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Chapter 11

A Theory of Power in Small Groups

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Abstract

A theory of power inspired by Wartenberg's account is presented in precise terms, together with various specializations amounting to different forms of power, and performing a theory-net. The notion of exerting power is characterized by the actors' intentions and by a believed causal connection between the actions involved. The subordinate agent performs "his" action although originally he did not intend to do so. Some variants of application of the models are discussed.

The most influential recent approaches to modelling small groups focus on the notion of exchange, like Blau (1964) or Thibeaut and Kelley (1959). Though these approaches do not exclude events in which one actor tries to impose its will upon another actor, they have to treat them indirectly, by reference to utility and certain kinds of strategic behavior. However, there are important instances of exertions of power in small groups the description of which in terms of exchange seems rather cynical, like a husband's beating his wife. Up to now "theories" of power, if they deserve this label at all, are found in the political sciences and in sociology. There, interest mostly is in larger groups involving institutions, like the political system of a country. But the notion of power also is important in the social psychology of small groups for at least two reasons. First, as already said, there are phenomena in small groups for which the term "power" seems to provide the most adequate way of verbalization, and which seem quite central to the understanding of the functioning of the group. Any detour of systematizing such phenomena in terms of exchange indicates a way of looking at the phenomena from an inadequate point of view.[1] Second, power yields an important and easy link to more comprehensive sociological theories, like theories of social institutions. Such theories are, or should be, based on underlying relations at the individual level, one of the most important of which is power.[2]

On the other hand, the notion of power is not easily accessible to operationalization. Some attempts, like Dahl (1957), do not seem to have convinced the scientific community. In the theory presented here, this problem is noted. I do nbt want to defend an operationalist approach for psychology, however. On the contrary, in the absence of rich data, strong and strongly hypothetical models seem to fare better than operationalist "modesty".

My aim in this paper is to present a rigorous formulation of a theory of power which in this form may be applied to small groups. The theory consists of a basic core and a variety of specializations of the core which together form a theory-net.[3] The theory has grown out of studies of Thomas Wartenberg's account of power: Wartenberg is eager to avoid any touch of operationalism, and resorts to rather comprehensive notions, like course of actions, understanding, and evaluation. In several attempts at formalizing Wartenberg's notions I was led to another group of notions like intention, belief and preference. Therefore I cannot claim that the present account is a reconstruction of Wartenberg's theory. Rather, it consists of a redefinition of his central notions in different vocabulary, together with formalization.

The claim associated with the theory presented is that it may be applied to small groups in interesting ways; that it allows for an easy connection to comprehensive sociological theories, and that it is precise to a degree which allows for computerization. I will use structuralist notation which I presuppose as known to the reader.[5]

1. Potential Models

The models of power are founded on some basic features of humans in general. Four notions are of particular interest here: causation, behavior, intention, and preference. These are formatted over a basis of actors and actions (or more general: events), and are relativized to time.

I use J to denote a set of human actors and E to denote a set of possible events. Actors in J are denoted by i, j, elements of E by a, b, c, d, e. The notion of an event is general enough to comprise actions as well as states, whether physical or mental. In most cases, the elements of E will stand for actions (of the actors in J). Time is represented by a set T of points of time, and an order relation $<$, to be interpreted as "later than". Causation is represented in the more general form of a relation PARCAUS of "being a partial cause of". The entities which function as partial causes and effects are taken to be events. Often, they will be actions, as in statements of the form "*i*'s performing action a is a partial cause for j's performing *b*", but mental states also can function as partial causes and effects. The notion of (partial) cause and effect is by no means trivial, and some progress towards its clarification is very recent.[6] In constrast to other notions, partial causation will be treated in an objective way, as though it were independent of the actors' beliefs. This assumption is made only for reasons of simplicity and may be easily removed.[7] Behavior is represented by means of a relation of performance which is time-dependent. I write

$$PERFORM(t, j, e)$$

to state that actor j, at time t, performs action e. In the same way intentions and preferences are treated. The standard syntax for intentions is "i intends to do a". I will use a more general syntax of the form

$$INTEND(t, i, j, a)$$

expressing that, at time t, actor i intends that actor j should perform action a. Setting i equal to j this yields the standard notion, relativized to time. Preference, as usual, is taken as a binary relation, the objects related being events. This is compatible with the more static view according to which preference obtains between objects, when we assume that objects can be characterized in terms of events and states, states themselves also being a special kind of events. I write

$$PREFER(t, j, a, b)$$

to express that actor j, at time t, prefers event (action, state) a to event (action, state) b. Putting all these notions together, and adding one axiom for performance, we obtain what I call a frame of actions.

D1 x is a ***frame*** of actions iff there exist J, E, T, $<$, PARCAUS, PERFORM, INTEND, PREFER such that
$x = \langle J, E, T, <, PARCAUS, PERFORM, INTEND, PREFER \rangle$ and
1) J, E, T are non-empty sets, and pairwise disjoint,
2) $\langle T, < \rangle$ is a finite, linear order,[8]
3) $PARCAUS \subseteq E \times E$, $PERFORM \subseteq T \times J \times E$, $INTEND \subseteq T \times J \times J \times E$, and $PREFER \subseteq T \times J \times E \times E$,
4) for all $t \in T$, all $i, j \in J$, and all $e \in E$: if $i \neq j$ and $PERFORM(t, i, e)$ then not $PERFORM(t, j, e)$.

PARCAUS(a, b) is read as "a is a partial cause of *b*". D1-4 requires that the same action must not be performed by two different persons at the same time. Essentially, this rules out joint actions, like carrying a table, to occur in E, it does not rule out, however, the analysis of joint actions in terms of their "individual parts". In a frame of actions, further notions may be explicitly defined. For later use, I mention the notion of a ***full*** cause, which in its most simple form is defined as a partial cause for which there is no other, different partial cause contributing to the same effect. That is, a is a ***full cause*** of b iff *PARCAUS(a, b)* and there is no c different from a such that *PARCAUS(c, b)*. On a probabilistic account of causality, a full cause might be defined alternatively as a partial cause which produces its effect with probability one. Another notion which can be defined is that of a goal, and goal directed action. I will not define the general notion[9] but use a stronger and more operational version which applies to cases in which action towards the goal has already occurred. An event e (which may be a state) is called a *goal* of actor i iff 1) i intends to achieve e ($INTEND(t, i, i, e)$ for all t later than some given t_0) and 2) there are actions $c_1,\dots,c_n$ such that i has performed each c_j ($PERFORM(t_j, i, c_j)$ for $j = 1,\dots,n$ and $t_0 < t_j$), and each c_j is a partial cause of e ($PARCAUS(c_j, e)$ for $j = 1,\dots,n$). Accordingly, an action a performed by actor i is goal directed iff there is a goal e of i such that a is a partial cause of e.

