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THE SEEDS OF WEAK POWER: AN EXTENSION OF NETWORK EXCHANGE THEORY*

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We extend network exchange theory (Markovsky, Willer, and Patton 1988) to accommodate a new class of power phenomena. Previous theory and research have shown that structural configurations in some networks promote or inhibit exchange opportunities, leading to robust power and resource differentials. The extension identifies a structural basis for subtler forms of differentiation. Using computer simulations and laboratory experiments, we show that the degree to which this "weak power" is manifested in resource accumulations is conditioned by local and global network patterns, and by the experience and strategies of actors in the network. Experimental tests corroborate the predicted weak power effects and the consequences of variations in actors' negotiating experiences.

Network exchange theory (NET) was developed to predict negotiated distributions of resources in a class of networks consisting of interrelated individual or corporate actors (Markovsky, Willer, and Patton 1988). These networks provide a fertile context for addressing issues of power and exchange, social dynamics, structural transformation, micro-macro connections, and other questions central to sociology. A recent issue of the journal *Social Networks* (Vol. 14 (3–4), Sept.–Dec. 1992) is devoted to locating power in exchange networks. We report on a newly discovered phenomenon in exchange networks, *weak power*. Informally, we define weak power as a condition that promotes significant advantages for some network positions, but severely restricts those advantages relative to their potential maxima. We also offer a formal definition that distinguishes weak power networks from other network types.

The extension of NET to weak power phenomena results from theory competition. Yamagishi and Cook (1990) observed that early versions of NET did not predict certain power differentials produced by their computer simulations. We show that those power differentials arise from structural properties that were not addressed in any previous theory. We develop and empirically test an extension of NET that identifies the general class of networks and the specific relations in which weak power emerges, and the direction and strength of the weak power effect.

THEORETICAL BACKGROUND

In NET, a *relation* is an exchange opportunity between a pair of individual or corporate decision-making actors, and an actor's *position* contains the actor and is designated by its pattern of relations to other actors. A *network* is a set of positions and relations that forms a unitary structure.

Although it functions as a self-contained theory, NET developed within a much broader theoretical research program. This program, "elementary theory," addresses basic social

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forms including coercive, conflictual, and exchange relations (Willer and Anderson 1981; Willer 1987; Willer and Markovsky forthcoming).[1] Within the exchange relations branch of the elementary theory are subbranches for exclusionary, inclusionary, and mixed exchange networks. These designations indicate types of restrictions on actors' efforts to obtain resources in exchange networks. In an *exclusionary network,* actors with two or more relations cannot exchange in one or more of their relations. In an *inclusionary network,* actors must exchange in more than one relation. In a *mixed network,* actors can exchange only in some relations and must exchange in more than one relation.[2] We focus here on the exclusionary exchange networks branch of the broader theory.

NET's seven scope conditions delimit the situations to which the theory may be applied:

> (1) all actors use identical strategies in negotiating exchanges; (2) actors consistently excluded from exchanges raise their offers; (3) those consistently included in exchanges lower their offers; (4) actors accept the best offer they receive, and choose randomly in deciding among tied best offers; (5) each position is related to, and seeks exchange with, one or more other positions; (6) at the start of an exchange round, equal pools of positively valued resource units are available in every relation; (7) two positions receive resources from their common pool if and only if they exchange. (Markovsky et al. 1988, p. 223)[3]

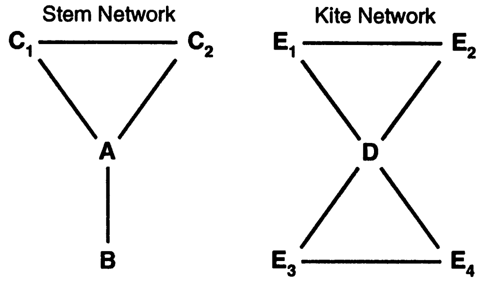

Figure 1. The Stem and Kite Networks

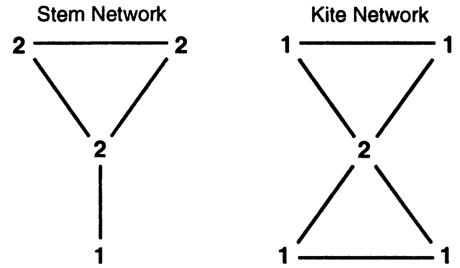

Figure 2. Initial GPI Values for Stem and Kite Networks

The Graph-Theoretic Power Index

When the scope conditions are satisfied, NET predicts relative power (higher, lower, or equal) for each position in a network relation. *Power* is defined as a "structurally determined potential for obtaining relatively favorable resource levels" (Markovsky et al. 1988, p. 224). Power is measured by the graph-theoretic power index (GPI). Figure 1 presents two illustrative networks, the "stem" and the "kite." Calculations are simpler in networks containing two or more structurally identical positions.

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[1] Similarly, the self-contained "vulnerability" models of power in networks (Cook, Emerson, Gillmore, and Yamagishi 1983; Cook, Gillmore, and Yamagishi 1986) developed within the more general program of power-dependence theory (e.g., Emerson 1981). Markovsky et al. (1988) contrasted vulnerability models and the graph-theoretic model of network exchange theory.

