The Shapley-Emerson framework and the power-definition paradox

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Abstract

This paper builds on an important paper by Emerson (1962) and its central idea that unbalanced dependency, or power, relations tend to balance out. We show how the Shapley (1953) value from cooperative game theory can be linked to Emerson's paper in a fruitful manner. We also argue that power-over definitions are always value-laden. either in a payoff-centered or in an action-centered definition. Finally, we suggest a research program that builds on the Shapley-Emerson framework.

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1. Introduction

[1]It is commonplace to observe that no accepted definitions of power exist, neither in the form of power-to nor in the firm of power-over (see, for example, Bartlett 1989, pp. 9-10). At the same time, power is considered a (or even the) central concept of the social sciences (see the title of the introduction to the SAGE Handbook of Power by Haugaard & Clegg 2009b). We comment on that claim in the conclusions.

It is nearly impossible to oversee the multitude of power definitions. Power has many dimensions, two of which are particularly relevant for our paper. First of all, power may be defined with reference to actions (actor 1 forces actor 2 to perform an act against 2's will) or with reference to payoffs (actor 1 benefits more than actor 2). This corresponds to the difference between I-power (with I standing for "influence") and P-power (with P denoting "prize" or "payoff") by Felsenthal & Machover (1998).

Second, most authors (including the present one) prefer to understand power relatively, i.e., in terms of the power an actor 1 exercises over another actor 2. Proponents of this tradition are Weber (1978), Emerson (1962), Cartwright (1959,

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p. 196), and Hösle (1997, p. 394-396), to name put a few. In particular, we like to quote Dahl's (1957, pp. 202) influential definition of power-over: B has power over A to the extent that he can get A to do something that A would not otherwise do.

Our paper is a companion article to the somewhat neglected paper by Emerson (1962) (not mentioned in the nearly 500 pages thick Handbook of Power) and to a recent paper by Wiese (2009) from which we quote liberally. For Emerson, power-over is dependency reversed. The author convincingly argues that unbalanced dependence relations (or unbalanced power-over relations) tend to balance out. Wiese builds his paper on the observation that dependency in the form of "where would you be without me" can easily be modeled by way of cooperative game theory and, in particular, with the help of the famous Shapley (1953) value. However, although "where would you be without me" can be seen as a manner to operationalize dependency, the link between Emerson and Shapley was not stated in that paper and, to the best of our knowledge, has never been observed. We argue that Emerson and Shapley are basically concerned with the same topic although their approaches are very different.

We find it useful to embed the comparison between Emerson and Shapley into a discussion of power-over definitions. Against the above definition by Dahl and similar definitions in the literature, it has been noticed (for example, by Vanberg 1982, p. 59, fn 48) that in every exchange relationship both sides do what they would not have done without the influence (or existence) of the other party. Indeed, if 1 offers 2 some money to perform a service and 2 obliges, does 1 has power over 2? Or, the other way around, does 2 have power over 1 because he "forces" 1 to give him money for some important (to 1) service? According to everyday usage, 1 exerts power over 2 if 1 obtains the service for "too little" money ("exploitation") while 2 exerts power over 1 if 2 asks for "too much" and 1 is in urgent need for the service ("profiteering", "extortion", "usury").

In line with this observation, we claim that every fruitful definition of power-over needs a reference point which may concern a "usual", "normal", or "moral" situation. It seems quite unavoidable that these reference points contain some measure of arbitrariness and need to be defended rather specifically. However, the Shapley value allows to work with a non-arbitrary reference point, the "where would you be without me" reference point. As we will see later, this reference point is rather useless in identifying power-over. In fact, we find symmetry between any two persons A and B : A suffers from B's withdrawal as much as B suffers from A's withdrawal.

One side result of our argument, to be explained in detail later on, is the power-definition paradox: If we want to talk about power-over, value judgements cannot be avoided. (This power-definition paradox should not be confused with the well-known paradox of power which refers to the theoretical possibility that more parliamentary seats (or agenda-setting power or ...) may work against the interest of the allegedly powerful party (see, for example, Ordeshook 1992, pp. 162).)

