

Research Article

A Theoretical Solution to the Doping Problem: Talk About It!

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What effect would talking about doping have? All players in a classical doping game have the option of telling their opponent that they will announce their doping decision before the sports competition is executed. What effects, if any would such a move have? This question is analysed in the paper at hand. As opposed to most people's intuition, the effect on classical doping games is limited. Still, some peculiar situations prove otherwise.

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1. Introduction and a brief literature survey

1.1. Relevant literature

Doping and game theory is often referred to as 'Economics of Doping'. The term was first introduced by Berentsen ^[1]. However, the true pioneer in the subject was most certainly Gunnar Breivik ^[2], who already in the eighties identified the Prisoner's Dilemma structure of the doping phenomenon. In the near 40 years after Breivik's pioneering article, many contributions have extended the knowledge within the field. Already mentioned, Berentsen ^[1] and Haugen ^[3] formalized and generalized different mathematical doping models. Eber ^[4], ^[5], followed up Haugen's work adding fair play norms, showing that a sense of conscienceless may dampen athletes' inclination to use doping. Haugen et al. ^[6] extended the game from a 2-player to a multi-player setting, showing that prize function characteristics are vital for doping tendency. Krâkel ^[7] and Ryvkin ^[8] have "polished" the theory further, while Kirstein ^[9] investigated effects of incomplete information and Marino and Stilo ^[10] (recently) have analysed doping through evolutionary game theory.

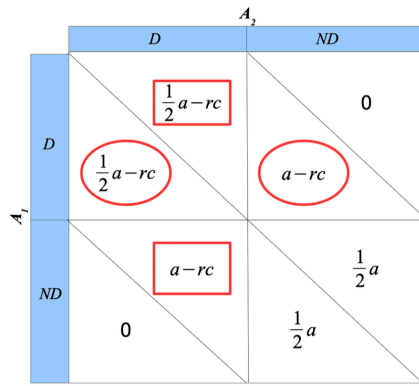
1.2. The announcement strategy

Although many aspects of economics of doping have been analysed – see above, one obvious extension has, to the best of this author’s knowledge, not been studied yet: That is, the announcement strategy. It is well known– see for instance Dixit and Nalebuff ^[11] and Haugen ^[12] – that under reasonable added assumptions, any simultaneous (imperfect information) game can, by player action, be transformed into a sequential (perfect information) game. This can be achieved simply by any player announcing that he/she will reveal their action before the game starts. In the doping game, telling your opponent what you intend to do before the actual competition starts, is both possible and feasible. Even far distant competitors are nowadays readily available through social media. Furthermore, if an athlete wants to make a public announcement, this is also unproblematic today.

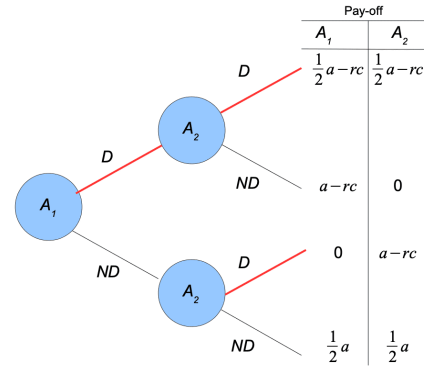
In section 2, the sequential version of the original performance-enhancing drug (PED) game is analysed and compared to the simultaneous version. In section 3, more advanced and somewhat new versions of the game is analysed with the aim of identifying when and if possible first (or second) mover advantages may occur. Section 4 concludes.

