{n+1}$ is black is insensitive.

This analysis holds independently of whether counterfactuals are allowed to be backtracking or not. In both cases, the nearest possible worlds where $raven_{n+1}$ is not black are such that it is an albino raven but where $raven_1$–$raven_n$ is black. In these possible worlds, Carl still believes via induction that $raven_{n+1}$ is black. Hence, his belief is insensitive. Thus, in RAVEN, a case of enumerative induction, the subject believes insensitively, regardless of whether we allow backtracking interpretations of counterfactuals or not.[18]

Notably, a similar case of *temporal* induction yields a different outcome:

BLACKBIRD (temporal induction)
Miles observes that $blackbird_n$ has been black until yesterday and believes via induction that $blackbird_n$ is black right now.
Non-backtracking: We only consider the nearest possible worlds where $blackbird_n$ is not black *right now*, and, hence, worlds where $blackbird_n$ has been black until yesterday. We ignore possible worlds where $blackbird_n$ changed its color earlier and worlds where it has never been black. In the nearest possible worlds considered Miles believes via observation and induction that $blackbird_n$ is black right now. Hence, his belief is insensitive.
Backtracking: If counterfactuals are backtracking the situation is different. In this case, the nearest possible worlds where $blackbird_n$ is not black right now are presumably such that it is an albino $blackbird_n$ that has been white all the time. They are not worlds where it changed the color since yesterday. Accordingly, in the nearest possible worlds where $blackbird_n$ is not black right now Miles does not believe via observation and induction that it is black right now. Thus, Miles' inductive belief that $blackbird_n$ is black right now is sensitive.[19]

So far we have seen that in the enumerative induction case of RAVEN, Carl's belief is insensitive no matter whether counterfactuals can be backtracking or not. However, in BLACKBIRD, a case of temporal induction, Miles' belief is insensitive if counterfactuals are non-backtracking but sensitive if they are backtracking. At this point, one might suppose that enumerative induction is typically insensitive whereas the sensitivity of temporal induction depends on whether we opt for a non-backtracking interpretation or a backtracking one. However, this generalization is incorrect as the following cases will show. Take a second instance of enumerative induction that delivers *sensitive* beliefs in case of non-backtracking and backtracking counterfactuals:

EXAMINER (enumerative induction)
Ina is a lazy examiner. When she has received all the exams she throws a dice and all the examinees get the same grade. For a particular test, she throws a 2 and, accordingly, marks all exams with B. Rachel is an examinee and does not know Ina's habits. Rachel asks numerous peers about their grade. Among them are peers of whom she knows that they were better prepared than herself and peers of whom she knows that they were worse prepared. All peers report that they got a B. Rachel forms the belief that she also got a B. The nearest possible worlds where Rachel does not get a B are such that Ina's dice throw delivered a different result than 2 and all students got a different grade than B, but the same one. In these possible worlds, Rachel does not believe via testimony and induction that she got a B. Thus, her belief that she got B on the exam is sensitive.

---

[18] We will soon reflect on cases of enumerative induction that behave differently.
[19] It might be disputable whether instances of enumerative induction can plausibly have a backtracking reading. However, in case of temporal induction the concept of backtracking and non-backtracking interpretations is highly plausible.

The grades of all students are determined at the same time. Thus, no matter whether counterfactuals can be backtracking or not, the nearest possible worlds where Rachel does not get a B are such that all the other students do not get a B. In these possible worlds, Rachel does not believe via testimony and induction that she got a B. Thus, Rachel's belief is sensitive, regardless of whether counterfactuals can be backtracking or not. RAVEN and EXAMINER are both cases of enumerative induction. In RAVEN, the target belief is insensitive, no matter whether counterfactuals can be backtracking or not, and in EXAMINER, it is sensitive in both cases.

So far we have reflected on one case of temporal induction, BLACKBIRD, where the belief is insensitive with a non-backtracking interpretation of counterfactuals and sensitive with a backtracking interpretation. We will now see that temporal induction can deliver different sensitivity results in different cases. Let's sketch a further case:

T-SHIRT (temporal induction)
Sarah has seen Tim wearing a red T-shirt the whole day until 30 minutes ago and forms the inductive belief that Tim is wearing a red T-shirt right now.

