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 are 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] formalised and generalised different mathematical doping models. Eber [4], [5], followed up Haugen's work adding fair play norms, showing that a sense of conscience 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.

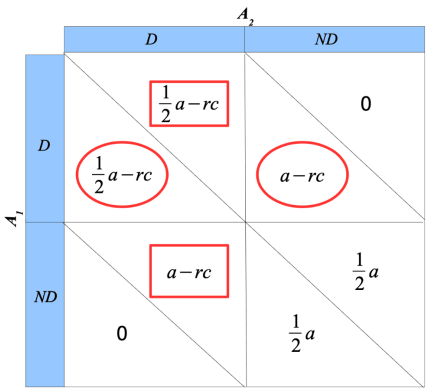
### *1.2. The announcement strategy*

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.

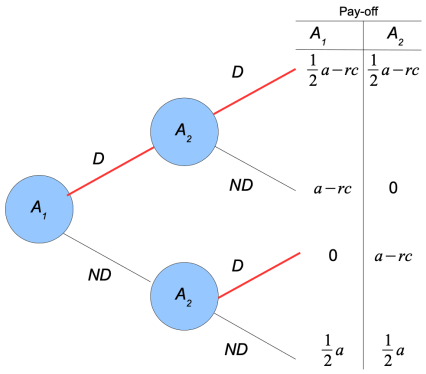
In section 2, the sequential version of the original performance-enhancing drug (PED) game is analysed and compared to the simultaneous version. In section 3, more advanced and somewhat new versions of the game are analysed with the aim of identifying when and if possible first (or second) mover advantages 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 WADA[1], 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 Haugen (2016) is shown. By the simple assumption (which is argued to be reasonable in Haugen (2016)):

$$\frac{1}{2}a - rc > 0, \tag{1}$$

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 realise 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 $a - rc > \frac{1}{2}a$ produces the lower 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 equilibria[2] (see for instance [13]) often predicts first mover advantages.

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

In this section, the focus is on possible player-specific values for 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. These include actual costs related to bans and fines as well as loss of medals and prize money, but also potential costs related to stigma. Stigma might be defined as society's negative reaction to you if you are 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. This was an obvious reduction. Hence, stigma may have an impact on performance after a massive doping scandal. As a consequence, $c$ must also 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.

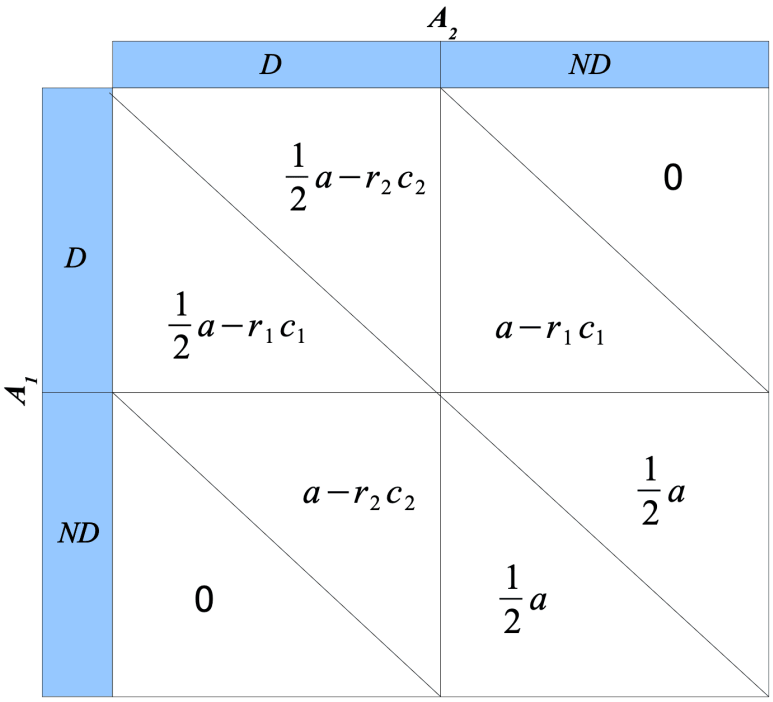



**Figure 2.** The game with player-dependent $r_i, c_i$.

Figure 2 holds the reformulated game. As can be observed, the only change involves the substitution of $rc$ by $r_1 c_1$ and $r_2 c_2$ linked to players $A_1$ and $A_2$. Of course, if