In D1, the set of events being involved in each relation plays an important role. As already indicated, I take actions to be a particular kind of events, so there is no need to introduce an extra primitive for actions. The same applies to states. A state may be regarded as an event in which no change occurs, but which nevertheless still is an event. In spite of the wide range of applicability of events it will be convenient to replace events by propositions. There are good reasons to do so.[10] First of all, propositions will be needed anyway as the appropriate objects of belief, belief being introduced as a further basic human feature. When propositions are available they may be regarded as representations of certain events, just in the way in which an event may be represented by a sentence. We might use representation as a further primitive, relating events and propositions. The resulting theory, however, is rather clumsy. Therefore it seems admissible to blur the distinction between an event and it's representing proposition(s), and treat events as propositions rightaway. In applications it always will be easy to pass over from a proposition to some corresponding event represented by it. The reverse step, from events to propositions, which is more problematic, is not really needed in applying our theory. There is another reason to resort to propositions. It will be necessary in the following to ascribe beliefs and partial causes to complex entities the particular structure of which has to be spelled out in order to state my theory. This is best seen with an example. It will be necessary, for instance, to state that William believes that striking the match causes the wood to bum. Representation of this is achieved in two steps. First, a sentence is needed to represent the relation of causation, second, William's belief in the corresponding proposition is expressed as a further sentence. Formally, writing "a" for "William strikes the match, "b" for "the wood starts burning", the first sentence s_1 is "$PARCAUS(a, b)$", while the second may be written in the form $BELIEF(i, s_1)$ with "i" for "William" and "BELIEF" for "believes that". So sentence s_2 : BELIEF(&s_1) contains reference to another sentence s_1. Technically, this problem is solved by assuming that the language used contains an operator [ ] such that for each sentence A, $[A]$ is a term of that language. By using this operator, s_2 may be taken to be of the form $BELIEF(i, [PARCAUS([a],[b])])$.

For these reasons I will replace the set of events in D1 by a set P of propositions. What was said about PARCAUS, PERFORM, INTEND and PREFER remains valid if the interpretation is adjusted. Thus, in case of PERFORM for example, $PERFORM(t, i, a)$ is read as "at t, i performs action a" where now a really is a proposition representing the action performed by i.

Intuitively, a proposition is an equivalence class of sentences of the same meaning. More precisely, propositions may be construed as follows. Let L be a set of sentences of a many-sorted formal language. We also use the word "language" for L itself. Assume that, on L, a binary relation $\leq^*$ is given which imposes on L the structure of a distributive, complementary lattice'' with 0 and 1. $\leq^*$ is interpreted as representing a kind of implication in meaning. Such implication is much weaker than logical implication. For example, walking in this sense implies moving, or kissing implies touching. Assuming that $<L, \leq^*>$ is distributive and complementary, and assuming the existence of 0 and 1 assures that the usual sentential connectives: "non" $(\neg)$, "and" $(\wedge)$, "or" $(\vee)$, "if then" $(\rightarrow)$ and "iff" $(\leftrightarrow)$ can be introduced. On the structure $<L, \leq^*>$ a relation $\approx$ of equivalence of meaning may be defined by

(0) $s \approx s'$ iff ($s \leq^* s'$ and $s' \leq^* s$), for $s, s' \in L$.

By factorizing L and $\leq^*$ with respect to $\approx$, we pass over to propositions. Thus a proposition is a set of sentences of L which forms an equivalence class relative to $\approx$, i.e. it is a maximal set of sentences which are equivalent in meaning. Among propositions, a corresponding implication $\preceq$ may be defined by

(1) $p \preceq p'$ iff there are $s \in p$ and $s' \in p'$ such that $s \leq^* s'$.

In the following, I will need a set of propositions rich enough to contain representatives for the primitives of the theory of power: belief, partial cause, performance, intention, preference, and feasibility. These primitives will be represented by the symbols

BELIEF, PARCAUS, PERFORM, INTEND, PREFER and ***F***, each symbol being a predicate or function symbol of a many-sorted type to be specified below. In order to assure that the propositions "contain" these primitives we simply may assume that the language in which sentences of L are formulated is a many-sorted language containing, among other things, the symbols just introduced. Moreover, ***L*** should contain variables of a distinguished sort, the "sort of events". If language L, in addition, contains expressions for n-tuples $<x_1,...,x_n>$, elementship, quantifiers and equality, I say that the propositions generated by L and s* form a ***space of propositwns.***

In other words, a structure $<P, \preceq>$ is a ***space of propositions*** iff there exist ***L*** and s* such that

1) ***L*** is the set of sentences of a formal, many-sorted language containing a special sort: that of events,
2) $<L, \leq^*>$ is a distributive, complementary lattice with 0 and 1,
3) ***L*** contains predicate and function symbols ***PERFORM, INTEND, PARCAUS, PREFER, BELIEF*** and ***F*** of the types specified in the following,
4) ***L*** contains an operator ⌈ ⌉ assigning a term ⌈*A*⌉ of the sort of events to every sentence ***A*** of L,
5) ***L*** contains n-tuple brackets, elementship, quantifiers, and equality
6) ***P*** is the set of equivalence classes of sentences from ***L*** with respect to the relation ≈ defined in terms of s*, and $\preceq$ is the relation defined on propositions by (1) in terms of $\leq^*$.

Two propositions ***p, p'*** are equal if and only if both consist of the same sentences. In this case any two sentences ***s*** E ***p*** and ***s'*** E ***p'*** are equivalent in meaning according to definition ***(0)*** above. Put differently, two sentences have the same meaning if and only if their equivalence classes are the same. Note that the operator ⌈ ⌉ introduces an element of impredicativity typical for higher-order logical systems. This feature is typical for human language and has to be expected to be present in every non-trivial theory about the social sphere. Note further that by replacing events by propositions that operator is no longer necessary. If, in the above example, ***BELIEF*** is a predicate of propositions, and ***PARCAUS(a, b)*** is regarded as a proposition we simply can write ***BELIEF(i, PARCAUS(a, b))***. This possibility will greatly simplify the description of special forms of power below.

Replacing events in ***D1*** by propositions and introducing belief and a power-relation completes the list of primitives. The structures in which all primitives can be interpreted, or are realized, are called potential models. I also take the meaning implication $\preceq$ on propositions, defined by ***(1)*** above, as a primitive. This is simpler, and in principle allows to treat $<P, \preceq>$ directly (i.e. without reference to ***L*** and s* as a complementary, distributive lattice with 0 and ***1***. In the following I will not sharply distinguish between propositions and their representing sentences.