2. Analysing the announcement strategy

One important question to address is whether a public announcement would be probable in this setting. As I see it, it seems obvious that a rational agent would never announce a doping strategy. Given the added assumption that the sporting competition at hand is within say Olympic sports, regulated by WADA², such a strategy would never be optimal – publicly. It will most certainly result in a doping verdict. Furthermore, given that the doping strategy is “unavailable”, the only public announcement possibility is the no-doping strategy. Given the unavailability of the doping announcement, a no-doping announcement would hold no information value. As a consequence, a public announcement seems highly unreasonable. The point here is very simple. One important parameter, the probability of doping revelation through a doping test, r will definitely be affected if a public announcement would be an option. When such an option is not available, neither of the original model parameters a (the winning prize), c (the revelation cost) nor r , the doping revelation probability should be affected by a private announcement. Hence, the original model could be applied between the “old” and the “new” game without any parameter changes. The consequences can be observed in Figure 1.



(a) The simultaneous version of the PED game



(b) The sequential version of the PED game

Figure 1. The PED game as a simultaneous and a sequential game. Given the assumption $\frac{1}{2}a - rc > 0$, with best replies as red rectangles/ellipses (a) and red arcs (b)

To the left in Figure 1 (a), the main result of the original doping model in [3] is shown. By the simple assumption (which is argued to be reasonable in [3]):

$$\frac{1}{2}a - rc > 0, \quad (1)$$

it is easy to show that $a - rc > \frac{1}{2}a \Rightarrow a - \frac{1}{2}a - rc > 0 \Rightarrow \frac{1}{2}a - rc > 0$ and as a consequence, all best reply functions are determined by inequality (1) alone. Hence, this model contains a unique single Nash equilibrium, the $\{D, D\}$ equilibrium. That is, both athletes take drugs.

Now, moving to the right part (b) of Figure 1, the corresponding sequential game is shown by a game tree. It is straightforward to realize that under the same single assumption of inequality (1), applying a standard backward induction technique on the tree, that for player A_2 , $\frac{1}{2}a - rc > 0$ producing the top right red arc, while $a - rc > \frac{1}{2}a$ produce the low red arc. Then, moving one step to the left in the tree, the fact that $\frac{1}{2}a - rc > 0$ produces the red arc between nodes A_1 and A_2 . Finally, moving left to right in the tree, it is readily seen that this case also produces the $\{D, D\}$ Nash equilibrium.

As this game is symmetric, and it is proven in [12] that for a symmetric 2-player simultaneous game, the sequence of the announcement between A_1 and A_2 is irrelevant. Changing the sequence will hence provide no extra information.

So, both game models produce the same Nash equilibrium prediction and the “value” of announcement is not present. This may be somewhat unexpected as general economic theory comparing Nash with Stackelberg equilibria³ (see for instance [\[13\]](#)) often predict first mover advantages.

3. The announcement strategy in more advanced versions of the PED game

In this section it is focused on possible player-specific values on the parameters r , the probability of being revealed in a doping test and c , the cost of such a disclosure.

Starting with r , we have observed examples of player-specific values. In the winter Olympics in Sochi (2014). A big scandal was revealed after the games involving all Russian athletes competing. The Russian version of WADA, RUSADA was involved in a scheme where possibly positive urine samples of the Russian athletes were substituted with clean samples to hide doping. See [\[14\]](#), [\[15\]](#) or [\[16\]](#). That is, different values of r for different players must be allowed.

The costs of being exposed as a doper, c can contain many elements. Actual costs related to bans, fines as well as loss of medals and prize money, but also potential costs related to stigma. Stigma might be defined as the society’s negative reaction to you, if you are being exposed as a doper. The point here, is that this stigma may be substantial, and according to some research on the matter, culturally dependent. See for instance [\[17\]](#), [\[18\]](#) or [\[19\]](#).

A good example of a costly stigma is the so-called Finnish doping Scandal [\[20\]](#), [\[21\]](#), [\[22\]](#). In the Nordic Ski World Championship in Lahti (Finland) in 2001, the whole Finnish cross country skiing team was exposed for using the banned plasma expander – Hemohes. After this scandal, not only skiers were banned, but almost all of the Finnish Ski world was hit hard. Before 2001, Finland used to be a very decent cross-country skiing nation with many Olympic gold medals. After 2001, Finnish cross country skiing was a shadow of itself. In the 7 winter Olympics before 2001, Finland won 8 gold medals in cross country skiing while the next 7 winter Olympics produced only 3 golds. An obvious reduction. Hence, stigma may have impact on performance after a massive doping scandal. As a consequence, also, the c must be allowed to be player specific.

