for a similar purpose, since S5 is considered an important epistemic logic [22], (see [21] for a recent overview of the research in this direction), and so S5 is a basis of both single and multi-agent logical systems. In that respect, we intend to extend the dynamic proof theory introduced in [5] from sequent-based frameworks to hypersequent-based ones, so that the S5-based hypersequential frameworks presented here will allow an agent to automatically reason about knowledge, beliefs, obligations, and arguments, depending on the interpretation of the modalities.

Another interesting direction for future work is to further increase the expressive power of the frameworks by adding preferences among the arguments. Note that to some extent this may be done already in the current setting. Indeed, when e.g $\mathcal{S} = \{\Box p, \neg p\}$ is taken as (part of) the set of premises, the argument $\Box p \Rightarrow \Box p$ defeats $\neg p \Rightarrow \neg p$ (this is so since $\Box p \supset p$ is an S5-axiom and double-negation elimination holds in S5), but not vice versa. For a more fine-grained approach one would probably need to incorporate a priority function for expressing preferences among arguments , or introduce a preference criterion, based on the number of modalities in a formula, as is done in other contexts of prioritized or probabilistic argumentation frameworks (see, e.g., [3, 29] for some discussions and further references). In both cases, the attack rules, like those in Example 4.1, would remain the same, but their application will be determined by the relative strengths of the attacking and the attacked arguments (that is, the attacking argument should not be weaker than the attacked argument [3, 15]).

ACKNOWLEDGMENT

We thank the reviewers for their helpful suggestions and comments. This work is supported by the Israel Science Foundation (grant 817/15). The first author is also supported by the Alexander von Humboldt Foundation and the German Ministry for Education and Research.