[2] To formalize the typology of relation types, let N be the number of an actor's direct relations with others, M is the maximum number of exchanges that can benefit the actor, and Q is the minimum number of exchanges that the actor must complete to realize any benefit. The actor's relations are exclusionary when $N > M \geq Q = 1$, inclusionary when $N = M = Q$, and mixed when $N > M > Q > 1$. For mixed relations, when $N = M > Q = 1$, the relation is null; the relation is inclusion-null mixed when $N = M > Q > 1$ (Willer and Markovsky forthcoming). Tests for the two mixed types are in progress.

[3] The scope conditions do not *define* exchange. An exchange is a mutually agreed-upon distribution of valued resources between actors. This could be an agreement to divide resources from a common pool, or the transfer of ownership of different objects, e.g., A gives B $10 for two of B's baseball cards. The scope conditions also do not minimize the importance of individual agency in networks (Markovsky 1987, 1992; Barron and Smith-Lovin 1991). The scope conditions delimit the class of actors for which the structurally-derived predictions of the theory are claimed to be accurate. A wide range of specifications for individual-level strategies and behaviors remains open to exploration. Our present focus on structural effects makes no statement about the relative "power" of actors versus structures.

Table 1. Path Lengths, by Position, for the Stem Network and the Kite Network

	Stem Network			Kite Network	
Path Length	Position A	Position B	Position C	Position D	Position E
1	3	1	2	4	2
2	1	1	1	2	1
3	0	1	1	0	1
4	0	0	0	0	1
Graph-Theoretic Power Index (GPI)	2	1	2	2	1

In such networks a nonsubscripted label indicates structurally identical positions, e.g., C stands for C_1 and C_2.

The first step in calculating GPIs is to count the number of *nonintersecting paths* of every length stemming from each position. These counts for the stem network and the kite network are shown in Table 1. For example, E_1 in the kite network has two paths of length 1, E_1–D and E_1–E_2; one nonintersecting path of length 2, e.g., E_1–E_2–D (any other path of length 2 must intersect this one at E_2 or D and so is not counted); one path of length 3, e.g., E_1–E_2–D–E_3; and one path of length 4, e.g., E_1–E_2–D–E_3–E_4. There are no nonintersecting paths with lengths greater than four. This analysis holds for each E in the kite network.

The theory specifies that position i has structural power over position j when i can, without cost, exclude j from exchanging. This induces j to accept lower payoffs. By this reasoning, odd-length paths benefit their position of origin by enhancing its capacity to exclude (Markovsky et al. 1988). Even-length paths are detrimental because they increase the chance of being excluded. Thus, to calculate GPI, add the number of a position's odd-length paths and subtract the number of even-length paths. These initial GPI values for each position in each network appear at the bottom of Table 1 and in Figure 2.

Axioms

Four axioms determine the relative power of network positions. In Axiom 1, GPI is calculated using a more general equation for networks in which actors can make $e \geq 1$ exchanges, each with a different actor. In such networks, subnetworks or *domains* may emerge. Positions residing in more than one domain have a GPI for each domain.[4] Let m_{idk} represent the number of nonintersecting paths of length k in domain d that originate from position i, and h is the longest such path. At i, an actor's power in domain d is

$$\text{Axiom 1: } p_{id}(e_d) = \left(\frac{1}{e_d}\right)\sum_{k=1}^{h}(-1)^{(k-1)} m_{idk}.$$

Axiom 1 defines GPI_2. The remaining axioms use GPI_2 to infer when actors will and will not seek to exchange with each other and to anticipate their relative exchange outcomes:

Axiom 2: i seeks exchange with j if and only if $p_i > p_j$ or if $(p_i - p_j) \geq (p_i - p_k)$ for all k related to i.

Axiom 3: i and j can exchange only if each seeks exchange with the other.

Axiom 4: if i and j exchange, then i receives more resources than j if and only if $p_i > p_j$.

[4] To calculate domain memberships, let i and j indicate two related positions, and an e^+ position has more than e relations. Given the set V of all positions on a path between i and j, i and j are in the same domain if and only if there exists a path such that either V = {Ø}, or all positions in V are e^+ positions. Markovsky et al. (1988) investigated a network in which each of three positions had two GPI values, one indicating equal power in one domain and another indicating low power in a second domain. Results strongly supported predictions. Because we are dealing here with networks in which $e = 1$, the terms "network" and "domain" are coterminous, and we use "network" throughout. In general, however, our assertions about networks are more accurately viewed as assertions about domains.

In previous experiments, hypotheses derived from these axioms accurately predicted relative exchange profits for different positions, network decompositions at certain relations, and power reversals induced by changes in *e* (Markovsky et al. 1988). The research also refuted alternative hypotheses from power-dependence theory (Cook et al. 1983; Cook et al. 1986).

NEW THEORETICAL CONCERNS

Other researchers have questioned the ability of the GPI to predict power levels in stem and kite networks. Yamagishi and Cook (1990), using a computer simulation, claimed that positions A and D have high power, in contrast to GPI predictions of equal power in all stem and kite relations after Axiom 2 is applied.[5] However, their simulation's profit differentials were very small (equality ± 2) relative to empirical studies and other simulations they described (Cook et al. 1983). Furthermore, they did not publish the simulation algorithm, show how to derive their predictions, or present any empirical evidence. Stolte (1990) provided a formal model, but noted that it "does not perform well in predicting positional power, as conditioned by remote structural influences" (p. 141). Hence, although both studies recognized that power differences can exist in these structures, they did not offer a testable theory for predicting specific power differences or identifying the class of structures in which these power differences should occur.