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

then nothing happens. Both Nash equilibria in Figure 1 are unchanged and remain $\{D, D\}$ in both the simultaneous and sequential versions. The assumption (2) is not hard to defend. In Haugen (2016), there are many 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, top-level athletes still make 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:

$$\frac{1}{2}a - r_1 c_1 > 0 \text{ and } \frac{1}{2}a - r_2 c_2 < 0 \tag{3}$$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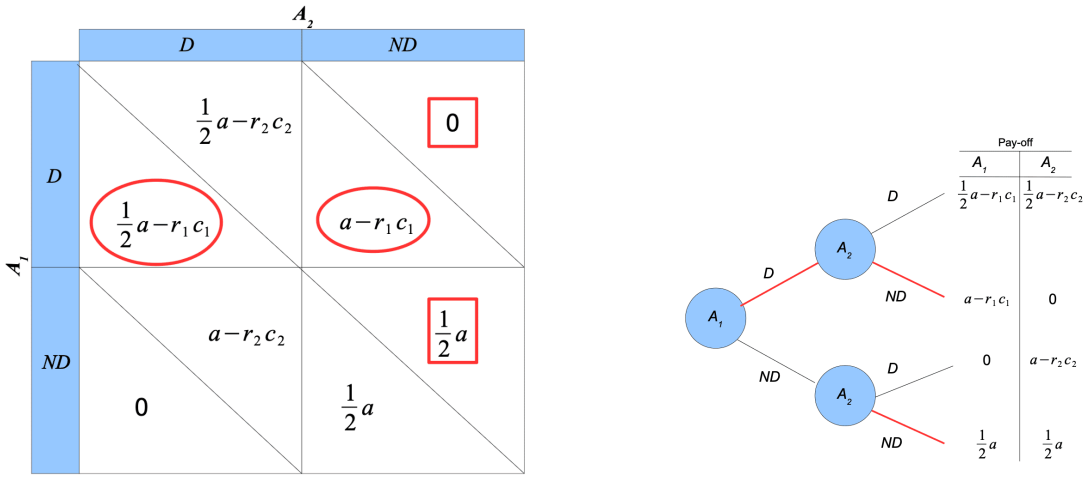
So, the situation in (3) is that $A_1$ comes from a "normal" cultural environment with both low $r_1$ and $c_1$. $A_2$, however, comes from a culture with high stigma and hence high $c_2$. In this case, it is so high that $r_2c_2 > \frac{1}{2}a^3$. Combining high $c_2$ and low $a$ makes it more reasonable to reverse the inequality in (2).

Now, performing an analysis similar to the one leading to Figure 1, Figure 3 is found.




(a) The simultaneous version of the PED game

(b) The sequential version of the PED game

**Figure 3.** The PED game as a simultaneous and a sequential game. Given the assumption $\frac{1}{2}a - r_1c_1 > 0$ and $\frac{1}{2}a - r_2c_2 < 0$ 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 two is definitely a significant reduction. Furthermore, the introduction of 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 announcement first, or if $A2$ 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 utilise this asymmetry, it turns out to be necessary 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 two-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 lead to an addition of $b$ to all payoffs. In this case, the sequential game (b) in Figure 3 is changed to the version shown in Figure 4.

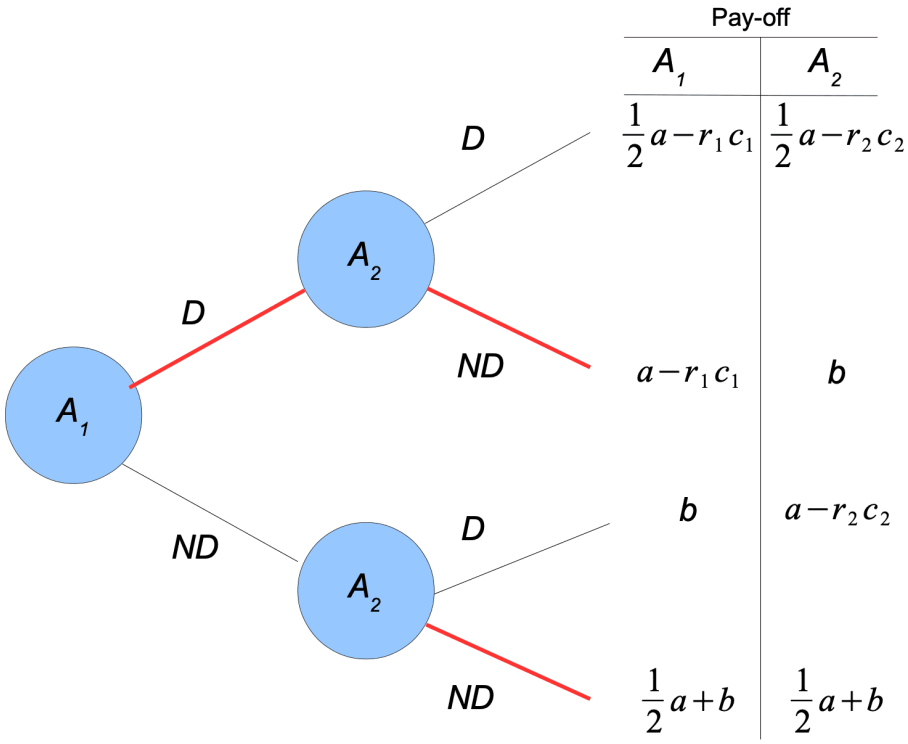



**Figure 4.** The sequential game with the addition of the $b$-parameter

Observe from Figure 4 that the Nash equilibrium is obtained by the following assumption,

$$a - r_1 c_q > \frac{1}{2}a + b, \tag{4}$$

and that this assumption may be discussed. A slight rearranging of equation 4 gives: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$$b < \frac{1}{2}a - r_1 c_1 \tag{5}$$