The paper is structured in the following manner. In the next section, we briefly mention a few famous definitions of power and power-over before focussing on Emerson's approach. In section 3, we then present a payoff-based definition of power-over which, however, suffers from the reference problem. The "where would you be without me" reference point, introduced in section 4, avoids this problem but cannot identify power-over within a payoff-based definition. Instead, it leads to value-laden conception of power-over in terms of actions. We then suggest a research program for power-over in terms of the power-definition paradox in section 5. Section 6 concludes the paper.

2. Emerson's definition of power-over

This paper owes a lot to Emerson's (1962, p. 32) definition of dependence:

> The dependence of actor A upon actor B is (1) directly proportional to A's motivational investment in goals mediated by B, and (2) inversely proportional to the availability of those goals to A outside of the A-B relation.

Intuitively, this definition makes a lot of sense. If A wants to have something (Emerson's "motivational investment", (1)) that is controlled by B, A depends on B. Similarly, if A has providers other than B (Emerson's "availability of goals", (2)) for whatever he likes to have, his dependence is diminished.

Emerson (1962, p. 33) then goes on to claim

$$PAB = DBA,$$

i.e., "the power of A over B is equal to, and based upon, the dependence of B upon A." Thus, Emerson defines power-over as inverse dependence.

Emerson's (1962, p. 34) theory of power now builds on his concept of balancing operations "as structural changes in power-dependence relations which tend to

reduce power advantage"

$$PAB - PBA.$$

Emerson's procedure seems clear-cut: In line with (1) and (2) above, power-over balances out if the powerless party A becomes less interested in goals that depend on B or if A finds alternative sources to satisfy his needs. Similarly, balancing may involve B becoming more interested in the A-B relation or being cut-off from alternative sources to A.

While we find Emerson's ideas path-breaking, we point out that we do not think of (1) and (2) on a similar plane. In our mind, (1) is a balancing operation while (2) may create unbalancedness. We elaborate on this distinction in this paragraph and the next. With respect to (1), the examples provided by Emerson (playing children, dating adults) make clear that "motivational investment" refers to the terms under which relationships exist. For example, if one child B in an A-B relationship finds another playing buddy, she can impose her favorite game on A more often than before (see Emerson 1962, pp. 35). Under these unfavorable (for A) terms, the power equilibrium that was momentarily unbalanced due to B's new playfellow is restored.

Turning to (2), Emerson is surely right that alternative sources may balance unbalanced power-over relationships. However, they may just do the opposite. Irrespective of whether power relations are balanced or not, it is surely in every agent's interest to increase the number of own alternative sources and to decrease the number of the other's alternative sources. An economic example may help to clarify this important point: A firm B that offers attractive products to a customer A (so that A depends on B) may nevertheless try to merge with other firms thereby decreasing A's "availability ... outside of the A-B relation" (and thereby increasing dependence even further).

As noted by Emerson (1962, p. 32) himself, he does not define dependence itself, but "can do no more than specify the directional relationships" involved. For Emerson, dependence is that relationship between agents that increases or decreases with "motivational investments" and "availability of goals" in the appropriate manner. In our view, the need for an arbitrary reference point (see introduction) may be a very good (but possibly unwitting) reason to adopt the modest definitional approach taken by that author. Emerson (1962, p. 32), however, uses a different line of defense by referring to the empirical problems of ascertaining "the precise nature" of how dependence is linked to "motivational investments" and "availability of goals".

3. Value-laden (arbitrary) reference points

3.1. Defining power by way of payoff differences

Leaving aside Emerson for the time being, we propose the following definitions of power-over, the first with respect to actions, the second with respect to payoffs:

Definition 3.1. *Person* 1 *has power over person* 2

- *if* 1 *can induce* 2 *to perform an action that is not "normal" or "ethical" (action-based definition of power-over), or*
- *if* 1 *is better off and* 2 *is worse off in comparison with a "normal" or "ethical" situation (payoff-based definition of power-over). In that case,* 1*'s power over* 2 *can be operationalized by*

$$\begin{array}{rl} & 1\text{'s payoff due to power-over} \\ & \text{minus} \\ & 1\text{'s payoff in the absence of power-over} \\ > & 0 \end{array}$$

and

$$\begin{array}{rl} & 2\text{'s payoff due to power-over} \\ & \text{minus} \\ & 2\text{'s payoff in the absence of power-over} \\ < & 0 \end{array}$$

