Article:

Chowdhury, S.M. (2019) The attack and defense mechanisms: perspectives from behavioral economics and game theory. Behavioral and Brain Sciences, 42. e121. ISSN 0140-525X

https://doi.org/10.1017/s0140525x19000815

The Attack and Defense Mechanisms – Perspectives from Behavioral Economics and Game Theory *

Subhasish M. Chowdhury

Department of Economics, 3 East, University of Bath, Bath BA2 7AY, United Kingdom. Phone: +44 1225 384 655, E-mail: s.m.chowdhury@bath.ac.uk

Published as: Chowdhury, S.M. (2019). The Attack and Defense Mechanisms – Perspectives from Behavioral Economics and Game Theory. Behavioral and Brain Sciences, 42, e121.

Abstract

This commentary complements the article by De Dreu and Gross (2019) from the perspectives of behavioral economics and game theory. It aims to provide a bridge between the psychology / neuroscience research with that of economic research in attack-and-defense by stipulating relevant literature, clarifying theoretical structures, and suggesting improvements in experimental designs and possible further investigations.

JEL Classifications: C72, C91; D72; D74
Keywords: Conflict; Contest; Experiment; Attack and Defense

---

*Commentary on "*Revisiting the Form and Function of Conflict: Neurobiological, Psychological and Cultural Mechanisms for Attack and Defense Within and Between Groups*" by Carsten K.W. De Dreu & Jörg Gross – forthcoming in the *Behavioral and Brain Sciences*.

Commentary

De Drew and Gross (2019) survey the literature on various behavioral aspects of attack-and-defense. While focusing mainly in the areas of Psychology and Neuroscience, they often use game theoretic structure, and results from Behavioral Economics to construct their review. The aim of this commentary is to complement their analyses with further relevant readings from Behavioral Economics and Game Theory, such that the baseline theoretical predictions may be clearer. We also provide some suggestions for the improvement and advancement of the experimental studies.

First, consider the game theoretic aspects of attack-and-defense. Any conflict has the feature that the involved parties expend resources to win (or to avoid loss) and, irrespective of the outcome, the resources expended become sunk. 'Contest Theory' is the area of game theory that analyzes these situations. There are two popular functions to determine the probability of winning of player i in such games. Both take the form: $p_i = (x_i^r / \sum_i x_i^r)$ where p_i is the winning probability and x_i is the resources spent by player i, and $r \geq 0$ is a parameter. When the outcome of a conflict is deterministic, i.e., when a player who expends even a little more resources than the rivals wins for sure, then it is an all-pay auction (Baye et al., 1996) and $r = \infty$. However, when there is enough noise in the conflict and the outcome is not that straightforward, then it is modeled as a 'lottery' (Tullock, 1980) and $r = 1$. Individual attack-and-defense conflicts feature rank-order spillovers, and these two types provide very different results (see Baye et al. (2012) for all-pay auction, and Chowdhury and Sheremeta (2011) for lottery). Whereas all-pay auction is covered at the end of Section II.2, the important case of lottery is not considered.

The game-theoretic and behavioral models of attack-and-defense involve network externalities. But the those for individual players and for groups are distinct (it is unclear in the article, see footnote iv). See reviews of the theoretical and the experimental research by Kovenock and Roberson (2012), and by Dechenaux et al. (2015).

In the individual multi-battle contests, players fight on multiple battlefields with limited resources. There may be an attacker (terrorist) who tries to destroy such battlefields, and a defender (government) who tries to save those. Here the battlefields are connected as weakest-link for the defender, and as best-shot for the attacker. The theoretical solution for such models are provided in Clark and Konrad (2007), Arce et al. (2012), Kovenock and Roberson (2018) etc. Experimental evidences (Kovenock et al., 2018) find that the theory predicts subject behavior better for all-pay auction than for lottery.

In a group-conflict group-members exert resources that go through a production technology to create 'group-effort', which then determine the winning group. The technology can be additive (an easy version of this with all-pay auction *a la* Baik et al. (2001) is considered in the article), or it can be something else. For attack-and-defense, the attackers face a best-shot whereas the defenders face a weakest-link technology. The solutions are included in Chowdhury and Topolyan (2016a) for all-pay auction and in Chowdhury and Topolyan (2016b) for lottery; and the predictions are very different. Currently there is no experimental research investigating such situations.

Note some important discontents between psychology/neuroscience and economics experiments. Whereas economists stress on using theoretical benchmark to understand behavioral mechanisms, others apply distinct techniques (e.g., fMRI). However, it is possible to combine both and arrive at better understandings. Different areas also often re-arrive on results that are not shared. For example, the high dispersion result (Section IV.3) is recognized as 'overspreading' in economics (Chowdhury et al., 2014), but is never tested for an attack-and-defense frame.

For the individual attack-and-defense research, the article introduces a normal form AD game. This (reproduced in Table 1) suggests that although the theoretical equilibrium is in symmetric mixed strategies, in reality defenders will choose 'defend' more than attackers choose 'attack'.