Is Sarah's belief that Tim is wearing a red T-shirt right now sensitive? This depends on how we fill in the details. Let us consider two different scenarios:

Scenario 1: Tim and Sarah are on a hiking trail and they split thirty minutes ago. Sarah has seen Tim wearing a red T-shirt the whole day and forms the inductive belief that Tim is wearing a red T-shirt right now. Tim does not have another T-shirt with him. Thus, he could not easily get a fresh T-shirt. Suppose further that Tim accidentally grabbed a red T-shirt in the morning, but that he might easily have grabbed a T-shirt of a different color. If counterfactuals can be backtracking, then the nearest possible worlds where it is false that Tim is wearing a red T-shirt right now are such that he grabbed a T-shirt of any other color in the morning. In these possible worlds, Sarah does not believe via observation that Tim was wearing a red T-shirt until thirty minutes ago and, therefore, does not believe via induction that he is wearing a red T-shirt right now. Thus, her belief is sensitive. If counterfactuals can only be non-backtracking then we only consider possible worlds where Tim recently changed his T-shirt. In this case, Sarah's belief that Tim is wearing a T-shirt right now formed via observation and induction is insensitive. Hence, for Scenario 1, we acquire the same result as for BLACKBIRD—a non-backtracking interpretation of counterfactuals implies insensitive beliefs and a backtracking interpretation sensitive beliefs.

Scenario 2: Sarah and Tim were on a hiking trail until 30 minutes ago where Tim was wearing a red T-shirt. In fact, for security concerns, Tim only wears red T-shirts for hiking. Thus, it is not easily possible that he had a non-red T-shirt for hiking. After the hiking trail, Sarah and Tim split and Tim walks downtown for a drink. Sarah has seen Tim wearing a red T-shirt the whole day until 30 minutes ago and forms the inductive belief that Tim is wearing a red T-shirt right now. If counterfactuals can only be non-backtracking, then we only consider possible worlds where Tim recently changed his T-shirt. In these possible worlds, Sarah believes via observation and temporal induction that he is wearing a red T-shirt right now and, consequently, her belief is insensitive. However, even if we allow for backtracking counterfactuals, then the nearest possible worlds where Tim is not wearing a red T-shirt right now are such that he changed it recently downtown, given Tim's strict habit of only wearing red T-shirts for hiking.[20] Again, Sarah believes that Tim is wearing a red T-shirt right now and her inductive belief turns out to be insensitive.

_____

[20] Due to the modal details of the case, possible worlds where Tim changed his T-shirt downtown are closer than possible worlds where he did not wear a red T-shirt until 30 minutes ago. Nevertheless, Scenario 2 has to be understood such that it is highly unlikely that Tim changes his T-shirt downtown. The inductive inference in

In both scenarios, a non-backtracking interpretation of counterfactuals yields insensitive beliefs, but if we allow for backtracking interpretations, then Scenario 1 yields a sensitive belief whereas Scenario 2 yields an insensitive belief. In this respect, whether one's belief is sensitive in cases of temporal induction depends on how the cases are spelled out in detail.

We can now summarize the acquired results about sensitivity and induction: RAVEN is a case of enumerative induction. Carl's belief that $raven_{n+1}$ is black is *insensitive* regardless of whether counterfactual conditionals can be backtracking or not. EXAMINER is a further case of enumerative induction. However, Sarah's belief that she got a B for the exam is *sensitive* regardless of whether counterfactuals can be backtracking or not. BLACKBIRD is a case of temporal induction. Miles's belief that $blackbird_n$ is black is *insensitive* if counterfactuals can only be non-backtracking, but it is sensitive if they can be backtracking. As for T-SHIRT, a further case of temporal induction, sensitivity depends on how we fill in the details. In Scenario 1 and 2, Sarah's belief that Tim is wearing a red T-shirt right now is insensitive if counterfactuals can only be non-backtracking. If they can be backtracking, then her belief is sensitive in Scenario 1 but insensitive in Scenario 2. These results are captured by the following tables:

Raven (Enumerative induction)	Sensitivity
Non-Backtracking:	-
Backtracking:	-

Examiner (Enumerative induction)	Sensitivity
Non-Backtracking:	+
Backtracking:	+

Blackbird (Temporal induction)	Sensitivity
Non-Backtracking:	-
Backtracking:	+

T-shirt (Temporal induction)	Sensitivity
Non-Backtracking:	-
Backtracking:	+/-

Let me provide a more systematic analysis: Suppose S observes that object o has property F from t_1 to t_n and believes via temporal induction that o has property F at t_{n+1}. If we generally accept that counterfactuals can be backtracking, then S's inductive belief is sensitive only if, in the nearest possible worlds where o is not F at time t_{n+1}, o is not F from t_1 to t_n.[21] This is the case if worlds where o lost property F from t_n to t_{n+1} are more remote than worlds where o does not have property F from t_1 to t_n, e.g. if it is more crucial for o to constantly be F (or to constantly be not-F) from t_1 to t_{n+1} than to be F from t_1 to t_n, as in BLACKBIRD and Scenario 1 of T-SHIRT, where Tim does not walk downtown. In Scenario 2, where Tim walks downtown after the hiking trail, worlds where Tim changed his T-shirt downtown are closer than worlds where he was not wearing a red T-shirt on the hiking trail. Here, it is more crucial for o to be F from t_1 to t_n than it is to be constantly F or constantly not be F from t_1 to t_{n+1}. Consequently, Sarah's belief is insensitive. In contrast, if counterfactuals can only be non-backtracking, then we can only consider possible worlds where o changed property F from t_n to t_{n+1}. In this case, beliefs formed via temporal induction are always insensitive. Thus, despite the heterogeneity of the overall results,

---

Scenario 2 still has the same epistemic strength--according to the factors briefly mentioned earlier and more thoroughly analyzed later--as in the other cases considered, including Scenario 1.

[21] I assume here that observation is sensitive concerning o being F, i.e. observation of o from t_1 to t_n would not deliver that o is F from t_1 to t_n if o were not F from t_1 to t_n. If observation does not fulfill this sensitivity condition, then the sensitivity conditions for backtracking counterfactuals about o being F at t_{n+1} are different. This assumption is not problematic for my purposes of establishing that sensitivity and induction suffer from a heterogeneity problem. This result is also gained (or even strengthened) if we take further varying factors into account.

at least we can say that temporal induction always yields insensitive beliefs if counterfactuals can only be non-backtracking.

We obtain slightly different results concerning *enumerative* induction. If the nearest possible worlds where o_{n+1} does not have property F are such that o_1-o_n does not have property F, then S's belief that o_{n+1} is F formed via observation of o_1-o_n and enumerative induction is presumably sensitive.[22] This condition is fulfilled if it is rather accidental that o_{n+1} is F but characteristic for o_1-o_{n+1} that they have the same status of being F (or not being F), as in EXAMINER. However, if the nearest possible worlds where o_{n+1} does not have property F are such that o_1-o_n still *has* property F, then S's belief formed via observation and induction is insensitive. This holds for RAVEN. Notably, theories of counterfactuals that allow for non-backtracking counterfactuals and theories that do not deliver the same results for each individual case of enumerative induction, i.e. both types of theories imply that the target belief is sensitive or both theory types imply that it is insensitive. Perhaps we can construct cases of enumerative induction such that backtracking and non-backtracking theories deliver different results with respect to sensitivity, but I suspect that these instances of induction also involve a temporal element.[23]

3   Heterogeneity: The problem for sensitivity and induction

Let me now diagnose what I regard as the real problem of sensitivity and induction. There is at least a tendency among proponents and critics of sensitivity that there is a homogenous picture of sensitivity and induction. Critics of sensitivity accounts of knowledge, but also some adherents such as Becker, tend to think that induction yields insensitive beliefs whereas Wallbridge suggests that it yields sensitive beliefs. However, none of these opposing views is correct, since some instances of induction yield sensitive beliefs whereas some others yield insensitive ones.

