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Article

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THE PROBLEM OF INDEX-INITIALISATION IN THE TEMPO-MODAL SEMANTICS

Summary: In Kripke-semantics for modal logic, the truth value of a sentence depends on the choice of a semantic index (e.g. world, time, or place). It means that application of such semantics to natural language analysis requires indication of an index relevant for semantic analysis. It is commonly accepted that the relevant index is initialised by the context of an utterance. The idea has been rejected by the semanticists investigating tempo-modal languages in the framework of indeterminism, which generated the problem of initialization of the semantic index. I present the main argument of those semanticists and describe several responses to the initialisation problem. I finally argue that under certain metaphysical and semantic assumptions, one can respond to the initialisation failure in the classical way, even in indeterministic contexts.

Keywords: future contingents, semantics of modal languages, context dependence, modal metaphysics.

The truth value of the sentence "It is snowing in Cracow" depends on the time. The truth value of the sentence "There are mountains around" depends on the place. The truth value of the sentence "Pigs fly" depends on what the world is like. When modelling this phenomenon using Kripke's semantics, we postulate that the semantic value of expressions can

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change along with the semantic index. In the semantics of temporal operators, sentences can have different values at different moments. In the semantics of spatial operators, sentences change their truth-value depending on the choice of spatial coordinates. In the semantics of possibility and necessity, sentences can assume different truth-values in different possible worlds. When we work with multimodal language, the semantic index must be rich enough and contain a parameter for the interpretation of each modality: a parameter of world for necessity, a parameter of time for temporal modalities, a parameter of place for spatial modalities etc.[1]

The variability of semantic value of an expression along with a changing semantic index parameter is an essential feature of semantics for modal languages as the function of modal operators is nothing else but shifting an appropriate semantic index parameter. For instance, the operator of possibility changes the parameter of possible world: in a world w, the sentence "Pigs could fly" is true if and only if the sentence "Pigs fly" is true in a world w', accessible from the world w. Similarly, temporal operators change the parameter of time: The sentence "It was snowing" is true at the moment t if and only if the sentence "It is snowing" is true the moment t', which is earlier than the moment t. One can say that within the semantics for modal languages respective parameters of the semantic index must be "mobile".

The classic semantics of quantifier logic has a similar feature; in this case, the changeable parameter is the valuation function. Just as in modal semantics the semantic value of a sentence can change along with a change in the world, in the semantics for quantifier logic the semantic value of the formula $P(x)$ can change along with the changes to the valuation function (a formula can be satisfied by one valuation and not fulfilled with another). The analogy reaches even deeper; notably, as the main function of modal operators is to shift the modal parameter of the semantic index, the main function of quantifiers is to shift (i.e. appropriately change) the valuation function.

[1] In the entire text, I will interpret modal modifiers as sentence operators rather than quantifiers, even though this assumption is disputable (see e.g. King 2003). I assume this rather for the simplicity of exposition than out of deep conviction. I need to stress, however, that the problem of index initialisation discussed in the text arises regardless of the choice of the formal representation of modality.

This is, of course, not a full analogy. On the formal level, it is easy to notice that the valuation function is a much more subtle tool than the possible world. For example, it allows for independent quantification over different variables while the modal operator has only one possible world "at its disposal". The analogy between the semantics of modal operators and the semantics of quantifiers also breaks at the level of application to natural language analysis. Within the language of quantifier logic, there is a common distinction between open formulas and sentences (closed formulas). The difference is that in an open formula there is least one free variable (beyond reach of any quantifier). Most, if not all, sentences of natural language that can be translated to the language of quantifier logic become closed formulas after translation (except for, maybe, sentences like "This is white" where the context does not specify what exactly is meant by "this").

The fact that the typical natural language sentences translate to closed formulas is consequential when we apply logic to the analysis of natural language sentences. An important feature of the quantifier language semantics is that the truth-value of the closed formulas, contrary to the open formulas, is independent of the valuation function. This means that while an open formula can change its semantic value depending on the valuation function (it can be satisfied or not), a closed formula is satisfied with every valuation if it is satisfied with one (and if it is not satisfied with one valuation, then it is not satisfied by any other). The valuation function parameter is the key supporting tool, which makes the recursive definition of the satisfaction function possible, but on the level of assigning semantic values to closed formulas (i. e. sentences), its value ceases to be relevant. Thanks to this characteristic of closed formulas, semantic analysis of the sentences of natural language using the tools of quantifier logic is uncontroversial. Even though, for the sake of uniformity, the valuation function should be indicated to assess the semantic value of a sentence of language, we are not forced to specify which particular valuation function is "right" as the choice of one or another function is irrelevant.

