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When social preferences and anxiety drive behavior and vasopressin does not

– An neuroeconomic analysis of vasopressin and the Hawk-Dove game –

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Abstract

We delineated the causal influence of vasopressin on behavior in an iterated Hawk-Dove game. While subjects treated with vasopressin tend to be more aggressive in response to group members who did not coordinate on equilibrium instantaneously, this effect vanishes as soon as the subjects reach an equilibrium. More than vasopressin, social preferences and trait anxiety of the subjects predict the observed behavior.

Keywords
Hawk-Dove game, anti-coordination game, neuroeconomic experiment, vasopressin, psychological aspects

JEL Classification
C72, C92, D03, D87

1 Introduction

The Hawk-Dove game (see Table 1; Smith & Price, 1973) is an anti-coordination game allowing for two strategies: hawk and dove. In equilibrium, the players resort to different strategies and accept different payoffs: the payoff of the hawk exceeds the payoff of the dove. In a repeated version of the Hawk-Dove game, the attractiveness of the equilibria depends on the payoff sum in equilibrium and the payoff sum when both players resort to dove. Here, to ensure equal payoffs and efficiency, the players can alternate, i.e., reciprocate (Neugebauer et al. 2008), between both equilibria. In the Hawk-Dove game of Table 1, both players could reach an average payoff of 50 per period by alternating both equilibria, whereas both resorting to dove (hawk) would yield a payoff of only 35 (0). Typically, the hawk strategy is perceived as an aggressive strategy, as in equilibrium, the hawk gains at the cost of the dove, whereas the dove strategy is a defensive strategy.
Although we know that reciprocity and aggression are potential motives for the behavior in the Hawk-Dove game, we still do not know why some subjects are more aggressive or demonstrate stronger reciprocity than others. Neuroeconomics and specifically the research on

neuropeptides offer an explanation. Recent research investigating the impact of the social neuropeptides vasopressin and oxytocin indicates that even complex behavioral patterns are often the result of simple molecular mechanisms (e.g., Kosfeld et al. 2005, Meyer-Lindenberg et al. 2011). In particular, vasopressin has been linked to the motivating aspects for behavior in the iterated Hawk-Dove game: (1) aggression is correlated with cerebrospinal fluid levels of vasopressin (Coccaro et al. 1998) and (2) vasopressin increases reciprocity in an iterated prisoners' dilemma (Rilling et al. 2012).

Table 1: Hawk-Dove game

		Player 2	
		Hawk	*Dove*
Player 1	*Hawk*	(0, 0)	(**80**, **20**)
	Dove	(**20**, **80**)	(35, 35)

2 Material and methods

To investigate the impact of vasopressin on behavior in the iterated Hawk-Dove game, we recruited 148 healthy adult male subjects (aged 20 to 35) to avoid known gender effects of vasopressin (Rilling et al., 2014). For every session, we assigned one half of the subjects to the Placebo treatment and the other half to the Vasopressin treatment. Throughout the experiment, only subjects who received the same treatment interacted.

Upon arrival in the laboratory, all subjects signed a consent form and received a nasal spray with 40 international units of either vasopressin or a placebo. Next, subjects answered psychological questionnaires (an aggression questionnaire, Buss & Perry, 1992; a mood questionnaire, Steyer et al. 1997; an anxiety questionnaire[1], Spielberger et al. 1983 and a questionnaire on risk preferences). Afterwards, the subjects read the experimental instructions. According to known vasopressin peak levels in cerebrospinal fluid (Born et al. 2002), the task started 30 min after drug administration, and subjects played the Hawk-Dove game from Table 1 iterated 10 times. At the end of each period, we informed subjects about the strategy of the other group member. The experiment ended with the subjects answering the same psychological questionnaires as in the beginning of the experiment and a fairness task.

In addition to the show up fee (10.00 SFR), we paid the subjects based on their performance in the iterated Hawk-Dove game, and we implemented one out of ten fairness tasks. The average

[1] Only 88 out of 148 subjects answered the anxiety questionnaire. We introduced it after the third session, to ensure that all subjects answered questionnaires for approximately 30 min.

payoff per player was 24.06 SFR (minimum: 15.43 SFR, maximum: 38.50 SFR). The experiment lasted 1 h and 15 min on average.

3 Results

Only if one half of the subjects played hawk and the others played dove, all subjects reached one of the equilibria. Hence, we first investigated the fraction of hawks in the population (Figure 1).