I developed various cases of enumerative and temporal induction. In each of these cases, the subjects make an empirical observation and draw an inductive inference. Importantly, we intuitively judge that the subjects in these cases are in equally good epistemic positions. This view about the equality of the epistemic positions is also supported when applying plausible parameters for induction. Let me briefly explain. The epistemic force of induction comes in degrees. The epistemic strength of inductive reasoning from cases c_1-c_n to case c_{n+1} (or from time interval i to point in time t) and whether it can yield justification and knowledge intuitively depends on various factors. The strength of induction depends first on the number n of cases observed (or on the length of the observed time interval). All else being equal, the larger n is, the greater the epistemic strength of a particular induction; Secondly, the epistemic strength of induction varies with the relevant similarity between the cases observed and

---

[22] Again, I assume here that observation is sensitive with respect to o_1-o_n being F.

[23] In the description of the cases certain details are made salient, e.g. habits of the target person. These details determine which facts are kept fixed and which facts differ in the nearest possible worlds considered. One might think that this leads to a contextualist sensitivity account in that different facts are salient to the knowledge attributor (in this case the reader) in different contexts and this salience determines which cases the attributor takes into account and whether her sensitivity attribution is true or false. However, this is not the way the alternative cases have to be understood. In T-shirt, we do not have alternative descriptions of one case leading to alternative judgements about whether Sarah's belief about Tim's T-shirt is sensitive. Rather, there are different cases whose constitution determines which possible worlds we have to consider and whether the target beliefs are sensitive. Notably, DeRose (1995) defends a sensitivity-based contextualism about 'knows' where in some contexts sensitivity is required for knowledge but in others it is not. However, he does not develop a contextualist account of sensitivity itself.

the case induced (or on the relevant similarity between the observed time interval and the point in time induced).[24] The more similar c_{n+1} is to c_1-c_n in the relevant sense, the stronger the inductive reasoning is. Third, the epistemic strength of inductive reasoning depends on whether there exists a defeater d for the inductive conclusion, either rebutting or undercutting, such that S is propositionally justified in believing d and this justification undermines S's justification in holding an inductive belief about c_{n+1}. Finally, the predicate involved has to be projectible.

Moreover, the amount of justification for the conclusion of an induction is also affected by the strength of the justification for believing the premises. All else being equal, the stronger the justification for believing the premises, the stronger the justification for believing the inductive conclusion.

This paper aims at showing that sensitivity accounts of knowledge have highly implausible consequences when it comes to inductive knowledge. In order to make this point, it suffices to refer to intuitively plausible criteria for inductive knowledge. We need not develop a detailed theory of induction and confirmation, involving Bayesianism or alternative conceptions.[25] For the purposes of this paper, it suffices to accept that in the cases discussed, the inductive reasoning is intuitively of the same epistemic strength according to the plausible parameters specified. That means that the subjects in the cases have equally good evidence about an equally high number of n cases (or a sufficiently long time interval i), case c_{n+1} is equally similar to the observed cases c_1-c_n, there is no defeater d for S, rebutting or undercutting, such that S is justified to believe that d and this justification undermines her inductive justification, and the predicates involved are equally projectible.[26]

Since the subjects are intuitively all in equally good epistemic positions, the minimal standards that a theory of knowledge has to fulfill is that it delivers the same outcome with respect to knowledge in all cases discussed. Here there are two options, first that the subjects know in all cases of induction presented and, second, that they are precluded from knowing in all cases.[27] I assume that there is a wide agreement among epistemologists that we can have knowledge via induction. Accordingly, the first, positive option is far more popular than the second, negative one. However, sensitivity accounts of knowledge cannot deliver any of these two uniform pictures.