Markovsky, Willer, and Patton (1990) agreed that GPI predicted no power differences among actors in the kite and stem networks, but pointed out that although Yamagishi and Cook's intuitions could be correct, the lack of an alternative model and empirical evidence weakened their argument. We have since replicated Yamagishi and Cook's simulations for the kite and stem networks and explored many other networks. Our goal was to provide an explicit, general method for predicting the emergence of this *weak power effect* coupled with empirical evidence.[6]

During our research we made several discoveries. (1) Weak power differentials are sensitive to the particular strategies adopted and behaviors enacted by actors in particular network positions. (2) Weak power differentials have the same microfoundation as strong power differentials: Actors seeking to avoid exclusion from exchanges accept deals favorable to others and unfavorable to themselves. (3) Weak power is produced by a subtle interaction between network structures and exchange conditions. (4) Although the networks in which weak power emerges had already been identified (Markovsky et al. 1988), a refinement was needed to locate the specific weak power relations within those networks.

GPI_3: AN ITERATIVE REFINEMENT

Our extension of network exchange theory builds on GPI_2 to generate refined predictions of weak power. Under GPI_2, ongoing exchanges can produce temporary changes in the number of an actor's available exchange partners, the number of the partners' partners, and so on (Markovsky et al. 1988, p. 225*n*). Thus, the extension, GPI_3, must take into account temporary power shifts that arise as some actors exchange in a given time period and leave behind altered substructures. The stem and kite networks illustrate these problems, but our solution generalizes to all weak power networks.

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5 Stolte (1990) asserted that A has an advantage and presented experimental evidence for this claim. However, his experiment violates our scope conditions because subjects' exchange outcomes had no bearing on their actual payments (Stolte 1988). The relevance of his results to NET therefore remains undetermined.

6 We employed a user-friendly simulation program for exchange networks, X-Net, which is available on request from the first author. The researcher can create or select any network configuration and choose the number of "experiments" and negotiation "rounds," resource pool sizes, exchanges per round, and actors' decision strategies. Unless otherwise specified, an actor decreases all offers in the next round by one unit if the actor makes all the exchanges it seeks in a given round. If the actor makes fewer deals than were sought, then the actor (1) decreases its offers by one unit to those with whom a deal was completed, and (2) increases offers by one unit to those with whom a deal was not completed. In a given round, an actor can seek exchange only from a number of others equal to the maximum number of exchanges it can complete in the round. In the current version of X-Net, three partner-choice strategies are available: (1) actor randomly seeks exchange with any partner whose offer is "complementary," e.g., actor offers 14,

The new procedure analyzes *exchange-seeks*. In the original formulation, an actor *i* was said to be seeking exchange when his, her, or its offers to another, *j*, are competitive with *j*'s alternative offers.[7] Exchange-seek analysis is a tool that generates predictions of a network structure's effect on exchange outcomes. Whether applied to human, corporate, or simulated networks, the theory's exchange-seek *axioms* need not correspond to actual events. However, the axioms are not arbitrary — they were designed to generate derivations and hypotheses for exchange outcomes that are more precise and accurate than alternatives. As with any formal theory, its derived *hypotheses* must be empirically informative — not necessarily its axioms (Jasso 1988). In the case of NET, derived hypotheses predict (1) when actors in empirical tests *will not* seek exchange and, thus, where the network breaks from disuse, and (2) the relative exchange outcomes at different positions.

Figure 3, Step 1 applies Axiom 2 to the stem and kite networks. For example, "C_1Æ A" indicates "C_1 seeks exchange with A." Step 2 applies Axiom 3 and shows reciprocal exchange-seeks. GPI_2 is then recalculated for the subnetworks (Step 3). Because all GPI_2 values are equal, all original relations are restored. When an isolate emerges, e.g., D in Step 2, it receives a value of 1.[8] Applying Axiom 2 to the recalculated GPI_2 values indicates that all actors seek exchange in all relations and there should be no permanent breaks in the networks. Also, according to GPI_2 values, there are no structurally-based power advantages, i.e., *no positions can consistently exclude others from exchanging without themselves suffering losses.* Thus there will be no bidding wars driving offers toward extremes.

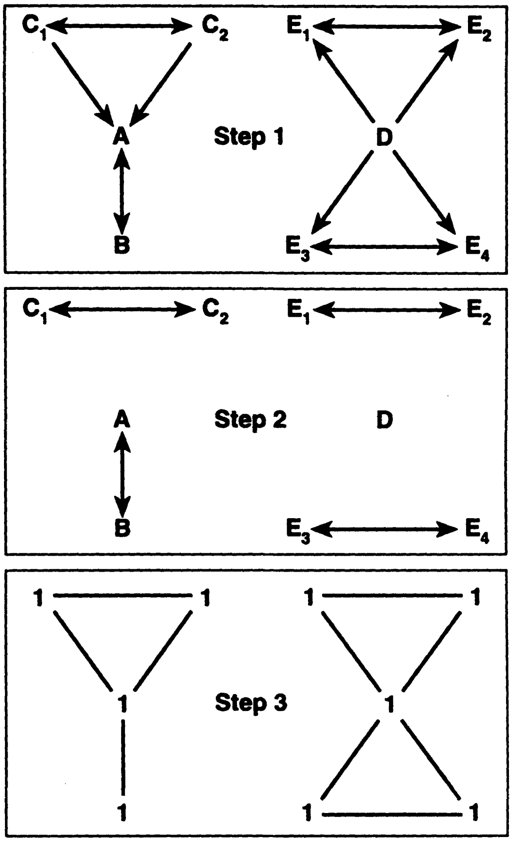

Figure 3. Iterative Analysis for Computation of GPI_2 for Stem and Kite Networks

Even when positions in a network have the same GPI_2, as in the stem and kite networks, they may still be differentiated by a structural property weaker than that producing strong power. The reasoning is this: An actor in a position with two or more equal power relations initially has no preference among the alternatives. As negotiations proceed, however, one or more of the alternatives may have already exchanged and thus become unavailable. In the stem network, for example, if A and B exchange first in a given round, the C's are not excluded and can exchange with each other. If A and C_1