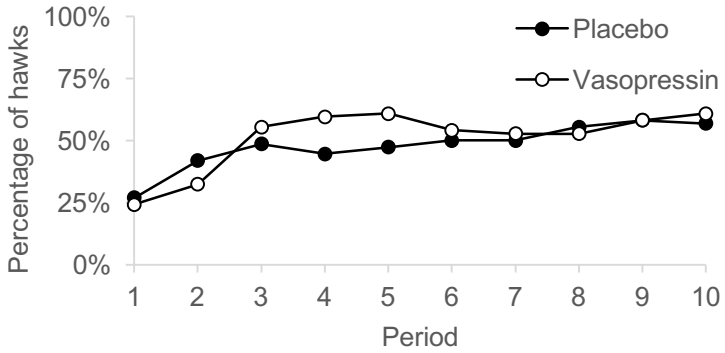


Figure 1: Percentage of hawks per period

In the first period, the fraction of hawks does not differ between both treatments (Mann Whitney U, two-sided, p=0.754): Approximately 25% of subjects in both treatments, Placebo and Vasopressin, choose the hawk strategy. However, subjects in the Placebo treatment coordinate faster towards one of the equilibria. Starting in period 3, approximately one half of the subjects in the Placebo treatment choose hawk, while subjects in the Vasopressin treatment reach this state at period 6. Hence, although the fraction of subjects resorting to dove does not significantly differ in periods two and three (Mann Whitney U, two sided; period 2: p=0.216, period 3: p=0.359), it is significantly higher in the Vasopressin than in the Placebo treatment in periods 4 and 5 (Mann Whitney U, two sided; period 4: p=0.057, period 5: p=0.085).

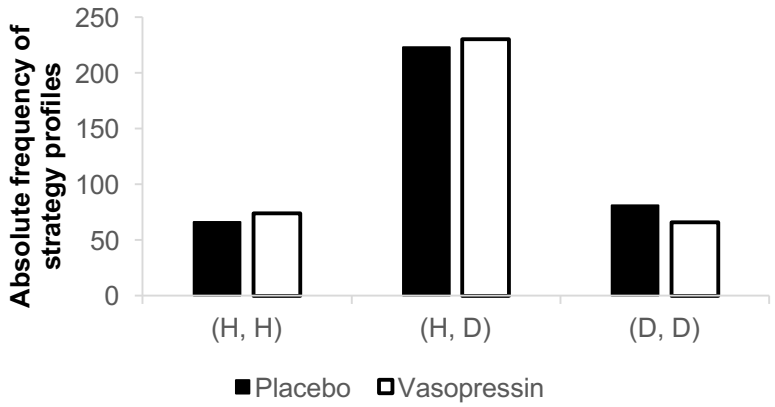
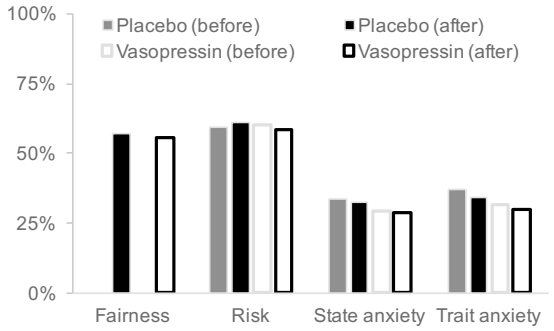


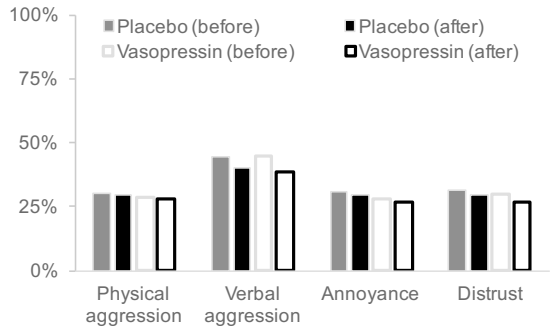
Figure 2: Number of strategy profiles per treatment

As soon as the groups reach one of the equilibria, the behaviors between both treatments do not differ any longer: After period 5, approximately 50% of the subjects resort to hawk, and neither treatment differs significantly (Mann Whitney U, two sided; period 6: p=0.569, period 7: p=0.657, period 8: p=0.656, period 9: p=0.968 and period 10: p=0.464). In both treatments, the fraction of hawks increases toward the end of play. However, this effect is not significant. As a consequence of the fraction of hawks being similar during the first periods and after reaching one of the equilibria, the payoffs throughout the game do not differ (Mann Whitney U, two sided, p=0.688), as does the distribution of strategy profiles (see Figure 2, Chi squared, p=0.351).

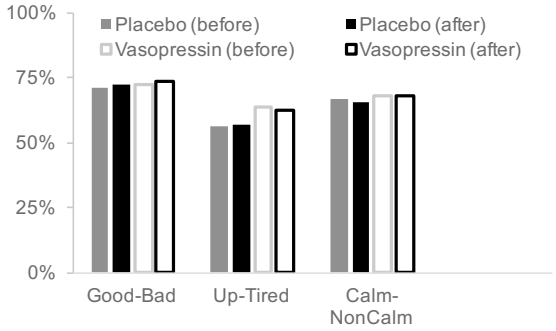
4 Discussion

Given the existing literature (Coccaro et al. 1998; Rilling et al. 2012), we predicted that vasopressin (1) increases the number of subjects choosing the "aggressive" hawk strategy and (2) enhances reciprocal behavior. We see an indication for a modulatory role of vasopressin on aggressiveness (1), as subjects who do not coordinate on the equilibrium, overcompensate their behavior by playing hawk compared to the Placebo treatment. The degree of reciprocity (2) is similarly high in both treatments after reaching equilibrium.





