Philosophical Studies
XXIII

Contents

Department of Philosophy
Graduate School of Humanities and Sociology
The University of Tokyo
2004

Does Probability Collapse or Retroact?

Masaki ICHINOSE
(The University of Tokyo)

1, Probability of the Past Event

It is sometimes questioned, as C. S. Peirce once doubted[1], whether decision-makings based upon probability can be justified as rational or not. Even though, for example, we choose the option as the most rational one whose expected probabilistic utility was the highest, an unexpected event whose probability was very low might result as a matter of fact. In that case, did we make the rational decision? If you say we did, our reason seems to be useless.[2]

I think here is a deep philosophical question concerning rationality, but what I will focus my attention upon this time by referring to this question is not the question about rationality itself, but the hidden intuitive idea that happens to appear in the above question. That is to say, the value of probability must be suddenly fixed as 1 or 0 the moment the event the probability was attributed has been actualized or failed to be so. The question above picks up the case that an event was attributed low probability, nonetheless the event actually happened. Then it was doubted why the decision from probability can be called 'rational decision', if we judge backwards after the occurrence of the less probabilistic event. Obviously, behind this question there must be the idea that, as soon as the less probabilistic event has happened, the event is no longer less probabilistic, but has been already fixed with the maximum probability, namely, probability 1. Otherwise the result of the decision would remain still pending, so we can't denounce the decision as irrational. As it were, the situation is suddenly reversed and then settled, which the decision couldn't follow despite being imposed to follow as far as it professes itself to be 'rational decision'. Of course, if some model of kinematics of probability is adopted like Jeffrey's classic theory[3], then the change at that moment might not be sudden. Nevertheless, even in that case, the situation is the same, since there happens a decisive leap from uncertainty to certainty the moment the event concerned has occurred. Rather, I suspect that a high probability just before the final moment in such

---

[1] Peirce (1986), pp.281-2.

[2] David Papineau presented the same question when he talked at the philosophy of science speakers series in the University of Oxford on 31 October 2002 under the title of 'Decisions in a No-Collapse Universe'. He examined the orthodoxy of decision theory that appeals to the notion of expected probabilistic utility, compared with Everettian view of many worlds, and said that the principle of expected probabilistic utility might lead to an actual unexpected result, notwithstanding that the actual result crucially matters in decision theory.

[3] Cf., Jeffrey (1983), chapter 11.

kinematics can be assigned retrospectively only after the event concerned has actually occurred. Anyway, thus, some people suspect that the principle of maximizing expected probabilistic utility might not be rational, taking into account the case that an unexpected result has been actualized, namely, the probability of expected result has been fixed as 0. We can paraphrase this idea into the next claim that I want to call the Principle of Probability of the Past Event (PPE);

(PPE) As soon as an event is recognized as just now HAPPENED in a specified way, the probability of its occurrence must be 1, at least as far as the probability of single event is concerned[4].

In fact, David Lewis clearly declares this intuitive idea, by saying, 'What's past is no longer chancy. The past, unlike the future, has no chance of being any other way than the way it actually is'[5]. Is there anything more self-evident than the idea that the probability of the event already having happened is 1? It is true that probability 1 is usually introduced as applying to logical tautology according to Kolmogorov's axiom like, for example, '$P(t) = 1$ if t is a tautology[6]', but this suggests that being tautology is only a sufficient condition for probability1. This means that there could be another case which is assigned probability 1. That is precisely the case of the past event having just happened. This seems to be an intuitive idea. Or, in other words, we might say that, when we have the intuitive idea, we actually committed ourselves to such a sort of tautology as 'what has happened has happened,' thus the probability 1 of past events could be subsumed in Kolmogorov's axiom. In any case, the crucial point of PPE is that, although probability of an event is clearly lower than 1 before recognition, its probability suddenly rises to 1 as soon as we recognize the event. PPE is typically illustrated, for instance, by this situation; probability of the event that the lightening strikes me is lower than 1 before the event occurs, nevertheless its probability leaps to 1 the moment I am actually struck by the lightening. Who could believe otherwise? I think that this intuitive idea is universally true of the concept of probability, no matter what interpretation of probability is taken, unless the notion of the probability of single event is excluded as in the case of Von Mises' version of the frequency interpretation.

In reality, PPE is clearly confirmed by two major interpretations of probability, i.e. the propensity theory (in an original Popper's sense in order to make sense of single event's probability) and the epistemic (including subjective and interpersonal) interpretation. If we adopt the propensity theory, there is no doubt that we have to assign probability 1 to

---

[4] For the time being, I don't search the question of what the bearer of probability is, by roughly taking both the event and the sentence 'the event happens' to be equally the bearer, since my argument would not seem to be influenced by the question.

[5] Lewis (1986), p.93.

[6] Howson & Urbach (1993), p.21.

an event if we actually just observed it happen. What else could we do? In reality, this point is conjoined with quantum mechanics that motivated Popper to propose the propensity theory, which I shall discuss later. Also that must be true of the epistemic interpretation, apparently. When we find something just now actually appear in front of me, we automatically accept that the sentence, 'the thing has occurred,' is completely true as far as my epistemic understanding is concerned, apart from philosophical problems of illusion or 'theory-laden.' In that sense I said that PPE is universally true. As a matter of fact, Bayesian epistemology, which is based upon epistemic probability, basically presupposes that evidence gets probability 1 when it is actually observed[7]. Of course, I am fully conscious that there is a crucial difference between the propensity theory and the epistemic interpretation, i.e. the former concerns an event itself and the latter the degree of belief. But, at least, that difference can be virtually ignored as regards the case of probability 1 in PPE.

However, what should we think about the past event that is unrecognized? I think that there are two cases of unrecognized past events. The first one is the past event that is not recognized at all but merely supposed to have happened in an unspecified or vague way regarding space and time, for example, an event that something existed before the earth was born. PPE avoids mentioning this kind of unrecognized past events. Certainly, if we accept the propensity theory, even events that we don't recognized at all but just generally suppose to have happened might be assigned probability 1. But, on the contrary, since it is supposed in an unspecified way, it seems to be impossible to individuate a particular event as a bearer of probability. It's hard to see what probability we are talking about. Then, what if we adopt an epistemic interpretation? Perhaps, even from such interpretation, we

---

[7] Here I have to refer to the case in which we can't give probability 1 to a sentence, 'S is P,' despite actually observing the phenomenon right now. This situation with uncertain evidence was initially noticed by Richard Jeffrey. He gives such an example that; the agent inspects a piece of cloth by candlelight, and gets the impression that it is green, although he concedes that it might be blue or even (but very improbably) violet. Thus, he proposes a conditionalisation to formulate posterior probability of a hypothesis in such cases. This is his formulation (which I modify a bit to make it clearer),

$$P_{pos}(h) = P_{pri}(h \mid e)\, P_{pos}(e) + P_{pri}(h \mid \sim e)\, P_{pos}(\sim e).$$

This is called *Jeffrey Conditionalisation* (in which P_{pri} means prior probability and P_{pos} posterior probability). Jeffrey claims that this is not different from usual *Bayesian Conditionalisation*, since both conditionalisations will be the same when $P_{pos}(e) = 1$ can be affirmed. See Jeffrey (1983), pp.164-172. Well, then, how should we think of PPE in this case? The event to be considered by PPE in this case is the one that the cloth is lit by candlelight. When an event is observed, there could be many sentences to describe the observation, but the fact that the event is observed is determinate. As far as such determinate fact is concerned, probability 1 could be assigned. Actually, Jeffrey Conditionalisation can't start without probability 1 in this sense, which is corresponding to probability 1 of ($P_{pos}(e) + P_{pos}(\sim e) = 1$).

might claim that some past events, even if not specifically recognized, surely happened in an abstract sense, so can be given probability 1. Maybe those who have personal religious faith might have such claim if it's particularly concerned with their faith. But, the most honest comment about the claim is that we are not certain about that. Therefore, I made PPE not touch those cases. The second case is the past event that is not recognized but represented in a specified way, for instance, an event that a newspaper was on the desk in my room at 4:00 pm yesterday (provided that it was not recognized at that time). I want PPE to claim that the probability of such event must be smaller than 1. This must be another implication of PPE. Otherwise, PPE wouldn't imply the sudden change of probability at the moment of recognition. In fact, if we choose the epistemic interpretation, we must give smaller probability than 1 to such kind of event, because the event is not an actual one but just an uncertain imaginary, at most inferred, one. But, what if we accept the propensity theory? It's independent of our belief, so the event has probability 1 if it really happened despite being not known by us. My idea is that; as far as the propensity theory comes from quantum physics, it is not completely unreasonable for us to assign smaller probability than 1 to such kind of event if we take into account the measurement problem in quantum mechanics. This idea might sound very weird, but I think that we can make sense of the idea by reflecting on both Popper's argument of propensity and the concept of past in connection with probability, which I shall try later.

Anyway, here I will examine PPE thus formulated, in order to understand the concept of probability as clearly as I could. Perhaps, my argument will be just hypothetical or thought-experimental, but all that I intend to do is to take a step forward.

2, Mysteries of Probability 1

Honestly speaking, it has been my longtime question, what is probability 1? Because probability 1 seems to be too self-evident, nobody seriously tried to explain what it is, as long as I know. But, apparently, probability 1 is very problematic. I can instantly raise at least three basic difficulties about it, that is to say, MODAL, TEMPORAL, and CAUSAL difficulties. First, I can pick out the MODAL difficulty about probability 1. Probability 1 is intuitively applied to the past event that has been actualized, as in PPE. But, undoubtedly, as I've mentioned, it is also applied to logical tautology or necessary truth like 'that dog is male or not.' In other words, probability 1 is connected with two fundamental modal concepts, namely, actuality and necessity. But, a difficulty seems to arise, particularly from the side of necessity. If the probability of necessary truth is 1, the probability of non-necessary, contingent sentence must be smaller than 1. I think that this is an implication of accepting necessary truth as having probability 1. This is easy to understand if we imagine the case of prediction. Let's think of those two prediction sentences (suppose that it is January 2005 now);

A: Tony Blair either resigns or doesn't resign from British Prime Minister in April 2005.
B: Tony Blair resigns from British Prime Minister in April 2005.