Belief is treated as a predicate on propositions, and relativized to time and individuals.

$$BELIEF(t, i, p)$$

is read "individual i at time t believes that p". The power-relation which is the central theoretical term in the present theory is equiped with six arguments. I write[12]

$$POWER(t, t', i, a, j, b)$$

which is read: "at time t, person i by performing action a exerts power over person j such that j at time t' performs action b".

D2 x is a *potential model* ($x \in M_p$) iff there exist $J, T, P, <, \preceq$, PERFORM, INTEND, PARCAUS, BELIEF, PREFER and POWER such that
$x = \langle J, T, P, <, \preceq, PERFORM, INTEND, PARCAUS, BELIEF, PREFER, POWER \rangle$
and
1) J, T and P are non-empty sets, and pairwise disjoint,
2) $\langle T, < \rangle$ is a finite, linear order,
3) $\langle P, \preceq \rangle$ is a space of propositions,
4) $PERFORM \subseteq T \times J \times P$, $INTEND \subseteq T \times J \times J \times P$,
$PARCAUS \subseteq P \times P$, $BELIEF \subseteq T \times J \times P$, $PREFER \subseteq T \times J \times P \times P$,
and $POWER \subseteq T \times T \times J \times P \times J \times P$,
5) for all $t \in T, i, j \in J$ and $e \in P$: if $i \neq j$ and $PERFORM(t, i, e)$ then not $PERFORM(t, j, e)$.

In the following, I shall denote the relations resulting from relativization to an instant and an actor by adding t and j in parentheses. For example, $INTEND(t, j)$ denotes the relation defined by: for all $i \in J$ and all $e \in P$, $INTEND(t, j)(i, e)$ iff $INTEND(t, j, i, e)$. Similarly, I'll write $PREFER(t, j)$, $BELIEF(t, j)$ etc.

A potential model roughly consists of a set J of actors, each actor being endowed with intentions, preferences and beliefs which change over time. Moreover, there is an "objective" relation of partial causation "independent" of the actors. All actors have a common space of propositions. This space may be regarded as representing the language spoken by members of J. The assumption that all individuals have the same, common space of propositions amounts to a strong condition of consistency and homogeneity. If this condition turns out to be too strong, one may relax it, and work with individual spaces of propositions $\langle P(t, i), \preceq(t, i) \rangle$ instead.

2. The Basic Model of Power

I now introduce a class of models from which a basic theory-element for the theory of power may be constructed. The basic models of power obtained in this way consist of a potential model plus one axiom for the relation of power. This is stated in the form of a biconditional (D3-2 below). It is not meant, however, to provide a definition of power. Rather, the power-relation is regarded as an ordinary primitive which happens to be connected with the other primitives in the form of a biconditional. The situation here is analogous to that in mechanics or in thermodynamics.[13] The three requirements for exerting power (D3-2) may be restated informally as follows. i) says that the actions a, b are actually performed at the two instants, ii) says that the exertion of power has to overcome a non-existing or even negative intention of j to do b, and iii) says that at least one of the two actors at at least one of the two instants involved believes that a partially causes b. In the formal definition I use the fact that a finite linear order $\subset$ T, **< >** has a unique maximal element which is denoted by t_{max}.

D3 *x* is a basic *model* of power ($x \in$ M,) iff there exist
J, T, P, c , $\preceq$, *PERFORM, INTEND,* PARCAUS, BELIEF, PREFER and POWER such that
$x =$ cl, *T,* P, <, $\preceq$, *PERFORM,* INTEND, PARCAUS, BELIEF, PREFER, *POWER*>
and
1) *x* is a potential model,
2) for all $t, t' \in$ T such that $t \subset t_{max}$ and for all *i, a, j,* b:
POWER(*t, t', i, a, j,* b) iff $t \subset t'$ and
i) *PERFORM*(*t, i,* a) and *PERFORM*(*t', j,* b),
ii) *INTEND*(*t, i, j,* b) and not *INTEND*(*t, j, j,* b),
iii) there exist k $\in$ {*i, j*} and t* E {*t, t'*} such that
BELIEF(t^*, *k*)(*PARCAUS*(*a,* b)).

t' in D3-2 cannot be chosen as *t* + 1 in general, i.e. as the unique minimal point of time after *t*, far one model may capture several different exertions of power so that between *t* and t' for two actors *i*, j there may be other instants relevant for other actors. 2-i) distinguishes the present definition from that of having power in which ii) and iii) need to hold only dispositionally. ii) and iii) capture the main characteristics of power. According to ii) some resistance of j has to be overcome.[14] This is seen more easily when the second part of ii) is strengthened to express that j intends to perform some action c incompatible with b. I have chosen the weaker version in order to have a larger domain of application. There are borderline cases still satisfying ii), like that of influence through advertizing, in which ordinary language would not use the term power. This objection is recognized, it is not regarded as decisive, however. Every scientific theory may deviate to some extent from ordinary language. ii) also captures the intentional nature of power. Omitting ii) would leave us with a mere connection of causal belief. iii) expresses this causal connection in a rather weak way. Very often, iii) holds for both agents and at both times. Two features of iii) deserve further attention. First, some causal connection between a and b is necessary to distinguish exertions of power from connections by mere chance. If i) and ii) are satisfied, it still might be the case that b is done for causes different from a, and, from the perspective of a, accidentally. I may call the police to remove a car in front of my garage, whereupon the owner actually removes the car; not because he recognized my action (the police did not yet arrive) but because he wanted to drive away anyway. In such a case the connection between actions a and b is accidental, and I cannot be said to exert power by means of doing a. Second, it is not generally required that both agents have to believe in a causal connection. Some forms of power explicitly depend on one of the agents being unable to see this connection.

It is helpful to compare this definition with Wartenberg's according to which exerting power for actor i means to strategically change j's action-environment. Some change also is expressed in the second part of ii) and the second part of i), namely a change of *j's* attitude towards doing b. While, at *t*, j does not intend to do *b*, at t' he nevertheless performs b. That the change is strategically brought forth by i to some degree is expressed in the first part of ii). And that the change is brought about by i is contained in **iii)**, to some extent.

Some trivial implications may be noted.

