

FAKE NEWS LOGIC

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ABSTRACT. In this paper, we attempt to combat some of the confusion surrounding FAKE NEWS by providing a formal logical framework to encode and evaluate statements in a consistent manner. We expand the typical language for epistemic logic language with two novel modalities, FN and AF , and provide semantics for both. We demonstrate that this language stands in accord with typical instances that we are trying to capture, and model the tragic *Bowling Green Massacre*. Lastly, we briefly indicate how one should think about axiomatizing this logic.

1. INTRODUCTION

In late 2016, the problem of FAKE NEWS was brought to the attention of the public by the *corrupt media*.¹ The *corrupt media* claimed wildly and without base that several forms of social media had witnessed the arrival of a multitude of sites publishing FAKE NEWS for a profit. Most thankfully, the record was set straight with the arrival of new executive leadership, henceforth referred to as the d. The d rescued the term and restored its status as a descriptor of all major news outlets – that is, the *corrupt media*. However, many have most unfortunately misinterpreted his decrees regarding FAKE NEWS. In this paper, we address this misinterpretation by formalizing his commentary in a modal logic, thus dispelling the provably false claim that the d was, or ever could be, wrong.

We expand the language of epistemic logic, \mathcal{L}_{EL} , to the language of FAKE NEWS, \mathcal{L}_{FN} . We motivate the informal interpretation of the expansions with important phenomena, and distill these interpretations into a formal semantics for what we call *FAKE NEWS logic* (FNL). We apply these semantics to model a well-known scenario, and consider what might be involved in designing a sound and complete logic for the language.

2. LANGUAGE AND SEMANTICS: IDENTIFYING FAKE NEWS

We begin with standard epistemic logic, which takes as given a countable set of propositions, Φ , and a finite set of agents, G . Since we are only concerned with the knowledge statements of one individual, the d, G will be the singleton $\{d\}$. The language of epistemic logic, \mathcal{L}_{EL} , is generated inductively:

¹The term was first brought to the fore by Mark Zuckerberg in an inspirationally unempathetic remark in response to the problem of pervasive misinformation. See here.

$$p \in \Phi \mid \neg\varphi \mid \varphi \wedge \psi \mid K_d\varphi$$

Recall that formulas are evaluated in models at worlds. A model $M = \langle W, \sim_d, V \rangle$ consists of the following:

- A set of possible worlds, W .
- An epistemic relation over these worlds, $\sim_d \subseteq W \times W$. $(w, w') \in \sim_d$, sometimes writted as $w \sim_d w'$, should be read as ‘from w , the d has epistemic access to w' ’.
- An evaluation function $V : \Phi \rightarrow 2^W$, which assigns to every proposition p a set of worlds JpK_d where the proposition is true. This evaluation will be extended in a coherent way to the entire language via the semantics given below.

p is true at w in M just when $w \in [p]_d$, written $M, w \models p$.² We note immediately that standard semantics for the K operator will not suffice for present considerations. Typically, $K_d\varphi$ is true in a pointed model M, w when for every other world, w' , epistemically accessible by d from w , it is the case that $M, w' \models \varphi$. However, it occurs frequently that the assertion $K_d\varphi$ is handed down from above when it is commonly known that at *no* possible world is φ true. Thus, maintaining typical semantics for the K operator would require that we render the epistemic access relation, \sim_d , empty; we disregard this possibility and offer the alternative semantics for K_d .³

$$(M, w) \models K_d\varphi \text{ iff for some } w' \text{ in } M, w \sim_d w' \text{ and } (M, w') \models \varphi$$

Note that this is simply the dual of the typical semantics for K_d , read as, ‘the d knows that φ is true if d has access to at least one world where φ is true.’ We find this reading of the K operator to be a faithful translation of the statements under consideration.

Importantly, this reading of the K operator allows for the d ’s frequently contradictory proclamations of knowledge; were we to preserve the semantics of the K operator, if \sim_d were nonempty then our logic would reduce to triviality.⁴⁵

We write $[\varphi]_V$ for any $\varphi \in \mathcal{L}_{EL}$ to denote the set of worlds at which φ is true according to V and the given semantics.

It will be worthwhile presently to identify some of the properties of \sim_d . Firstly, it is clear that \sim_d is not reflexive, as no evidence guarantees that the d has any access to the actual world. Indeed, since all utterances of the d seem to engage with a different reality, we characterize \sim_d as *anti-reflexive*: $(\forall w \in W)(w \not\sim_d w)$.

²We endorse a typical abuse of notation by saying ‘ w in M ’ instead of ‘ w in W ’.

³If \sim_d were empty, this would mean that the d has access to *no* possible worlds. Clearly, this is an interesting and plausible possibility that should be explored; we disregard this possibility here because the tools offered by epistemic logic are not suitable to such an investigation.

⁴Again, this is a possibility which merits further investigation – indeed, there is much reason to suspect that any formal characterization of the d ’s language should reduce to triviality – but we set this aside for another discussion.

⁵For an incomplete listing of contradictions, refer to this article.

This is supported by several decrees from the d. We posit furthermore that the d has no *extended access* to the actual world, either. That is, there is no chain of worlds w, w', w'', \dots such that $w \sim_d w' \sim_d w'' \sim_d \dots \sim_d w$. Thus, we stipulate that \sim_d is a *acyclic*.