I adopt the standard notation about probability, i.e. P(A) means the probability of the occurrence of event-A or the probability of the truth of sentence-A. Then, obviously, P(A) = 1 since A is a logical necessary truth, while P(B) < 1 because it is not necessary but contingent. Nevertheless, if Tony Blair actually resigns from British Prime Minister in April 2005, it suddenly comes to that P(B) = 1 because it is an actuality, although B still remains just a contingent truth. But, nevertheless again, even after B is actualized, we can say that still P(B) < 1 in the sense that we are not necessarily in the possible world in which B is true if we adopt some simple possible world semantics to explain modal concepts. Thus, P(B) < 1 & P(B) = 1, which is a manifest contradiction, at least at first sight. Perhaps a similar difficulty doesn't arise if we start from the side of actuality, since actuality might extensionally include necessity. Well, in any case, I think that the contradiction thus produced over necessity is one of the basic difficulties concerning probability 1. Probably, in order to confront this difficulty, the first thing we should do is to consider how modal concepts are understood if the time, or finally the tense, is taken into account. In addition, there is another difficulty which is more closely related to PPE. If we focus upon the problem about the relation between PPE and actuality, and recognize that the event already actualized in the past is given probability 1, then we are treating actuality as in the past. So, what about actuality in the present? How is the past actuality related to the present actuality? I believe that this question, which again attempts to cross modal concepts and the tense, is also to be seriously taken in connection with the problem of probability 1[8].

Second, we have to mention the TEMPORAL difficulty with respect to probability 1. Even though we easily accept PPE, namely, the idea that probability of the event just having happened must be 1, it can be questioned whether the probability of the event will remain 1 permanently hereafter or not. In other words, we have to ask whether probability 1 is temporally immutable or not after it is established. This question deeply concerns in a rather perplexed way both the ontological status of probability and the metaphysical significance of the past. Is probability a sort of natural property inhering in reality, or just a concept functioning in our thoughts? Does the past eternally persist, or change and vanish as

[8] It is often said that probability is contrasted with certainty. However, exactly speaking, it is not true, of course, because probability covers both certainty and uncertainty. If P=1, probability is equivalent to certainty, and if P<1, probability can be take as uncertainty. Well, can we think that the very certainty must be the essential feature of probability 1 in common to actuality and necessity? I believe that we can't think so easily, since, as far as I understand, actuality and necessity are typical modal concepts, while certainty is an epistemic concept.

time goes by? There is no room here to develop some arguments about those questions in detail, but, for the time being, I have one thing to affirm; as a matter of fact, we sometimes take probability to be a natural property, and sometimes to be just a sort of mental state, and similarly, we sometimes regard the past as eternally existing in a fixed way, and sometimes as only appearing in our memory. Indeed, if probability isn't understood in such a flexible manner, it is difficult to explain why probability is actually working in quantum mechanics as well as our action of betting on horse racing. This might be also suggested by the fact that pluralism is often proposed with regard to the interpretation of probability[9]. As to the past, on the one hand, we firmly believe that the past is already fixed and we can't change that, but, on the other hand, we think that we can't ascertain the past truly and sometimes doubt the past by saying that it's shrouded in a mystery. If that is the case, we could safely say that the event in the past will gradually reduce its probability from 1 to smaller than 1, even though we accept PPE. Why is this? Because we might forget the past event. As far as there is an epistemic aspects of probability and there is an idea of the past as memory, it is not inconsistent with our ordinary concepts of probability and past to introduce the factor of forgetting about probability 1. Timothy Williamson grasps the situation of PPE as the case of evidential probability 1, and, as correctly as usual, rejects the next claim he calls MONOTONICITY by taking into account the factor of forgetting;

(MONOTONICITY) Once a proposition has evidential probability 1, it keeps it thereafter[10].

Williamson reaches the rejection of (MONOTONICITY) through his firm idea of the higher-order probability of the propositions about the evidential probability. This is an insightful argument certainly, but at the same time, it clearly indicates an embarrassing situation as regards probability 1, since it somehow compromises PPE, and perhaps challenges the immutability of the past (maybe with an anti-realistic flavour)[11]. In any

---

[9] For example, Cohen and Gillies clearly propose the pluralism of the interpretation of probability. See Cohen (1989) and Gillies (2000). Incidentally, I myself don't side with pluralism. It is true that several interpretations of probability are actually working, depending upon contexts, but it's just a fact. We have to question whether there is some more fundamental moment that penetrates into all of those interpretations, for example, as regards our practical actions in using probability concepts, or their relationship with the tense concepts. Hopefully, this article is meant to be one of such attempts as consider the fundamental moment in common to all interpretations of probability.

[10] Williamson (2000), p.218 ff.

[11] I personally asked Timothy Williamson in April 2003 whether his strategy of rejecting MONOTONICITY might lead to anti-realism about the past or not. He instantly answered that his standpoint is not an anti-realism in a Dummett's sense. Of course, it is not. This problem depends upon whether values of probability should be thought to be subsumed in the concept of past as its inseparable component. If it's

case, we have to say that this situation is one of the natural implications about probability 1. Thus, here is also a serious difficulty we must face[12].

Third, we have to confront the CAUSAL difficulty concerning probability 1. The situation which strikingly appears when we accept PPE is that probability is suddenly changed into 1 once the event concerned becomes past. This is remarkably represented by the case that some highly uncertain prediction comes true. For instance, suppose that the probability of the proposition, 'I win this lottery,' is estimated at 0.001, and then I actually win. In this case, the moment the number of my lottery is selected, the probability instantaneously rise from 0.001 to 1. Isn't there some problem here? Few people have put this situation in question so far. But, can we accept this sudden change of probability as a perfectly unproblematic phenomenon that needs no explanation? I don't think so. The change is often very dramatic and drastic as in the case above, so it seems to be very natural to ask why this happens. In fact, we human being has been developing scientific knowledge by observing conspicuous changes in physical phenomena and asking why or how they change. I think that, in asking such questions, we usually look for causal relations among phenomena. Therefore, I also want to propose this causal question in this context, i.e. what causes this sudden change of probability from smaller than 1 to 1? This is the third basic difficulty with regard to probability 1, which seems to be extremely hard to answer.

3, The Collapse of Probability

Now, then, which is the most noteworthy difficulty we must face first of those three ones? Obviously the modal difficulty should be discussed from the metaphysical or logical point of view, and the temporal difficulty has to be examined from the epistemic or epistemological standpoint. What about the causal difficulty? I think that the causal problems in general span all fields of philosophical topics including metaphysical and epistemic problems, therefore it seems to be very convenient to focus our attention first upon the causal difficulty, whose examination might suggest some promising routes towards some appropriate understanding of other two difficulties[13]. Furthermore, it is not only convenient but also crucial

---

so subsumed, the rejection of MONOTONICITY might reach the idea of changing the past in a literal sense. But, if probability values are just some numbers externally attached to the past, this problem has nothing to do with any anti-realism.

[12] David Hume once proposed the similar problem to this second difficulty in the chapter entitled 'Of unphilosophical probability' of his *Treatise*. He points out the fact that all of our knowledge whatsoever must become less probable as the time passes, because our memory gets fainter and fainter. It is a very interesting argument and can't be ignored, but I am afraid that this argument would be applied to philosophers' own assertions in a self-destructive manner. This devastating point might be true of my second difficulty as regards probability 1. Cf. Hume (1978), pp.143-155.

[13] Someone might wonder how the causal difficulty is related to the modal difficulty. But, is it nonsense to question how necessity or actuality is caused? I don't think so. In fact, for example, a certain type of the causal theory of time as Michael Tooley develops explains actuality in terms of causal process. Even logical necessity, as long

to scrutinize the causal difficulty first, since other two difficulties could arise only by taking it for granted that something having probability 1 already existed, whereas the causal difficulty brings into question how probability 1 appears, or what the process of something's getting probability 1 is. The causal difficulty is the most basic, so it must be questioned first. That question is my very aim this time.

I must mention one point before examining the causal difficulty. That is to say, there can be a philosophical problem concerning which notion is more basic, probability or causality. It is well known that some people try to understand causality by appealing to the notion of probability. That is called Probabilistic Causality, whose main idea is to define the concept of cause as raising the probability of its effect[14]. Obviously, the theory of probabilistic causality requires the notion of probability to be prior to causality. However, on the contrary, the causal difficulty that I propose here about probability 1 can make sense only provided that causality is more primitive than probability, since the difficulty questions what the cause of probability 1 is. How can we reconcile this situation? I want to say; this situation doesn't have to be reconciled in advance. Both probability and causality are so extremely fundamental that it is very natural for them to be entangled with each other.

In fact, even if we find the cause of probability 1, there is still room for the cause itself of probability to work in a (higher-ordered) probabilistic way. The similar situation is likewise true of the side of probabilistic causality. For example, it is well known that Ramsey develops his elaborate subjective theory of probability based upon the supposed relation

---

as we take it as one of our (metaphysical) notions, could be questioned as regards its causal status. I think that metaphysical problems have more to do with causality than we usually expect (Cf., Tooley 1997). But, certainly it is difficult to understand the relation between PPE and probability 1 of logical necessity. All that I can do about this tentatively is to propose another principle parallel to PPE, and then to suggest the relation of both principles. The another principle, which can be called the Principle of Probability of Necessary Truth (PNT), is like this;

(PNT) As soon as a sentence is regarded as NECESSARY truth, its probability must be 1.

If we can formulate the case of probability 1 about necessary truth by PNT, we might say that probability 1 of necessity is subsumed under PPE, because our regarding the sentence as necessary is also temporally made, so it is factually equivalent to having ALREADY regarded it as necessary. Of course, then, we have to ask those two questions, namely, (1) was the probability of the sentence smaller than 1 before our regarding it as so? (2) is the probability 1 of logical necessary truth changeable in the future? As to (1), I think that, as soon as we regard the sentence as logically necessary, we extend the necessity to the past, as it were retrospectively, by taking the necessity to obtain timelessly. Thus, it seems to me that concepts of necessity and past have a close affinity to each other. But, what about the future? If it's necessary timelessly, won't it be permanently necessary even in the future? This question leads to (2), which is, as you easily perceive, nothing but the temporal difficulty I called.

[14] Cf., Eells (1991), p.1, and Mellor (1995), p.67.

between belief/desire and action. And, he regarded the relation as causal[15]. If so, and we propose the theory of probabilistic causality by appealing to the subjective interpretation of probability, then we must fall into circularity. Of course, some people believe the effectiveness of the idea of probabilistic causality and try to make the idea more acceptable and plausible. Papineau, for instance, attempts to make up a more exquisite theory of probabilistic causality through replacing the idea of the screening-off asymmetry, which is usually used to decide the direction of causation in the theory of probabilistic causality, with another new requirement. That is, 'the requirement that effects should have probabilistically independent causes.[16]' But, then, what is 'probabilistically independent'? According to Howson and Urbach, two sentences, h_1 and h_2, are called probabilistically independent iff $P(h_1 \& h_2) = P(h_1)\,P(h_2)$[17], which leads to that $P(h_1 \mid h_2) = P(h_1)$ in terms of the definition of conditional probability. Is this nothing but that the probability of changing in connection with other factors is 0, in other words, the probability of remaining the same despite changes of other factors is 1? Thus, elaborating the theory of probabilistic causality induces us to ask what probability 1 is, and eventually to run into the causal difficulty about probability 1. Probability and causality are so bewilderingly tangled in an intrinsic sense. Therefore, I defer the reconciliation of those two basic concepts until the end of this article, for my article itself is an attempt to consider the relation between probability and causality.

