

**Final report of research of Andreas Flache as
Research fellow of the Royal Netherlands Academy of Arts and Sciences 1999-2004**

Andreas Flache, November 2004

The research project was directed at two main topics, 1) adverse effects of social networks on social solidarity, particularly in work groups, and 2) the relationship between behavioral mechanisms at the micro-level and solidary behavior in social dilemma situations, with particular focus upon the role of backward-looking learning behavior for the explanation of solidarity (see original research proposals submitted to KNAW in 1999 and 2002). The results and publications that were achieved with regard to these two main topics are summarized in turn. Numbers in brackets, e.g. [1], refer to the list of publications that is given in section 2. In section 3, a brief outline is given of the future research plans of Flache, that partly continue work from the KNAW-financed research in a new project that will be based upon a VIDI-research grant that Flache received from NWO in 2004.

1. Summary of main results

1.1. Theoretical and empirical research on the “weakness of strong ties”

In the study of adverse effects of social networks, the KNAW-supported research allowed Flache to further develop and test the counterintuitive and innovative hypothesis of a “weakness of strong ties”. This is the hypothesis that a dense network of informal relations may under certain conditions undermine cooperation in a group (Flache 1996; Flache & Macy 1996). In the course of the research, this hypothesis was generalized theoretically and submitted to an empirical test in the context of work organizations.

The theoretical generalization resulted in various publications that used formal model building to identify new conditions under which strong ties may be detrimental for group solidarity. Flache, Macy and Raub (2000, [26]) analyzed to what extent the hypothesis depends on the original behavioral assumption that actors are “backward-looking”, i.e. adapt their behavior based on reinforcement learning. The authors compared this to a “forward-looking” model assuming strategic rationality and concluded that rational actors can avoid the collectively inefficient outcome of a weakness of strong ties and mobilize instead social relations for enforcement of cooperation. Flache (2002, [7]) then reconciled strategic rationality with the notion of a weakness of strong ties. The paper analyzed game theoretically the effect of imperfect information in terms of task uncertainty. It derived that task uncertainty reduces the extent to which members of a group enforce norms of solidary behaviour, and increases the extent to which they invest in personal relationships that are unrelated to their partner’s level of solidarity with the group. A further paper (Flache, forthcoming, [2]) generalized this prediction beyond the particular micro-assumption of strategic rationality and also derived the effect of task-uncertainty from a backward-looking learning model, elaborated in terms of an agent-based computer simulation. Paper [2] also identified new conditions related to the use of virtual (computerized) communication in so called semi-virtual work teams. Broadly, it was argued that – contrary to most of the present literature - virtual communication may

improve group cooperation in comparison with face-to-face interaction *if* group members are strongly dependent on affective social rewards from their peers. In that case, the greater social distance of online interactions can avoid the previously identified negative effects of high social cohesion on work performance.

In subsequent empirical work the applicant collaborated with researchers of the NWO-financed project “Solidarity at Work” (Sanders, NWO-9817), to collect data on informal networks and organizational cooperation in a large sample of dutch employees. These data have been collected in 2003 and 2004. Flache (2003, [4]) found based on a subsample of the dataset (N=51) support for the hypothesized negative effect of social ties. A number of hypotheses were developed and tested in a factorial survey. Respondents assessed for hypothetical work group scenarios the extent to which they would act solidary with their team. Characteristics of both the worksituation and of social relationships were systematically varied between scenarios. The analyses showed – as expected - that respondents indicated more *unsolidary* behavior for scenarios in which they were embedded in close social ties with colleagues. It was concluded that cohesive informal relationships foster work group solidarity only under specific conditions that are discussed in the paper. In two follow-up papers, Flache (2003, [32]) and Lambooy & Flache (2004 [29]) used larger samples of the dataset (N=252 and N=512, respectively) to analyze the relationship between the local closure of social networks and cooperation both in the local work team and with respect to the company as a whole. Paper [32] showed – in line with the hypothesized weakness of strong ties – that employees tend to cooperate less with respect to the company as a whole, when they are more locally embedded in their own team. Paper [29] related the effect of networks to career mobility at the workplace. In particular it tested the previously analyzed effects of task uncertainty. The authors found that – as predicted by paper [7] – an interaction effect of task uncertainty and informal network density. The data suggest that dense networks can have a negative effect on cooperation with team colleagues *if* task uncertainty is high. Further publications based on the data collected in the second phase of the research are currently under preparation.