other offers its complement, 10; (2) actors randomly seek exchange after compromising with others using a "split-the-difference" rule; (3) actors seek exchange from those making the most profitable offers after compromising. The modular program design also facilitates exploration of other strategies via programming changes.

[7] For example, if *i* offers 5 units to *j*, and *j*'s best alternative offer is 10, then *i*'s offer is not competitive with the alternative. From the standpoint of our analytic method, *i* is *not seeking* exchange with *j* in this case. This definition of exchange-seeking (and nonseeking) enables us to predict which network relations will be used. The definition embodies no implicit assumptions about actors' motives, interpretations, strategies, etc.

[8] The procedure yields identical predictions if the isolate is assigned a GPI_2 of 0, but doing so results in additional steps. We have not yet fully explored the implications of assigning 1 versus 0 to isolates. More than one iteration of the exchange-seek analysis may be required in more complex networks. In complex networks, the analysis is complete when index values remain unchanged.

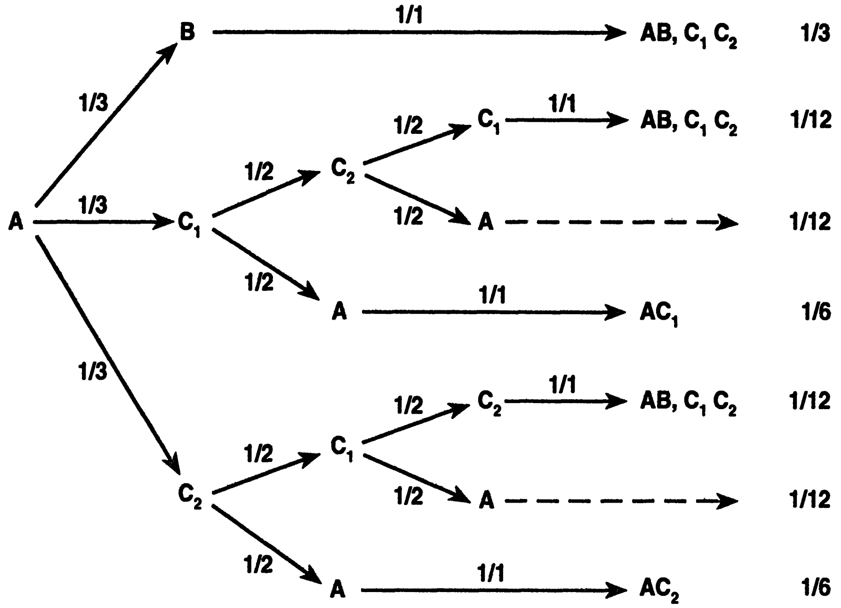

Figure 4. Tree Diagram for Computing GPI_3 for the Stem Network

exchange first, however, B and C_2 are excluded for that round. Unlike the situation in strong power structures, the consequences of such exclusions are not severe because it is relatively inexpensive for an excluded position to be included subsequently. If A and C_1 exchange, in the next round B and C_2 can attract A by raising their offers only slightly above C_1's. If A then exchanges with B, C_1 and C_2 may exchange with each other. If, instead, A exchanges with C_2, B will have been excluded twice and can offer slightly more — an amount that should then be A's best offer. Under the scope conditions of the theory, B should not be *consistently* excluded and thus should not have to offer more than occasional small concessions to continue exchanging with A. Thus, the stem and the kite networks are examples of *weak power structures.*

Strong and Weak Structural Forces

Despite their common basis in exclusion, strong power and weak power have important differences. (1) In strong power structures, exchange outcomes approach maximum differentiation across positions, constrained only by the size of the resource pools; in weak power structures, differentiation is independent of pool size. (2) Only strong power structures exhibit a "ratcheting" process whereby actors in structurally disadvantaged positions serially outbid one another through ever-increasing offers to the advantaged. (3) As a result of such bidding wars among the structurally disadvantaged, even passive bargaining stances result in extreme profit advantages for actors in structurally advantaged positions in strong power networks. In weak power networks, obtaining more than minimal profit advantages requires more active strategizing by the structurally advantaged. (4) Consequently, in weak power networks structural forces keep exchanges relatively close to equal profit divisions. Conversely, in strong power networks structural forces move outcomes toward maximum differentiation. (5) A fundamental difference is that strong power structures *guarantee* that one or more actors will be excluded by another actor who is never excluded. Weak power structures ensure that either all positions are prone to exclusion (as in the kite), or that no position — not even a position that of structural necessity is never excluded (e.g., A in the stem) — is assured of being able to exclude another without cost. Thus, the certainty of exclusions in strong power networks is replaced by the possibility of exclusions in weak power networks.