Table 1. Proposed AD-game

		Attacker	
		Not Attack	Attack
Defender	Not Defense	2, 1	0, 2
	Defense	1, 1	1, 0

Indeed, that turns out to be the case in the experiments, and it is explained through the idea of loss-aversion. The subjects seemed to view the game as in Table 2. Since loss-averse defenders weigh the negative amounts higher than their numerical values and play 'defense' more.

Table 2. Intended AD-game

		Attacker	
		Not Attack	Attack
Defender	Not Defense	2, 1	2-2, 1-1+2
	Defense	2-1, 1	2-1, 1-1+0

However, until the game is framed as in Table 2 explicitly, it is unlikely that subjects understand the game in such a way. They view the game as in Table 1, and choose the 'defense' option since that is the riskless option.

Chowdhury et al. (2018) investigate the same but introduce a game with lottery and continuous level of resources (instead of only two-options). They essentially provide a general version of Table 2, control for risk, and still provide support for of loss-aversion in attack-and-defense.

The simple AD-game in Table 1 cannot reflect the sunk cost of conflict, and the one in Table 2 is simply an easy version of Chowdhury et al. (2018) with binomial space and all-pay auction. Hence, it will be interesting to investigate a similar general set-up as in Chowdhury et al. (2018) but with all-pay auction – as implemented in the current study. It will also be useful to control for risk behavior along with the other behavioral aspects as detailed in the current study.

The target article successfully presents the audience with an overview of attack-and-defense experiments (mainly) from psychology and neuroscience. We point out, to bridge between those areas and behavioral economics / game theory, existing games that may be better fit to investigate the same questions, will allow theoretical benchmark and behavioral mechanisms for predicted results. We also note that the current economics experiments do not exploit the techniques (e.g., response time, cognitive ability, eye tracking, neurological effects etc.) employed regularly in psychology and neuroscience. Employing such techniques can provide broader knowledge. We hope for such bridge to attain in the future.

References

Arce, D. G., Kovenock, D., & Roberson, B. (2012). Weakest-link attacker-defender games with multiple attack technologies. *Naval Research Logistics (NRL)*, *59*(6), 457-469.

Baik, K. H., Kim, I. G., & Na, S. (2001). Bidding for a group-specific public-good prize. *Journal of Public Economics*, *82*(3), 415-429.

Baye, M. R., Kovenock, D., & De Vries, C. G. (1996). The all-pay auction with complete information. *Economic Theory*, *8*(2), 291-305.

Baye, M. R., Kovenock, D., & De Vries, C. G. (2012). Contests with rank-order spillovers. *Economic Theory*, *51*(2), 315-350.

Chowdhury, S. M., Jeon, J. Y., & Ramalingam, A. (2018). Property rights and loss aversion in contests. *Economic Inquiry*, *56*(3), 1492-1511.

Chowdhury, S. M., & Sheremeta, R. M. (2011). A generalized Tullock contest. *Public Choice*, *147*(3-4), 413-420.

Chowdhury, S. M., Sheremeta, R. M., & Turocy, T. L. (2014). Overbidding and overspreading in rent-seeking experiments: Cost structure and prize allocation rules. *Games and Economic Behavior, 87*, 224-238.

Chowdhury, S. M., & Topolyan, I. (2016a). Best-shot versus weakest-link in political lobbying: an application of group all-pay auction. *Social Choice and Welfare*, *47*(4), 959-971.

Chowdhury, S. M., & Topolyan, I. (2016b). The Attack-And-Defense Group Contests: Best Shot Versus Weakest Link. *Economic Inquiry*, *54*(1), 548-557.

Clark, D. J., & Konrad, K. A. (2007). Asymmetric conflict: weakest link against best shot. *Journal of Conflict Resolution*, *51*(3), 457-469.

Dechenaux, E., Kovenock, D., & Sheremeta, R. M. (2015). A survey of experimental research on contests, all-pay auctions and tournaments. *Experimental Economics*, *18*(4), 609-669.

Kovenock, D., & Roberson, B. (2012). Conflicts with multiple battlefields. In M.R. Garfinkel, & S. Skaperdas (Eds.), *The Oxford Handbook of the Economics of Peace and Conflict* (pp 503 – 531). Oxford University Press, New York.

Kovenock, D., & Roberson, B. (2018). The optimal defense of networks of targets. *Economic Inquiry*, *56*(4), 2195-2211.

Kovenock, D., Roberson, B. & Sheremeta, R.M. (2018). The attack and defense of weakest-link networks. Public Choice, In press, https://doi.org/10.1007/s11127-018-0618-1

Tullock, G. (1980). Efficient rent seeking. In J.M. Buchanan, R.D. Tollison & G. Tullock (Eds.), *Toward a theory of the rent-seeking society* (pp 97–112). College Station: Texas A&M University Press.