(a) Fairness, risk and anxiety questionnaire



(c) Mood questionnaire

(b) Aggression questionnaire

	Vasopressin vs. Placebo		*Before vs. after*	
	Before	*After*	*Placebo*	*Vasopressin*
Fairness	-	0.983	-	-
Risk	0.474	0.742	0.338	0.153
State anxiety	0.217	0.139	0.888	0.852
Trait anxiety	0.200	0.260	0.012	0.098
Physical aggr.	0.642	0.465	0.747	0.243
Verbal aggr.	0.987	0.390	0.001	0.001
Annoyance	0.299	0.163	0.143	0.149
Distrust	0.725	0.277	0.014	0.002
Good-Bad	0.314	0.449	0.333	0.485
Up-Tired	0.011	0.156	0.406	0.491
Calm-Not calm	0.833	0.240	0.533	0.900

(d) P-values of two-sided Mann Whitney U (vasopressin vs. placebo) and Wilcoxon Signed Rank Test (before vs. after)

Figure 3: Results of different psychological questionnaires

The weak impact of vasopressin might be the consequence of emotions induced by playing the game having a stronger impact on strategic behavior than vasopressin. A comparison of the questionnaires (Figure 3) demonstrates no difference between the subjects receiving vasopressin and the placebo (see column "vasopressin vs. placebo", Figure 3).[2] The picture changes if we compare the questionnaires conducted before and after the experiment. Several scales connected to aggressive behavior, namely, verbal aggression, distrust and trait anxiety, decrease during the experiment (see column "before vs. after", Figure 3) for both treatments.

Regression analyses investigating the impact of the questionnaires on the played strategy demonstrate (Table 3) that both fairness and risk preferences have a significant impact on the played strategy. However, the impact of risk vanishes if we control for the impact of anxiety. Now, only the impact of fairness preferences and anxiety remains. In neither of the regressions does vasopressin make a difference. Confirming the claim, vasopressin has only a weak impact on behavior in the game.

Table 2: Generalized linear mixed model predicting the played strategy

	Fairness & Risk		***Aggression***		***Mood***		***All***	
Intercept	-1.297	(0.257)***	-1.230	(0.325)***	-1.089	(0.471)**	-0.913	(1.015)
Partner strategy in t-1	2.260	(0.140)***	2.260	(0.140)***	2.263	(0.140)***	2.353	(0.174)***
Dummy vasopressin	0.164	(0.138)	0.165	(0.139)	0.190	(0.145)	0.030	(0.183)
Fairness preferences	-0.314	(0.164)*	-0.313	(0.166)*	-0.302	(0.168)*	-0.492	(0.213)**
Risk preferences	0.780	(0.341)**	0.751	(0.359)**	0.772	(0.368)**	0.482	(0.458)
Physical aggression			0.270	(0.746)	0.297	(0.749)	-0.632	(0.966)
Verbal aggression			0.094	(0.551)	0.073	(0.572)	0.724	(0.772)
Annoyance			0.143	(0.597)	0.102	(0.614)	0.583	(0.805)

[2] The only exception is the measure for alertness, i.e. the item Up-Tired, subjects in the Placebo treatment are more tired after receiving the intranasal treatment than the subjects in the Vasopressin treatment.

Distrust		-0.698	(0.551)	-0.757	(0.562)	0.731	(0.850)
Good/Bad				0.246	(0.598)	0.478	(0.832)
Up/Tired				-0.309	(0.525)	-0.615	(0.635)
Calm/Not calm				-0.199	(0.448)	0.030	(0.670)
State anxiety						2.490	(1.313)*
Trait anxiety						-4.073	(1.207)***
N	1152		1152		1152		792

Note: All regressions only utilize the questionnaires conducted prior to the experiment. All items measured prior and after the experiment strongly correlate. Values stand for the estimate, values in brackets are standard errors, and stars indicate significance levels with *: $p < 0.10$; **: $p < 0.05$ and ***: $p < 0.01$

5 Conclusions

In this paper, we investigated the impact of vasopressin on behavior in the Hawk-Dove game. We find that under vasopressin influence, more subjects resort to hawk in early periods and that the effect vanishes as soon as the players coordinate on one of the two equilibria. In consequence, we find no effect of vasopressin for all periods of the game. The result is surprising: fairness and anxiety clearly influence the observed behavior in our experiment and according to literature both fairness by way of reciprocity (Rilling et al. 2012) and anxiety by way of aggressive behavior (Coccaro, 1998) should correlate with vasopressin levels.

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