Well, then, how could we cope with the question, 'what causes the sudden change of probability from smaller than 1 to 1?' Perhaps, one of possible answers, which can be easily thought of, is that the time itself, in particular the present itself, causes the sudden change of probability. But, this is too implausible to be instantly adopted. First, this view represents the time as a sort of real existence or substance with causal efficacy, which can be supported only by some peculiar metaphysics, so everyone is not convinced of it. Second, if we acknowledge that the time causes the sudden change of probability, then there might be a possibility that any change in our world must be said to be produced by the time, consequently, this view would have no explanatory power. Then, how should I answer next? Obviously, the crucial point is how it is established that the event has happened. A simple answer is that ; it is the very fact that it just happened and went away into the past, which needn't be elucidated further more. But, I am afraid this line of thought might come back again finally to the previous implausible view that the time itself causes the sudden change, because this simple answer eventually appeals only to the change of the tense in order to explain the sudden change of probability. This is just a refusal of investigation, which doesn't seem to be philosophical.

---

[15] Ramsey (1990), p.65.
[16] Papineau (2001), p.28.
[17] Howson & Urbach (1993), p.41.

Now, what is another possibility? A slight consideration enables us to remember an existing theory that explains the sudden change of probability into 1. That is what is called 'the collapse (or reduction) of the wave packet' in quantum mechanics. Mentioning this in this context is not inappropriate, since, as I said earlier, problematic phenomena coming from quantum mechanics are one of sources that produced a powerful interpretation of probability, namely, the propensity theory. Usually the propensity theory, in particular in an original form by Popper, is classified as the objective interpretation of probability, but, exactly speaking, such classification isn't necessarily true in spite of Popper's own intention if we consider his way of introducing the propensity theory in connection with quantum mechanics. I will discuss this point later. Anyway, as a matter of fact, apart from its purely mathematical notion, 'probability amplitudes', quantum mechanics itself doesn't always declare anything clear about how to interpret the concept of probability despite the fact that its main idea lies in the appeal to probability when describing the reality of nature. Hence it is sometimes seriously discussed in a philosophical context how we should interpret probability in quantum mechanics.[18] Actually we could say, independently of Popper's context, that it is doubtful whether probability in quantum mechanics must be objective in a literal sense, because, taking into account the so-called measurement problem, we might even say that probability concept in quantum mechanics is subjective in a certain sense rather than objective (Popper seemed to recognize this situation, then propose the propensity theory by explicitly criticizing the situation). Therefore, I take up 'the collapse of the wave packet' as a material that can be universally applicable to the concept of probability, irrespective of what interpretation of probability to choose, as far as PPE is concerned[19]. Of course, to consider quantum mechanics in detail is not my intention here, so my argument in the following provisionally focuses upon the classical Copenhagen interpretation[20]. I believe that this

---

[18] For instance, Michel Paty recently published his thoughts about it, and asserted that we should carefully distinguish two meanings of probability in quantum physics, i.e. theoretical (relational and mathematical) and empirical (in a statistical sense) meanings. See Paty (2001), pp.235-255.

[19] When I considered the relation between subjective interpretation and objective one of probability along quantum mechanics, I got some hints from Logue (1995). In addition, I had an opportunity to attend at Logue's lectures at Oxford in the spring of 2003, which was entitled 'Philosophy of Probability and Induction'. I learnt a lot from his lecture, too. Here I express my gratitude to him.

[20] But, as far as I see, for example, even the many-worlds approach would be also involved in another sort of the sudden change, because, if we observe quantum phenomena in a fixed way and recognize that we are in this particular world, then there is the sudden moving from one present world to another particular world, even if it might have nothing to do with probability concept as the Copenhagen interpretation deals with. This is confirmed by this Polkinghorne's description of the many-world approach; 'at every act of measurement, physical reality divides into a multiplicity of separate universes, in each of which different (cloned) experimenters observe the different possible outcomes of the measurement.' (Cf. Polkinghorne (2002), p.52). This

strategy wouldn't undermine my points which I'm going to propose as a kind of hypothesis or thought-experiment.

Now, then, what is the collapse of wave packet? How does the probability suddenly change? How is that caused? It is enough here to reconfirm only the basic points for my purpose. I call for the lucidly summarized expression of an authority. John Polkinghorne simply describes like this;

> Measurements must be occasions of instantaneous and discontinuous change. If an electron was in a state with probability spread out 'here', 'there', and, perhaps, 'everywhere', when its position was measured was measured and found to be, on this occasion, 'here', then the probability distribution had suddenly to change, becoming concentrated solely on the actually measured position, 'here'. Since the probability distribution is to calculated from the wavefunction, this too must change discontinuously.....This phenomenon of sudden change, called the collapse of the wavepacket[21].....

In addition, I quote the next Dirac's expression in order to confirm clearly what the result of the collapse is;

> The state of the system after the observation must be an eigenstate of α, since the result of a measurement of α for this state must be a certainty[22].

This argument is already well known of itself, and also well known for producing many perplexed difficulties in a philosophical sense as well as in a scientific sense, which are not to be argued here. Now, rather I want to ask, what causes the sudden change of probability into certainty? What causes the sudden change of probability from smaller than 1 to 1? Well, as is suggested in the description above, measurement or observation must have something to do with this. Polkinghorne expressed that as 'occasions of instantaneous and discontinuous change.' It sounds to be the way a classical occasionalist, Malebranche, talks. Undoubtedly, here is a very deep philosophical question about causality. According to Barret, Heisenberg 'must have meant that it was an observer's act of observation that then forced nature to make a particular choice'[23]. Yes, it is a reasonable and safe opinion to say that nature is the real cause of the sudden change. But, it's too safe to keep our ordinary concept of cause.

---

approach contrived the way of avoiding using probability concepts crucially, but the structure is exactly parallel to the standard approach with regard to the sudden change. Perhaps we may ask likewise, what causes this sudden change? That question is precisely equivalent to the causal difficulty as I offered even if not using probability concepts.

[21] Polkinghorne (2002), pp.25-26.

[22] Dirac (1930), p.49.

[23] Barret (1999), p.26.

When I give a lethal injection to someone and the person die, it is not a mistake to say that nature is the cause of her death. Or, when I leave a burning match in the dustbin of a house and then the house burns, it is not a mistake either to say that the burning is caused by nature. Yet, nobody thinks that such excuses can make sense. Usually, a thing that is an occasion of other thing and without which the other thing doesn't happen is loosely called a cause of the other thing. As the history of philosophy proves, an attempt to strictly define the cause is either unsuccessful or vague of itself because of its looseness. In fact, Dirac declares in later years; 'a measurement always cause the system to jump into an eigenstate of the dynamical value that is being measured.[24]' Thus, let's judge, hypothetically, that our measurement or observation is the very cause of the collapse of wave packet. I think there is nothing which can reject this judgment as entirely ridiculous. Actually I couldn't imagine another possibility at least in this context.

Of course, strictly speaking, those argument concerns the collapse of wave packet, not the sudden change of probability itself. But, the concept of cause is actually very loose, intrinsically loose, therefore, if there is the co-extensional phenomena with a cause of some event, we may call the phenomena the cause of the event, too. This is applied to the case of the sudden change of wave packet and of probability, since both of sudden changes are clearly co-extensional. Thus, if it is our observation that causes the collapse of wave packet, then our observation is also regarded as the cause of the sudden change of probability. As it were, the collapse of probability happens here simultaneously with that of wave packet, in the sense that probability distribution collapses and probability becomes concentrated solely on the actuality position, '1'. My assertion is that; the same situation is analogously true of the sudden change of probability in general as appears in PPE. Consequently, I propose the next thesis as a hypothesis, which I call 'the Collapse of Probability Hypothesis (CPH);

(CPH) If PPE is true, then our observation CAUSES the probability of an event to collapse into the value 1 as soon as we observe the event pass away into the past[25].

Unless the time itself or the fact itself can be the cause of the sudden change of probability, I think that our observation is actually the only

---

[24] Dirac (1958), p.36.

[25] I refer not to the present but only to the past, because I think that the present is always perishing, so actually impossible to grasp as it is. Presentism, as Zimmerman tries to defend, seems to fatally ignore the empirical vanishing character of the present. Cf. Zimmerman (1998), pp.206-219. But, on the other hand, the concept of the past has its peculiar difficulty, namely, the past no longer exists, so, exactly speaking, it is fundamentally hard to understand what the truth-maker is about sentences in the past tense. This is one of traditional puzzles since Aristotle, which is definitely worthwhile examining further in another occasion.

plausible and explanatory candidate as the cause[26]. There are infinite numbers of factors that can be theoretically the cause of the sudden change of probability depending on each case, but what I'm looking for is the cause that equally explains all cases. As far as PPE is accepted, our observation corresponding to the phrase in PPE, 'is recognized as', seems to be an only option as the cause. And, the sudden change of probability into 1 in PPE is remarkably similar to the case of the collapse of probability in quantum physics as regards the structures of their situations. Thus, I came to CPH. In fact, rather I want to suggest a bolder claim by reversing the order. That is to say, probability intrinsically collapses, therefore the collapse of wave packet and of probability in quantum mechanics is just one of natural consequences derived from the concept of probability in general. Probably, this claim could eliminate the seeming weirdness of my strategy of appealing to quantum mechanics which is highly controversial in itself, because my aim is to clarify the nature of probability in general by using quantum mechanics as just one possible gate to lead to the nature. I don't intend to at all, and needn't at all, found my argument upon quantum mechanics.

4, Popper's Legacy

It wouldn't go amiss to turn our eyes to Popper's argument now, or rather my argument thus far naturally induces us to do that, since CPH I've just reached is proposed basically through considering the significance of probability in quantum mechanics, which is precisely what Popper focused on when constructing his propensity theory of probability. Actually I have already mentioned Popper's propensity theory a couple of times, so I should determine my attitude towards his theory to a certain extent, which is so remarkable in the history of the philosophy of probability as to be called 'Popper's Legacy.' My argument would be reinforced, and the implication of CPH would be made more explicit, by looking back a bit over Popper's Legacy.