Let me explain in more detail. I regard it as an open question whether counterfactual conditionals can only be correctly interpreted as backtracking or also as non-backtracking. However, in any case we acquire an unsatisfactorily heterogenous picture. Suppose first that counterfactuals can only be non-backtracking. Presumably, temporal induction always provides insensitive beliefs, given a non-backtracking analysis of counterfactuals as in BLACKBIRD and T-SHIRT. However, some instances of enumerative induction can yield sensitive beliefs, e.g. EXAMINER, but some others not, e.g. RAVEN. Thus, according to a sensitivity account of knowledge, S does not know in RAVEN, BLACKBIRD, and T-SHIRT but knows in EXAMINER, given that counterfactuals can only be non-backtracking.

---

[24] It is a non-trivial task to determine the relevant similarity between the cases observed and the case induced, but plausibly the cases discussed can be set up in a way that the criteria for relevant similarity are to the same extend fulfilled. This is sufficient for the purposes of the paper.

[25] For an overview of theories of confirmation, induction and Bayesianism, see Crupi (2016).

[26] RAVEN, BLACKBIRD, and T-SHIRT involve ordinary color predicates whereas EXAMINER involves the more superficial property of getting a particular grade. However, EXAMINER could be reformulated as a case where a subject throws a dice to determine which color a certain set of objects should be or a group of persons should wear. Moreover, the kinds of objects in the discussed cases are of different types, RAVEN and BLACKBIRD involve natural kinds whereas T-SHIRT and EXAMINER do not. However, I do not see any reason why induction should not be applicable to different types of objects.

[27] Knowledge can be based on inductive reasoning and inductive justification of different strengths. There might exist a threshold that these inductive strengths must exceed for being able to constitute knowledge, but determining such a threshold is not crucial for the purpose of this paper.

This result is counterintuitive since the epistemic position of the subject is intuitively equally good in all four cases. Suppose now that counterfactuals can be backtracking. In this case, EXAMINER, BLACKBIRD and Scenario 1 of T-SHIRT yield sensitive beliefs, but RAVEN and Scenario 2 of T-SHIRT yield insensitive beliefs. Again, sensitivity accounts of knowledge are committed to accept that the subjects know in the first three cases but not in the latter two.

Thus, in both cases of backtracking and non-backtracking theories of counterfactuals, some processes of induction yield sensitive beliefs but some others insensitive beliefs. Hence, sensitivity accounts of knowledge deliver in both cases an implausibly heterogeneous picture about inductive knowledge.[28] In both cases, we know via some instances of induction but do not know via some other instances. This heterogeneous picture is no less problematic than the orthodox view, dominant so far, that sensitivity accounts of knowledge preclude us from any kind of inductive knowledge.

These results affect extant pessimistic and optimistic accounts of sensitivity in various ways. The orthodox view about sensitivity and induction is based on cases of insensitive inductive beliefs that plausibly constitute knowledge, as presented by Vogel (1987 and 1999) and Sosa (1999). The popular generalization of these cases has it that any instance of induction yields insensitive beliefs and that we cannot have any inductive knowledge according to sensitivity accounts of knowledge. This generalization is incorrect. However, Vogel and Sosa mainly aim at arguing against sensitivity accounts of knowledge by presenting counterexamples of insensitive knowledge via induction. This goal can still be reached by pointing out that sensitivity accounts of knowledge imply that we do not know in *some* (paradigmatic) instances of induction that plausibly yield knowledge.

Becker (2007) accepts that induction yields insensitive beliefs but argues that this does not pose a serious problem since we can still acquire knowledge about the probability of the target proposition.[29] This is already problematic since knowledge via induction seems highly plausible. Becker suggests that any instance of induction provides insensitive beliefs. What he should say is that in some cases of induction we have knowledge of the target proposition, but in some very similar cases we only have knowledge about the probability of the target proposition. This outcome is too heterogeneous for being plausible and, thus, not more convincing than Becker's original conclusion.