The general idea of defining power-over by way of (payoff) differences can already be found in Galtung (1969) who defines "violence ... as the cause of the difference between the potential and the actual". Violence may be personal (e.g., one person hurting or killing another one) or structural. Structural violence is somewhat difficult to grasp. In order to operationalize structural violence with respect to life expectancy, Hoivik & Galtung (1971) define the so-called avoidable difference, specifying "the average number of years of life lost by a person because of the existing distribution of socio-medical resources". Less directly, Lukes (1986, p. 5) suggests "that to have power is to be able to make a difference to the world." Also, Gomez, Gonzalez-Aranguena, Manuel, Owen, Pozo & Tejada (2003)

use the difference of Shapley values to define a centrality measure. In fact, the link between centrality and power has long been a much researched question in the sociology literature (see, for example, Bonacich (1987) and Mizruchi & Potts (1998)).

Payoff differences can also be justified by reference to Willer (1999b)'s Network Exchange Theory. While Elementary Theory, in the early 1980s, had exchange, conflict, and coercive structures as its main themes, Network Exchange Theory grew from Elementary Theory some 10 years later, by highlighting the exchange dimension. Willer (1999a) argues that power has to be conceived as control and/or as benefit. Agent 1 has power over 2 as 1 benefits more than 2 and/or as 1 controls 2 more than 2 controls 1, see Willer (1999a, p. 16). Willer (1999a, p. 19) reconciles the benefit with the control dimension of power by stating that 1 controls 2 in order to benefit from 2. This formulation makes clear that power as benefit has prominence over power as control in Network Exchange Theory. Incidentally, Willer (1999a, p. 16) traces payoff differences to Karl Marx, for whom "power as differential benefit" is called exploitation.

Last, but certainly not least, we need to mention an early and very thoughtful discussion by Goldman (1972, p. 260) who presents this definition of power-over: "Smith has power over Jones, we might say, if and only if Smith has power w.r.t. issues that affect Jones - i.e., that make a difference to Jones' welfare." In his discussion about power-over, Goldman (1972, section V) distinguishes power w.r.t. behavior and power w.r.t. welfare. Power w.r.t. welfare is present if a person 1 can make another person 2 do what she, person 1, likes. Power w.r.t. welfare asks how person 1 affects person 2's welfare. The author argues that in order to account for a man's "overall power" we have to look at power w.r.t. welfare.

There is an obvious parallel in Goldman's and Willer's thinking. Power w.r.t. welfare (Goldman) can be equated with power as benefit (Willer) while power w.r.t. behavior (Goldman) corresponds to power as control (Willer).

3.2. The Shapley value – an intuitive primer

Wiese (2009) suggests to measure power-over by way of payoff differences where the payoffs are the Shapley values in cooperative game theory. The reader who is interested in the technicalities of the Shapley value is referred to that article or to one of the textbooks on game theory, for example to Peleg & Sudhölter (2003). Here, we try to explain the gist of the Shapley value without delving into the

mathematical details.

In cooperative game theory, some set of people N, the players, is given. The central concept is a so-called coalition (or characteristic) function v that describes the social and/or economic possibilities open to various groups of players, called coalitions. Formally, the coalition function assigns a "worth" $v(K)$ to any subset K of N.

In many cases, the economic, political, or social situation clearly points to the worths coalitions can obtain. In the gloves game, for example, holders of left and right gloves buy and sell gloves with the purpose of assembling pairs of gloves. It is assumed that single gloves are useless while a pair of gloves carries the worth of 1. For example, two holders of left gloves and one holder of a right glove can create the worth 1 (the minimum of 2 and 1) while two holders of left gloves and three holders of right gloves create the worth of 2 (the minimum of 2 and 3).

After defining a coalition function, cooperative game theory goes on to apply some or other "solution concept" (core, nucleolus, Shapley value) to such a coalition function. The idea is that these solutions predict the payoffs the players can expect to achieve. For our purpose, we find the Shapley value to be useful. It is a function that maps coalition functions into payoffs for all players. The general idea is to devide the worth for all players, $v(N)$, according to some average of the "marginal contributions".