What I hope to focus on first is that Popper offers this thought-experiment in the part entitled 'A Random Walk and the 'Transition from the Possible to the Actual" in his *Quantum Theory and the Schism in Physics*,

> A soldier in the desert is given a pocket roulette-wheel and instructed to set it up, letting the pointer spin and come to rest, and then to march for one minute in the direction indicated by the pointer; and then to repeat the performance, letting the pointer spin again, and again marching for one minute in the direction of the pointer. It is at once intuitively clear

26 If we connect the notion of observation with the notion of self or spirit, this view might be regarded as one variant of Berkeley's classical standpoint. See, for example, Berkeley (1951), section 30. Incidentally, Berkeley was highly reassessed by Popper as one of pioneers of scientific instrumentalism that could be concerned with quantum mechanics. See Popper (1963), pp.97-119.

that, on the basis of this instruction, we obtain a probability distribution for the position of the soldier which spreads with the soldier's marching speed from the starting point in all directions —a kind of cloud which is dense in the centre and thins out towards its periphery.....

Now let us *observe* the soldier, after one hour, when he is just consulting his pocket roulette-wheel. Then, we may say, the old cloud disappears, and a new cloud is started at the point at which we have observed the soldier.

This is precisely the same thing as the 'reduction of the wave packet,'.....It even occurs, though in a slightly more trivial way, in any such game as tossing pennies: relative to the information that we have tossed heads, the (relative) probability that we have tossed heads from ½ to 1. That this is fundamentally the same problem as that which has disturbed the quantum theorists[27].

In short, Popper points out that the sudden change of probability occurs even in the case of throwing a coin, and that those trivial phenomena are precisely what the reduction of wave packet means. Obviously this claim has the same way with my argument of suggesting that the problem of collapse of wave packet in quantum mechanics is just one sign of characteristics of probability concept in general. However, Popper extends his claim to even say that there is nothing problematic in that sudden change. He develops the same point as this and makes a stronger claim in other parts of the same book or his *The Logic of Scientific Discovery* in terms of this next thought-experiment that comes from Einstein and that Heisenberg also mentions[28].

Take a semi-transparent mirror, and assume that the probability that light will be reflected by it is ½. Thus the probability that light pass through will also be ½, and we have the next equation (α), if the event 'passing through' or 'transmitted' is *a*, and the experimental arrangement *b*,

(α) $P(a,b) = ½ = P(-a, b)$,

where '$-a$' (that is, 'non-*a*') stands for the event 'reflection.' Provided that the experiment be carried out with one single photon, the probability wave packet associated with this photon will spirit, and we shall have the two wave packets corresponding to $P(a,b)$ and $P(-a, b)$ in the above equation. Now let us assume that we find, with the help of photographic plate, that the photon was reflected, i.e. $-a$. Then, according to Heisenberg, the probability of finding the photon in the other part of the packet *immediately becomes zero*[29]. What has happened? We had, and

---

[27] Popper (1982), pp.123-124.
[28] Popper (1982), pp.76-78 and Popper (1959), pp.235-236.
[29] Heisenberg (1930), p.39.

still have, the relative probabilities expressed by (α). If we take the information $-a$, then relative to this information we get this (β),

(β) $P(a, -a) = 0$, $P(-a, -a) = 1$.

Certainly it is true that $P(a, -a) = 0$, but it is quite wrong to suggest that it is a kind of changed form of the original packet $P(a, b)$ which 'immediately becomes zero.' The original packet $P(a, b)$ remains equal to ½, which is to be interpreted as meaning that if we repeat our original experiment, the virtual frequency of photons being transmitted will equal to ½. And $P(a, -a)$, which is zero, is quite another relative probability. It refers to an entirely different experiment which, although it begins like the first, ends according to its specification only when we find that the photon has been reflected. No action is exerted upon the wave packet $P(a, b)$, because $P(a, b)$ is the propensity of the state of the photon relative to the original experimental conditions. This has not changed. Thus, the reduction of wave packet clearly has nothing to do with quantum theory: it is a trivial feature of probability theory that, whatever a may be, $P(a, a) = 1$ and $P(a, -a) = 0$. When we toss a coin, the probability of each of its possible states (i.e. head or tail) equals ½. As long as we do not look at the result of our toss, we can still say that the probability will be ½. If we bend down and look, it suddenly 'changes.' Was there a quantum jump, owing to our looking? Was the coin influenced by our observation? Obviously not. That's Popper's argument, which rather seems to be so strong as to trivialize CPH.

I will raise three points towards the Popper's argument. *First*, it must be extremely counterintuitive to accept Popper's argument altogether, because his point would make probability kinematics impossible in principle although that is usually recognized as one field of the philosophy of probability. Actually we don't think at all there is something problematic about saying that probability changes, but, Popper's argument seems to forbid us from saying so, which sounds ridiculous. Additionally if we follow his argument, we might lead to such an idea that the world is re-born every moment into a new different one without any continuation. This idea sounds to be utterly unacceptable. It is true that it's possible to accept the idea, but doing so makes a lot of sacrifices. In fact, Popper himself virtually mentions the notion of probability-change when saying; 'it is the objective propensity of a which may become zero.[30]' This seems to contradict his criticism against Heisenberg. *Second*, Popper asserts that $P(-a, -a) = 1$ has no problem at all since this is just a trivial tautology, but it seems to me that he passes thorough a philosophical question without stopping to consider. If we follow his idea and formulate exactly, what matters here is how P('the photon is reflected', 'the photon was reflected') should be dealt with, which isn't necessarily treated as a

[30] Popper (1982), p.88.

self-evident tautology. The second term is the sentence in the past tense, while the first one is tenseless or in the future tense, and perhaps based on a counterfactual supposition. Undoubtedly here is a delicate philosophical problem hidden like temporal difficulty I mentioned. In any case, all that Popper can claim is that P('the photon was reflected', 'the photon was reflected') = 1, which is absolutely trivial, making no sense and useless here.

Third, as is shown by Popper's declaration that observation has no influence on the coin at all, he tacitly makes a presupposition that only physical phenomena could be accepted as causal influence, upon which he concludes that observation, knowledge or ignorance has nothing to do with causal process. The same argument can be found in the part in which he makes fun of Pauli by saying that Pauli takes our ignorance to increase entropy[31]. However, such argument isn't fair at all. Obviously, it is merely a dogma that causal influence takes place only about physical phenomena, as we can draw as many examples as we like concerning causal influence in a psychological or epistemic phase. For instance, it would be inevitable that, if I suddenly recognized the person in front of me to be my boss that I haven't met yet, the recognition will causally influence my psychological state. Considering this, Popper's argument will not necessarily work, if the observer in the collapse of wave packet or probability could be supposed to be something giving causal influence in such a non-physical level. Actually, as a matter of fact, the causal understanding of physical phenomena depends upon our network of knowledge, which would make it not so unreasonable to think that an observer's action of applying the network to the phaeneomana is the cause to trigger the whole process. In fact, even Popper himself declares that; 'even the 'observation' of a part of the track of the particle in position space is.....actually an *interpretation* in the light of theories, in spite of its apparent intuitive obviousness.[32]' This line of thought would affect the objective status of Popper's 'propensity,' which can be actually confirmed by this Popper's definition of the notion of propensity;

> This application of probability theory to single cases is precisely what the propensity interpretation achieves. But it does not achieve it by speakinfg about particles or photons. *Propensities are properties of neither particles nor photons nor electrons nor pennies.* Propensity statements in physics describe properties of the situation, and are testable if this situation is typical, that is, if it repeats itself (such as in the case of the emission of light). They are, therefore, also *properties of repeatable experimental arrangements*: physical and concrete[33].

If so, we can ask; who sets up the repeatable experimental arrangement?

---

[31] Popper (1982), pp.109-110.
[32] Popper (1982), p.143.
[33] Popper (1982), p.79-80.

Who arranges it? Obviously someone must artificially arranges it with the background of some scientific knowledge. Accordingly, here is definitely some person who has a particular knowledge of science and gives a particular idea, contrary to Popper's official treatment of 'propensity' as objective. If we mean an independence of observer's knowledge by 'objective,' Popper's 'propensity' could not be objective by definition. Rather it seems that we could say it's epistemic. Anyway, however, it is also certain there was room in the side of quantum mechanics that incurred Popper's criticism, since they seemed to describe causal influence of observation in the collapse of wave packet as if in the same level with physical phenomena (as if it is light emitted from our eyes). Thus, in any case we can say that it's possible for our observation to cause the collapse of probability, as CPH claims. At least my argument so far confirms that PPE and CPH is concerned with epistemic interpretation of probability as well as objective one, because Popper's theory of propensity, which gives my argument main materials, seems to commit itself to an epistemic interpretation with professing itself to be an objective theory.

To sum up, Popper's theory supports my argument in that he also takes what is called the collapse of wave packet to be not restricted to microcosmic quantum movements but ordinarily recognized anywhere in our daily life concerning the concept of probability. However, at the same time, I could show that my argument is applicable to any interpretation of probability concept by pointing out that Popper's theory, which gives my main materials as a representative view of objective interpretations, substantially commits itself to an epistemic interpretation.

5, Argument from Humphreys' Paradox

In the following, I'm going to verify whether CPH is capable of explaining anything probabilistic or not, and clarify what kind of implication CPH eventually brings. In order to do that, I take up the problem called 'Humphreys' Paradox'. The paradox is not only thought to raise a fundamental difficulty about the concept of probability, but also seems to be a typical example of puzzles that could be solved by applying CPH. That is a process of verifying CPH. After that, I want to consider what results CPH produces by scrutinizing why 'Humphreys' Paradox' is thought to be a problem. This is the next step of clarification of CPH's implication, which will lead to a deeper difficulty.

Now, what is Humphreys' Paradox? This paradox was first proposed by Paul Humphreys, and then published by Salmon[34], after which it was named 'Humphreys' Paradox' by Fetzer[35]. The paradox originally casts doubt on the propensity interpretation through making inverse conditional probability in terms of Bayes's theorem. There are some versions of this paradox, of which I quote the next clearest one that Salmon re-mentioned in a later year;

---

[34] Salmon (1979), pp.183-216.
[35] Fetzer (1981), p.283.

(Can Opener Case)
Consider, for example, a factory that produces can opener. There are only two machines, which we may designate A and B, in the factory. Machine A is ancient; it produces one thousand can openers per day, and 2.5% of these are defective. Machine B is more modern; it produces ten thousand can openers per day, and only 1% of its products are defective. Suppose, at the end of the day, that all of the defective can openers (which have been stored by the inspectors) are placed in a box. Someone randomly picks a can opener out of the box, and ask for the probability that it was produced by the modern machine B. We can easily calculate the answer; it is 4/5. Nevertheless, I find it quite unacceptable to say that this defective can opener has a propensity of 0.8 to have been produced by machine B. It makes good sense to say that machine B has a propensity of 0.01 to produce defective can openers, but not to say of the can opener that it has a certain propensity to have been produced by that machine[36].