1.2 Research on solidary behavior and behavioral mechanisms

In the first part of the research the main focus was upon the relationship between backward-looking learning behavior and solidarity. The first central result of this part of the research is that a weakness of strong ties does not only follow from backward-looking behavior but is also consistent with forward-looking rationality. This has been discussed above under 1.1.

The second central result pertains to the emergence of solidary behavior in long term interactions between two participants. Computer simulations revealed that various specifications of the simple backward-looking mechanism of “reinforcement learning” could explain solidary behavior, where the aspiration level of actors was identified as a crucial condition. More in particular, Flache generalized in collaboration with Macy (Cornell University) previous studies and showed in a high impact publication (Macy & Flache 2002, [8]) that actors’ aspiration level is a decisive condition for cooperation

between backward-looking learning players across a range of different social dilemma situations. In a subsequent study, Flache and Macy (2002, [6]) integrated and compared two specifications of reinforcement learning from the sociological and the economics literature, respectively. Their study highlighted previously unnoticed differences between the two models. The authors showed that differences in the learning dynamics change the predicted conditions for solidarity. According to the Roth-Erev mechanism, solidarity does *not* suffer from high aspirations, but negative effects of low aspirations on solidarity are even worse than predicted by the Bush-Mosteller algorithm.

A series of further papers addressed more generally the relationship between behavioral assumptions and conditions under which solidary behavior can be expected to arise, mostly using formal methods. In research with Hegselmann (University of Bayreuth), the microassumption of individual risk preferences was addressed. In paper [10] (Flache, 2001) the innovative prediction was derived that risk aversion may have non-linear effects on the level of solidarity in a social network. Papers [11] and [13] (Flache & Hegselmann 2000, 1999) compared the effects of strategically rational and backward-looking behavior on cooperation in social exchange. Broadly, these papers revealed two predictions that are robust to variation in the microfoundation. First, cooperation in long term exchanges is possible even between strictly egoistic exchange partners. Second, the more different are exchange partners in terms of their attractiveness, the more restrictive are the conditions under which cooperation can arise. Flache and Macy (*accepted*, [17]) compare in a similar vein backward-looking behavior to decision-making based on Lindenberg's framing theory. The authors show that the theories are consistent in their predictions that long-term reciprocity can arise even in social dilemma games, but learning theory suggests that relationships may be more stable against large amounts of noise. In addition, in paper [12], Flache and Hegselmann (1999) use an agent based simulation model to study the effect of individual altruism on cooperative behaviour in exchanges. Counter intuitively, they show that sometimes altruism may actually reduce cooperation. The underlying condition identified by the model is the scarcity of desirable (needy) exchange partners. When needy exchange partners are scarce, altruists compete with each other for opportunities to give help, which may result in exclusion of those who would be most capable to actually provide the help.

In subsequent work, it was explored to what extent consensus and stability of opinion formation – as a special form of social solidarity – are affected when actors adapt in a social influence process their salience for issues based on “backward-looking” mechanisms. Flache and Torenvlied (2004, [3]) integrated in previous models of opinion formation the new assumption that decision-makers raise their level of salience in response to previous decision outcomes, in order to reduce expected losses from decision-outcomes. While most earlier models failed to explain unstable decision dynamics, Flache and Torenvlied could derive persistently unstable outcome patterns under conditions related to the social network and to intolerance for expected losses.