A marginal contribution is the additional worth brought about by a player. For example, if we have two left gloves and one right glove, an extra player with a left glove has a marginal contribution of 0 (because the worth is 1 without and with him) while an extra player with a right glove has a marginal contribution of 1 (because the worth increases by 1, from 1 to 2).

The Shapley value produces "reasonable" payoffs. If we have three players, one with a left glove and two with a right glove, the left-glove holder obtains the payoff $Sh_1 = \frac{2}{3}$ while the right-glove holders get $Sh_2 = Sh_3 = \frac{1}{6}$ each. Thus, the Shapley value reflects the market power of player 1 (who is the holder of the scarce glove).

3.3. Shapley payoff differences

Following up on the idea of value-laden payoff differences, Wiese (2009) employs the Shapley value to illustrate power-over. Let us assume one left-glove holder (player 1) and 4 right-glove holders (players 2 through 5). The left-glove holder is in a monopoly position, or, from the point of view of network theory, the left-glove

holder is the center of a hub-and-spoke network. The Shapley value awards the payoff of $\frac{4}{5}$ to player 1 and $\frac{1}{20}$ to each of the other players.

Assume that player 1 sells his left glove. He obtains the price of $\frac{4}{5}$ (if the Shapley value is a good predictor for the market outcome). Each of the players 2 through 5 have the chance of $\frac{1}{4}$ to buy the glove for a price of $\frac{4}{5}$. Hence, each right-glove holder has an expected payoff of $\frac{1}{4}\left(1-\frac{4}{5}\right)=\frac{1}{20}$.

Let us now invoke the norm of equal splitting of gains between player 1 and player 2 to whom player 1 happens to sell the left glove. Then, payoffs are $\frac{1}{2}$ for players 1 and 2, and 0 for the other three players.

In line with our intuition, we find that player 1 has power over player 2. The conrete numbers are

$$\begin{array}{l}\text{1's payoff due to power-over}\\ \text{minus}\\ \text{1's payoff in the absence of power-over}\\ Sh_1-\dfrac{1}{2}=\dfrac{4}{5}-\dfrac{1}{2}=\dfrac{3}{10}>0\end{array}$$

and

$$Sh_2-\frac{1}{2}=\frac{1}{20}-\frac{1}{2}=-\frac{9}{20}<0.$$

4. Non-arbitrary reference points

4.1. General definition

The above attempts to operationalize power-over suffer from a serious defect. They crucially depend on the arbitrarily chosen reference points. Similar to Wiese (2009), we propose the following definition for a non-aribrary reference point in the case of payoff-based power-over:

Definition 4.1. *Person* 1 *has power over person* 2 *if* 1 *suffers less from a withdrawal by* 2 *than* 2 *suffers from a withdrawal by* 1. *In that case,* 1*'s power over* 2

can be operationalized by

$$\begin{array}{rl} & 1\text{'s payoff in the presence of player } 2 \\ & \text{minus} \\ & 1\text{'s payoff in the absence of player } 2 \\ < & 2\text{'s payoff in the presence of player } 1 \\ & \text{minus} \\ & 2\text{'s payoff in the absence of player } 1. \end{array}$$

The idea behind this definition is that people may say to each other: "where would you be without me?" Power-over means that the threat of withdrawal may in general be more effective for one agent than for another one. Thus, our definition is closely aligned to Emerson (1962) who suggests that power-over results from dependence.

4.2. Withdrawal for cooperative games

Of course, we need to find an operationalization for "absence" or "withdrawal" in the context of concrete models. Luckily, withdrawal is easy to define for cooperative games. We simply consider

$$Sh_2\,(\text{original game}) - Sh_2\,(\text{original game without player } 1)$$

for player 2's dependence on 1.

Let us revisit the gloves game with one left-glove holder (player 1) and 4 right-glove holders (players 2 through 5). It might seem that player 1's threat of withdrawal carries more weight than player 2's threat of withdrawal. However, this is not the case. In the presence of all four right-glove holders, player 1 obtains $\frac{4}{5}$ while player 1's Shapley payoff is only $\frac{3}{4}$ if player 2 withdraws so that we have only 3 right-glove holders. Thus, player 1's "where would you be without me" payoff difference is

$$\begin{array}{rl} & Sh_1\,(\text{original game}) - Sh_1\,(\text{original game without player } 2) \\ = & \frac{4}{5} - \frac{3}{4} = \frac{1}{20}. \end{array}$$

For player 2, we find

$$\begin{array}{rl} & Sh_2\,(\text{original game}) - Sh_2\,(\text{original game without player } 1) \\ = & \frac{1}{20} - 0 = \frac{1}{20}. \end{array}$$

Thus, we have the payoff difference of $\frac{1}{20}$ for both. This is a striking result and bad news for our attempt to arrive at a non-arbitrary definition of power-over.