The situation changes drastically if one tries to use modal logic to analyse sentences of natural language. Elementary formulas of the language of modal language represent sentences like "It is raining", "Pigs fly" and their truth-value *depends* on the choice of an appropriate semantic index parameter (world, time, place etc.). Hence, while the choice of valuation function is not relevant to the semantic values of the sentences of quanti-

fier logic, the choice of the possible world, place or time has key influence on the semantic value of sentences like "It is raining".

Thus, anyone intending to use the formal apparatus of modal logic for semantic analysis of sentences of natural language is confronted with the question: which of the modal parameter values should be chosen to assign semantic values to the sentences of ordinary language? I am going to call this question the problem of index initialisation.

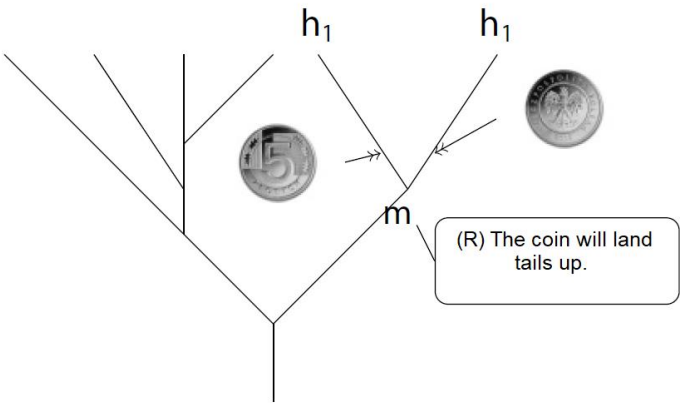
An answer to a problem so stated was outlined already by Kazimierz Twardowski, who addresses a similar issue in his paper *On the So-Called Relative Truths*: "Circumstances accompanying the utterer's words supplement what the words do not express" (Twardowski, 1900, p. 68; translation by Agnieszka Przybyła-Wilkin). In the contemporary literature, the "circumstances accompanying the utterer's words" are usually called context and the "supplementing" Twardowski writes about will be called "index initialisation" by me. Twardowski presents a very natural solution to the problem formulated above: if the truth-value of a sentence depends on the choice of the semantic index parameter, then this parameter is initialised by the context in which the sentence is uttered. Thus, to assign the truth-value to the sentence "It is raining" uttered on top of the Castle Hill in Lvov on the 1st of March 1900 (in our world), one should choose the following parameters: the Castle Hill in Lvov as place, the 1st of March 1900 as time, and our world as possible world. This approach was popularised by David Kaplan, who, in the commentary to his groundbreaking work *Demonstratives*, strongly emphasised the double role of context: as a tool to interpret occasional expressions and as a tool to initialise the appropriate semantic index for interpretation of natural language sentences. (see Kaplan, 1989, p. 595). It seems that, thanks to the support of the context of an utterance, the problem of index initialisation disappeared as quickly as it had appeared. However, not all philosophers are fully satisfied by this answer.

Problem with the World of Context

The answer by Twardowski-Kaplan to the problem of index initialisation has been questioned in the context of semantics created to analyse time-dependent possibilities (possibilities that vanish with time). A good tool to examine these possibilities turned out to be the model of branching histories (or worlds). This model assumes that histories can overlap in an initial interval and then part ways. The history that "branched" in the

past of a given point represents the possibility that was accessible in the past but vanished as the time passed. Such possibility can be exemplified with a history in which the citizens of Great Britain vote for remaining in the EU. It was available before the referendum, which took place on the 23rd of June 2016, but the real development of the referendum annihilated that possibility. Mutual relations between histories can be pictured as a tree, as Figure 1 shows (the first version of the model of branching histories was proposed by Arthur Prior, who was inspired by Saul Kripke's suggestions, see Prior, 1966; 1967; Øhrstrøm, 2012).