To make more refined predictions, we must turn this "possibility" of exclusion into a probability measure that applies when structurally dissimilar network positions have the same GPI_2 values. To perform the weak power analysis, we calculate each position's likelihood of inclusion under a "random exchange-seek" assumption. The resulting probability measure is GPI_3. The easiest way to grasp this measure is with the tree diagram for the stem network shown in Figure 4. Branches correspond to events (e.g., exchange-seeks) that are assigned probabilities. A series of connected branches represents a combination of events whose overall probability is the product of the values assigned to its constituent branches. The probability of a particular outcome, e.g., a mutual A–C_1 exchange-seek, is the sum of all of the probabilities associated with branch combinations leading to that outcome. The GPI_3 value for a position, then, is the sum of the probabilities across its relations.[9]

In Figure 4, arbitrarily beginning with A does not affect calculations because the tree accounts for all exchange-seek combinations. Dashed lines are combinations of exchange-seeks that lead to no mutual selections. These occur 1/12 + 1/12 = 1/6 of the time. For each of these branches, the entire tree begins again at each of the two dashed lines. Thus, the long-run probability of no mutual exchange-seeks is an infinite series whose members approach 0 and whose sum over the two relevant branches approaches 1/6. The probability values for the other branches are then adjusted by a factor of 1/(1 – 1/6) = 1.2 in this case. The probabilities for each *relation* are:

$$p\{AB\} = 1.2 \times \left(\frac{1}{3} + \frac{1}{12} + \frac{1}{12}\right) = .6,$$

$$p\{AC_1\} = p\{AC_2\} = 1.2 \times \left(\frac{1}{6}\right) = .2,$$

$$p\{C_1C_2\} = 1.2 \times \left(\frac{1}{3} + \frac{1}{12} + \frac{1}{12}\right) = .6.$$

The probabilities of mutual exchange-seeks for each *position* are:

$$p\{A\} = p\{AB\} + p\{AC_1\} + p\{AC_2\} = 1.0,$$

$$p\{B\} = p\{AB\} = .6,$$

$$p\{C\} = .2 + .6 = .8.$$

Applying the same analytic method to the kite network, we obtain:

$$p\{DE_i\} = .2051,$$

$$p\{E_1E_2\} = p\{E_3E_4\} = .5898,$$

$$p\{D\} = \sum_{i=1}^{4} p\{DE_i\} = .8205,$$

$$p\{E_i\} = p\{E_iE_j\} + p\{DE_i\} = .7949.$$

If mutual exchange-seeks promote exchanges, then these probability values differentiate positions according to a structurally-based likelihood of inclusion in exchange. These probabilities can then be used to generate hypotheses for exchange outcomes.

Individual Forces

Although our goal is to improve GPI_2's ability to predict exchange outcomes based on network structures, under certain conditions actors can systematically alter structurally-induced exchange outcomes. Our approach is to (1) treat structural-level factors as setting a baseline for exchange outcomes as detailed above, (2) consider how individual-level behaviors can modify outcomes relative to that baseline, and (3) conduct tests that manipulate a particular individual-level condition expected to affect such behaviors.

The two most important decisions that actors in our networks make are (1) with whom to exchange and (2) whether and how to adjust offers contingent on prior or anticipated outcomes. In our computer simulations of weak power structures, unconditional (i.e., random) offer-adjustment strategies consistently pro-

[9] This probability analysis extracts information on a particular *structural* property — it does not predict actual behaviors. We have two different computer programs that calculate these probabilities, both available from the authors on request: WPOWER calculates exact probabilities, WEAKNET estimates probabilities by simulating thousands of rounds of random exchange-seeks and exchanges. WEAKNET estimates converge on WPOWER calculations.

duce small but systematic outcome differentials. For example, when simulated actors in the stem network adjust their offers randomly by –1, 0, or +1 following exchange or exclusion, A still has a consistent advantage over B of one or two points above equal profit levels. With conditional adjustment strategies (e.g., "add one to last offer following exclusion; subtract one following inclusion"), varying partner-choice strategies result in varying advantages for A. Some strategies give A larger advantages, but never as great as those in strong power structures. In general, most strategies either sustain minimal weak power differentials or enhance them to levels still well below those for strong power. Furthermore, although certain combinations of strategies affect outcomes in strong power structures (Markovsky 1987), strong power is clearly more robust than weak power.

These simulations have direct implications for empirical research. In network exchange experiments, subjects are instructed to try to maximize profit. Few hesitate to do so. However, when subjects must conduct simultaneous negotiations in multiple relations, optimal strategies may not be obvious. In such cases, subjects' strategies should improve with experience. The research reported below examines whether experienced subjects discover more potent strategies. Further, based on the simulation results, those more potent strategies should favor subjects in advantaged positions over subjects in disadvantaged positions, and so amplify the weak power effect.[10]

METHOD AND HYPOTHESES

Subjects were undergraduates at a large university who agreed to participate in the research in return for pay. After arriving at the laboratory, each subject received general information about the research. Instructions noted that the experiment investigates the effect of social structures on negotiation. Subjects were told the size of the resource pools to be divided (24 units) as well as the monetary value of each point (5 cents).