It is worth noting that the above equality of payoff differences does not only hold for this specific example. Indeed, the axiom of balanced power-over relations is well-known in the literature – it has been introduced by Myerson (1980) under the heading of "fairness" and holds true for any game and any pair of players who obtain the Shapley value.

4.3. Linking Emerson and Shapley

In the example of the previous subsection, the players 1 and 2 obtain the same payoff $\frac{1}{20}$. The intuitive reason for the equality of these differences is this: Player 1 obtains a price of $\frac{4}{5}$ for his left glove in case of 4 potential buyers, but a price of $\frac{3}{4}$ in case of 3 potential buyers. So indeed, player 2's withdrawal would not do much damage to player 1. But player 2's disutility caused by player 1's withdrawal is small also. As noted before, if player 1 is around, player 2 will have a small chance $(\frac{1}{4})$ of getting the glove and will also have to pay a high price $(\frac{4}{5})$. Therefore, player 2 gets the payoff $1 - \frac{4}{5} = \frac{1}{5}$ with a chance of $\frac{1}{4}$ only and hence the expected payoff $\frac{1}{4} \cdot \frac{1}{5} = \frac{1}{20}$. If player 1 withdraws, player 2's payoff is zero because no pairs can be formed.

To our mind, the high price charged by player 1 in the five-player gloves game is a special instance of what Emerson (1962, pp. 34) calls "balancing operation" of type (1). By paying a high price to player 1, player 2's motivational investment in trading with 1, and hence 2's dependence on 1, is reduced.

Another example is provided by Emerson's (1962, pp. 35) playing children. Child B is in a stronger position than child A because B has found another playing buddy C. In order to rebalance the power equilibrium now disturbed, A needs to give in to B's wishes more often than before.

In both cases, changes in "motivational investments" bring about the equality of power-over. The terms of exchange (which games to play, which price to pay) are adjusted so that, finally, power is balanced out. As argued in section 2, we think that Emerson is not right in treating "alternative sources" as a balancing operation in the same way.

5. The research program of the power-definition paradox

Looking back at the arguments presented so far, we seem not to have made much progress. Either we define power-over by way of payoff differences on the basis of value judgements (section 3). Or, following Shapley and Emerson, we use a non-arbitrary definition of power-over which seems incapable to identify power-over due to the balancing inherent in both Shapley's and Emerson's approaches. However, even in the second case, value judgements lurk around the corner. Depending on one's view of appropriate actions, one may find "unjust" or "unfair" the fact that child A gets to play her favorite game less often than child B or that player 1 gets the lion's share of the gains from trade.

Thus, we are prompted to state the power-definition paradox:

> The symmetric power-over with respect to payoffs points to value-laden asymmetric power-over with respect to actions.

This seems a purely negative conclusion. However, we like to argue that the Shapley-Emerson framework is very useful for structuring our thoughts on these complicated power issues. In fact, the power-definition paradox suggests a research program: Whenever we have a seemingly asymmetric power-over relationship we should look out for asymmetric power-over in action terms by assuming balanced dependence or power relations (Emerson) or by equalizing the payoff differences with respect to the threat of withdrawal (Shapley). For example, power-over relationships may exist between parents and children, God and humans, a king and his subjects, a bureaucrat and people obtaining permission, master and slave, etc.. Which actions equalize dependence or "where would you be without me" payoff differences? For example, the price for a scarce glove (which mirrors the strong bargaining position of our left-glove owner) is determined so as to make all the glove owners equally dependent on each other. Similar, by playing B's favorite games two-thirds of the time, the balance of power is restored between the children A and B.