Figure 1



The language in which we want to talk about temporal modalities contains temporal operators: "it will be the case that", "it was the case that" as well as the operator of historical necessity: "it is inevitable that". To interpret these modalities, we need two parameters in the semantic index: the parameter of time and the parameter of history (or world). While the initialisation of the time parameter by context does not raise any serious doubt, the initialisation of the history parameter turned out to be much more controversial. Consider a sentence (R) "the coin will land tails up" uttered at the moment m indicated in Figure 1. While it is clear which time is initialised by the context—the time at which the sentence (R) is uttered—it is not clear which history (world) should be initialised. Our answer cannot be analogous—the history in which the sentence (R) has been uttered—because the sentence (R) has been uttered both in the history h_1 and in the history h_2. This fact was emphasised by several authors: "Unlike worlds, histories overlap, so that a single speech

act will typically belong to many possible histories" (Belnap, Perloff, & Xu, 2001, p. 152), "the utterance takes place in many worlds" (MacFarlane, 2008, p. 85). Consider a concrete case in which a sentence is used [...]. There will be many worlds, in general, that represent the very same past and present happenings [...]. The concrete episode of use takes place in all of them." (MacFarlane, 2014, p. 208).

However, if the sentence is uttered simultaneously in a number of different histories, it is not possible to indicate "one history in which the sentence has been uttered". As a consequence, there is no simple method to indicate "the only history of the context", which restores the problem of index initialisation. Semantics requires an indication of an index—of time and of history—to commence the analysis of the sentence "The coin will land tails up", while metaphysics does not allow us to distinguish any index.

We cannot use the argument that helped us with quantifier semantics. Semantics for quantifier logic also requires indication of a certain valuation function to allow semantic analysis of a sentence. Obviously, no such function is determined by the context of the utterance. In the case of quantifier logic, however, it quickly turned out that it does not matter which function we indicate as the semantic value of a sentence (closed formula) is independent on the choice of valuation function. This is not the case here. The semantic value of the sentence "The coin will land tails up" is dependent on the choice of the history parameter. This sentence is true in the history h_1 but false in the history h_2. however, this value is not established by the context. Thus, it turns out that the application of modal logic semantics for analysis of natural language sentences brings about a fundamental difficulty, particularly if we focus—as in our example—on future contingents.

(Post)Semantics of the Future

To tackle this problem, philosophers and logicians suggested a wide array of solutions. The first attempt was made by Arthur Prior who defined the semantics he called Peircean (Prior, 1967).[2] The Peircean theory gives up the operators of possibility and necessity while it enriches the temporal operators with the component of necessity. In ordinary temporal

[2] The name is a reference to the thought of Charles Sanders Peirce, whose writings inspired Prior's solution.

logic, we shall say that the sentence "The coin will land tails up" is true at the moment m if and only if the sentence "The coin is landing tails up" is true at the moment m' later then m. Peircean semantics modifies this condition, saying that:

> The sentence "The coin will land tails up" is true at the moment m iff in every history the moment m belongs to the sentence "The coin is landing tails up" is true in a moment m' later than m. Otherwise, it is false.

Thus, the difficulty with indicating the right history is solved by quantifying over all histories, which results in the operator "it will be the case that" containing a component of necessity "it is inevitable that it will be the case that". Such an alteration of meaning, however, makes the Peircean semantics a worse tool for the analysis of grammatical tenses. For instance, in Peircean semantics, before the coin toss, the sentence "The coin will land heads up or tails up but it will land neither heads up nor will it land tails up" ($F(p \vee q) \wedge \neg Fp \wedge \neg Fq$) is true, even though it sounds like a contradiction. To see that, one just needs to look at the model depicted in Figure 1. The sentence $F(p \vee q)$ is true at the moment m because in each history going through m, there is a later moment in which it is true that the coin lands heads up or tails up ($p \vee q$). At the same time, both sentences Fp and Fq are false at the moment m because the coin does not land tails up in all histories and does not land heads up in all of them.

Another suggested solution to the index initialisation problem is to adapt Łukasiewicz's trivalent logic to the models of branching histories.[3] In this adaptation we will say that:

> The sentence "The coin will land tails up" is true at the moment m iff in each history the moment m belongs to, the sentence "The coin is landing tails up" is true at a moment m' later than m.
>
> The sentence „The coin will land tails up" is false at the moment m iff in each history the moment m belongs to, the sentence "The coin is landing tails up" is false at every moment m' later than m.

[3] Interestingly, Prior introduced his tense logics—Peircean and Ockhamist—as an answer to Łukasiewicz's trivalent logic, which he had earlier defended. However, Prior's logics were hard to accept for Łukasiewicz because the logical operators present in them are extensional.