This leads to a simple change in the original PED game: $r, c \rightarrow r_i, c_i$. This model enhancement is formulated in [\[23\]](#), but not further developed into analysis. Let us perform this analysis here.

		A_2	
		D	ND
A_1	D	$\frac{1}{2}a - r_2c_2$ $\frac{1}{2}a - r_1c_1$	0 $a - r_1c_1$
	ND	$a - r_2c_2$ 0	$\frac{1}{2}a$ $\frac{1}{2}a$

Figure 2. The game with player dependent r_i, c_i .

Figure 2 holds the reformulated game. As can be observed, the only change involves substitution of rc by r_1c_1 and r_2c_2 linked to players A_1 and A_2 . Of course, if

$$\frac{1}{2}a - r_i c_i > 0, \forall i \in \{1, 2\}, \quad (2)$$

then nothing happens. Both Nash equilibria in Figure 1 are unchanged and remains being $\{D, D\}$ in both the simultaneous and sequential version. The assumption (2) is not hard to defend. In [3] there are lots of arguments why this is a reasonable assumption. Prizes and wages for top athletes are extremely high, while doping exposure probabilities are low and even if costs may be substantial in some cases, the top level athletes still makes too much money, and the inequality in 2 is normally satisfied.

However as argued above, the stigma may be big enough. Of course this holds for certain cultures, but still, it is not impossible to construct “practical situations where the inequality sign in (2) may be reversed. Let us now look at such a situation and assume:

$$\frac{1}{2}a - r_1c_1 > 0 \text{ and } \frac{1}{2}a - r_2c_2 < 0 \quad (3)$$

So, the situation in (3) is that A_1 comes from a “normal” cultural environment with both low r_1 and c_1 . A_2 however, comes from a culture with high stigma and hence high c_2 . In this case, so high that $r_2 c_2 > \frac{1}{2} a^4$ Combining high c_2 and low a makes it more reasonable to reverse the inequality in (2).

Now, doing a similar analysis as the analysis leading to Figure 1, Figure 3 is found.

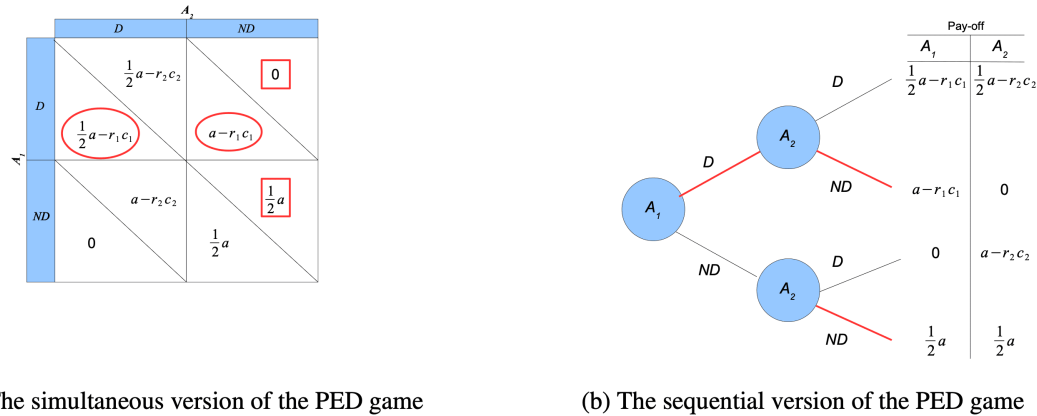


Figure 3. The PED game as a simultaneous and a sequential game. Given the assumption