Hence, the magnitude of the value of a clear conscience ($b$) decides whether the Nash equilibrium becomes $\{D, ND\}$ or $\{ND, ND\}$. The interesting outcome is observed if we change the announcement strategy of this game. Now, let player $A_2$ make the announcement first. That is, a game as shown in Figure 5.

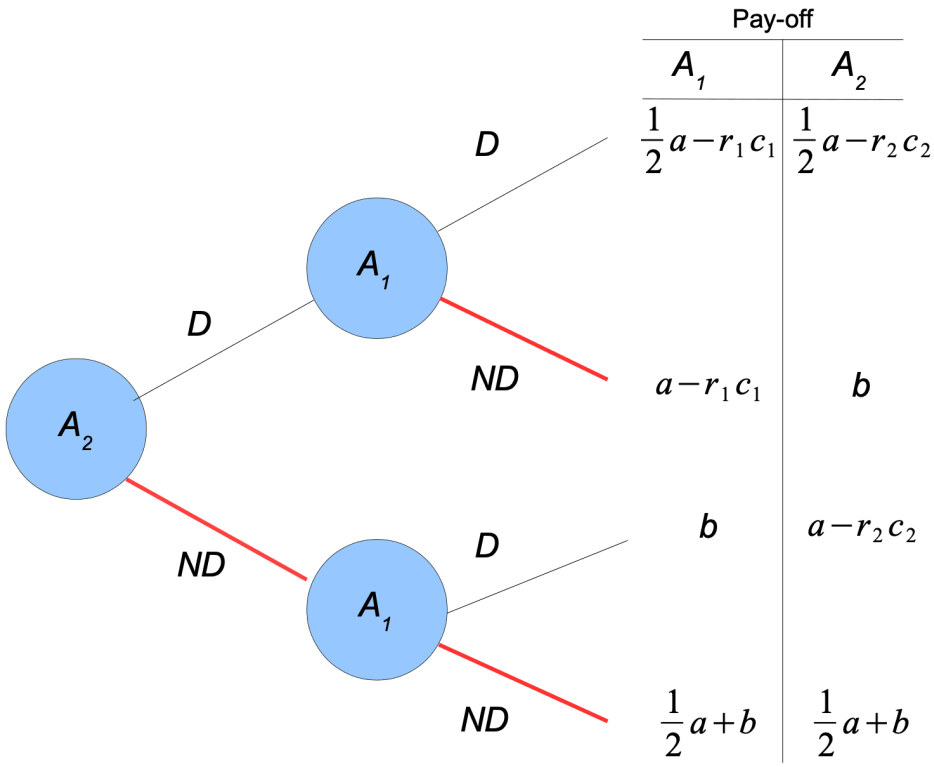


**Figure 5.** The sequential game where player $A_2$ makes the announcement first

Note from Figure 5 that it contains the unique pure Nash equilibrium $\{ND, ND\}$ – nobody takes drugs. And, in this case, there are no doubts. The necessary inequalities to satisfy are:

$$a - r_1 c_1 > \frac{1}{2}a - r_1 c_1 \Rightarrow a > \frac{1}{2}a \tag{6}$$

which always holds. And,

$$\frac{1}{2}a + b > b \Rightarrow \frac{1}{2}a > 0 \tag{7}$$

which, of course, also holds. So, a kind of "first mover advantage" is obtained, and doping is eliminated.


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## 4. Conclusions

The simple fact that the given extension of the traditional simultaneous PED game involves 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 standardise doping legislation is not necessarily 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 ($b$) are necessary. One way of achieving such differences may be a non-standardised legislation system.

Furthermore, the final version of the sequential PED game indicates even more "improvement". This version predicts no doping at all. This is achieved by an announcement strategy where $A_2$ is the leader. $A_2$ is different from $A_1$, characterised by low $A$ and high $c$.

For those interested in trying to remove doping from sport, this may seem like 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 underlying practical situation 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, there 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 importantly, after the actual $D/ND$, is the fellow player to be trusted? After all, it may not be easy for a follower to place trust in either the $D$ or 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 cannot be ruled out.

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

Still, the simple examples shown in the article indicate 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 will enhance both theoretical knowledge and practical implementability.

## Footnotes

[1] World Anti Doping Agency

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

[3] If needed, we can also realise 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 number of professional athletes as citizens than most other countries.

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## Declarations

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