Wallbridge (2018) claims that inductive knowledge is sensitive, given that we accept backtracking counterfactuals in some contexts, or at least he leaves the reader with the challenge of presenting cases of insensitive induction. He suggests that we should not exclude backtracking counterfactuals in evaluating modal knowledge conditions like sensitivity or safety. In this respect, Wallbridge's analysis advances the existing debate about sensitivity and induction. However, he does not tell the whole story about sensitivity and induction since his challenge of finding instances of insensitive induction can be easily met. Moreover, sensitivity is not a matter of backtracking or non-backtracking interpretations of counterfactuals, as he suggests, since there are cases of sensitive induction and cases of insensitive induction for backtracking and non-backtracking interpretations.

---

[28] We can directly derive the heterogeneity of knowledge from the heterogeneity of sensitivity only if sensitivity is not only necessary but also sufficient for knowledge, However, various sensitivity accounts of knowledge, for example those of Nozick (1980) and Becker (2007), assume that sensitivity is only necessary. These accounts defend further conditions such as adherence (Nozick) or reliability (Becker), but these conditions are fulfilled by induction. Hence, inductive knowledge is determined by the sensitivity of induction. These accounts are thus also committed to accepting the heterogeneity of inductive knowledge.

[29] For a discussion, see Roush (2005, 66) who defends a similar view as Becker.

Thus, sensitivity accounts of knowledge do not face the problem of precluding us from any inductive knowledge, as the orthodox view suggests, nor is it true that induction typically provides sensitive beliefs, as Wallbridge argues. Rather, some processes of induction yield sensitive beliefs whereas some very similar processes yield insensitive beliefs. Given this heterogenous outcome, I do not see how a sensitivity account of knowledge can plausibly integrate a theory of inductive knowledge.

At this point adherents of sensitivity might stick to their guns and claim that the acquired results about inductive knowledge are correct, since a sensitivity account of knowledge is correct, even though these results seem implausible at first sight. Nozick (1981) himself frequently endorses a similar line of argumentation, as when he argues that knowledge does not transmit via conjunction elimination, a principle that is highly plausible.[30] However, such lines of argumentation are usually regarded as a vice of Nozick's account rather than virtue. Even adherents of sensitivity usually do not choose this strategy when defending sensitivity accounts of knowledge. For example, DeRose (1995) and Roush (2005) develop sensitivity accounts that avoid Nozick's implausible consequences of closure failure and Adams and Clarke (2005) defend Nozick's account against Kripke's (2011) objection by arguing that in Kripke's particular case knowledge closure is not violated. None of these defenses of sensitivity simply claim that the reductio arguments against sensitivity accounts fail because their highly counterintuitive consequences are the correct ones. This strategy is not more plausible in the case of induction.

The state of the discussion about sensitivity and induction has evolved as follows. Sosa and Vogel started the discussion by arguing that sensitivity precludes us from any kind of inductive knowledge, or at least from paradigmatic instances of inductive knowledge. Wallbridge objected that inductive beliefs are typically sensitive, providing a rejoinder to the cases presented by Sosa and Vogel. We have seen that neither of these positions is correct, pointing out instead that the relationship between sensitivity and induction is actually quite heterogenous. Interestingly, this development resembles the development of the discussion concerning sensitivity and higher-level knowledge, another purported challenge to sensitivity accounts of knowledge. Sosa (1999) and Vogel (2000) pointed out that one's beliefs that one does not falsely believe that p are insensitive. From this, Vogel concludes that sensitivity accounts of knowledge preclude us from any kind of higher-level knowledge while Sosa argues that this fact leads to implausible instances of closure failure since one can know that p without knowing that one does not falsely believe that p. Becker (2007) and Salerno (2010) respond to these concerns, pointing out that beliefs in weaker propositions with the formal structure $\neg(B(p) \wedge \neg p)$ are insensitive but beliefs in the stronger propositions with the formal structure $B(p) \wedge p$ or $B(p) \wedge \neg\neg p$ can be sensitive. They conclude that we can have the relevant kind of higher-level knowledge according to sensitivity accounts. In Melchior (2015), I argue that the outcome that we know stronger higher-level propositions but fail to know weaker higher-level propositions is too heterogenous to be plausible, calling this the heterogeneity problem for sensitivity accounts.[31] Sensitivity does not preclude us from all inductive knowledge, nor does every instance of induction yield sensitive beliefs. In fact, some instances of induction yield sensitive beliefs, but very similar processes of induction lead to insensitive beliefs. We face a further instance of the heterogeneity problem for sensitivity accounts of knowledge when it