Theorem 1 If $x \in M$, then'' for all $t, t' \in T$, $i \in J$ and $a, b \in P$:
not *POWER*(t, t', i, a, i, b).
Proof: *POWER*(t, t', i, a, i, b) would imply, by **D3-2-ii,** the contradiction *INTEND*(t, i, i, b) and not *INTEND*(t, i, i, b) □

Theorem2 **If $x \in M_0$ then for all $t, t' \in$ $i, j \in J$ and $a, b \in P$:**
if *POWER*(t, t', i, a, j, b) then not *POWER*(t, t', j, a, i, b).
Proof: If i = j, the theorem follows from **T1.** Otherwise, suppose that *POWER*(t, t', i, a, j, b) and *POWER*(t, t', j, a, i, b). From D3-2-i we obtain *PERFORM*(t, i, a) and *PERFORM*(t, j, a) which, by D2-5, yields a contradiction □

Theorem 3 There exist $x \in M$, and t, t', i, a, j, b such that
POWER(t, t', i, a, j, b) and *POWER*(t, t', j, b, i, a).
Proof: Construct an example with two actors i, j, two actions a, b and two instants t, t' such that the following hold:
PERFORM(t, i, a), *PERFORM*(t', j, b), *PERFORM*(t, j, b), *PERFORM*(t', i, a), *INTEND*(t, i, j, b), not *INTEND*(t, j, j, b), *INTEND*(t, j, i, a), not *INTEND*(t, i, i, a), *BELIEF*(t, i)(PARCA*US*(a,b)), *BELIEF*(t, j)(*PARCAUS*(b, a)). Then D2-5 is satisfied. Define POWER to contain exactly the tuples <t, t', i, a, j, b> and <t, t', j, b, i, a>. Then D3-2 also is satisfied, so the structure is a basic model of power □

Theorem 1 may be rephrased as saying that no actor can exert power over himself. By Theorem 2, the positions of i and j are uniquely determined in the expression *POWER*(t, t', i, a, j, b). In the following, I will always use "i" to fill in the third, and "j" to fill in the sixth argument place. i will be called the superordinate and j the subordinate **agent.**[16] These labels are relative to a given tuple <t, t', i, a, j, b>. Any such tuple e = <t, t', i, a, j, b> for which *POWER*(t, t', i, a, j, b) holds, I call a power-event, and I say that actors i and j are involved in the power-event e iff i and j occur in e. Finally, I define i ***exerts*** power over j (at t, t') by: there exist a, b such that *POWER*(t, t', i, a, j, b). In this sense it is well possible that in $x \in M$, actor i exerts power over actor j and at the same time j exerts power over i. This follows directly from Theorem 3 which states the stronger case that the actions in both exertions are the same. The only odd feature about Theorem 3 is about intentions and performance, for the model in this case implies that PERFORM@i, a) and not *INTEND*(t, i, i, a), and the same for j and b. So both actors perform their action without intending it. It is difficult, for this reason, to find real-life examples of such a situation. Also, it has to be noted that although in each power-event there is a distinguished "direction" in which power is exerted, namely from i to j, this does not hold with respect to two given actors in the whole model. Both actors may be involved in many power-events of differing directions in the model.

3. Special Forms of Power

I shall now consider several special forms of power. Each form is characterized by adding further requirements to those of D3. In this way, the power-relation takes on more special forms. The situation is completely analogous to that in physics, where a basic theory-element gives rise to a "theory" (= theory-net) by providing a basis which is specialized in various ways.'' Following **Wartenberg,** I distinguish between force, coercion, influence and manipulation, and at the end I propose bniary as another form **of** its own not yet considered in the literature. I will formulate the extra assumptions for just one single power-event in each case. So a model of power may contain several **different** forms of power-events at the same time.

The characteristic feature of force is that it operates entirely at the material level. The enforced action is brought about simply as the unavoidable material effect of an appropriate cause. I capture this by requiring that the cause a in the power-event must be a full cause. This means that the cause leads to the effect with certainty. No deliberation is necessary at the subordinate's side. Moreover, the subordinate agent intends to do non-b at the same time he is forced to perform b.

D4 x is a model containing force ($x \in M$,) iff
1) $x = \langle J, T, P, <, \preceq, PERFORM$, INTEND, PARCAUS, BELIEF, PREFER, $POWER\rangle \in M$, and
2) there exist $t, t' \in T, i, j \in J$ and $a, b \in P$ such that
2.1) $POWER(t, t', i, a, j, b)$,
2.2) $INTEND(t', j, \neg b)$,
2.3) a is a full cause of b.
Moreover, $e = \langle t, t', i, a, j, b\rangle$ is an event of exertion of force in x iff 2.1-2.3 hold for e.

Negative examples of force abund in punishment, for a positive example think of a baby's being forced **by** her mother to swallow a medicine.

The next form of power, coercion, is much more complex. Informally, coercion works as follows. The superordinate agent i utters a thread (the utterance being action a) towards j, namely that he would perform some action a* unless j does b. a* is chosen such that it is much worse for j to suffer the effects of a* than to do b. Therefore, with a bit of rationality, a will prefer to do b, which he would not have done without the thread. Of course, the situation has to be such that i's thread is credible, and j must believe this. There are several ways to make this precise, the crucial point being a comparison of the effects of a* and of b. One way to proceed is to consider one distinguished event, c, caused by a*, and let j evaluate c with respect to b. If b ranks higher in j's preference order this should be reason for j to perform b even if originally he does not intend to do so. The problem with this account is that the effect of a* often does not simply consist in another alternative to be chosen. Rather, it consists in a global restriction of the range of possible actions. Though other actions, preferred to c, will physically still be possible, they are no longer really relevant because of the high weight of c. If c is not performed the damage will be so great that most alternative actions have to be cancelled. I therefore take a different route[1], and introduce a new primitive: a set F of feasible actions. For actor j, I write $F(t,j)$ for the set of actions feasible for j at time t. Feasibility is much more restrictive than ordinary possibility. Many actions may be physically possible without being feasible on social, economic, or psychological grounds. By reference to a function

$$F : T \times J \rightarrow Po(P)$$

the effect of the action a* in coercion may be **described** as a restriction of j's set of feasible actions. This set is restricted in the transition from t to t' in such a way that b is preferred by j to all other elements of $F(t',j)$.

D5 x is a model containing coercion ($x \in M_c$) iff
$x = \langle J, T, P, <, \preceq, PERFORM, INTEND, PARCAUS, BELEIF, PREFER, POWER \rangle \in M$, and there exist $t_1, t_2, t^*, i, j, a, b, a^*$ such that
1) $POWER(t_1, t_2, i, a, j, b)$,
2) $t^* \in T$, $t_2 < t^*$ and $a^* \in P$,
3) $PARCAUS(a, BELIEF(t_1, j, \neg PERFORM(t_2, j, b) \leftrightarrow PERFORM(t^*, i, a^*)))$,
4) $PARCAUS(a^*, \forall t > t^* \forall c\, (PREFER(t_1, j, c, b) \wedge c \in F(t_1, j) \rightarrow c \notin F(t, j)))$.
Moreover, $e = \langle t_1, t_2, i, a, j, b \rangle$ is an event of coercion in x iff iff e satisfies **1)-4)** with respect to appropriate t* and a*

D5-3 says that the superordinate agent's action a - the thread - causes j to believe that he (i) will do a* if and only if j does not perform b. D5-4 may be rephrased as follows. Action a* causes a restriction of j's range of actions feasible after t* to contain no alternative that is preferred to b and was feasible for j earlier (at t_1). Instead of t, any other instant before t^* might be used here.