> Otherwise, the sentence "The coin will land tails up" assumes the third truth-value.[4]

The fundamental difficulty of the trivalent semantics, however, is the fact that the sentence "The coin will land tails up or it will not land tails up" is assigned the third truth-value while we intuitively deem it true.[5]

An innovation allowing us to solve this problem is Richmond Thomason's (1970; 1984) semantics of supervaluations. In this solution, Thomason employs two kinds of valuations simultaneously. Basic bivalent valuations assign classic truth-values to sentences in relation to the moment/history pairs and supervaluations assign truth-values to sentences in relation to moments only, according to the pattern explained below. The supervaluation technique allows for introduction of (super)truth-value holes while keeping the tautologies of classical, modal, and temporal logic. Thomason's solution was inspired by the work of Bas van Fraassen (1966).

Analysing Thomason's solution, John MacFarlane (2003) identifies the (super)truth at a moment with truth at the context and the truth in the pair moment/history with truth at the index. He argues that the latter notion has only a supporting function. Its purpose is to clarify the earlier one, which should model our immediate intuitions concerning the truth-value of sentences uttered under concrete circumstances. MacFarlane calls the theory connecting the notion of truth at the context with the notion of truth at index "postsemantics". In this terminology, postsemantics of supervaluations addresses the problem of index initialisation as follows:

> The sentence "The coin will land tails up" is true at the context m iff it is true at every index $\langle m, h\rangle$ where m is an element of h.
>
> The sentence "The coin will land tails up" is false at the context m iff the sentence "The coin will not land tails up" is true at the context m.
>
> Otherwise, the sentence "The coin will land tails up" lacks the truth-value at the context m.

[4] This is a definition proposed by John MacFarlane (2014, ch. 9.6); an alternative definition, preserving the extensionality of all operators, can be found in (Wawer, 2016, ch. 4.4).

[5] Notably, Łukasiewicz himself agrees in his *On determinism* that we should assess this sentence as true (see Łukasiewicz, 1961, p. 124).

If we apply this definition to the example in Figure 1, it turns out that at the context m the sentence "The coin will land tails up" is neither true nor false. At the same time, the sentence "The coin will or will not land tails up" is true at the context m (as it is true in every history running through m).

A problematic consequence of the semantics of supervaluations is the fact that the classic logical connectors (like disjunction) are not extensional at the context. In the above example, an alternative of two sentences without truth-value is true but we can easily find examples where an alternative of two such sentences has no truth-value. For instance, if I make a wager that the coin will land tails up, the disjunction "The coin will land tails up or I will win the wager" has no truth-value.

Another problem of the semantics of supervaluations, particularly stressed by MacFarlane, is that although the sentence "The coin will land tails up" has no truth-value at the context m, at the later context m', which belongs to the history h_1, the sentence "It was true that the coin would land tails up" is true. MacFarlane states that this characteristic leads to counterintuitive consequences. MacFarlane's objection is very subtle and has changed its form over time (see MacFarlane, 2003; 2008; 2014). Therefore, I will not delve into details here. A summary of the discussion can be found in Wawer 2016, ch. 4.6.

MacFarlane's answer to the problems of postsemantics of supervaluations is his own assessment relativism. According to this theory, the semantic value of a sentence should be established upon consideration of not only the context of the utterance, but also the context of assessment.

Coming back to our example, the sentence "The coin will land tails up" uttered at the moment m has no truth-value when assessed in the context m; when assessed in a later context within history h_1, it is true; when, in turn, assessed in a later context of the history h_2, it is false. This effect is achieved by MacFarlane thanks to the following definition:

> The sentence "The coin will land tails up" is true at the context of utterance m and the context of assessment m' iff it is true at every index $\langle m, h\rangle$ at which m' is an element of h.
>
> The sentence "The coin will land tails up" is false at the context of utterance m and the context of assessment m' iff the sentence "The coin will not land tails up" is true at this pair of contexts.

> Otherwise, the sentence "The coin will land tails up" has no truth-value at the context of utterance m and context of assessment m'.[6]

MacFarlane makes a case for his semantics by referring to our intuitions on accuracy of utterances. He argues that the act of uttering "The coin will land tails up" is not accurate before the coin toss, while after the toss in which the coin has landed tails up, that very same act of uttering is accurate (or, more precisely, was accurate). This can be explained by indicating that the sentence uttered before the toss is not true in the earlier context of assessment but is true in the later one (assuming that the truth is a necessary condition of the utterance's accuracy, i.e. truth is a norm of assertion). I have a number of doubts concerning both the diagnosis and the treatment proposed by MacFarlane. Commenting on my doubts, however, would take us too far away from our main point; I will therefore leave this comment for another occasion and move on to one more reaction to the problem of index initialisation.