Subjects interacted via interconnected microcomputers located in separate rooms. The exchange network configuration was displayed on subjects' screens, along with full information on current offers and completed exchanges. Prior to the experiment, assistants showed subjects how to interpret information on their computer screens and how to use the keyboard to make and accept offers. This training period ended with a practice session in which subjects "negotiated" with simulated others. The practice session was realistic in that subjects made and received offers as they would in the experiment; but practice was unrealistic with respect to the others' offers and their likelihoods of accepting the subjects' offers. The practice network also differed from the networks actually tested in the study.

Experiments were organized by rounds, periods and sessions. Each session involved a different set of subjects — eight sets of four subjects each for the stem network and six sets of five subjects each for the kite network. Subjects were rotated to new positions between periods by a software reconfiguration, and each subject eventually occupied every position. This allowed us to distinguish network effects from idiosyncratic subject-pair effects.[11] Each period contained four negotiation rounds of up to five minutes each. At the end of each round, subjects were informed of their earnings in that

[10] Technically speaking, our computer simulations embody *auxiliary assumptions* (vis-à-vis NET's axioms) regarding actors' decision strategies, and the outcomes of those simulations provide *derivations* that predict long-run exchange outcomes and frequencies. Translating those derivations into operational terms yields the individual-level *hypotheses* that we test empirically.

[11] One reviewer suggested that owing to the relatively small number of rounds per period, the effects of exclusion may be attributable to subjects' perceptions of its likelihood rather than to its incidence. This could be the case, but GPI_3 predicts exchange outcome ranks, not empirical exclusion rates. GPI_3 correctly predicts exclusion rates in WEAKNET simulations and so, with refinements, could serve as the basis for a model of actual rates. Moreover, actual inclusion rates were in fact closest to GPI_3 values for inexperienced subjects who, presumably, would be more likely than experienced subjects to learn by being excluded. Although rotating subjects between periods may have prevented them from developing regular patterns of exchange with their partners, as they would in natural settings, our purpose was to test the weak power formulation, not to reproduce any particular "natural setting" in the laboratory. Webster and Kervin (1971) provided a cogent rationale for the use of artificiality in social scientific experiments.

round. At the end of the session subjects were paid based on the points they earned. The average was $10.

All subjects received the same training, but subjects differed in their previous experience with network exchange experiments. For the stem network, four groups contained subjects who had prior experience in experiments on another network structure, while the other four groups were composed of inexperienced subjects. For the kite network, four groups were experienced and two were inexperienced.

Structural Effects

The probability analyses permit us to state critical hypotheses for exchange outcomes in experimental stem and kite networks. Hypotheses pertain to mean resource units obtained per exchange, and are derived by relating theoretical inclusion probability ranks to exchange outcome ranks.

H_1: In the stem network, the order of exchange outcomes by position is

H_{1a}: A > B when A and B exchange;

H_{1b}: A > C when A and C exchange;

H_{1c}: (A – B) when A and B exchange > (A – C) when A and C exchange.

H_2: For the kite network, the predicted order is

D > E when D and E exchange.

Individual Effects

Strategic behavior tends to enhance weak power differentials, as observed in computer simulations. Assuming that experienced subjects use more effective strategies than inexperienced subjects:

H_3: Resource differentials predicted in H_1 and H_2 will be greater for experienced subjects than for inexperienced subjects.

Strong Power vs. Weak Power

The extension of the theory to allow for structural effects coupled with the computer simulations for individual effects permit the following prediction:

H_4: Resource differentials will be greater in strong power networks than in weak power networks.

RESULTS

Analytic Method

A dummy variable, constrained regression analysis was used to estimate positional effects (Winer 1962; Skvoretz and Willer 1991). The units of analysis are the observed exchanges and non-exchanges among pairs of subjects. During a session, a series of M exchanges occurs among different subjects in different relations. We index the elements of this series as $m \in \{1, 2, \ldots, M\}$. Let i and j indicate different subjects such that $i, j \in \{1, 2, \ldots, N\}$, where N is the number of subjects and also the number of positions in the experimental network. Variables in the statistical model are defined as follows:

P_{im} is i's outcome ("profit") from the m-th exchange. For an i–j exchange, either i's or j's outcome may serve as the datum as long as it is always the one used.

$R(i, j)$ refers to the occurrence of exchange/nonexchange between i and j. For each exchange in the network, $R(i, j) = 1$ if subjects i and j exchange; $R(i, j) = 0$ otherwise. There are $N(N-1)/2$ different $R(i, j)$'s in the network.

Q_k is the positional advantage/disadvantage in relation k. Two related *positions* are either structurally distinct or identical, e.g., in the stem network, C_1 and C_2 occupy structurally identical positions; A and B occupy structurally distinct positions. Any two *relations* are also either structurally distinct or identical, e.g., A–C_1 and A–C_2 are structurally identical relations; A–B and A–C_1 are structurally distinct relations. For relations involving distinct positions, the theory predicts which position is structurally advantaged and which is disadvantaged. Q_k is then an "effect variable." Let $k = 1, 2, \ldots, K$ enumerate structurally distinct relations involving structurally distinct positions. These are A–B and A–C in the stem network, D–E in the kite network. If the m-th exchange is i–j, where i and j reside in relation k, then $Q_k = 1$ if i occupies the (theoretically specified) advantaged position, –1 if i is disadvantaged, and 0 otherwise. The statistical model for exchange outcomes is

$$P = 12 + \sum a_{ij}R(i, j) + \sum b_kQ_k + \text{error}.$$

Table 2. Position Effects From Regression of Exchange Outcomes on Network Characteristics

Network and Relation	Position Effect: Total (1)	Experienced (2)	Inexperienced (3)
Stem Network			
A–B relation	2.424***	3.288***	1.401***
	(.320)	(.461)	(.412)
A–C relation	3.334***	4.487**	2.749**
	(.880)	(1.488)	(.990)
R^2	.653	.718	.531
Number of exchanges	226	116	110
Kite Network			
D–E relation	1.152***	2.054***	–.075
	(.348)	(.507)	(.325)
R^2	.502	.498	.656
Number of exchanges	236	158	78

** $p < .01$ *** $p < .001$ (one-tailed test)

Note: Numbers in parentheses are standard errors. A's or D's estimated advantage in a given relation is 2 × the position effect.