The "mechanism" of coercion contains an appeal to j's rational deliberation. Those possible future actions which still will be open to him after the thread is realized, are all inferior to b. This, as well as the other, better, options available later in case he *does* b, is reason enough to perform b eventhough b in itself may be of little or even negative value to j. We might investigate more precisely the assumptions of rationality which are **necessary** to derive that j performs b at t_2. It is easy to see how to proceed as long as we do not care about the details. One has to introduce numerical degrees of belief and of partial causation, and to see that *j's* degree of belief in D5-3 as well as the degrees of partial causation in D5-3 are high, so that a high degree of belief can be attached to j's belief in the causal connection between his not doing b and the restriction of his range of feasible actions expressed in D5-4: "$\forall t > t^* \forall c (PREFER(t^*, j, c, b) \wedge c \in F(t_1, j) \rightarrow c \notin F(t, j))$".

A "reasonable" assumption of rationality therefore would be that

(R) $BELIEF(t_2, k, PARCAUS(PERFORM(t_2, k, b), \forall t > t^* \forall c (PREFER(t, j, c, b) \wedge c \in F(t_1, j) \rightarrow c \notin F(t, j))) \rightarrow PERFORM(t_2, k, b)$.

This is admittedly a rather complex definition which perhaps may be further simplified. On the other hand, its complexity explains to some extent why it has not been empirically studied, given the central role of coercion in society.

The third form of power is influence. It is characterized by the fact that the causal change (D3-2-iii) concerns the internal components of j in such a way that after the change j actually wants (intends) to do b. By the internal components I mean j's relations of intention, preference and belief. In connection with belief, the implication $\precsim$ also might be considered, and if PARCAUS were treated relative to action and time the same would hold for PARCAUS. An example of the change of PARCAUS as a case of influence is a witchdoctor in a "primitive" society who changes j's relation $PARCAUS(t, j)$ and thus exerts influence about j.

As far as $\precsim$ is concerned, its change goes together with that of the belief-relation BELIEF of course. It is admitted that such change is important, in particular during education, and in the process of language acquisition. However, as $\precsim$ belongs to the "language" spoken in the group, its change by influence goes beyond the intended range of application to small groups, and therefore is not considered here. It may be noted that propositions and $\precsim$ can be relativized to actors and time[19] rather easily.

Concentrating on the three components: intention, preference and belief, there are clearly three ways of change and therefore of influence, each concerning the change of one of these components. These of course may occur in various combinations, and I do not claim that there are no other forms of change, more subtle than those considered here.

In order to have one compound entity that is changed in each case, consider the psychological state of actor i at time t, $PS(t, i)$, in a model $x \in M$, as defined by

$$PS(t, i) = \langle INTEND(t, i), PREFER(t, i), BELIEF(t, i)\rangle.$$

Such a state consists in other words of the intentions, preferences and beliefs of actor i at time t.

D6 x is a model containing influence ($x \in M_I$) iff $x = \langle J, T, P, <, \precsim$, PERFORM, INTEND, PARCAUS, BELIEF, PREFER, $POWER\rangle \in M$, and there exist t_1, t_2, i, a, j, b such that
1) $POWER(t_1, t_2, i, a, j, b)$ and D3-2-iii is satisfied for i at t_1 and at t_2,
2) $PS(t_1, j) \neq PS(t_2, j)$,
3) $PARCAUS(a, PS(t_1, j) \# PS(t_2, j))$.
Moreover, any power-event $e = \langle t_1, t_2, i, a, j, b\rangle$ satisfying 1)-3) is called an event of influence in x.

Instead of D6-3 we might require that i believes a being such a partial cause. As I do not have theoretical arguments for this, I stick to the simpler, objective version. Note that for influence it is required that the superordinate agent be aware of the causal connection between a and b (D6-1). Typically, the subordinate agent is not so aware.

Influence may be further specialized. Mere change of the components of the psychological state yields rather unspecific models which are needed for later reference.

D7 x is a model with change of intention (resp. preference, resp. ***belief***) with respect to e (x E M,) iff x = <*J*, *T*, P, <, $,PERFORM, INTEND, PARCAUS, BELIEF, PREFER, ***POWER***> is a model of influence and e = <t_1,t_2,*i*, a, j, *b*> is an event of influence in x such that ***INTEND***(t_1,*j*) $\neq$ ***INTEND***(t_2,*j*) (resp. ***PREFER***(t_1,j) # ***PREFER***(t_2,j), resp. ***BELIEF***(t_1,j) # ***BELIEF***(t_2J)).

Concentrating on change of belief we may consider models in which the action b is induced in the subordinate agent because she learns to see b's effect of bringing about some desired state c.

D8 x is a model with ***immediately*** relevant change of belief (x E M,) iff x = <*J*, *T*, P, <, ≤, ***PERFORM***, INTEND, PARCAUS, BELIEF, PREFER, ***POWER***> is a model with change of belief with respect to e = <t_1,t_2,*i*, a, j, *b*> and there exists c $\in$ P such that
1) for all t* E {t_1,t_2} : ***INTEND***(t^*, j, j, c),
2) not ***BELIEF***(t_1,*j*, ***PARCAUS***(*b*, c)),
3) ***BELIEF***(t_2,j, ***PARCAUS***(*b*, c)),
4) ***PARCAUS***(*a*, ¬***BELIEF***(t_1,*j*, ***PARCAUS***(*b*, c) A ***BELIEF***(t_2,*j*, PARCAUS (b, c))).
Moreover, if e = <t_1,t_2,*i*, a, *j*, *b*> satisfies 1)-4) with respect to some suitable c, e is called an event of immediately relevant change of belief in x.

Here, a "goal" c is used such that j comes to believe that b **contributes** to c at t_2, while at t_1, j did not have that belief. Requirement 4) expresses that the belief-change is caused (partially) by the superordinate agent's action a.

Immediately relevant change of intention occurs when the negative intention concerning b is changed into a positive one.

D9 x is a model of immediately relevant change of intention ($x \in$ M,) iff x = <*J*, ..., POWER> is a model with change of intention with respect to e = <t_1,t_2,*i*, *a*, *j*, *b*> and ***INTEND***(t_2,*j*, j, b).

With respect to preference, three main kinds of changes may occur, the disjunction of which I introduce to characterize models with change of preference. First and second, the domain of the preference relation may be extended (**D10-a** below) or restricted (**D10-b**), third, the preference ordering itself may be reversed for some **pair(s)** of events (**D10-c**). The domain of ***PREFER***(*t*, j), D_I(*t*, j), is defined as the set of all c in P such that c is related to some other e in P through ***PREFER***(*t*, j).