We now turn to our additions to the language, the modal operators FN and AF . We begin with FN . FN should, intuitively, apply only to formulas which are regarded as FAKE NEWS from the present world. Furthermore, we claim that FN should apply only to *propositions*: what the d knows or doesn't know is not subject to discussion – especially not by the *corrupt media*.⁶ While FN will be designed to apply only to propositions, we may informally regard it as applying to boolean combinations of propositions, too.

We first note that FN stands in a close relationship with the modality K_d . In particular, if the d does not know p , then p is FAKE NEWS. Formally, this is stated as follows

$$(M, w) \models \hat{K}_d \neg p \text{ implies that } (M, w) \models FNp$$

The novel component of FAKE NEWS, however, is that *it includes anything disliked by the d*. Formalizing this essential information will require a minimality condition on the set of propositions, Φ .⁷

For every proposition p in Φ , there is the proposition $l_p \in \Phi$

We read l_p as ‘the d likes p’. The valuation function V now acts on this expanded set; $M, w \models l_p \wedge p$ denotes, for instance, that p is true at w and the d likes that. The additional sufficient condition for FN may be informally stated as follows: if the d does not like p and has the conceptual capacity to regard p as an active possibility, then p is FAKE NEWS. Formally:

$$(M, w) \models \neg l_p \wedge K_d p \text{ implies } (M, w) \models FNp$$

These are the only conditions under which FNp will be true at a world. Note that when taken together, these conditions imply that the necessary and sufficient condition for FNp is just $\neg l_p$ – as desired, p is FAKE NEWS just when the d does not like p .

We now turn to the second notion we represent in our language, that of *alternative facts*. This concept was first introduced by one of the d's top henchpersons in defense of a proclamation made by one of the d's meeker and less articulate henchpersons: “You’re saying that it’s a falsehood and... [we] gave alternative facts to that.”⁸ We interpret this comment to point to the d's metaphysical take on truth: the d – and by extension, his underlings – subscribes to the belief that truth is a purely linguistic artifact; that there are no external and independent facts to which true utterances correspond. Alternative facts are introduced, then, to capture this flexibility of truth – any statement which *could* be

⁶Indeed, it has been observed that even the d's underlings are hesitant to make any declaration regarding the d's epistemic state.

⁷Note that this minimality condition does not increase the cardinality of Φ .

⁸Witness the exchange here.

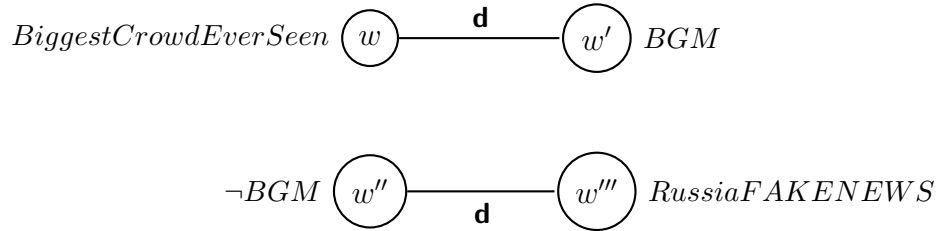
regarded as truthful according to some linguistic scheme may be regarded as an alternative fact. We introduce the modality AF with the following semantics:

$$M, w \models AF\varphi \text{ iff there is some } M', w' \text{ such that } M', w' \models \varphi$$

In words, $AF\varphi$ holds at a world if there is some model and some world that satisfy φ ; or, φ is not a contradiction. The permissive nature of this concept captures the sort of semantic freedom exercised by the d. Note that alternative facts are independent of worlds and models; their assertion relates in no way to *local* circumstances.

We name the language of epistemic logic, \mathcal{L}_{EL} expanded with the operators FN and AF , the language of FAKE NEWS logic, \mathcal{L}_{FN} . To demonstrate its utility, we capture a well-known phenomenon relating to the matters of FAKE NEWS.

The tragic *Bowling Green Massacre* was despicably underreported by the *corrupt media*, until brought to light by the same top henchperson who introduced alternative facts.⁹ The national concern over the matter was captured with the tweet, “The real lesson from Bowling Green. Who will cover? Who will care?”¹⁰ We model the situation of the Bowling Green Massacre (BGM) as follows:



We leave the interpretation of this model (in particular, the undirected edges) up to the reader.

In closing, we provide some considerations towards the construction of a sound and complete logic for this language. Clearly, the K operator may be easily axiomatized. The FN operator may also be easily axiomatized, if a relation is introduced to the language to capture the correspondence between propositions p and l_p . However, the AF operator is difficult to capture, as its truth conditions include metatheoretic requirements. The difficulty is in importing such requirements into a syntactic setting, without significantly strengthening the language. We propose that this particular difficulty is not a mark *against* our characterization, however. Indeed, we think that any faithful description of these phenomena will render impossible any kind of coherent corresponding derivation system; such a system would undermine the very flexibility of truth which is so essential to the d’s public image.

⁹We send our thoughts and prayers to those whose attempts to stifle cultural diversity were thwarted by the unfair and baseless allegations that the Bowling Green Massacre never occurred.

¹⁰This tweet may be found here.