$\frac{1}{2} a - r_1 c_1 > 0$ and $\frac{1}{2} a - r_2 c_2 < 0$ with best replies as red rectangles/ellipses (a) and red arcs (b)

As can be observed from Figure 3, the introduction of player specific r_i, c_i changes the Nash equilibrium under the assumption (3). The original (maximal doping equilibrium), $\{D, D\}$ now becomes a $\{D, ND\}$ equilibrium. Some might find this interesting. The introduction of nation or culture specific disclosure probabilities and costs may actually reduce the athletes' tendency to use performance-enhancing drugs. Only one using doping versus 2 is definitely a significant reduction. Furthermore, the introduction an announcement strategy does not have any effect here either. The Nash equilibrium remains the same as in the simultaneous game. Even if we reverse the players announcement strategies, no changes are observed. That is, in this case, if player A_1 makes the announced first, or if A_2 talks first, no changes between the two sequential games are observed

However, as noted earlier (see section 2), a proof regarding symmetric games and the invariance of player sequence in Nash equilibria was performed in [12]. The fact that we have introduced player specificity in the last version of the game means that this proof does not necessarily hold. The game is no longer symmetric. However to utilize this asymmetry let us try to perform a slight remodelling.

Assume now that a clear conscience has a value. Let us define this value as b , where $b > 0$ seems appropriate. Surely, this parameter may depend both on the stigma introduced previously, but also on whether your opponent chooses a drug taking strategy or not. Hence, in reality this b parameter could be at least 2 dimensional (b_{ij}). However, to prove the point these are unnecessary complications and we stick to the simplest case – only a single b . This leads to new potential sequential models where all $\{ND\}$ strategies leads to an addition of b to all pay-offs. In this case, the sequential game (b) in figure 3 is changed to the version shown in figure 4.

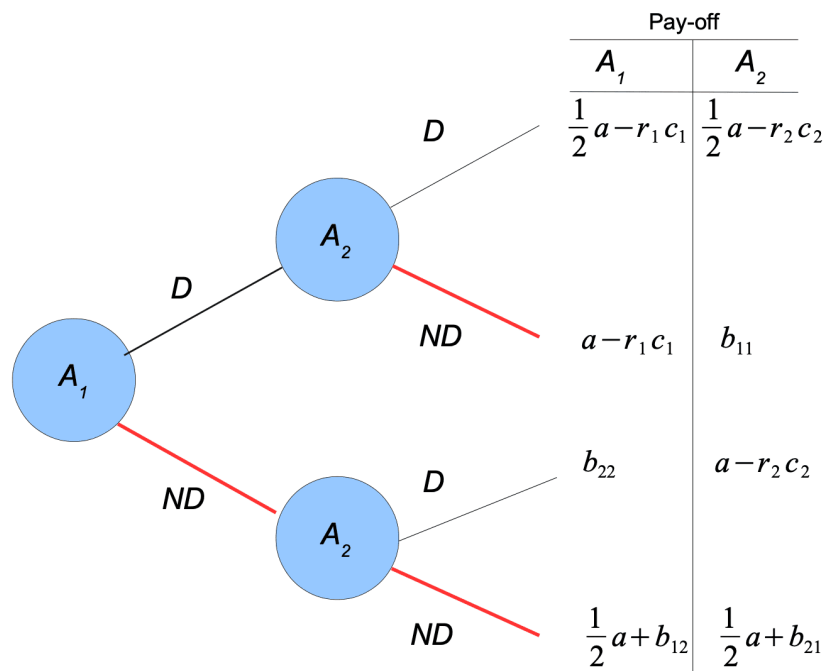


Figure 4. The sequential game with the addition of the b_{ij} -parameter

Observe from Figure 4 that the $\{ND, ND\}$ Nash equilibrium is obtained by satisfying the following 3 inequalities,