Let D = that the picked can opener is defective. Let A = that it was produced by machine A. Let B = that it was produced by machine B. Then, by definition, $P(D \mid A) = 25/1000$, $P(D \mid B) = 1/100$, $P(A) = 1/11$, $P(B) = 10/11$. The probability questioned here is $P(B \mid D)$. We can calculate this by using Bayes' theorem as follows;

$$P(B \mid D) = P(D \mid B)P(B) \ / \ P(D)$$

$$= P(D \mid B)P(B) \ / \ P(D \mid A)P(A) + P(D \mid B)P(B)$$

$$= 1/100 \times 10/11 \ / \ 25/1000 \times 1/11 + 1/100 \times 10/11$$

$$= 100/11000 / \ 125/11000$$

$$= 4/5$$

That is perfectly clear, as far as Bayes' theorem is accepted. And I have no reason to refuse Bayes' theorem at all. Then, what is the problem? Gillies lucidly describes how this is paradoxical by using the frisbee example, so I paraphrase his expression using can openers instead of frisbees. That is to say, 'the picking of a defective can opener from the box in the evening is a partial cause of weight 4/5 of its having been produced by machine B earlier in the day. Such a concept seems to be nonsense, because by the time the can opener was selected, it would either definitely have been produced by machine B or definitely not have been produced by

[36] Salmon (1984), p.205.

machine B. We can make the point more vivid by supposing that machine A produces white can openers and machine B orange can openers. If the defective can opener picked at the end of the day was orange, it would definitely have been produced by machine B, and it is not clear what would be the sense of saying that it had a propensity 4/5 to have been produced by machine B'[37]. In short, if we understand the can opener example in terms of the propensity theory, we have to adopt the notion of PARTIAL BACKWARD CAUSATION, which seems to be too absurd to be accepted.

Roughly speaking, three types of reaction to Humphreys' Paradox have been presented. First, it is claimed that this paradox shows the inappropriateness of the propensity interpretation of probability, therefore we simply have to give up the propensity theory. This is advocated by Humphreys himself and Milne. Humphreys is fully aware of the causal difficulty appearing here, and initially declares; 'the causal nature of propensities cannot be adequately represented by standard probability theory.[38]' Milen similarly emphasizes the strangeness of applying Bayes' theorem of conditional probability to propensity of events, and concludes that 'conditional probabilities cannot adequately be treated in realist single-case interpretation of probability,' then suggesting the shift to an interpretation based upon the long run frequencies[39]. Milen points out that this paradox consists of three premises, namely, conditional probability, the link between realist single-case interpretations and the indeterminate, and the claim that the past and the present are determinate unlike the future. Then he said that any one rejection of these premises is an unhappy choice[40]. The second reaction is that we should clarify which case is and which case is not suitable for us to apply Bayes' theorem to the propensity of events. This is developed by McCurdy. He tries to secure the situation in which inverse conditional probabilities about propensity is perfectly meaningful by taking into account the time when we calculate the conditional probability. For instance, take up again the can opener example and let t_1 indicate the morning before machines move, t_2 any arbitrary daytime when machines are working, t_3 the end of the day when someone picks a can opener from the box, and suppose that $Pt_i(Dt_j \mid Bt_k)$ is interpreted as "the probability at t_i for D at t_j, conditional upon B occurring at t_k. Let's compare those two probabilities (ignoring the background information now for brevity),

(1) $Pt_1(Bt_2 \mid Dt_3)$

(2) $Pt_3(Bt_2 \mid Dt_3)$

McCurdy's claim is to the effect that (1) perfectly makes sense and is given

---

[37] Cf. Gillies (2000), p.131.
[38] Humphreys (1985), p.557.
[39] Milne (1986), p.131.
[40] Milne (1986), p.132.

the value 4/5, while (2) is an absolute nonsense, because once the event Dt_3 or $\sim Dt_3$ has been realized, there is no indeterminacy about the occurrence of the event Bt_2 — it has either occurred or not[41]. In other words, on the one hand, he entirely agree that Humphreys' case is involved in a paradoxical difficulty when we understand it in the sense of (2), but on the other hand, he maintains that inverse conditional probability through Bayes' theorem is unproblematically applicable to the propensity interpretation when we consider Humphreys' case before events concerned occur, as (1). This is an attempt of defending the propensity theory even if partially. Then, McCurdy, appealing to Niiniluoto's suggestion[42], also adds the point that (1) is a physical probability, whereas (2) is an epistemic probability[43]. Now, the third reaction is simple. Namely, since Humphreys' paradox only proves that the propensity theory as realist single-case interpretation of probability is insupportable, we can still support and refine the long-run propensity theory, which is immune from the paradox. That is alluded by Milne as above, and deliberately proposed by Gillies[44]. But, this third reaction is outside the scope of my interest, because I provisionally want to discuss only the probability of single event as PPE shows.

Certainly, here is a truly serious difficulty about probability. Then, what reaction should I offer by applying CPH? There are several things to say, but first of all, I want to make sure this point; as soon as I pick a (either white or orange) can opener from the box and see it, the probability of the can opener's being orange collapses into 0 or 1 according to CPH, therefore there is no room to ask the probability, at least soon after the collapse. So, if Humphreys' case takes the issue of probability after the collapse, it is very natural for the case to fall into a paradoxical unsolvable situation because no substantial question exists. It's like the case of questioning what the probability of probability 1 is. In this sense, I think that Humphreys' paradox is nonsense from the outset, so it's not persuasive to conclude the inappropriateness of the propensity theory from this paradox. However, I don't intend to say that Humphreys' paradox doesn't touch any crucial point at all about probability. It seems that some hidden significant implication about probability will come into view by modifying and remaking the paradox and then applying CPH to it. How do we modify it? Well, suppose the next condition in the can opener case.

(Modified Version)

The box in which all defective can openers are placed at the end of the day is made of wood, so its content isn't seen from the outside. Then, I am told to pick one can opener from the box. I put my hand into the box

---

[41] McCurdy (1996), p.107 ff.

[42] Niiniluoto (1998), pp.103-04 note 16.

[43] McCurdy (1996), p.121.

[44] Gillies (2000), p.131-136.

and grasp a particular single can opener. At that moment I am asked what is the probability that it was produced by the modern machine B. Namely, I am asked before I take it out and see it.

This situation is just arranged in a more detailed way than the original, so nothing is changed with regard to the calculation of probability. Therefore, it still come to that $P(B \mid D) = 4/5$ in terms of Bayes' theorem.

Now, how do we understand the result, $P(B \mid D) = 4/5$, in this situation? Is it paradoxical? According to CPH, the probability hasn't collapsed yet, since we haven't observed it, or in other words along the terminology of PPE, we haven't recognized whether it's white or orange[45]. Thus, the case must be that $P(B \mid D) < 1$ as far as we accept CPH. We have strong reason to follow Bayes' theorem to assign 4/5 to $P(B \mid D)$. Let t_3 indicate the time when I grasp a particular can opener, and I think that even the calculation, $P_{t_3}(B_{t_2} \mid D_{t_3}) = 4/5$, which was presented along McCurdy's argument above, is likewise accepted. Is there something wrong? The problem is undoubtedly our intuitive idea that the can opener grasped by me was already actually fixed either white or orange, irrespective of being seen or not. This idea urges us to refuse to simply apply Bayes' theorem even to the modified version of Humphreys' paradox as well. Yes, I agree with the idea. I usually live with having such an idea as this, of course. But, I'm now considering a philosophical problem through a kind of thought-experiment. From such theoretical point of view, what must be noticed first is that this idea is supported by determinism about the past, which insists that the past event either happened or not, wherefore the probability of its occurrence must be either 1 or 0. To put it differently with Dummett's taste, that idea takes it for granted that the law of excluded middle is applied to the past. That is presumed. Well, how can it be presumed? By what ground? Honestly speaking, I think there is no decisive ground on which we have to presume it. We are usually living having that presumption, and maybe the presumption could be inferred with A CERTAIN DEGREE OF conviction. But, still there is nothing to completely block other possibilities, which means that the conviction is not perfect, not reaching probability 1. A.J. Ayer once correctly pointed out about the notion of sense-data that sense-data language is just chosen by our resolution and nothing more than that[46]. I want to say the same thing here. Our intuitive idea of determinism about the past is always only

---

[45] Someone suspects that the concept of observation or recognition is quite vague here, for grasping something can be a sort of recognition in a tangible sense, although I'm not sure it can be also called a tangible observation (?). But, this doubt can be easily dispelled by modifying further, if necessary, the condition into that; each defective can opener placed in the wooden box is randomly numbered by the inspector from 1 to 125, and then I am told to choose a particular number within those and asked what is the probability that the particular can opener with the number was produced by the modern machine B. Modifying in this way, we avoid being involved in the problem of vagueness about the concept of recognition.

[46] Ayer (1940), p.28.

chosen by our (perhaps instinctive?) resolution. The past event that isn't recognized yet, although vividly represented in a specified way (e.g. in this particular box right now), must be assigned smaller than probability 1, as I said earlier. As I mentioned before, Milen regarded the determinacy of the past as a basic premise incapable of rejection. But, it's not necessarily true. This is an implication of CPH. In other words, the difficulty of Humphreys' paradox directly arises from determinism about the past rather than from partial backward causation. So, since determinism can be rejected, Humphreys' paradox can be solved.

Certainly, this argument might sound strange first, but it's always neither absurd nor inconsistent with our common sense. In reality, what can you say about the content of the wooden box? We may suppose that we surely had seen white and orange can openers placed in the box. Even if so, can we be truly sure that those can openers remains to be with the same fixed colours in an absolutely perfect sense? You may say, it is certainly confirmed if we actually check the content. But, I'm asking about the case before being checked as in the modified version. Determinism, which is just a result of our resolution, isn't completely grounded, either. Thus, theoretically speaking, the probability of can openers' keeping the same situation in the box must be smaller than 1. In fact, we are ordinarily thinking in this way with regard to historical events. It is not strange at all to use the concept of probability in describing history, even though it was clearly in the past. Suppose the case that a certain historical figure was confirmed to be in a particular place at a particular time, but the person was missing for two years after that, then some plural stories had been told about her behaviours for that missing period. In that case, we usually apply probability to each story in such an unrecognized case, and then assign probability smaller than 1. Actually it is not rare that Bayesian theory is applied to confirm a hypothesis about historical events, as McCullagh investigates[47]. This kind of argument might also remind someone of a famous discussion concerning the reality of miracle that Hume once presented by appealing to the concept of probability[48]. In any case, those arguments regarding history is quite normal, and is entirely consistent with PPE and CPH. Thus, even ordinarily speaking, we may say that the probability of the can openers' keeping the same situation in the box is smaller than 1. If so, there is nothing wrong in applying Bayes' theorem to the modified version of Humphreys' paradox and drawing the result, $P(B \mid D) = 4/5$.