This reaction is presented by Belnap, Perloff and Xu (2001, ch. 6C). According to them, asking for the semantic value of the expression "The coin will land heads up" at the context m is simply nonsense. They compare the expression "The coin will land heads up" to the formula "x is white". Just as in the latter case there is no sense in asking whether the formula is fulfilled without indicating a valuation, it makes no sense in the earlier one to ask about the truth of the expression without indicating a suitable parameter of history. On the other hand, when we do indicate the suitable parameter, the answer is simple: "x is white" is true with respect to a valuation that ascribes snow to "x" and "The coin will land heads up" is true when we choose a history in which the coin lands heads up as a parameter of evaluation. Thus, we can think of the expression "The coin will land heads up" as a formula containing a free variable ranging over the set of histories. One can assume that the deep structure of this expression actually has a form "In the history h the coin will land heads up", where h is a variable.

What causes my uncertainty towards such an analysis is the fact that we do not usually think of the expression "The coin will land heads up" as a sentence function, which changes its value depending on the arbitrarily chosen value of the parameter h. We rather consider this expression

[6] If there are no histories containing both m and m', the truth-value at the pair of contexts is reduced to supertruth at the context m.

a full-fledged sentence, which, after specifying the moment of utterance, is truth-apt. In everyday practice, we do not even get the idea that the sentences we utter about the future cannot be ascribed a truth-value unless one of the possible future histories has been indicated (not to mention that it is not quite clear what the indication of a possible history should look like).

Moreover, while no sensible person will use the expression "x is white" to communicate a thought, we do not have problems using sentences like "The coin will land heads up" or "Next week I will be in Lublin". One of the explanations of the lack of analogy is that (contrary to Belnap's argument) in the first case, one cannot sensibly ask for the truth-value of these expressions, while in the other two one can do it. Belnap, Perloff and Xu (2001) propose an alternative explanation to this discrepancy (this answer is discussed in more length in [Belnap, 2002]). They believe that the difference on the pragmatic level—we assert sentences about future, we do not assert open formulas—stems from a different *modal profile* of the two cases. Even though the formula "The coin will land tails up" is neither true nor false, it will *have been decided* in the future that the sentence was true or it will *have been decided* that it was false.[7] One can say that over time, a sentence uttered today becomes independent of the choice of history parameter, which makes it usable in the language practice. However, instead of a detailed description of Belnap's ideas, I will suggest an alternative answer to the index initialisation problem.

The Possibility of Futurism

Contrary to the well-established opinion among the researchers of branching histories, I will argue that one needs not reject the natural interpretation of temporal operators or change logic to answer the problem of index initialisation. I believe there is no reason not to refer to the context as a source responsible for establishing both the time and the history, even considering the undetermined future. I will opt for Twardowski-Kaplan's conservative answer to the index initialisation problem.

I think that the impression that the model of branching realities precludes the traditional solution to the problem of index initialisation stems

[7] This observation of Belnap's inspired MacFarlane to create the assessment relativism.

from a very special interpretation of this model, which I call "branching realism". According to this interpretation, alternative histories in some ways resemble David Lewis's possible worlds (see Lewis, 1986). Like Lewis's worlds, all histories are equally real and metaphysically on par with the history (or histories) we belong to. All histories consist of concrete events and none of them is metaphysically distinguished. Moreover, just as the inhabitants of each of Lewis's worlds can rightfully say about their world that it is the actual world, the inhabitants of every point in the tree can rightfully say that their situation is actual.

Although the theorists of the branching model try to avoid unequivocal metaphysical declarations, many of them suggest that their reflection is based upon such realism. One of the branching theory classic authors, Richmond Thomason, writes:

> Consider two different branches, b_1 and b_2, through t, with $t < t_1 \in b_1$ and $t < t_2 \in b_2$. From the standpoint of t_1, b_1 is actual (at least, up to t_1). From the standpoint of t_2, b_2 is actual (at least, up to t_2). And *neither standpoint is correct in any absolute sense.* (Thomason, 1984, p. 145, emphasis added)

Then he adds:

> See D. Lewis (1970), and substitute "the actual future" for "the actual world" in what he says. *That* is the view of the thorough-going indeterminist. (Thomason, 1984, p. 145, note 14, emphasis in original)

Belnap, Perloff and Xu write in a like spirit:

> To suppose that there is one from among the histories in *Our World* [as the authors call the branching model—J. W.] that is the absolutely actual history is rather like purporting to stand outside Lewis's realm of concrete possibilia and pointing to the one that is actual. But this is wrong in both cases. (Belnap, et al., 2001, p. 163)[8]

Some statements by John MacFarlane also suggest modal realism:

> There is nothing in the branching model that corresponds to a car moving along the branching road, and nothing that corresponds to the decision the

[8] There is also a realistic overtone to their definition of "Our World", which can be found in Belnap, et al., 2001, pp. 139–140.