D10 x is a model with immediately relevant change of preference (x E M,) iff x is a model of change of preference with respect to e = <t_1,t_2,*i*, a, j, *b*> and one of conditions a), b), c) obtains:
a) $D_I(t_1,j) \subset D_I(t_2,j)$ and $b \in D_I(t_2,j) \setminus D_I(t_1,j)$,
b) 1) $D_I(t_2,j) \subset D_I(t_1,j)$,

2) for all $c \in D_I(t_2,j)$: $PREFER(t_2,j,b,c)$,
3) there is $d \in D_I(t_1,j)$ such that $PREFER(t_1,j,d,b)$,
c) there is c such that $PREFER(t_1,j,c,b)$ and $PREFER(t_2,j,b,c)$.

Case a) in D10 obtains when a new possibility is added to *j's* domain of preferences as an effect of *i's* action. In this case the action b performed by j is among the new alternatives. That is, b was not considered in j's preference ordering at t_1, but is so considered at t_2. Note that this does not contradict *b's* being in the domain of j's relation of intention at t_1. Case b) means that an action is removed from j's domain of preferences as impossible or unfeasible through *i's* action a, and b in this case is maximally preferred by j at t_2, while at t_1 there exist actions preferred to b in j's domain of preferences. In case c) the preference-order between b and c is reversed.

A third type of influence I want to consider is manipulation. This is a form of influence in which a goal pursued by the superordinate agent is concealed to the subordinate agent who, by doing *b*, **contributes** to that goal unknowingly. The notion of a goal may be used here as defined in **Sec.1.**

D11 x is a model containing manipulation ($x \in M_m$) iff $x = \langle J,\ldots,POWER\rangle \in M$, and there exist t_1,t_2,i,a,j,b and $c \in P$ such that
1) x is a model of influence with respect to $\langle t_1,t_2,i,a,j,b\rangle$,
2) c is a goal for i at t_1,
3) $BELIEF(t_1,i,PARCAUS(b,c))$,
4) not $BELIEF(t_1,j,INTEND(t_1,i,i,c))$.

D11-4 entails that j does not believe that c is a goal of i (by the earlier definition of a goal).

The final specialization investigated here is bribery. Informally, bribery occurs when i gives some means to j (usually money) and signals that he hopes j will do b. This is a rather weak form of power, and often exerted by actors with a lower over actors with a higher social position. Also, the causal connection is very weak so that a is only a very partial cause of b. In order to formulate my conditions, I have to refer to the feasible actions already used in connection with coercion. $F(t,j)$ is the set of actions feasible for j at t, whether physically, economically, or socially.

D12 x is a model containing *bribery* ($x \in M_b$) iff $x = \langle J,\ldots,POWER\rangle \in M$, and there exist F, t_1,t_2,i,a,j,b and $c,d \in P$ such that
1) $F: T \times J \rightarrow Po(P)$,
2) $\langle t_1,t_2,i,a,j,b\rangle$ is a power-event in x,
3) $PARCAUS(a,c)$,
4) $c \in F(t_2,j)$ but not $c \in F(t_1,j)$,
5) for many $e \in F(t_1,j)$: $PREFER(t_2,j,c,e)$,
6) $b \in F(t_1,j)$,
7) $BELIEF(t_1,i,PARCAUS(a,INTEND(t_2,j,j,b)))$.

i believes that his doing *a* partially causes j to intend to do b, and so to perform b. 6) means that b was feasible for j also before bribery was attempted. The phrase "for many" in 5) is of course vague, and depends on the context. If PREFER is represented numerically by a utility funtion one e would be enough, provided its utility would be high so that 5) expresses that *c* is rather valuable for j. c in **3)** and 4) represents the means given to j, or rather j's state when the means were received. Note that cases in which c is not handed over unless b is performed - which in ordinary language also might be termed bribery - under our analysis should be seen as cases of coercion rather than bribery. This is a nice example in which precise theoretical analysis corrects ordinary talk.

4. The Net of Power Theory

According to the previous definitions power theory takes on the form of a theory-net, consisting of several specializations of the basic model of power. The specializations themselves again may be specialized, as was the case with models containing influence. The classes $M_0, M_1, ..., M$, of models defined above thus form a net as shown in Figure 1, in which lines from top to bottom represent the relation of set-theoretic inclusion. If these model classes are enriched by the necessary structuralist items they yield theory-elements, and the above net becomes a net of theory-elements, i.e. a theory-net in the technical structuralist sense. The inclusions depicted in this net are trivial to verify.

Theorem 4 For i = 1,...,9, M_i is a proper subset of M, and for i = 4,...,7, M_i is a proper subset of M,.

Still rather trivial is the fact that all model classes have non-empty intersections. This is due to the way in which M,, ...,M, were defined. In each model only one power-event has to satisfy the respective special conditions. So taking two disjoint power-events it is easy to satisfy the requirements for two model classes, and to construct a model contained in both classes. This also holds for intersections of more than two model classes. Omitting the details of construction this yields

Theorem 5 For $0 \leq i \leq 9$ and $j_1,...,j_i \leq 9 : \bigcap \{ M_{j_r} : r = 1,...,i \} \neq \emptyset$.

On the other hand, those classes for which this was not explicitly stated before, are not specializations of each other.

Theorem 6 a) not M, $\subseteq$ M, and not M, E M,,
b) not M, E M_3 and not M, $\subseteq$ M,,
c) not M, $\subseteq$ M, and not M, E M_3.
Proof: By construction of counterexamples for each case □

The same relations also hold among M,, M, and M,.

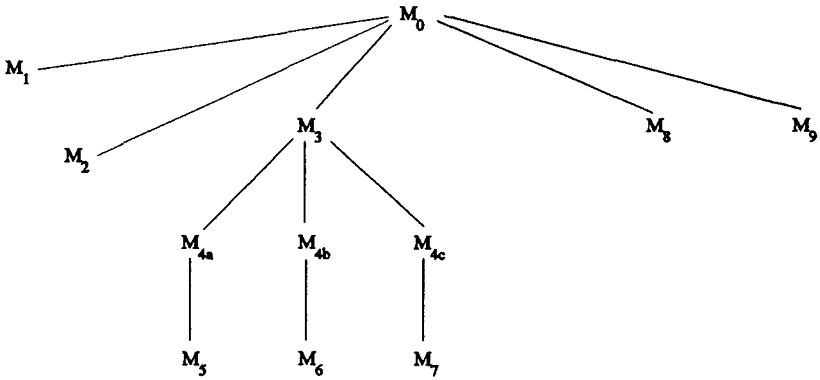

Figure 1: ***The net of power-theory***

M_0 = class of basic models of power
M_1 = class of models containing force
M_2 = class of models containing coercion
M_3 = class of models containing influence
$M_{4a,b,c}$ = class of models with change of a: belief, b: intention, c: preference
M_5 = class of models with immediately relevant change of belief
M_6 = class of models with immediately relevant change of intention
M_7 = class of models with immediately relevant change of preference
M_8 = class of models containing manipulation
M_9 = class of models containing bribery

The more interesting, and less trivial question is whether different forms of power may be realized in the same power-event. This is in fact so, and I will indicate for some cases why this is so.