Now, someone has already found that what I argued so far is remarkably similar to the measurement problem in quantum mechanics, at least as regards their structure of argument. Yes, I think so, too. Actually, there are three reasons for that. First, since even macrocosmic phenomena are composed of microcosmic quantum phenomena, the problem deriving from quantum phenomena is theoretically applicable to

---

[47] McCullagh (1984), pp.57-64.
[48] Hume (1975), Section X.

macrocosmic phenomena, even though by an infinitely subtle amount. Second, Humphreys' paradox was originally presented in relation to the propensity theory which had been initially motivated by quantum mechanics, so it may be natural for the analysis of the paradox to result in the situation similar to the measurement problem. Third, the collapse of probability that arises out of the measurement problem in quantum mechanics can be rather thought to be one of natural implication of probability concept in general, as I said earlier, so the case is inverse, i.e. the collapse of probability expressed in CPH finally leads to the measurement problem in quantum mechanics as one result.

However, we mustn't stop here, because the measurement problem is the very problem which is still controversial. I have said earlier that determinism isn't completely grounded, but it's just a theoretical remark. As a matter of fact, we always choose determinism about the past, even if it's not an only possible option. Therefore, the measurement problem sounds truly problematic, which was shed light on in an enormously impressive way by well known Schrödinger's cat. I think that the same thing is true of Humphreys' paradox concerning the structure of argument, although, of course, we mustn't overlook the fact that there is a big difference between Schrödinger's cat and Humphreys' paradox from the viewpoint of physics. At all events, anyway, we should say that Humphreys' paradox is theoretically not paradoxical, but practically still paradoxical. If so, we have to examine further how such a paradox practically arises and what consequence the paradox brings about.

Before moving to the next stage, I want to notice one basic point. What I discussed so far concerns mainly the propensity interpretation of probability, as is clear from remembering how Humphreys' paradox was initially presented. However, I want to emphasize that this paradox is applied to the epistemic interpretation as well. Look at the modified version of the paradox. In this case, an application of Bayes' theorem perfectly makes sense, because we are subjectively uncertain of whether the grasped can opener is white or orange. But, at the same time, we also accept determinism about the past even from the subjective point of view. We don't believe that the situation of can openers is changed or unstable after they are placed in the wooden box, unless something special happens. Therefore, we subjectively believe that the colour of grasped can opener is already fixed the moment I grasp. Namely, it is probabilistic in a subjective or epistemic sense whether I grasp a white can opener or an orange one, but it is certain even in a subjective sense that the grasped can opener was already made by either machine A or B independently of my grasping. The distinction between the physical probability and the epistemic probability as Niiniluoto and McCurdy suggested seems to miss the mode of our subjective belief in determinism about the past. Humphreys' paradox is the paradox to the epistemic interpretation of probability, too. Accordingly, my argument so far is concerned with not only the propensity interpretation but also the subjective one. Actually this point was already confirmed by examining Popper's propensity theory

in the previous section.

6, Retroactive Assignment of Probability 1

Now, let's face the question, why do we accept the determinism about the past in an objective sense? Why do we believe in the determinism about the past subjectively as well? Clearly, this question is deeply conjoined with a question about how to understand the past. This is so grand a question that I can't deal with it thoroughly here, of course, but perhaps, presenting my basic intuition about the past might be forgiven. It seems to me that the past registers in our minds most realistically when we regret something we did or feel nostalgic for what we were. Can we think that such case is an original occasion for us to learn the meaning of the past, and then we extend the meaning to other cases by generalizing it? It might be. So, I suppose hypothetically that it is the case. Thus, these two points should be noticed.

(a)When we regret something or feel nostalgic for something, the past scene in the memory is vividly represented in a specified way, although the memory might be wrong.
(b) The past scene is thought to be inalterable, which characterizes regret or nostalgia differently from out attitude towards the future, i.e. such an attitude that we can somehow alter or control the future.

According to PPE and CPH, (a) seems to simply imply that the probability of the event concerned must be 1, and that our representation causes the probability 1. However, we must note that PPE and CPH stipulate only the case of the moment the event has happened (thus I inserted, 'as soon as', 'just now'), whereas (a) covers the case long after the event happened as well as the case of the moment it has happened. Therefore, to be exact, it's not appropriate to apply PPE and CHP to the case of regret or nostalgia. As a matter of fact, past events regretted or felt nostalgic can be mistaken, hence I added, 'the memory might be wrong'. In addition, such case might also be involved in the temporal difficulty of probability 1 that I mentioned earlier by appealing to the factor of forgetting. Thus, it's utterly reasonable to assign probability smaller than 1 to the events regretted or felt nostalgic, except for the case that we regret or feel nostalgic for something which has just now happened. But, nevertheless, the notion of regret or nostalgia, perhaps grammatically, requires that all past events regretted and felt nostalgic actually happened and were already fixed in terms of (a) and (b). Otherwise, those notions will lose their intrinsic meanings. If the event concerned could be non-existent or altered, neither regret nor nostalgia would arise. But, thus, how could we understand this situation? My understanding might sound Humean; some FICTION as if we are observing it now is introduced here. We regret or feel nostalgic for something past by fictitiously representing those past events as actually just now happened, so as having probability 1. In this case, the probability of those events is supposed to have probability smaller than 1

before our representation. At least they can't have probability 1 at all before representation in the sense of PPE and CPH. Therefore, the sudden change of probability appears to occur here. If we think analogously to CPH, we could say that our representing when regretting or feeling nostalgic, as it were, CAUSES the sudden change of probability from smaller than 1 to 1. In other words, probability of those past events collapses in a RETROACTIVE way by our fictitious representation.

The argument thus far is concerned only with such special cases as regret and nostalgia. But, can there be other cases of representing the past that are structurally similar to regret and nostalgia? I think there is. That is the case that we recognize something static as the same as it was some while before. In this case, we represent the shape of it in the past and recognize the present one as the same. Rather, we overlap two shapes. As a result, we represent the past event very vividly. Does this resemble the case of regret or nostalgia with regard to the way of representation? Yes, definitely. Thus, the retroactive collapse of probability by fictitious representation seems to appear, too. The probability of the existence of the static thing in the past is estimated as 1 although this case doesn't exactly meet PPE and CPH. This process, if any, seems to be immensely influential in our conception of the past, since static things, the most fundamental of which is the earth, forms the most basic background of our epistemic activities. Therefore, this process of retrospectively assigning probability 1 to the past event is naturally extended to the whole understanding of the past in general, however fictitious it is. Thus, determinism is born here. We become inclined to think that past events are already determined and fixed irrespective of our recognition, wherefore the probability of the occurrence of those events must be 1. Perhaps, this way of thinking suits very well our ordinary language in a practical sense, because the concept of responsibility or ascription forms a very important part of our practical talk, and such concept obviously requires the fixed and determined status of the past, hence I call this context practical rather than theoretical. Anyway, I propose what I argued thus far as the Retroactive Probability Hypothesis (RPH) in the following;

(RPH) Our fictitious representation of past events CAUSES probability to RETROACT to the past and collapse into value 1, from which DETERMINISM about the past appears.

RPH might seem to be odd at first sight, but such first impression could be eliminated by a bit of reflection about our actual notion of the past. I mean the condition that the past is nowhere by definition of the notion, so its verification is impossible in nature therefore the past is spoken necessarily through some fictitious taste. To be fictitious is the intrinsic character of the past. In this respect, it is quite natural that the narrative theory of history is often claimed. At least, regarding the past as real in the literal sense is either a philosophical deception or an intellectual

negligence.

Two points should be confirmed. First, we could explain why Humphreys' paradox sounds paradoxical by applying RPH to it. As a matter of fact, we tend to think that can openers in the wooden box has been already fixed with regard to their colours, i.e. their probabilities of being made by machine B must be either 1 or 0, before we see them, hence it sounds absurd to apply Bayes's theorem to a particular can opener grasped by me in the box in order to calculate the probability of having already been made by machine B. All of this arises only from our fictitious representation at the time of grasping the particular can opener, namely, the representation as if we had been observing the can opener in the box in spite of the fact that it wasn't actually observed. Thus, RPH elucidates this quite perplexed situation. In this respect, Timothy Williamson's objection to my modified version of Humphreys' paradox is worth mentioning. He objected that my modified version will not make sense if some videos machine would be set in the box, since in that case the colour of a particular can opener is known to have been fixed before we see it[49]. To this, first of all, I would like to answer that probability about the information recorded in video machine would also collapse the moment we see it, so this case couldn't be an objection to my argument. But, his video example is very suggestive, because this example will illustrate well the situation expressed by RPH. Namely, as his example impressively alludes, we are strongly inclined to make a fictitious representation as if we were observing the past, thereby virtually causing the retroactive collapse of probability into 1 through the representation. Thus, RPH might be strengthened by his video example. Well, incidentally, it seems to me that the paradoxical impression given by Schrödinger's cat might be partly derived from our similar fictitious representation as if we were seeing the inside of the box in which a cat is placed. Anyway, determinism about the past necessarily appears in those situations, where paradoxes stand up.

Second, RPH clearly implies some form of BACKWARD CAUSATION in the sense that our present representation is the cause of the collapse of probability in the past, even though in a fictitious way. As I mentioned, Milne and Gillies diagnosed Humphreys' paradox as coming from a ridiculous notion of (partial) backward causation. They are right in a certain sense. Some backward causation really matters in Humphreys' paradox. However, what backward causation is concerned is not in the partial contribution (by 4/5) to produce the past result, but in the overall formation of determinism about the past which provides us with the background to make the partial backward contribution paradoxical. Then, how should we treat this backward causation? Should we abandon it instantly as complete nonsense? Certainly, my argument is consistent with this strategy of abandoning backward causation, since I take the idea expressed by RPH to be a fiction. But, what we should notice is that, if we

[49] Williamson raised this objection on 29th May 2003 when I visited his office at New College of Oxford.

abandon the notion of backward causation altogether, we simultaneously have to abolish the conception of determinism about the past, according to RPH. All are dependent upon how we should estimate the concept of fiction. If we must reject everything fictitious, we have to give up the determinism about the past. Yet, on the contrary, if we accept that our epistemic activities are intrinsically involved in something fictitious, as it were, in the form of metaphysical commitments concerning reality, time and causation, we should face the fact that we are living with having the determinism about the past in a fictitious sense. I think that the latter route is more natural and reasonable. Perhaps, what we should do after accepting the latter route is to be very careful to distinguish those fictitious factors as fictitious when understanding our epistemic activities. In truth, we can regard the fictitious representation in RPH as a sort of counterfactual conditionals such as, 'if we had seen the inside of the box, we would have found an orange can opener.' And, such sort of counterfactual conditionals is quite common for us to use in order to understand a dispositional character of usual physical things like, 'fragile', 'flammable', and so on. Additionally, as is often discussed in the philosophy of freewill, we ordinarily appeal to the conception, 'could have done otherwise', to judge whether a certain person are responsible or not[50]. Obviously, this ordinary conception is also made through a form of counterfactual conditionals[51]. If so, the fictitious representation in RPH shouldn't be instantly refused by reason of being fictitious.