> car will have to make to go down one branch or the other. If worlds branch, then *we branch too*. (MacFarlane, 2014, p. 212, emphasis in original)

A similar metaphysical vision transpires from the semantic objections by Belnap and MacFarlane cited above. The authors agree that a concrete utterance is a part of many different histories/worlds. Such vision is also suggested by Figure 1. The image shows the utterer as an inhabitant of a tree whose all parts are as real as the speaker and their utterance.

It is worth noting here that the realism of branches is in some significant ways different from David Lewis's realism of worlds. First of all, histories (lines in a tree) overlap while Lewis's worlds are disjoint. It is, however, noteworthy that Lewis's attitude to overlapping worlds is not unequivocally critical. He believes that the worlds so understood are in opposition to some common-sense statements (Lewis, 1986, pp. 207–208; incidentally, I believe that Lewis is wrong in this respect). However, he also notices that realism so understood can relatively easily solve problems with which he himself had to struggle (such as the problem of transworld identity, see Lewis, 1986, p. 209). He also adds that

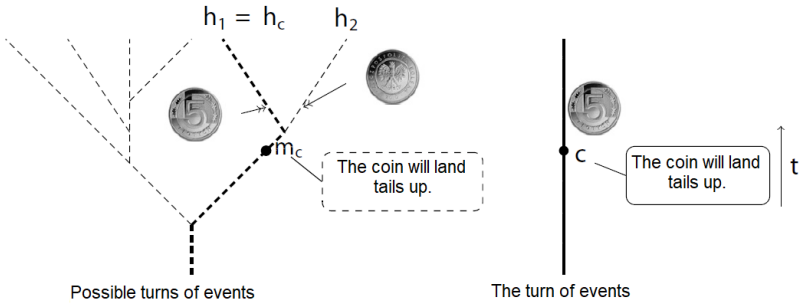
> Overlap spoils the easiest account of how worlds are unified by interrelation: namely, the mereological analogue of the definition of equivalence classes. But alternative accounts are available [...], so I presume that a modal realist who wished to accept overlap would not be in serious difficulty on this score. (Lewis, 1986, p. 209)

The realists advocating branches also distance themselves form some of Lewis's views (see esp. Belnap, et al., 2001, ch. 7A.6) but in general, they have more similarities than differences. In particular, they agree that an absolute distinction between the actual and the possible is wrong. They believe that each possibility is actual from its own perspective and none of the modal perspectives are distinguished.

This is, however, not the only available interpretation of the structure of branching possibilities. Instead of accepting Lewis's vision of possibility, one can join Adams (1974), Plantinga (1976) or Kripke (1980) and accept some form of modal actualism. From the point of view of our problem, the key aspect of modal actualism is the postulate of *absolute*, i. e. not only relative, distinction between the actual and the possible. Contrary to what Lewis states, possible worlds are not metaphysically similar to the world we live in. The world which we belong to is an entity of a different nature—an entity that *realizes* one of the possibilities. With such an ap-

proach, the branching model is a visualisation of *possible* temporal evolutions of our world, yet these possible evolutions are fundamentally different from the world we are part of. Importantly, while possibilities branch over time, the world does not have a branching structure like this. It evolves in a linear manner and with time, it fulfils one of the possibilities available.

Figure 2



When we adopt such perspective, the problem of index initialisation is seen in a completely different light. We cannot say, like the modal realists, that a specific act of uttering is a part of many possible histories. Utterances do not occur in possibilities but in the concrete reality. Every such utterance is a part of only one world ("our" world). This situation is visualised by Figure 2. The line on the right shows all the events that have occurred, are occurring and will occur in our world while the tree on the left shows all possible courses of events. One of the possible courses of events is, of course, the way events have actually turned out and will turn out (the world evolves in a "consistent" manner, realizing only one of the possibilities). I marked this possibility with a bold line.

Such take on the relation between the actual and the possible allows for a completely different answer to the problem of index initialisation. Contrary to what Belnap and MacFarlane say, the utterance of the sentence "The coin will land tails up" does not take place in many different histories/worlds. The utterance occurs in exactly one world, which allows us to return to the standard answer to the index initialisation problem: the world of context is the world in which the utterance takes place. More precisely, the world/history indicated by the context is the only possible history accurately representing the way the world was, is and will be.