Theorem 7

a) There is ***x*** ∈ ***M***, n ***M***, and a power-event ***e*** in ***x*** such that ***e*** is an event of force and an event of coercion.
b) There is *x* E M, n ***M***, and a power-event ***e*** in ***x*** such that ***e*** is an event of coercion and influence.
c) There is ***x*** E ***M***, n ***M***, and a power-event ***e*** in ***x*** such that ***e*** is an event of coercion and bribery.
d) There is ***x*** E ***M***, n ***M***, and a power-event ***e*** in ***x*** such that ***e*** is an event of immediately relevant change of belief and an event of immediately relevant change of preference.
e) There is ***x*** E ***M***, n ***M***, and a power-event ***e*** in ***x*** such that ***e*** is an event of immediately relevant change of preferences and of manipulation.

Proof: By construction of respective models. I just indicate how to proceed. The crucial point in each case is to assume that ***PARCAUS*** can be defined such that the requirements on both sides are satisfied. In a), ***PARCAUS*** has to be such that ***a*** is a full cause of b and such that belief concerning ***a,*** b and ***a*,*** c in D5 can obtain. Such a ***PARCAUS***

can be constructed if BELIEF is chosen accordingly. b) In coercion ***PARCAUS*** holds between a^* and c where c expresses the restriction of j's feasible actions. In influence ***PARCAUS*** applies to $<a,d>$ and/or to $<a,e>$ where d and e represent the changes of intention, preference and belief, respectively. As these events are disjoint, there is no problem in defining ***PARCAUS.*** c) In bribery, ***PARCAUS*** applies to $<a,g>$ and $<a,h>$ where g represents the means-handed over (D12-3), and h represents $INTEND(t_2,j,j,b)$. Again, the events d,e from part b) and g h can be chosen to be disjoint so that no problems occur. d) and e) are treated similarly □

Theorem 7 says that different forms of power may be realized by the same power-event, the difference being located in the actors' psychological states mainly. This clearly indicates that the theory of power studied here falls in the domain of social psychology. It is worth while noting the analogy to the natural sciences. In classical mechanics, for instance,"' the same position function may occur as the result of different forces acting according to different force laws at the same time. Setting the position function analogous to a power-event, and the different force-functions (and laws) analogous to the forms of power, a strong similarity is seen.

It is not easy to provide real-life examples for all the cases of overlap stated in Theorem 7. Force is so dominating that it usually covers features of coercion which also might be present. Coercion may go together with influence when the subordinate agent changes its psychological state in order to eliminate the tension created by the coercive thread in the sense of balance theories. Bribery may have effects of influence.

The different forms of power are effective in different degrees.[21] Clearly, force is very unproductive, it usually works negatively, preventing actions on j's side, and involves high cost for the superordinate agent. Coercion works more efficient in this sense. There is little cost (just an utterance), and the resulting action may be "positive", not only for i, but also for j (e.g. in paternalistic application). The same holds for influence. The difference between coercion and influence is that coercion presupposes some power in the sense of capacity on *i's* side, some established (or clearly recognizable) superior position, be it physically, economically, or socially superior, in order to lend credibility to the thread. Influence does not need this capacity. Here, the capacity is typically replaced by the ability to exert influence over a long period, like in education. Bribery again is unproductive, and depends on the social background of the subordinate agent. If his social or economic position as well as the probability of getting detected is very high he may not be bribed even by large amounts of money.

It cannot be claimed at the present stage that these forms of power are all that exist or all that are worth while to be studied. As seen in the case of coercion, the exertion of power takes on rather complicated forms in order to become more effective. Which forms are really important for the understanding of small groups, or relevant for incorporation in more comprehensive sociological theories, will depend on further empirical investigations.

5. Problems of Application

This leads to the question of application of the present theory. At a first glance it does not look very empirically. It seems to provide a definition of power on the basis of other concepts which are not much easier to determine empirically.

Putting on one side the methodolocical prescriptions which have been suggested on the basis of considerations of physics, the most natural approach to the question of application is to look at what is claimed by a theory about real systems. What is it, new and interesting, that the theory tells us about the world? I do not want to provide a general answer here, but rather stick to the particular theory at hand.[22] What does this theory of power claim about the world? It seems that there are different claims which can be made by means of this theory. Let me proceed from the particular to the general.

A first claim which can be made is that certain observed, or real, sequences of actions are power-events, that is, are exertions of power. When I see a man beating his wife, I may want to claim that he exerts power over her, and the present theory shows what this amounts to. A claim of this kind is validated by checking the conditions in D3 where power is connected with the notions of performance, intention and causation. In order to show that the man exerts power over his wife, I have to verify the conditions put forward in D3.

A second claim that can be made is that a certain observed sequence of actions is an exertion of a particular form of power, say of coercion. Again, to verify this claim one has to check the conditions on performance, intention and causation of D3, and in addition the requirements put forward for coercion in D5. A priori, in both cases the claim might turn out as false. This might happen when the determination of performance, intention and causation yields data which do not satisfy the axioms of the present theory. In the case of coercion, for example, we might find out that there is no indication that the alledgedly subordinate agent believes that the superordinate agent can restrict her range of performance (D5-3). If such a result occurs the claim is no longer tenable. So the theory seems falsifiable, Popper would be satisfied. The question remaining is how to determine intentions and causes, performance being relatively unproblematic.

A more comprehensive claim which can be made with the theory of power is that a given set of actors and their actions form a basic model of power. For such a claim it is more difficult to see how it could be verified or refuted. A problem traditionally discussed in that context is the problem of theoretical terms. In order to verify a claim of this kind one tries to determine the observational terms, and then checks whether they can be extended to a full model. However, power-theory does not seem to fit nicely in that scheme. Intuitively, one would say that among all the primitives used only those of time, actors, and performance can be directly observed. The way of verification just considered then would amount to checking whether observed performed actions can be embedded in a model of power, which clearly is a trivial task: always successful. Sneed's account[23] of theoreticity might help here. According to Sneed, we have to ask which terms of power-theory can be determined without using power-theory. In addition to those just mentioned (actors, performance, time) this seems to be obviously true for the space of propositions $\langle P, \preceq \rangle$. With respect to intentions, preferences, causation and beliefs the question needs further investigation. With respect to power the result again is clear: power is power-theoretical in Sneed's sense.

