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:

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[1]The term was first brought to the fore by Mark Zuckerberg in an inspirationally unempathetic remark in response to the problem of pervasive misinformation. See https://www.forbes.com/sites/kalevleetaru/2017/02/17/did-facebooks-mark-zuckerberg-coin-the-phrase-fake-news.

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

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 $V : \Phi \to 2^W$, 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 $M, w \vDash p$.[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 $M, w' \vDash \varphi$. 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]

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

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*: $(\forall w \in W)(w \not\sim_d w)$.

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[2] We endorse a typical abuse of notation by saying 'w in M' instead of 'w in W'.

[3] If $\sim_d$ 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.

[4] Again, 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.

[5] For an incomplete listing of contradictions, refer to `http://www.politico.com/magazine/story/2016/05/donald-trump-2016-contradictions-213869`.

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 $w, w', w'', \ldots$ such that $w \sim_d w' \sim_d w'' \sim_d \ldots \sim_d w$. 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

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

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]

$$\text{For every proposition } p \text{ in } \Phi, \text{ there is the proposition } l_p \in \Phi$$

We read l_p as 'the d likes p'. The valuation function V now acts on this expanded set; $M, w \vDash l_p \wedge p$ 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:

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

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

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

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

[8]Witness the exchange at http://www.nbcnews.com/meet-the-press/video/conway-press-secretary-gave-alternative-facts-860142147643.

are introduced, then, to capture this flexibility of truth – any statement which *could* be regarded as truthful according to some linguistic scheme may be regarded as an alternative fact. We introduce the modality AF with the following semantics:

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

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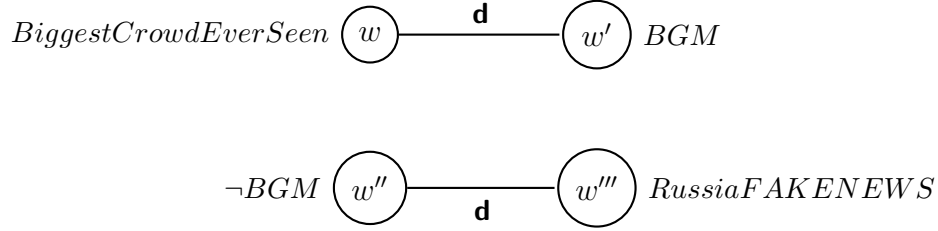
We leave the interpretation of this model (in particular, the undirected edges) up to the reader.

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.

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[9] We 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.

[10] This tweet may be found at `https://twitter.com/KellyannePolls/status/827583711126360065`.