In a further series of papers the analysis of backward-looking behavior and solidarity was taken a decisive step further by applying the assumption of adaptive behavior not only to changes in cooperation but also to simultaneous changes in the

social network in which actors are embedded. This line of work integrated the previously separated main topics of Flache's work, the influence of networks on solidary behavior and the influence of backward-looking decision making on solidary behavior. An initial study was conducted by Macy, Kitts and Flache (1999, [14]). In a follow-up paper, Macy, Kitts, Flache and Benard (2003, [22]) integrated positive and negative mechanisms of both social influence and network formation into a model of opinion formation in dynamic networks. In contrast with previous work that neglected negative influence and selection mechanism, the authors found that contacts between initially diverse people may undermine social cohesion. Initially diverse but moderately cohesive groups may tend to fall apart in polarized subgroups that negatively evaluate each other and are opposed on a number of normative issues. The line of work that lead to papers [14] and [22] eventually was further elaborated to propose a new research project in the Innovational Research Incentives Scheme of NWO (Vernieuwingsimpuls - VIDI). In September 2004, Flache received the corresponding VIDI grant from NWO.

Together with researchers from the University of Barcelona, the backward-looking approach was further applied to model the simultaneous emergence of networks and solidary behavior. In particular, these papers address the emergence of so-called complex networks, in particular so-called scale-free and small-world structures. The papers showed that the simultaneous, backward-looking formation of cooperative behavior and exchange relationships can give rise to complex networks, where the particular topological structure of the network may decisively depend upon conditions that shape the harshness of the cooperation problem actors face, in particular the level of risk and uncertainty involved (Pujol, Flache, Sangüesa, and Delgado 2004, [20]; Pujol, Flache, Sangüesa, and Delgado, *submitted* [28]).

Beyond the specific studies summarized above, the research has generated further articles that embed the results into more general literature reviews. Two papers with Wittek discuss research on solidarity in organizations (Wittek and Flache, 2001, [25]) and rational choice theories of organizations (Wittek and Flache 2003, [5]). Both papers put particular attention to the role of behavioral assumptions in these research fields. In a further overview article Flache and Macy (accepted, [1]), deal with agent based modeling in the social sciences, and discuss results derived from agent based modeling that pertain to the relationship between micro-level assumptions and the emergence of social solidarity and social order. Finally, Flache is co-editor and contributor to a number of chapters in a forthcoming book that deals with the integration and comparison of sociological and psychological theories of prosocial behavior, with particular attention to the application of the framing theory proposed by Lindenberg (Fetchenhauer, Flache, Buunk & Lindenberg, Accepted, [15]; See also [16];[17];[18] and[19]).

2. Publications and selected presentations based on KNAW-financed research, 1999-today

2.1 (Inter)national refereed journals, Accepted for publication, forthcoming and published.

Where available, ISI 2002 impact factors are indicated for publication in peer reviewed journals. In terms of impact factors, the most important publications generated by the KNAW-financed research are:

- Macy, Flache 2002. *Proceedings of the National Academy of Sciences U.S.A.*, Impact 10.7 (for comparison: highest impact in sociology ASR=2.85)
 - Flache, Macy 2002. *Journal of Conflict Resolution*. Impact 1.253, ranked 4th in Political Sciences.
1. **Flache, A., M.W. Macy.** *Accepted for publication.* “Bottom-up” Modelle sozialer Dynamiken. Agentenbasierte Computermodellierung und strategische Interaktion. *Kölner Zeitschrift für Soziologie und Sozialpsychologie*. Sonderheft 44. (in German). (ISI 2002 Impact = 0.614)
 2. **Flache, A.** *Forthcoming.* How may virtual communication shape cooperation in a work team? A formal model based on social exchange theory. *Analyse & Kritik*. Special issue on “Trust on the Internet” (Editors Lahno, Matzat, Baumann).
 3. **Flache, A., R. Torenvlied.** 2004. When do they ever make up their mind? The social structure of instability in decision making dynamics. *Journal of Mathematical Sociology* 28:171-196. (ISI 2002 Impact = 0.5)
 4. **Flache, A. 2003.** “Je vrienden val je niet af”. De negatieve effecten van informele netwerken op groepssolidariteit in werkgroepen. *Gedrag & Organisatie* 2003-16.3: 179-200.
 5. Wittek, R.P.M., **A. Flache.** 2003. Rational Choice und Organisationstheorie. In: Allmendinger, J., T. Hinz. Organisationssoziologie. *Kölner Zeitschrift für Soziologie und Sozialpsychologie*. Sonderheft 42:55-87. (in German). (ISI 2002 Impact = 0.614)
 6. **Flache, A., M.W. Macy.** 2002. Stochastic Collusion and the Power Law of Learning: A General Reinforcement Learning Model of Cooperation. *Journal of Conflict Resolution* 46(5):629-653. (ISI 2002 Impact = 1.253)
 7. **Flache, A.** 2002. The Rational Weakness of Strong Ties. Failure of Group Solidarity in a Highly Cohesive Group of Rational Agents. *Journal of Mathematical Sociology* 26:189-216. S. (ISI 2002 Impact = 0.5)
 8. Macy, M.W., **A. Flache.** 2002. Learning Dynamics in Social Dilemmas. *Proceedings of the National Academy of Sciences U S A*. May 14;99(10):7229-36. (ISI 2002 Impact = 10.7)
 9. **Flache, A., R. Hegselmann.** 2001. Do Irregular Grids make a Difference? Relaxing the Spatial Regularity Assumption in Cellular Models of Social Dynamics. *Journal of Artificial Societies and Social Simulation* 4 (4).
<http://jasss.soc.surrey.ac.uk/4/4/6.html>
 10. **Flache, A.** 2001. Individual Risk Preferences and Collective Outcomes in the Evolution of Exchange Networks. *Rationality and Society* 13 (3):304-348. (ISI 2002 Impact = 0.529).