---

[30] Hawthorne (2005) calls knowledge by conjunction elimination "incredibly plausible."
[31] For an objection to the heterogeneity problem, see Wallbridge (2017), and for a response, see Melchior (2017). For a related generality problem for higher-level knowledge, see Melchior (2014). For solutions to the heterogeneity problem, see Zalabardo (2016) and Bjerring and Gundersen (2019).

comes to sensitivity and induction. This supports the view that heterogeneity, along different dimensions, is a characteristic feature of sensitivity and a more systematic problem for sensitivity accounts of knowledge.[32]

4   Conclusion

The orthodox view about sensitivity and induction has it that induction always delivers insensitive beliefs. Critics conclude that sensitivity accounts of knowledge are mistaken. Adherents of sensitivity accounts also assume that induction is homogenous with respect to sensitivity. Becker accepts that any instance of induction is insensitive but argues that we still can have knowledge about the probability of the target proposition via induction. Wallbridge, in contrast, claims that induction yields sensitive beliefs. A careful analysis reveals more differentiated results. Some instances of induction yield sensitive beliefs but some instances in the neighborhood yield insensitive ones, regardless of whether we interpret counterfactuals as backtracking or non-backtracking. Sensitivity accounts of knowledge must, therefore, accept that we can know in some instances of induction but in very similar ones we cannot, although the epistemic situations of the believing subjects are intuitively equally good. These results are too heterogeneous for providing a plausible picture of inductive knowledge in terms of sensitivity.

References

Adams, Fred and Clarke, Murray (2005). Resurrecting the tracking theories. *Australasian Journal of Philosophy* 83(2), 207-221.

Baumann, Peter (2012). Nozick's defense of closure. *The Sensitivity Principle in Epistemology*. K. Becker and T. Black (eds.), Cambridge: Cambridge University Press, 11–27.

Becker, Kelly (2007). *Epistemology Modalized*. New York and London: Routledge.

Becker, Kelly and Black, Tim (2012). *The Sensitivity Principle in Epistemology*. Cambridge: Cambridge University Press.

Bjerring, Jens Christian and Gundersen, Lars Bo (2020). Higher-order knowledge and sensitivity. *Canadian Journal of Philosophy* 50(3), 339–349.

Cogburn, Jon and Jeffrey W. Roland (2013). Safety and the true–true problem. *Pacific Philosophical Quarterly* 94 (2), 246–267.

Crupi, Vincenzo (2016). Confirmation. *The Stanford Encyclopedia of Philosophy* (Winter 2016 Edition), Edward N. Zalta (ed.), URL = <https://plato.stanford.edu/archives/win2016/entries/confirmation/>.

DeRose, Keith (1995). Solving the skeptical problem. *The Philosophical Review* 104(1), 1–52.

DeRose, Keith (2004). Sosa, safety, sensitivity, and skeptical hypotheses, in *Ernest Sosa and His Critics*, J. Greco (ed.). Malden, MA: Wiley Blackwell 22–41.

DeRose, Keith (2017). *The Appearance of Ignorance. Knowledge, Skepticism, and Context, Vol. 2*. Oxford: Oxford University Press.

Enoch, David, Fisher, Talia and Spectre, Levi (2012). Statistical evidence, sensitivity, and the legal value of knowledge. *Philosophy and Public Affairs* 40(3), 197–224.

Hawthorne, John (2004). *Knowledge and Lotteries*. New York and Oxford: Oxford University Press.

---

[32] In Melchior (2019), I develop a sensitivity account of checking arguing that sensitivity is necessary for checking while it is plausibly not necessary for knowing. I defend this view by showing that the proposed sensitivity account of *checking* is not equally affected by problems of sensitivity and induction as sensitivity accounts of knowing.