Since the world evolves in exactly one of the possible ways, it is guaranteed that there is only one history that accurately represents this evolution. This is the history that should be chosen as the history of context. On the intuitive level this comes down to the trivial observation that the sentence "The coin will land tails up" is true if and only if the coin actually will land tails up in the future, which can be more formally presented in a form of a statement I call "futurism":

> The sentence "The coin will land tails up" is true in the context c iff it is true at the moment of context m_c and at the history of context h_c.

The moment of context is by default the present moment and the history of context is by default the actual history. One can, therefore, answer to the problem of index initialisation in the conservative style of Twardowski, even if the sentence analysed is a future contingent. However, in order to do this, we need to refer to the metaphysical principle of actualism: that the world which we belong to (and in which we utter sentences) is metaphysically of a different nature from the *ways* the world can evolve. When adopting such assumption, we can defend our argument against the objections of modal realists, raised against the notion of the world of context.

I achieved the connection between the metaphysics of actualism and semantics through observation that acts of uttering are a part of one specific world, which differs in nature from the possible evolutions. One can, however, object to this statement as follows: even the actualists, who distinguish metaphysically between actuality and potentiality, often accept a paraphrase of modal sentences in categories of possible worlds. Moreover, they will not have a problem accepting the statement that some utterances that never have taken place and never will take place, could have taken place. For instance, Senator Elizabeth Warren could have backed Bernie Sanders in the 2016 Democratic Party Presidential Primaries, yet she did not. Thus, even actualists are eager to admit that there is a possible world in which Elizabeth Warren utters the sentence "I shall do everything for Bernie Sanders to become the next president of the USA." Therefore, contrary to what I stated above, even within actualism, utterances are present not only in our world, but also in the possible worlds. If this, in turn, is true, our world has not the exclusive right to

utterances and so it cannot be used to solve the semantic index initialisation problem.[9]

One can answer a difficulty put that way in one of two manners: elitist or egalitarian. In the earlier strategy, we focus on the special status of our world and negate the statement that any utterances occur in any other possible worlds (this is the strategy I suggest in [Wawer, 2014]). The statement that there is a world in which Senator Warren says anything is, after all, just a useful *paraphrase*, or *metaphor*. What is paraphrased depends on the specific version of modal actualism. The statement that there is a possible world in which Elizabeth Warren says "A" could be, to name a few examples, be understood as follows:

- Elizabeth Warren could have said "A".
- E.W. had a disposition to say "A".
- There is an (abstract) non-contradictory set of propositions that represents E. W. saying "A".
- There is an (abstract) maximal state of affairs, part of which is E. W. saying "A".
- There is an (abstract) way the world could have been within which E. W. says "A".

What is important to us is that *none* of these paraphrases suggest that besides specific acts of utterance, which take place in our world, there are similar acts occurring in other worlds. For instance, the proposition that E. W. utters the sentence "A" is an entity radically different in its nature from a real utterance of the real E. W. Therefore, we need not be troubled with the acts of utterance taking place in other worlds as, literally speaking, such acts do not exist (there are only states of affairs or propositions representing such acts, dispositions to such acts, possibilities of such acts occurring etc.). Our task was to indicate a mechanism that connects a specific utterance with a suitable semantic index relevant for the semantic interpretation of this utterance. Since utterances take place only in one world, we have a full guarantee that the context of the utterance will establish the appropriate semantic index (actual history and present time). An elitist actualist of this type must, of course, face the obvious observation that E.W. could have said "Bernie Sanders will be

[9] I thank an anonymous reviewer for raising this objection.

the next president", or even that E. W. could have truly said "Bernie Sanders will be the next president". However, the analysis of the sentence "E. W. could have truly said 'Bernie Sanders will be the next president'" does not require us to assume that in some other place, E. W. really utters the sentence "Bernie Sanders will be the next president" (a proposed analysis of reports of utterances embedded within reach of modal operators can be found in [Wawer, 2016, ch. 6.3.6]).

One can also propose a more egalitarian, conciliatory line of answer to the difficulty outlined above. In this strategy, we approach the possible utterances more sympathetically and agree that every such utterance can be *treated as if* it was factual—or, more precisely, only the factual utterances take place but one can assume, or imagine, that a given utterance is factual and formulate a problem analogous to our index initialisation problem: Assuming that Elizabeth Warren indeed says "Bernie Sanders will be the next president", which of the histories running through this possible utterance should be used for the semantic analysis of her utterance? The problem might seem very acute as I have argued earlier that it is the particular, factual world and its turn of events that establishes the possible history relevant for the process of semantic analysis and in our example I explicitly assume that E. W.'s utterance is not a part of this world (E. W. never actually uttered these words). Thus, the possible situation of utterance "lacks a world" that could help us establish the appropriate semantic index.