The a_{ij} parameters are *relation effects,* i.e., idiosyncratic effects attributable to particular pairs of subjects. The b_k parameters are *position effects,* used to test for positional power in structurally distinct relations. By fixing the intercept at 12 (one-half the resource pool), relation effects and position effects can be interpreted as variations from equality.

This model has several important features. First, in exchanges between structurally identical positions, any profit variations are attributable to relation effects. Second, degrees of freedom for testing position effects are reduced considerably over the number used in a simple test of means. Including relation effects absorbs degrees of freedom and also reduces error that would otherwise be associated with the positional power hypotheses. Third, more precise tests for similarities or differences in position effects are possible, e.g., we estimate constrained models and assess the improvement in fit over less constrained models. Such comparisons between models are possible both within and between network configurations.

Analyses

Hypothesis 1. There were 226 exchanges in the eight stem groups. Six subject pairings × eight groups yield 48 relation (R) variables. A–B and A–C are the two structurally distinct relations (Q) involving structurally distinct positions. In both the A–B and A–C relations, A is predicted to be the advantaged position and is coded as such. Results are shown in column 1 of Table 2.

Hypotheses 1a and 1b are supported. A obtained 2.4 points beyond equality in A–B exchanges after controlling for subject-pair (relation) effects, which implies an estimated pool division of 14.4 – 9.6. For the A–C relation, A obtained 3.3 points above equality for an estimated pool division of 15.3 – 8.7. Both advantages are significantly different from 0. However, contrary to Hypothesis 1c, the effects were not significantly different from each other ($F[1,182] = .846, p = .359$). That is, the model in which both effects are estimated is not a significant improvement over a model in which both variables are constrained to have the same effect.

Hypothesis 2. There were 236 exchanges in the six kite groups and 60 relation variables (10 subject pairings × 6 groups). The only structurally distinct relation involving structurally distinct positions is the D–E relation. D is coded as the advantaged position. Column 1 of Table 2 shows that, as predicted, occupying the D position in the D–E relation of the kite network conferred a small but statistically significant advantage, approximately 13.2 – 10.8. Therefore, D exercises weak power in the kite network and Hypothesis 2 is supported.

Hypothesis 3. The regression analyses were repeated controlling for subject experience. Results are presented in columns 2 and 3 of Table 2. In the stem network, experienced and inexperienced subjects exploited weak power advantages to significant degrees. Moreover, experienced subjects had an additional outcome advantage of around 1.8 points, as predicted by Hypothesis 3. For the A–B relations, the difference was statistically significant, i.e., the null hypothesis that the position effects are equal for experienced and inexperienced groups was rejected ($F[1,180] = 9.098, p = .003$). The difference between position effects for the A–C relation in experienced versus inexperienced groups was not significant, however. In the stem network, then, experience has the strongest and most consistent effect in A–B relations.

Results for the role of experience in the D–E relation in the kite network conform very closely to predictions. Experienced subjects exploited their positional advantage, inexperienced subjects did not. The null hypothesis that the position effects are equal for the two groups was also rejected ($F[1,181] = 9.576, p = .002$), indicating that experience translates into significant profit advantages in this structure.[12]

Only one of the possible profit-enhancing strategies that structurally-advantaged actors in simulated weak power networks could adopt prevailed in our experiments: Experienced subjects in advantaged positions made higher demands, and experienced subjects in disadvantaged positions met these demands. That is, relative to inexperienced subjects, experienced subjects in advantaged positions did not have to discover their advantages and learn to exploit them, and experienced subjects in disadvantaged positions did not have to learn by trial-and-error to avoid exclusion by making more favorable offers. For instance, average offers to B were 9.52 points for inexperienced A's and 6.33 points for experienced A's. The average offer to A from inexperienced B's was 11.74 points, and 14.01 points from experienced B's. Results from an analysis of variance are presented in Table 3. In the stem network, the position × experience interaction indicates that for experienced subjects relative to inexperienced subjects, B's offers are more extreme in the positive direction and A's are more extreme in the negative direction. For inexperienced subjects in the kite network, D's offered E's 9.31 points on average, and E's offered 9.07 points to D's; for experienced subjects, the respective means were 9.09 and 12.17. Results of the analysis of variance in Table 3 indicate that the dominant effect of experience in the kite network was to raise E's offers. This potent experience-position combination also seems to produce the significant main effects, given that the other three position × experience combinations are relatively close to one another.[13]

Table 3. Analysis of Variance for Negotiation Offers in Stem Networks and Kite Networks

Variable	Sum of Squares	d.f.	*F*
Stem Network			
Position (A,B)	1552.433	1	194.766***
Experience	13.329	1	1.672
Position × experience	473.734	1	59.434***
Error	1992.690	250	—
Kite Network			
Position (D,E)	108.325	1	14.890***
Experience	110.753	1	15.224***
Position × experience	146.437	1	20.129***
Error	1716.864	236	—