11. Hegselmann, R., **A. Flache**, 2000. Rational and Adaptive Playing. A comparative analysis for all possible Prisoner's Dilemmas. pp. 75-97 in: *Analyse & Kritik* 22 (1). (Both authors contributed equally).
12. **Flache, A.**, R. Hegselmann, 1999. Altruism vs. Self-Interest in Social Support. Computer simulations of social support networks in cellular worlds. In: *Advances in Group Processes* 16:61-97.
13. **Flache, A.**, R. Hegselmann, 1999. Rationality vs. Learning in the Evolution of Solidarity Networks: A Theoretical Comparison. *Computational and Mathematical Organization Theory* 5:2:97-127.
14. Kitts, J., M.W. Macy, **A. Flache**, 1999. Structural Learning: Conformity and Social Control in Task-Oriented Groups. *Computational and Mathematical Organization Theory* 5:2:129-145.

2.2 Books or contributions to books

a) Accepted for publication

15. Fetchenhauer, D, **A. Flache**, S. Lindenberg, B. Buunk (editors). *Accepted for publication* by Kluwer Academic Publishers. *Solidarity and Prosocial Behavior. An integration of sociological and psychological perspectives*. To appear in *Series on Critical Issues in Social Justice*. Series Ed.: Lerner, Melvin J.
16. Lindenberg, S., D. Fetchenhauer, **A. Flache** and Bram Buunk. *Accepted for publication*. Solidarity and prosocial behavior - a framing approach. Chapter 1 in Fetchenhauer et al. *Solidarity and Prosocial Behavior. An integration of sociological and psychological perspectives*.
17. **Flache, A.**, M.W. Macy. *Accepted for publication*. Learning and Framing in Social Exchange. A theoretical comparison. Chapter 3 in Fetchenhauer et al. *Solidarity and Prosocial Behavior. An integration of sociological and psychological perspectives*.
18. Van der Vegt., G., **A. Flache**. *Accepted for publication*. Interdependence in work teams: "framed" social exchange as a theoretical integration of interdependence and categorization perspectives. Chapter 8 in Fetchenhauer et al. *Solidarity and Prosocial Behavior. An integration of sociological and psychological perspectives*.
19. Sanders, K., **A. Flache**, G. Van der Vegt, E. Van de Vliert. *Accepted for publication*. Solidary Behavior in Modern Organizations: a framing perspective on the effects of employees' social embeddedness. Chapter 9 in Fetchenhauer et al. *Solidarity and Prosocial Behavior. An integration of sociological and psychological perspectives*.

b)Forthcoming or published

20. Pujol, J.M., **Flache, A.**, Sangüesa, R. and Delgado, J. Forthcoming. "Emergence of Complex Networks through Local Optimization". Proceedings of the 16th European Conference on Artificial Intelligence. ECAI-04. Valencia, Spain (2004).
21. **Flache, A.** 2004. Stylized solutions for environmental dilemmas in a cellular world. Pp. 155-179 in: Suleiman, R., D. Budescu, D. Messick, I. Fischer. *Contemporary Psychological Research on Social dilemmas*. Cambridge: Cambridge University Press.