The "objective" way in which I treated causation suggests that ***PARCAUS*** can be determined independently of the theory of power. This becomes particularly clear when causation is seen in probabilistic terms. In order to determine partial causes the essential procedure in the present case is to determine relative frequencies of events; a task usually independent of power. The remaining three notions: intention, preference, belief, are difficult in this respect. The problem is that according to Sneed's criterion we have to consider methods of determination for these notions, but such methods simply do not exist. So a detailed investigation of whether these concepts are power-theoretical in Sneed's sense seems futile at the moment. If we assume (not without reservation) that preferences can be measured fundamentally in real-life systems, a Jeffrey-type decision theory would yield probabilities and utilities. If the probabilities obtained were suited to determine causation we could infer ***PARCAUS***, and from ***PARCAUS*** by means of observed performances we might come to intentions via goals.[24] But all this is just an idea rather than a real procedure. A sceptical attitude seems appropriate anyway.

However, Sneed's proposal of theoreticity and the resulting form of the empirical claim is just one special way to proceed. Without drawing a distinction between theoretical and non-theoretical terms, a more liberal way of testing the claim that a given real system of actors and actions is a basic model of power is obtained. The procedure is just to collect as many data as possible in all the primitives in whatsoever way, and then to check whether these data can be fitted to the models of power. It seems to me that this kind of procedure is more adequate in the present case. The four primitives: intention, preference, belief, and power are all of the same degree of empirical undeterminateness. There is little hope to determine all of them by an empiricist theory referring to "more fundamental" notions. It may be doubted whether there are any notions more fundamental than these. So it seems best to allow all means of determination available for them. This may lead to Sneedian circles in the theory's validation, but such circularities are compatible with the widely acknowledged bootstrap view of confirmation.[25]

A final claim, similar to the previous one, is that a real system of actors and actions is a model containing some special form of power, say influence. What has been said with respect to the previous kind of claim applies here, too. Although the additional requirements put forward for the special forms of power in some cases are rather strong, they do not allow to determine the psychological states in terms of performance only. Again, intentions, beliefs and preferences seem to be on the same level with power, as far as testability is concerned, so a more general approach to validation seems preferable to Sneed's procedure. This means that data may be formulated in terms of all the primitives, and that the collecting of data is not restricted to methods independent of power-theory.

This view of application of course has to face resistance from the established approach to empirical theories in psychology. The objection basically is that the kind of liberalism proposed in collecting the data amounts to ignoring the statistical methods of test and validation of hypotheses, and thus is nothing but a step backward as far as methodology is concerned. I certainly do not want to criticize the methods of statistical tests but I want to uphold what I said about application and test against this kind of objection. The objection is correct insofar as the standard statistical methods are neglected. It is not correct, however, to conclude that such neglectance methodologically is a step backward, for this would amount to the much stronger claim that statistical methods of test are the only ones admissible. I have some reservations about such monopolistic claims concerning methodology. In opposition to a monopoly of statistical methods in social science I want to make two final remarks.

First, statistical procedures are of an inductivist nature. They stress the data, and they assume many data in order to test an hypothesis.[26] When confronted with a complicated and less local theory, like the one under consideration it is far from clear how a set of data should have to look like in order to serve as a sample for testing whether the whole system is a model or not, nor is it clear what kind of statistical hypothesis would be employed. It seems to me that there is a gap between the kind of hypotheses that may be subjected to statistical test, and theories of the type considered here. It is difficult to see how standard statistical methods are used to test an axiom of the form of **D3-2.**

Second, the inductivist attitude of the statistical theory of testing has of course its well known opponent in the form of deductivism. Without going into any details it seems clear that a deductivist view of test is much better suited to cases in which there is a strong theory but only few data. Such is the case before us. Perhaps the theory is still too weak in that it does not allow enough deductions to yield interesting cases of empirical confrontation with data. At the moment, however, this is an open question to be settled by further investigation. Anyway, the lack of rich data can be replaced by using stronger theories so that the same degree of testability is retained.

Application and test of the present theory therefore seems easier along the deductive line. The theory is claimed to apply in this sense to small groups with a relatively short life-span of less than one human life. Institutions must not be completely comprised in such systems, though they may exist externally and be used by single actors as a means for the exertion of power in the group. The resulting empirical claim of the theory is that these systems are basic models of power, and in addition contain further special forms of power, the interest in such a claim being that one may "see" and systematize certain sequences of actions as exertions of (special forms of) power.

Notes

1 There is no space to argue for this in detail. Compare Balzer (1991) for some considerations in this direction.
2 Compare Balzer (1990) for such a new theory of social institutions.
3 Compare Balzer,Moulines and Sneed (1987), in particular Chap.4, for the notion of a theory-net.
4 Wartenberg (1988) and Wartenberg (1990).
5 Up to Sec.4, I'll stick to the notation of Balzer, Moulines and Sneed (1987).

6 Compare Mackie (1974) for the philosophical, and Suppes (1970) for the formal dimension.
7 For a relativized treatment, see Balzer (1990).
8 I.e. transitive, anti-reflexive, and connected.
9 For this, as well as for an explication of the notion of intention see Tuomela (1984).
10 I am indebted to R.Reisenzein here. A demonstration of the unifying power of propositions, as well as some systematic argument for their use, is found in Jeffrey (1965).
11 Compare Graetzer (1971) for lattice theoretic details.
12 Neglecting the two instants t,t', this relation has the same format as that in Dahl (1957).
13 In mechanics the formula I have in mind is the second law, in thermodynamics it is Moulines' central axiom as stated in Moulines (1975).
14 This feature is found already in Weber (1980), see e.g. p.28.
15 I use the convention to refer to the components of $x = \langle J, T, \ldots \rangle$ without any indication that these are the components of x, whenever this is clear from the context.
16 Following Wartenberg (1988).
17 The analogy would become even closer, had I used an extra "dummy" index for the power-relation in D3 to distinguish various forms of power-relations in analogy to the special force function in mechanics.
18 I am indebted here to several of the participants at the conference.
19 Compare Balzer (1990).
20 In McKinsey, Sugar and Suppes' formulation, see Balzer, Moulines and Sneed (1987).
21 A detailed discussion of this point is found in Wartenberg (1990).
22 For a general account, compare Balzer, Moulines and Sneed (1987).
23 As reproduced in Balzer, Moulines and Sneed (1987), in particular in Chap.2.
24 Compare Stephan (1990) for other approaches to utility.
25 See Glymour (1980).
26 This is meant to be the typical case. There are well-known procedures for small samples, of course.

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