*** $p < .001$

Hypothesis 4. To examine the relative strength of advantages in strong power networks versus weak power networks, we compared our findings with results from typical strong power experiments (Markovsky et al. 1988). The contrast is striking: There is no overlap in the distributions of mean advantages between strong power groups versus weak power groups. The *minimum* advantage observed for any strong power group was 6.66 points, compared to a *maximum* advantage of

[12] We also estimated a single-equation model that included a dummy variable to capture the effects of experience. This model is more complex because the experimental design forces a collinearity between the dummy variable for experience and the dummy variables for the individual pairs, and interpretation of the parameter estimates depends on which level of experience is chosen as the reference category, i.e., assigned a value of 0. Two specifications are possible. In the kite network, for example, when "inexperienced" is the reference category, structural position has no significant effect, but there is a significant, positive interaction between experience and structural position; when "experienced" is the reference category, structural position has a significant, positive effect while there is a significant, negative interaction between experience and structural position. Both specifications support our conclusion: Inexperienced subjects have no advantage; experienced subjects have an advantage; and the difference is significant.

[13] Analyses using experienced subjects in the stem network may provide insights into how experience affects behavior. One group of experienced subjects participated in the kite network in a prior session. The mean exchange outcome for members of this group occupying the A position was 13.86 points. In contrast, the other three groups of experienced subjects had previously interacted in a strong-power structure and, for these subjects, the mean outcome for A in the stem network was 17.00 points. The difference between the two means was statistically significant. This suggests that prior experience affects outcomes via the expectations they foster: Those who expect large profit advantages to

6.60 points in the present experiment. The average advantage in the strong power experiments was approximately 14 points versus approximately 4 points in the present study. Similar contrasts hold with regard to other experiments (Skvoretz and Willer 1991). In sum, the hypothesis that strong power produces larger profit differentials than does weak power is clearly supported.

SUMMARY AND CONCLUSION

By extending network exchange theory, we identified a new structural basis for positional power in networks. Experimental research on two different network structures tested hypotheses derived from the extended theory. These hypotheses predicted advantages or disadvantages for certain positions in certain relations, the relative magnitudes of strong power effects and weak power effects, and how resource differentials were affected by subjects having experience in other exchange networks. Overall, we found strong support for the extended theory.

The extended theory answers questions raised by Yamagishi and Cook (1990) and Stolte (1990). Corresponding to Simmel's notion of "formal sociology" (Simmel [1917] 1950, p. 21), and contrary to the usual approach in sociology, these questions were answered using simulations and experiments rather than work in the field. Of what general empirical import, then, is the phenomenon of weak power?

The weak power extension to network exchange theory bridges the relatively simple, sparsely-connected networks in which strong power effects are typically observed and the more complex and densely-connected networks generally found in natural social relations. Such variables are within the original purview of social exchange theory (Homans 1967, 1974; Blau 1964). Formally constituted structures like monopolistic markets and hierarchies are sparsely-connected — they illustrate strong power differentials. In contrast, informal structures like friendship groups are more densely connected and any power differences tend to be relatively small. The theoretical extension suggests that the heart of strong power lies in the absence of exchange opportunities for the weak and the exchange denials thus created. All else being equal, higher connectivity provides more opportunities for weak positions to "short-circuit" the structural advantages of the strong, and thus a greater likelihood of small resource differentials, i.e., weak power.

In addition to permitting the analysis of denser, more "realistic" networks, our weak power analysis has yielded other dividends. First, network exchange theory moves beyond simply identifying the phenomenon and addresses the more general question of *which* positions in *which* networks gain or lose from weak power. Our research has answered that question in theory and corroborated the answer in experiments.

Second, computer simulations revealed that the weak power effect is robust across negotiation strategies, and that some strategies amplify the effect. In fact, for some networks and strategies, the theoretical extremes of weak power should be significantly greater than those predicted and observed in our experiments while remaining below strong power effects. By detecting the weak power effect *at or near its weakest,* however, we provided a stringent test of the extended theory.

Finally, the extended theory vividly illustrates the mutual dependence of micro- and macroprocesses. Although we have shown that weak power depends on individual decisions and actions, exchange rules, and network structures, much remains to be learned about the complex interactions of these different factors. Our analysis shows that accounting for decisions and behaviors at the levels of individuals and relations can improve our understanding of structural effects, and that only by accounting for structural contingencies can lower level processes and outcomes be fully comprehended.

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accrue to advantaged positions demand them in the case of structurally advantaged actors, and grant them in the case of the disadvantaged. Supplemental analyses also revealed that actual inclusion rates were closest to GPI_3 values for inexperienced subjects. Compared to $\hat{p}\{B\} = .60$ from GPI_3, $p\{B\} = .66$ for inexperienced subjects and .77 for experienced subjects. For the kite network, $\hat{p}\{D\} = .82$ and $\hat{p}\{E\} = .79$. The probabilities for inexperienced subjects were .73 and .82, respectively, and for experienced subjects .59 and .85. In general, GPI_3 probability values should be empirically informative to the degree that subjects have no information beyond their own relations, and subjects have more rounds over which to negotiate and adjust offers. In such cases, actual exclusions would serve as a basis for informing counteroffers and partner choices.

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