22. Macy, M.W., J. Kitts, **A. Flache**, S. Benard. 2003. Polarization in Dynamic Networks: A Hopfield model of emergent structure. Pp 162-173 in: Ronald Breiger, Kathleen Carley and Philippa Pattison. *Dynamic Social Network Modelling and Analysis: Workshop Summary and Papers*. Washington: The National Academies Press.
23. **Flache**, A. 2002. De zwakke kant van hechte netwerken. Pp.35-40 in: Hackeng, T., H. Veenhof (eds.). *Over de grenzen van het weten. Jaarboek 2001. Vereniging van Akademie-onderzoekers*. Amsterdam: KNAW.
24. Van Veen, K., **A. Flache**, J. Kratzer, R. Wittek. 2001. Sociale netwerkanalyse voor kennismanagement: de blinde vlekken van wetenschap en praktijk. Pp. 263-277 in: Van Baalen, P., M. Weggeman, M., A. Witteveen (eds.). *Kennis en Management*. Schiedam: Scriptum.
25. Wittek, R. and **A. Flache**. 2001. Solidarität am Arbeitsplatz. Pp. 149-182 in: Bierhoff, H.W. and D. Fetchenhauer (eds.). *Solidarität. Konflikt, Umwelt und Dritte Welt*. Opladen: Leske und Budrich. (in German).
26. **Flache**, A., M.W. Macy, W. Raub, 2000. Do company towns solve free rider problems? A sensitivity analysis of a rational-choice explanation. In: Raub, W., J. Weesie (eds.). *The Management of Durable Relations: Theoretical and Empirical Models for Households and Organizations*. Amsterdam: Thela Thesis.
27. Hegselmann, R., **A. Flache**, V. Möller, 2000. Cellular Automata Models as Modelling Tool. pp. 151-178 in: Suleiman R., K.G. Troitzsch, N. Gilbert (eds.) *Tools and Techniques for Social Science Simulation*. Heidelberg: Physica.

2.3. Journal articles under review and selected working papers

28. Pujol, J.M., **Flache**, A., Sangüesa, R. and Delgado, J. *Under review at international peer reviewed journal*. Complex Networks from Local Social Exchanges.
29. Lambooi, M., **A. Flache**. 2004. Getting a network. Career mobility, network closure and employee cooperation in labor organizations. Paper presented at the ICS-forumday, November 3, 2004, Nijmegen (*To be submitted for publication in international peer reviewed journal*).
30. **Flache**, A. 2004. How may virtual communication shape co-operation in a work team? A formal model based on social exchange theory. *ISCORE discussion paper no. 216*.
31. **Flache**, A. and M.W. Macy .2004. Learning and framing in social exchange. *ISCORE discussion paper no. 217*.
32. **Flache**, A. 2003. Which informal networks foster which organizational solidarity? Paper based on invited presentation at the International Conference on Rational Choice and Social Institutions, Fukuoka, Japan, September 2003.
33. Wittek, R., **A. Flache**: *Informal Governance and Solidarity in Organisations*. September 2002. MOVEs-Working Paper Nr. 9. Department of Sociology, University of Groningen.
34. Macy, M.W., **Flache**, A. 2001. Learning to Cooperate in Social Dilemmas. *ISCORE discussion paper no. 190*. Institute for the Study of Cooperative Relations. Department of Sociology. University of Utrecht.

35. **Flache, A.**, Macy, M.W. 2001. Stochastic Collusion and the Power Law of Learning. *ISCORE discussion paper no 189*. 53 pages. Institute for the Study of Cooperative Relations. Department of Sociology. University of Utrecht.
36. **Flache, A.** 2001. "The Rational Weakness of Strong Ties. Failure of Group Solidarity in a Highly Cohesive Group of Rational Agents." *ISCORE discussion paper no. 182*. 66 pages. Institute for the Study of Cooperative Relations. Department of Sociology. University of Utrecht.
37. **Flache, A.** 2001. Individual Risk Preferences and Collective Outcomes in the Evolution of Exchange Networks. *ISCORE discussion paper no. 181*. 65 pages. Institute for the Study of Cooperative Relations. Department of Sociology. University of Utrecht.