In a sense, this research program is related to Weber's (1978, p. 53) famous definition of power: The owner of "alternative sources" (several alternative trading partners or several playfellows, respectively) "[carries] out his own will despite resistance" – the holder of a non-scarce glove would prefer a "fair price" of $\frac{1}{2}$ (the less popular child would like to be treated on equal terms). Also, power-over turns out to be "sociologically amorphous": The asymmetry can be traced

back to "[all] conceivable qualities of a person and all conceivable combinations of circumstances", again using

Weber's (1978, p. 53) words, two times. And, so we like to add, all sorts of different actions may help to equalize the payoff differences.

6. Conclusions

This paper argues that Shapley's value and Emerson's theory of dependence and power are closely interlinked. The Shapley value always fulfills Myerson's fairness property. The actions that bring about the equality of "where would you be without me" differences are left unspecified by cooperative game theory. Emerson's theory of power (the balancing due to "motivational investments" rather than due to the "availability of goals") alerts us to concrete mechanisms that lead to this equality.

We also hope to have shown that discussions of power-over are necessarily value-laden, either in the payoff formulation or in the action formulation. While this seems unsatisfactory from a scientific point of view, it is important to note that many discourses in the public arena make heavy use of "power" – Haugaard & Clegg (2009a, p. 1) quote the Google scores for "social power" and "political power" to underline this fact.

One may question our decision to bring the Shapley value into our analysis rather than to stick to Emerson's paper. In our mind, using cooperative game theory and the Shapley value in particular, has three advantages over a purely Emersonian analysis. First, it alerts us to focus on payoffs as much as on actions – both are needed for our arguments. Second, the Shapley value as a formal concept may help to structure our discussion, possibly more than a purely verbal analyses. Third, cooperative game theory provides a powerful apparatus to tackle all sorts of games. While we illustrate our results by way of the gloves game, other examples are easily found – Wiese (2009) discusses emotional dependence, centrality in a network, and armed robbery. In all examples, we obtain symmetric power-over with respect to withdrawal.

If we were not to use the Shapley value but another solution concept (from cooperative, or from non-cooperative game theory), we may well find a less clear result. However, in line with Emerson's discussion of balancing operations of type 1, we would like to argue that the general idea obtained from the Shapley value can be generalized: If person 1 is in a strong position (e.g., monopoly position) in relation to person 2, 1 will obtain more favorable terms than 2 so that both tend

to suffer by a similar amount from a break-down of the relationship. Exploring this conjecture in terms of specific models and examples has to be left to future research.

Readers familiar with the literatue on power may miss discussions of whether power-over entails overcoming resistance, of whether power-over is legitimate etc. (these and other questions are addressed by Haugaard & Clegg 2009b, pp. 400). Our excuse is simply that all these intricate questions are beyond the scope of this paper and do not add to the main messages.

Turning to the power debate in general, we remind the reader of Dahl's (1957, p. 201) suspicion that the study of power may be a "bottomless swamp". Dahl goes on to surmise that "it is probably too early to know" whether that is the case. We like to offer two comments: First, the Shapley-Emerson framework may well be a way out of the swamp as we try to show in this paper.

Second, after another half century has passed, we feel that the time may be ripe for some more pronounced critical remarks.

- It seems an odd feature that a huge part of the power literature is concerned with definitional problems. (Alas, this paper is no exception.)

- In our mind, another major problem with the power literature is the fact that substantive work belongs to quite different areas where advances in one of them does not necessarily help in others. In particular, research areas concerned with market power (consult the survey article by Bresnahan 1989), centrality and power (see, for example, Mizruchi & Potts 1998), emotional dependence (see the programmatic paper by Gewirtz 1956), or voting power (see the monography by Felsenthal & Machover 1998) use very different methodologies. Thus, while the words "power" or "power-over" feature in all these disparate areas, a common deeper link is missing nevertheless.

From these two observations, we conclude that power is not a central concept in the social sciences. Indeed, it seems doubtful to us whether a central concept in the social sciences exists. Many sociologist may consider "status" or "role" central concepts for their particular subbranch. Within economics, the equilibrium concept seems central. Power may assume a rather central place in political science. It also seems necessary to distinguish centrality of concepts with regard to content and with regard to methodology. In a very tentative manner, one may

use the following table as a starting point for these discussions:

	central concepts	
	with regard to content	with regard to methodology
economics	exchange, ...	equilibrium
sociology	status, role, ...	network
political science	elections, power, ...	?

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