Hawthorne, John (2005). The case for closure. *Contemporary Debates in Epistemology*, Matthias Steup and Ernest Sosa, (eds.), Malden, MA: Wiley Blackwell, 26–42.

Khoo, Justin (2017). Backtracking counterfactuals, revisited. *Mind* 126(503), 841–910.

Kripke Saul A. (2011). Nozick on knowledge. *Philosophical Troubles. Collected Papers, Volume I.* Oxford: Oxford University Press, 162–224.

Luper-Foy, Steven (1984). The epistemic predicament: knowledge, Nozickian tracking, and scepticism. *Australasian Journal of Philosophy* 62(1), 26–49.

McGlynn, Aidan (2012). The problem of true-true counterfactuals. *Analysis* 72(2), 276–285.

Melchior, Guido (2014). A generality problem for bootstrapping and sensitivity. *Croatian Journal of Philosophy* 14(40), 2014, 31–47.

Melchior, Guido (2015). The heterogeneity problem for sensitivity accounts. *Episteme* 12(4), 479–496.

Melchior, Guido (2017). Sensitivity has multiple heterogeneity problems: a reply to Wallbridge. *Philosophia* 45(4), 1741–1747.

Melchior, Guido (2019). *Knowing and Checking: An Epistemological Investigation*. New York: Routledge.

Melchior, Guido (2020). Sensitivity principle in epistemology. *Oxford Bibliographies Online*, DOI:10.1093/obo/9780195396577-0404.

Melchior, Guido (2021a). A modal theory of discrimination. *Synthese*, 198(11), 10661–10684.

Melchior, Guido (2021b). Sensitivity, safety, and impossible worlds. *Philosophical Studies*, 178(3), 713–729.

Menzies, Peter (2014). Counterfactual theories of causation. *The Stanford Encyclopedia of Philosophy* (Spring 2014 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/spr2014/entries/causation-counterfactual/>.

Nozick, Robert (1981). *Philosophical Explanations*. Cambridge, Mass.: Harvard University Press.

Pritchard, Duncan (2012). In defence of modest anti-luck epistemology. *The Sensitivity Principle in Epistemology*,. K. Becker and T. Black (eds.), Cambridge: Cambridge University Press: 173–192.

Roush, Sherrilyn (2005). *Tracking Truth. Knowledge, Evidence, and Science*. Oxford: Oxford University Press.

Salerno, Joe (2010). Truth tracking and the problem of reflective knowledge. *Knowledge and Skepticism*, J. K. Campbell, M. O'Rourke and H. S. Silverstein (eds.), Cambridge, Mass.: MIT Press, 73–83.

Sosa, Ernest (1999). How to defeat opposition to Moore. *Philosophical Perspectives* 13, 141–153.

Starr, William (2019). Counterfactuals. *The Stanford Encyclopedia of Philosophy* (Fall 2019 Edition), Edward N. Zalta (ed.), URL = <https://plato.stanford.edu/archives/fall2019/entries/counterfactuals/>.

Vogel, Jonathan (1987). Tracking, closure and inductive knowledge. The possibility of knowledge: *Nozick and His Critics*. S. Luper-Foy (ed.), Totowa, NJ: Rowman and Littlefield, 197–215.

Vogel, Jonathan (1999). The new relevant alternatives theory. *Philosophical Perspectives* 13, 155–180.

Vogel, Jonathan (2000). Reliabilism leveled. *Journal of Philosophy* 97(11), 602–623.

Wallbridge, Kevin (2017). Sensitivity hasn't got a Heterogeneity Problem - a Reply to Melchior. *Philosophia* 45(2), 835–841.

Wallbridge, Kevin (2018). Sensitivity, Induction, and Miracles. *Australasian Journal of Philosophy* 96 (1), 118–126.

Walters, Lee (2016). Possible world semantics and true-true counterfactuals. *Pacific Philosophical Quarterly* 97(3), 322–346.

Williamson, Timothy (2000). *Knowledge and Its Limits*. Oxford: Oxford University Press.

Zalabardo, Jose L. (2016). Reflective knowledge and the nature of truth. *Disputatio* 8(43), 147–171.