2.4 Selected presentations at international conferences

1. Macy, M.W.M; J. Kitts, **A. Flache**, S. Benard. 2004. Paper presented at the XXIV International Sunbelt Social Network Conference Portoroz, Slovenia, May 12 - 16, 2004
2. **Flache, A.**, J M. Pujol, R Sangüesa, J Delgado. 2004. **The Emergence of Complex Exchange Networks**. Paper presented at the XXIV International Sunbelt Social Network Conference Portoroz, Slovenia, May 12 - 16, 2004.
3. **Flache, A.** 2003. How may virtual communication shape cooperation in a work team? A formal model based on social exchange theory. *Invited paper* presented at the Zif-Workshop "Trust and Community on the Internet", July 31 – August 2, 2003, Bielefeld, Germany.
4. **Flache, A.** 2003. When social control may fail to solve cooperation problems: Theoretical mechanisms and empirical evidence. *Invited paper* presented at the Japanese European Conference on Social Networks, Utrecht, May 2003.
5. **Flache, A.** 2003. Which informal networks foster which organizational solidarity? *Invited paper* presented at the International Conference on Rational Choice and Social Institutions, Fukuoka, Japan, September 2003.
6. **Flache, A.** 2002. When Social Control May Fail to Solve Cooperation Problems. Theoretical Mechanisms and Empirical Evidence. *Invited presentation* in the section "Solidarity and Social Norms – Models and Mechanisms" at the 31. Kongress der Deutschen Gesellschaft für Soziologie in Leipzig 7.-11. Oktober 2002.
7. **Flache, A.** 2002. The weak side of social control. Models and Empirical Evidence. *Invited presentation* at the NIAS conference "Social Networks, Norms and Solidarity – New Approaches to Cooperation". June 9-11, 2002. Wassenaar, The Netherlands.

3. Future research activities

In September 2004, NWO selected Andreas Flache for a research grant (600 K) in the Innovational Research Incentives Scheme of NWO (Vernieuwingsimpuls - VIDI). The corresponding research proposal was elaborated and submitted in the period of the KNAW supported research of Andreas Flache and is based upon a part of the results of that research. The title of the granted proposal is “The importance of timing and structure: modeling effects of interpersonal contacts on social cohesion in diverse groups.” and the period of the research project will be 2005-2009.

Summary of NWO-VIDI research proposal by Andreas Flache (granted in 2004)

The way policy-makers and social scientists think about social cohesion is strongly influenced by the contact hypothesis: contacts between culturally different people improve their interpersonal relationships and thus foster social cohesion. A prominent example is the policy to assign schoolchildren from so-called “black-neighborhoods” to mixed schools. However, empirical tests of the contact hypothesis in various realms show a complex picture.

Various research lines study under which conditions contacts may foster cohesion. We aim to innovate this research through a systematic integration of three hitherto unrelated fields. Due to this integration we can identify previously unrecognized conditions under which contacts may foster cohesion in different empirical realms. In particular, we suggest that cohesion may be a matter of *timing* and *network structure of contacts*, conditions that can be utilized for policy design. We draw on *formal computational models of social differentiation* to generate precise predictions about the conditions and dynamics of social cohesion. Our innovations in this research line will be a systematic combination of positive and negative effects of social contact (assimilation and rejection) and an empirical test of underlying micro-level assumptions. We employ for the empirical test recently developed statistical techniques and datasets from *studies of intercultural friendship networks*. We aim to advance these studies by feeding their results about micro-level processes back into our formal analysis of the structural determinants of social cohesion. Finally, we incorporate a condition for group cohesion that was suggested by recent *research on subgroup formation in work teams* but has been overlooked by the other lines of study: so-called “faultlines” caused by clustering of members’ demographic attributes. Our new theory will first be tested in controlled group discussion experiments. Subsequently, field tests will be conducted on intercultural friendship networks in schools and on culturally diverse work groups.