REFERENCES

[1] Leila Amgoud. 2014. Postulates for logic-based argumentation systems. *International Journal of Approximate Reasoning* 55, 9 (2014), 2028–2048.
[2] Leila Amgoud and Philippe Besnard. 2013. Logical limits of abstract argumentation frameworks. *Journal of Applied Non-Classical Logics* 23, 3 (2013), 229–267.
[3] Leila Amgoud and Srdjan Vesic. 2014. Rich preference-based argumentation frameworks. *Journal of Approximate Reasoning* 55, 2 (2014), 585–606.
[4] Ofer Arieli and Christian Straßer. 2015. Sequent-based logical argumentation. *Argument & Computation* 6, 1 (2015), 73–99.
[5] Ofer Arieli and Christian Straßer. 2016. Deductive Argumentation by Enhanced Sequent Calculi and Dynamic Derivations. *Electronic Notes in Theoretical Computer Science* 323 (2016), 21–37.
[6] Arnon Avron. 1987. A constructive analysis of RM. *Journal of Symbolic Logic* 52, 4 (1987), 939–951.
[7] Arnon Avron. 1996. The method of hypersequents in the proof theory of propositional non-classical logics. In *Logic: Foundations to Applications*. Oxford Press, 1–32.
[8] Howard Barringer, Dov M. Gabbay, and John Woods. 2012. Modal and temporal argumentation networks. *Argument & Computation* 3, 2–3 (2012), 203–227.
[9] Kaja Bednarska and Andrzej Indrzejczak. 2015. Hypersequent calculi for S5: The methods of cut elimination. *Logic and Logical Philosophy* 24 (2015), 277–311.
[10] Trevor Bench-Capon and Paul Dunne. 2007. Argumentation in artificial intelligence. *Artificial Intelligence* 171, 10 (2007), 619–641.
[11] Philippe Besnard and Anthony Hunter. 2001. A logic-based theory of deductive arguments. *Artificial Intelligence* 128, 1–2 (2001), 203–235.
[12] Katalin Bimbó. 2014. *Proof Theory: Sequent Calculi and Related Formalisms*. CRC Press.
[13] Andrei Bondarenko, Phan Minh Dung, Robert A Kowalski, and Francesca Toni. 1997. An abstract, argumentation-theoretic approach to default reasoning. *Artificial Intelligence* 93, 1 (1997), 63–101.
[14] AnneMarie Borg, Ofer Arieli, and Christian Straßer. 2018. Hypersequent-based argumentation: An instantiation in the relevance logic RM. In *Porceedings of TAFA'2017 (LNAI)*, Vol. 10757. Springer, 1–18.
[15] AnneMarie Borg, Ofer Arieli, and Christian Straßer. 2018. Prioritized sequence-based argumentation. In *Porceedings of the 17th AAMAS*. This volume.
[16] AnneMarie Borg, Daniel Frey, Dunja Šešelja, and Christian Straßer. 2017. Examining Network Effects in an Argumentative Agent-Based Model of Scientific Inquiry. In *Proceedings of the 6th LORI*. Springer, 391–406.
[17] Martin Caminada and Leila Amgoud. 2007. On the evaluation of argumentation formalisms. *Artificial Intelligence* 171, 5 (2007), 286–310.
[18] Martin Caminada and Dov M. Gabbay. 2009. A Logical Account of Formal Argumentation. *Studia Logica* 93, 2 (Nov 2009), 109–145.
[19] Claudette Cayrol. 1995. On the Relation between Argumentation and Non-monotonic Coherence-Based Entailment. In *Proceedings of the 14th IJCAI*. 1443–1448.
[20] Agata Ciabattoni, Nikolaos Galatos, and Kazushige Terui. 2008. From Axioms to Analytic Rules in Nonclassical Logics. In *Proceedings of the 23rd LICS*. 229–240.
[21] Hans van Ditmarsch, Joseph Y. Halpern, Wiebe van der Hoek, and Barteld Kooi (Eds.). 2015. *Handbook of Epistemic Logic*. College Publications.
[22] Hans van Ditmarsch, Wiebe van der Hoek, and Barteld Kooi. 2007. *Dynamic Epistemic Logic*. Springer.
[23] Phan Minh Dung. 1995. On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming and n-person games. *Artificial Intelligence* 77, 2 (1995), 321–357.
[24] Alejandro J. García and Guillermo R. Simari. 2004. Defeasible logic programming: an argumentative approach. *Theory and Practice of Logic Programming* 4, 1–2 (2004), 95–138.
[25] Gerhard Gentzen. 1934. Untersuchungen über das logische Schließen I, II. *Mathematische Zeitschrift* 39 (1934), 176–210, 405–431.
[26] Davide Grossi. 2009. Doing argumentation theory in modal logic. Technical report, ILLC Technical Report PP-2009-24. (2009).
[27] Davide Grossi. 2011. Argumentation in the View of Modal Logic. In *Proceedings of ArgMAS 2010*. Springer, 190–208.
[28] Davide Grossi and Wiebe van der Hoek. 2014. Justified Beliefs by Justified Arguments. In *Proceedings of KR'2014*. 131–140.
[29] Anthony Hunter and Matthias Thimm. 2017. Probabilistic Reasoning with Abstract Argumentation Frameworks. *Artificial Intelligence Research* 59 (2017), 565–611.
[30] Ori Lahav. 2013. From Frame Properties to Hypersequent Rules in Modal Logics. In *Proceedings of the 28th LICS*. 408–417.
[31] George Metcalfe, Nicola Olivetti, and Dov M. Gabbay. 2009. *Proof Theory for Fuzzy Logics*. Applied Logic Series, Vol. 36. Springer.
[32] Grigori Mints. 1974. Lewis' systems and system T (1965–1973). In *R. Feys "Modal Logic" (Russian Translation)*. Nauka, 422–501.
[33] John Pollock. 1992. How to reason defeasibly. *Artificial Intelligence* 57, 1 (1992), 1–42.
[34] Garrell Pottinger. 1983. Uniform, Cut-free formulations of T, S4 and S5. *Journal of Symbolic Logic* 48 (1983), 900–901. Abstract.
[35] Henry Prakken. 1996. Two approaches to the formalisation of defeasible deontic reasoning. *Studia Logica* 57, 1 (1996), 73–90.
[36] Henry Prakken. 2010. An abstract framework for argumentation with structured arguments. *Argument & Computation* 1, 2 (2010), 93–124.
[37] François Schwarzentruber, Srdjan Vesic, and Tjitze Rienstra. 2012. Building an epistemic logic for argumentation. In *Proceedings of the 13th JELIA*. 359–371.
[38] Guillermo Simari and Ronald Loui. 1992. A mathematical treatment of defeasible reasoning and its implementation. *Artificial Intelligence* 53, 2–3 (1992), 125–157.
[39] Christian Straßer and Ofer Arieli. 2017. Normative reasoning by sequent-based argumentation. *Journal of Logic and Computation* (2017). https://doi.org/10.1093/logcom/exv050 Accepted.
[40] Michael Wooldridge. 2009. *An Introduction to MultiAgent Systems*. John Wiley & Sons.