I believe that a difficulty of this type stems from a misunderstanding whose root is a kind of doublethink: on one hand, we treat the utterance of E. W. as if it was factual while on the other hand, we stress that it is merely possible. This kind of vision is indeed problematic and leads to controversial conclusions.[10] Nevertheless, an actualist need not, or even should not adopt it. If we prefer the egalitarian approach to the branching model, we decide to assume that every possible situation can be the context of utterance. Still, in this case we should remember that when treating a given possible situation as the context, we must also assume that this situation is actual and, as such, it is a part of the actual course of events, which realizes one of the temporal possibilities available at the moment of utterance. If it is so, then the semantic index can be initialised

[10] Notably, this very kind of doublethink is spread among the critics of actualism in the context of the branching model, such as Nuel Belnap or John MacFarlane.

in the exact same way as we initialise it in the case of actual utterances. The time of context is the present time of the utterance and the history of context is the history that will be satisfied by the course of events containing the considered utterance. Hence, whether we adopt the elitist or the egalitarian attitude to the possible utterances, we reach a conclusion that when analysing semantically the utterance used in the given context, we must treat it as a part of the actual world and therefore, we can refer to this world to establish the appropriate semantic index.

It is worth noting that accepting Kaplan's traditional solution to the index initialisation problem, we take one side of the conflict going back to the ancient times about the truth-value of the future contingents. In the (post)semantics presented above—futurism—every sentence has exactly one of the two truth-values and future contingents can be true. I do not want to say that an actualist is forced to adopt this solution; they can decide to adopt one of the (post)semantics presented earlier and refuse to use the notion of the world of context instead. However, I believe this is a decision of a semantic, and not metaphysical, nature.

One should mind that when choosing one of the histories as the history of context, I indicated the history that "accurately represents the way the world was, is and will be". Consequently, in order to establish the truth-value of the sentence uttered in the given context, I implicitly referred to the past and future states of the world. Actualism guarantees that at every moment of the time, there is (was, will be) one such state. However, to use this state to our needs, we have to assume that we can refer to it when establishing the truth-value of an expression. I call this assumption "semantic transtemporalism". According to this statement, the truth-value of the sentence "At the time t, φ" assessed at the time t' depends on the way the world is (was, will be) at the time t, not the way it is at the time t'.

I believe the subject of the famous conflict between Kotarbiński (1913) and Leśniewski (1913) was in fact the question of justification of transtemporalism. Kotarbiński rejects this idea while Leśniewski defends it. Kotarbiński seems to have been swayed by Leśniewski's arguments but his way of thinking about the relation between truth and time was continued by Łukasiewicz.[11] Łukasiewicz persistently stood by localism, arguing that in order for the statement "At the time t' the coin lands tails up"

[11] It is not certain if Kotarbiński inspired Łukasiewicz in this matter or just on the contrary (see Woleński, 1990).

to be true at the time t, there must be conditions at the time t that *decide* that the coin lands tails up at the time t'. If t' is later than t, these conditions may be e. g. the angle or the force of the coin toss, as long as they combined guarantee the coin's landing tails up. If t' is earlier than t, the conditions are the traces left by the coin landing tails up (e. g. memories). If at the time t there are no conditions that guarantee the truth or falsity of the given sentence, it cannot assume any of the classic truth-values. This view is expressed by Łukasiewicz as early as 1922 (see Łukasiewicz, 1961, p. 122) and repeated by him in an almost unchanged form not long before his death (see Łukasiewicz, 1957, pp. 154–155).

This is, however, not the only way of thinking on the relations between truth and time. One can argue, in accordance with Leśniewski, that the truth-value of the sentence "At the moment t' the coin lands tails up" at the moment t should depend on what the state of the coin was or will be at the moment t' and not on the state the coin is in at the moment t. Not wanting to delve into the discussion of advantages and disadvantages of the two approaches here, I will only stress that I do not think transtemporalism should be in the losing position here.

Summing up, the traditional solution to the index initialisation problem is not excluded even for the tempo-modal semantics modelling indeterministic situations. However, a condition of applying this solution is to assume the metaphysical actualism and semantic transtemporalism. These are real commitments that one should be aware of. Nevertheless, I believe that when classical logic and a natural analysis of tempo-modal language is at stake, adopting these views is not too high a price.

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