$$b_{11} > \frac{1}{2}a - r_2 c_2 \quad (4)$$

$$b_{21} > \frac{1}{2}a - r_2 c_2 \quad (5)$$

$$b_{12} > \frac{1}{2}a - r_1 c_1 \quad (6)$$

Now, by the initial assumption:

$$\frac{1}{2}a - r_1c_1 > 0 \text{ and } \frac{1}{2}a - r_2c_2 < 0 \quad (7)$$

simple algebra yields:

$$\frac{1}{2}a - r_2c_2 < 0 \Rightarrow r_2c_2 - \frac{1}{2}a > 0 \quad (8)$$

and

$$\frac{1}{2}a - r_1c_1 + r_2c_2 - \frac{1}{2}a > 0 \Rightarrow -r_1c_1 + r_2c_2 > 0 \Rightarrow r_2c_2 > r_1c_1. \quad (9)$$

Given equation (9) it will normally hold (given not too big differences between b_{ji} 's) that

$$b_{12} > \frac{1}{2}a - r_1c_1 \quad (10)$$

is satisfied to secure a no-doping Nash equilibrium in the game.

4. Conclusions

The simple fact that the given extension of the traditional simultaneous PED game, involving player specific r_i, c_i is by itself interesting. The shift from a $\{D, D\}$ to a $\{D, ND\}$ Nash equilibrium indicates potential to reduce doping. After all, a situation indicating “both use doping” to a situation where only one uses doping suggests a major change. From a practical point of view, this indicates that an effort to standardize doping legislation not necessarily is a good idea. In order to move from the original PED game to this version, differences in nations and cultures as well as a clear conscience (b_{ij}) are necessary. One way of achieving such differences may be a non-standardized legislation system.

Furthermore, the final version of the sequential PED game (in Figure 4) indicates even more “improvement”. This version predicts no doping at all. Here achieved by an announcement strategy where A_1 is the leader. A_1 is different from A_2 characterized by high a and low c .

For those interested in trying to remove doping from sport, this may seem as an interesting idea, perhaps an idea too good to be true. Unfortunately, from a practical point of view, coordinating the player sequence in a sequential version of the game is not necessarily feasible or obtainable.

Firstly, the practical situation underlying will raise several questions of credibility. Note that the announcement strategy here indicates a message or signal that a D/ND decision will be announced. That is, the actual announcement for a choice of D or ND will come at a later point in time. Then the shift from a simultaneous game into a sequential version is a realistic description of the defined situation. So, from the follower player's point of view it will be a necessary question on credibility. After the

announcement, should he or she believe that the actual announcement decision is going to happen, and maybe even more important, after the actual D/ND are the fellow player to be trusted? After all, it may not be easy for a follower to place trust in neither the D nor the ND decision. It is after all common knowledge that testing for doping use is not that easy. Of course, a situation where the leader tries to prove his decision (especially if it is the D option) is feasible. For instance bringing some blood transfusion equipment to actually “prove” the intentions.

Secondly what stops the follower from copying the announcement at the announcement time. “I will make a similar announcement as you but before you”. Clearly this is an option that could not be ruled out.

The above arguments indicate that there are more potential games involved in the situation – much more complex games. Credibility and belief leads to games of incomplete/asymmetric information complicating everything a lot.

Still, the simple examples shown in the article indicates further potential in analysing doping with “economics of doping” methods. The fact that simple re-engineering of classic game models may lead to quite different results is interesting in itself. Hopefully, future and further research along these dimensions both will enhance theoretical knowledge as well as practical implementability.

Footnotes

¹ Help identifying an important typo by the referee, Jan Exner Charles University, Prag Czech Republic, is greatly appreciated.

² World Anti Doping Agency

³ Which essentially is the same as comparing simultaneous and sequential Nash equilibria in discrete strategy games.

⁴ if needed, we can also realize that certain cultures do not allow the athletes to keep all the a they earn – for instance through taxation. There must be reasons why Switzerland has a higher amount of professional athletes as citizens than most other countries.

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