Furthermore, a bit more careful deliberation enables us to notice that even backward causation is actually supposed in some cases. For instance, as Suppes points out, 'it is widely known, and often commented upon, that the basic equation of classical physics remain valid under a transformation from time t to $-t$.[52]' But, of course, this reversibility, or 'this invariance under a change of direction of time.....creates a natural philosophical tension about the nature of causal processes,[53]' for our ordinary causal concepts work only forwards. In any case, we shouldn't ignore that the possibility of backward causation is taken seriously at least in physics. In fact, tachyons or anti-particles are supposed to operate backwards[54]. Presumably, philosophical discussion about backward causation that has become one of indispensable topics in the philosophy of

---

[50] I discussed this problem in Ichinose (2003), pp.1-18.

[51] As to the character of 'could have done otherwise' condition as counterfactual conditionals, it was when I joined the lectures of Martha Klein at Oxford in the Trinity Term of 2003 that I came to realize the necessity to examine it. Her lectures entitled 'Free Will, Moral Responsibility and Punishment' was definitely stimulating and full of insights. I am thankful to her. Also cf. Klein (1990).

[52] Suppes (2001), p.203. Suppes himself firmly believes that causal relation works forwards, and emphasizes that not strongly reversible systems prevail in nature, which reinforces our personal experience to support the commonsense view of forward causation. See Suppes (2001), p.212.

[53] Suppes (2001), p.203.

[54] Cf., Horwich (1987), pp.101-102.

causation since Dummett might be encouraged by the current stream of physics. Moreover, it's even possible to find some examples of backward causation in our ordinary experience rather than theoretical physics. I want to mention an example of apparent motion which Nelson Goodman once discussed in an impressive way. This is a phenomenon in which we fictitiously perceive the motion of flashed spot if two spots short distant from each other are flashed in a certain interval. This phenomenon is actually common in the case of neon signs or pictures of TV. Then, Goodman asks, 'how are we able in the apparent motion to fill in the spot at the intervening place-time along a path running from the first to the second flash *before the second flash occurs?*[55]' Goodman answers that the apparent motion is constructed only after the second flash occurs although seen as running from the first to the second flash. He calls it the retrospective construction theory[56]. Obviously, this could be interpreted as an example of backward causation in the sense that our seeing the second flash causes the past motion of spot from the first flash to the second one. If that is the case, it's reasonable to think that we might be ordinarily involved in a certain form of backward causation, even if it's described as fictitious. Thus, the situation expressed by RPH must be taken to be more than simply fictitious.

7, Newcomb's Problem and Determinism

Now, how should we estimate the status of determinism that appears in RPH? I'm closing my argument by briefly verifying this. I want to mention here another paradox that is as perplexed as Humphreys' paradox, in order only to illustrate my points or make my points stand out. That is, Newcomb's Problem, which is well known since Nozick published it[57]. Here I quote the simplest description that Nozick gave in a later year.

> (Newcomb's Problem)
> A being in whose power to predict your choices correctly you have great confidence is going to predict your choice in the following situation. There are two boxes, B1 and B2. Box B1 contains $1,000; box B2 contains either $1,000,000 ($M) or nothing. You have a choice between two actions: (1) taking what is in both boxes; (2) taking only what is in the second box. Furthermore, you know, and the being knows you know, and so on, that if the being predicts you will take what is in both boxes, he does not put the $M in the second box; if the being predicts you will take only what is in the second box he does put the $M in the second box. First the being makes his prediction; then he puts the $M in the second box or not, according to his prediction; then you make your choice[58].

---

[55] Goodman (1978), p.73.
[56] Goodman (1978),p.81.
[57] Cf. Nozick (1985), pp.107-133.
[58] Nozick (1993), p.41.

It is also well known that a lot of literature on this problem has been piled up, and many views have been proposed. To examine those views is not my aim here. I make only summarized comments for the sake of concluding my argument. Those views about Newcomb's problem include so-called one-boxer (people claiming that we should choose the option (2) as far as we seek as much money as possible), two boxer (people claiming that we should choose the option (1))[59], and other views like no-boxer (people claiming that this problem is incoherent and underdetermined)[60] or Nozick's one (introducing another notion, symbolic utility, to clarify the complicatedness of the problem). Roughly speaking, I think that the viewpoint of no-boxer is a bit too honest to be interesting, since it's quite easy to argue that this problem is incoherent because of including the supernatural being that can predict correctly with an extremely high probability (but probability smaller than 1, otherwise the problem doesn't make sense). The attitude of no-boxer seems to be obstinately refusing any fictitious, or metaphysical, factors. But, such attitude doesn't harmonize with RPH. In fact, as Mackie describes, this problem might include a sort of backward causation in the sense that your choice causes the correct prediction if one-boxer's argument is somehow reasonable. Mackie himself seems to develop a no-boxer argument by mentioning various absurdities drawn from Newcomb's problem, one of which comes from backward causation[61]. However, as I have discussed, it's not necessarily an acceptable attitude to reject backward causation from the outset. Also two-boxer arguments seem to share such attitude with no-boxer in this respect. Those arguments appeal to our intuitive idea that, once the being makes a prediction and determines what is in the second box, the content of the second box is already fixed irrespective of your later choice. The reason why two-boxers think so is simply that the notion of backward causation is absurd, although they accept the setting of Newcomb's problem as possible unlike no-boxers, then offer the choice of two boxes as rational.

I want to emphasize, I don't intend at all to claim that the setting of Newcomb's problem is perfectly reasonable and realistic. There is no doubt at all that this is just a story. But, what I want to pay my attention to here is the fact that this story is possible to understand. We could imagine its situation as if it were actually happening. I wish to bring this understandability into focus. From this point of view, it's not appropriate to estimate Newcomb's problem by presupposing beforehand that notions of the being with supernatural power of prediction and backward causation are ridiculous. Evidently, Newcomb's problem is a kind of thought-experiment to verify our way of making decision, so it's not strange for it to include somehow unrealistic factors. Furthermore, as I said, our ordinary understanding of things is tinged with something

---

[59] Cf. Sainsbury (1995), p.60.
[60] Cf. Campbell (1985), pp.24-27.
[61] Mackie (1985), pp.145-158.

fictitious through dispositional words. In any case, we must say that particularly two-boxer argument is off the crucial point of this problem, since that argument ignores the role of the supernatural being. Then, what about the one-boxer argument? My view is that the one-boxer argument is the most natural and rational as long as we accept the setting of Newcomb's problem as understandable, although it sounds weird in the sense of implying a sort of backward causation. But, how relevant is such my view to the present context?

What we should notice here is that there is an obvious parallelism between Newcomb's problem and Humphreys' paradox. In the case of the original version of Humphreys' paradox, to apply Bayes' theorem and calculate the probability of a particular can opener's having been made by the machine B at 4/5 is nonsense, since the probability has already collapsed after your seeing the orange can opener. The same is true of Newcomb's paradox. To ascribe some probability of the being's having made the correct prediction after your choosing either (1) or (2) must be nonsense. But, as to the modified version of Humphreys' paradox, theoretically speaking, it's perfectly reasonable to apply Bayes' theorem to the grasped can opener to calculate the probability of its having been made by machine B, since the probability hasn't yet collapsed. For the same reason, it's not problematic at all to talk about the probability of the correct prediction before your actually choosing either (1) or (2), particularly if two boxes are not to be seen from the outside as in the modified version of Humphreys' paradox. Contents of box B can't be regarded as having probability 1, in principle. Of course, there is a difference between two puzzles. In Humphreys' paradox, there is mixture of white and orange can openers, so actually nobody knows which can opener you grasp in the box. On the other hand, Newcomb's case presupposes the special being who himself puts nothing or $M in box B, so at least the being definitely (i.e. assigning probability 1) know what is in the box B. But, even though it is the case, the content of box B mightn't be always said to have probability 1, as far as we consider the temporal difficulty of probability 1. Strictly speaking, the same argument is applied to box A if the box A is not to be seen from the outside. At all events, there is nothing irrational to apply the concept of probability to the correctness of the being's prediction before your actual choice.

However, those arguments so far concern only the theoretical aspects. If we practically think, the situation is changed and determinism about the past revives strongly. As I saw along Humphreys' paradox, we are, as it were fictitiously, inclined to think that the colour of the particular can opener has been already fixed and determined when you grasp it before seeing it, and in that stage determinism appears through the retroaction of probability in terms of backward causation according to RPH. A similar point will be true of Newcomb's problem. As a two-boxer argument unintentionally shows, we have a strong tendency to believe that, once the being made his prediction about your choice, the content of box B has been fixed and determined, so your choice has nothing to do with what is in the

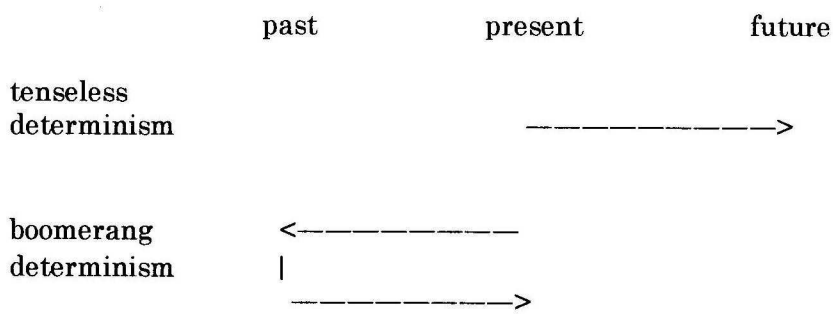
box B. If we accept RPH, this belief could be explained by your imaginary representation as if you had been observing the being's prediction and the content of box B until now. In other words, at the time of your choice or your resolution to choose either (1) or (2), your fictitious representation as if you had seen the prediction and the content of box B CAUSES the probability of the correctness of the being's prediction to RETROACT to the past and collapse into the value 1 or 0. Certainly, backward causation matters here, even if fictitiously. But, as I've already pointed out concerning Humphreys' paradox, backward causation in this context works in the overall formation of determinism about the past, rather than in the partial backward contribution of your choice to the past prediction. Thus, the close parallelism obtains between Humphreys' paradox and Newcomb's problem. In fact, if we suppose that the probability of the correctness of the being's prediction is 4/5 and try to choose (2) expecting $M, conditions of both puzzles would be exactly similar.

Nevertheless, we mustn't overlook a big difference between them. That is to say, Newcomb's problem includes the existence of the being with supernatural power of prediction, while Humphreys' paradox doesn't involve such a purely fictitious element. Thus, if we consider that even Humphreys' paradox is actually eroded by fictitious representations about the past and that there is a parallelism between two puzzles, we should say that Newcomb's problem only makes the core of the relation between probability 1 and the past come to the surface more manifestly. But, strictly speaking, Newcomb's case sheds light on a hidden implication of RPH, which Humphreys' case couldn't explicitly show, by introducing the notion of highly probabilistic prediction of the being. What's that? First of all, introducing such prediction makes it possible for the retroactive collapse of probability through backward causation to stand out vividly, because the concept of prediction grammatically requires a strong (probably causal) connection between an action of predicting and a predicted thing. As far as the structure of Newcomb's problem is exactly similar to Humphreys' paradox, a character of Newcomb's case must be helpful to understand better Humphreys' case and then the problem about the relation between probability 1 and the past in general. Additionally, there is another, more noteworthy point. If we took the viewpoint of the being at the moment he makes a prediction and determines the content of box B (i.e. we needn't consider the temporal difficulty of probability 1), his prediction would have two implications. The first is that the prediction will be true with an extremely high probability, and the second is that the content of box B has been just fixed and determined and he would intend the content to remain the same until your choice, otherwise the setting of the problem wouldn't obtain. I want to focus my attention on the second point. This is nothing but taking the viewpoint to look forward back after looking backward. In other words, first we fictitiously causes the retroactive collapse of probability by looking backward, and then (of course, fictitiously) take the standpoint of looking forward from that past point, which can be drawn from the setting of Newcomb's problem through the

notion of prediction. It is the merit of Newcomb's problem, as far as my question is concerned, that such a perspective as considering the aspect of looking forward back is clearly introduced to RPH.

Well, what does this perspective bring out? This perspective enables us to understand how determinism is extended to the future as well as the past. In fact, I have intentionally avoided so far mentioning the determinism about the future, since it sounds extremely offensive to my ears, although I know that the determinism is often supposed to virtually cover the future by being used tenselessly or timelessly. But, at least to me, it sounds totally implausible to use determinism without considering the temporal factor, for determinism usually concerns natural phenomena in space and time. And, more crucially, I can't imagine at all how we are sure of determinism applicable to any time including the future. Such overall determinism might be unproblematic as our ordinary belief or faith, but to claim it as true is absolutely beyond our capacity by definition. Thus, if we make the determinism about the future associated with such pure tenseless determinism, the situation must be completely hopeless. But, I think that there is another kind of the determinism about the future. That is the determinism which is established through the process of RPH, namely, such the process as we fictitiously cause the retroactive collapse of probability through looking backward and then look forward from that past point to the later time. This process is initially occasioned by the present representation about the past event and then retroacts to the past by regarding that past event as what determined this present situation, therefore a sort of determinism appears here. I think that this determinism can be said to be concerned with the future from the viewpoint of that past which probability retroacts to and collapses at. I call this determinism boomerang determinism in contrast to tenseless determinism. I attempt to illustrate those situations around the determinism about the future in the following diagram, which may be somehow helpful to see my point.

(Determinism about the Future)



In short, I claim that boomerang determinism is the only meaningful option as the determinism about the future, and this is clarified by examining Newcomb's problem. Boomerang determinism starts from a sort of prediction, and, as it were *a prior*, it is qualified to be called determinism, since that is defined to have been already verified by the present representation. In other words, the prediction is confirmed at present and then the prediction became the determinism in a retroactive way. That might sound bizarre. Yet, isn't it natural to characterize the determinism about the future as a sort of prediction? I think it is. And, probably, we also explain why people firmly believe the determinism about the future. That's because boomerang determinism has been always already verified by definition.

However, finally, I have to strongly emphasize that those processes to introduce all-out determinism is thoroughly fictitious, and involved in backward causation which is quite unacceptable without special qualifications. Probability 1 that is intuitively assigned to the past event as expressed by PPE eventually leads to those tricky paradoxical situations. Of course, we always have to make commitment to those fictitious states. But we must also recognize the fact that those commitments make us involved in perplexity about the concept of probability. As a result, we learn a lesson. Let's apply the concept of probability only to the pure future without using the notion of probability 1 and 0 at all (perhaps except the case of metaphor), and we will be exempt from weird complication about probability. Perhaps, on the contrary, the concept of causality is in principle the most appropriate tool for us to deal with past things, since what mostly matters concerning the past seems to be an ascription of origins of things and the language of causation is supposed to stem from our talk of attributing responsibility, whether the connection between cause and effect is perfectly certain or not. In a nutshell, it seems to me that causality leans to the past and probability works towards the future. But maybe, in any case, we can't actually restrict the concept of probability to the future. If so, all that we should do is to let that intrinsically paradoxical nature of probability be engraved on our minds when we use the concept of probability.

*My grateful thanks are due to Professor Timothy Williamson, Professor Hugh Mellor, and Professor Donald Gillies for their most helpful comments about this article that I received when I stayed in Oxford, England, from 2002 to 2003 by using my sabbatical.

References

Ayer, A. J. (1940). *The Foundation of Empirical Knowledge*, Macmillan Press.

Barrett, J. A. (1999). *The Quantum Mechanics of Minds and Worlds*, Oxford University Press.

Berkeley, G. (1951). *De Motu*, in *The Works of George Berkeley, Volume 4*, ed. by Luce,A. A. and Jessop, T. E. Thomas Nelson and Sons Ltd.
Campbell, R. (1985). 'Background for the Uninitiated', *Paradoxes of Rationality and Cooperation*, ed. by Campbell, R. & Sowden, L., The University of British Columbia Press.
Cohen, L. J. (1989). *An Introduction to the Philosophy of Probability and Induction*, Oxford University Press.
Dirac,P. A. M. (1930). *The Principles of Quantum Mechanics*, 1st edition. Oxford University Press.
— (1958). *The Principles of Quantum Mechanics*, 4th edition. Oxford University Press.
Eells, E. (1991). *Probabilistic Causality*, Cambridge University Press.
Fetzer, J. H. (1981). *Scientific Knowledge: Causation, Explanation, and Corroboration*, Boston Studies in the Philosophy of Science, Vol. 69, D. Reidel.
Galavotti, M. C., Suppes, P., and Constantini, D. (eds.) (2001). *Stochastic Causality*, CSLI publications.
Gillies,D. (2000). *Philosophical Theories of Probability*, Routledge.
Goodman, N. (1978). *Ways of Worldmaking*, Hacket Publishing Company.
Heisenberg, W. (1930). *The Physical Principles of Quantum Theory*, Dover.
Horwich, P. (1987). *Asymmetries in Time*, The MIT Press.
Howson, C. and Urbach, P. (1993). *Scientific Reasoning*, Open Court.
Hume,D. (1975). *An Enquiry concerning Human Understanding*, ed. by Selby-Bigge, L.A., Third edition by Nidditch, P. H., Oxford University Press.
— (1978). *A Treatise of Human Nature*, edited by Selby-Bigge, L. A., second edition revised by Nidditch, P. H., Oxford at the Clarendon Press.
Humphreys, P. (1985). 'Why Propensities Cannot Be Probabilities,' *The Philosophical Review* 94.
Ichinose. M. (2003). 'The Chance of Hume's Freedom' *Philosophical Studies* 21, Department of Philosophy, Graduate School of Humanities and Sociology, The University of Tokyo.
Jeffrey, R. C. (1983). *The Logic of Decision*, Second Edition, University of Chicago Press.
Klein, M (1990). *Determinism, Blameworthiness and Deprivation*, Oxford University Press.
Lewis, D. (1986). 'A Subjectivist's Guide to Objective Chance', in *Philosophical Papers, Volume II*, Oxford University Press.
Logue, J. (1995). *Projective Probability*, Oxford University Press.
Mackie, J. L. (1985). 'Newcomb's Paradox and the Direction of Causation', *Logic and Knowledge*, Oxford University Press.
Mellor, D. H. (1995). *The Facts of Causation*, Routledge.
Milne, P. (1986). 'Can There be a Realist Single-Case Interpretation of Probability?' *Erkenntnis* 25.
McCullagh, C. B. (1984). *Justifying Historical Descriptions*, Cambridge

University Press.
McCurdy, C. S. (1996). 'Humphreys' Paradox and the Interpretation of Inverse Conditional Propensities,' *Synthese* 108.
Niiniluoto,I. (1988). 'Probability, Possibility, and Plentitude,' in *Probability and Causality*, ed. by Fetzer, J. H., Reidel.
Nozick, R. (1985). 'Newcomb's Problem and Two Principles of Choices', *Paradoxes of Rationality and Cooperation*, ed. by Campbell, R. & Sowden, L. The University of British Columbia Press.
— (1993). *The Nature of Rationality*, Princeton University Press.
Papineau, D. (2001). 'Metaphysics over Methodology —or, Why Infidelity Provides No Grounds to Divorce Causes from Probabilities,' in Galavotti, Suppes, and Constantini (2001) .
Paty, M. (2001). 'Physical Quantum States and the Meaning of Probability,' in Galavotti, Suppes, and Constantini (2001)
Peirce,C. S. (1986). *Writings of Charles S. Peirce*, vol.3, Indiana University Press.
Polkinghorne, J. (2002). *Quantum Theory: A Very Short Introduction*, Oxford University Press.
Popper, K. (1959). *The Logic of Scientific Discovery*, Harper Torchbooks.
— (1963). *Conjectures and Refutations*, Routledge.
— (1982). *Quantum Theory and the Schism in Physics*, Routledge.
Ramsey, F. (1990). *Philosophical Papers*, ed. by Mellor, D. H., Cambridge University Press.
Sainsbury, M. (1995). *Paradoxes*, Second edition, Cambridge University Press.
Salmon, W. C. (1979). 'Propensities: a Discussion Review of D. H. Mellor *The Matter of Chance*', *Erkenntnis* 14.
— (1984). *Scientific Explanation and the Causal Structure of the World*, Princeton University Press.
Suppes, P. (2001). 'Weak and Strong Reversibility of Causal Processes', in Galavotti, Suppes, and Constantini (2001)
Tooley, M. (1997). *Time, Tense, and Causation*, Oxford University Press.
Williamson, T. (2000). *Knowledge and its Limits*, Oxford University Press.
Zimmerman, D. W. (1998). 'Temporary Intrinsics and Presentism', in *Metaphysics*, ed. by van Inwagen, P and Zimmerman, D. W., Blackwell.