A positive net profit strategy and a pure substrate transfer strategy are both necessary for an ensemble to succeed in the presence of a fixed cost.

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Rational net profit maximization or caring transfers according purely to need are two competing ideas seemingly excluding each other. Within the model "transfer space" I show that both strategies are necessary for an ensemble to succeed in the presence of a fixed cost. The transfer space of an ensemble consists of two parties, a source and a sink. Both parties have linear cost functions and saturating benefit functions. Both functions are dependent on the substrate concentration. In the presence of a fixed cost the net profit of a single party is negative at low and high concentrations.

An ensemble striving for superadditive net profit is unable to overcome the initial phase of negative net profit within sink as sink is inactive and a forced small test transfer results in subadditivity. This strategy is unable to start in the presence of a fixed cost.

The substrate transfer strategy is able to overcome the initial phase of negative net profit and subadditivity with patient transfers and enters the phase of superadditivity. This strategy fails later when the superadditivity turns into subadditivity again. This strategy is unable to stop the transfer.

Successful ensembles use both strategies in sequence. Ensembles of strangers and entangled ensembles transfer substrate when the success factor is sufficient. Entanglement reduces the necessity for a high success factor. A mistaken assumption of genetic entanglement within a not entangled ensemble harms performance. No ensemble can compete successfully with less quantity and less quality than the competitor.

An ensemble (e) of a source (so) and a sink (si) is an open system as substrate and energy flows through the ensemble. The whole process is basically powered by the sun. Therefore, the system will not arrive at a Nash equilibrium. A consumed substrate will be resupplied, a consumed party will be replaced, and a formed product will be removed. Within the transfer space the total substrate concentration is kept constant. The transfer obeys the conservation law.

The substrate has a benefit (b) and a cost (c) aspect to source and sink. This assessment is made under consideration of the local substrate concentration. Benefit and cost are a feature of the local conditions and may change through a transfer. Net profit (np) is the difference of benefit and cost (np=b-c) on the basis of the same units. The net profit of an ensemble is the sum of the net profits in source and sink ($np_e=np_{so}+np_{si}$).

The benefit in source and sink is a function of the substrate concentration according to Michaelis-Menten (figure 1, green):

- b=bf*Vmax*[S]/([S]+Km)

bf, benefit factor (here always 1 b*min/µmol; b is a placeholder for other units like KJ or € or $, bf is essentially a complexity factor (1); Vmax, maximal reaction velocity (µmol/min); [S], substrate concentration (mM); Km, Michaelis-Menten constant (mM).

In the past I usually omitted the consideration of a fixed cost (figure 1B) and used a simple linear cost function. Now I want to investigate the effect of a constant fixed cost (fix) (figure 1A) or substrate for free (figure 1C) in combination again with a linear cost function.

- c=cf*[S]+fix

cf, cost factor (in this investigation always 5/3 c/mM); [S], substrate concentration (mM); fix, fixed cost. The fixed cost is a constant substrate

concentration (mM) multiplied by a cost factor cf_{fix} (c/mM). This additional cost factor is set to be 1c/mM. The variable cost c and the fixed cost (fix) are placeholders for units like KJ or € or $.
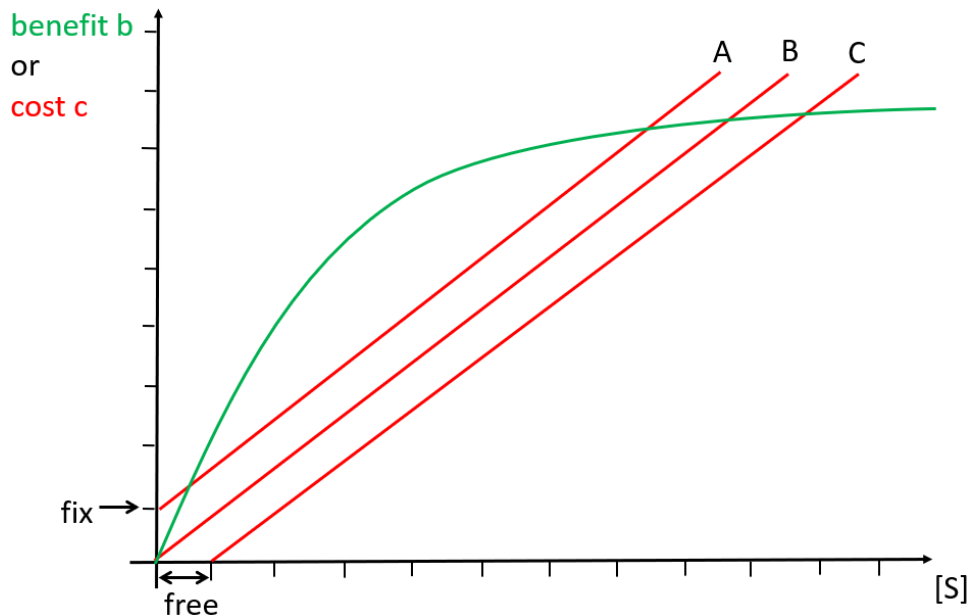
Figure 1

Figure 1
The green curve is the saturating benefit function according to Michaelis-Menten. The red linear graphs are possible, identical cost functions: A: with a fixed cost (fix); B: no fixed cost; C: part of the substrate is for free.

In case A a certain substrate concentration is necessary to achieve a positive net profit. In case B and C already a tiny substrate concentration results immediately in a positive net profit. The difference between the red and green graphs is proportional to the total net profit in source or sink. At higher concentrations of the substrate the cost becomes ("again" in case A) larger than the benefit and the net profit is negative (red above green).

The transfer space (literature 1, 2, and 3; figure 2 and 3) is a three-dimensional arrangement of source and sink. The three dimensions are the substrate concentration in source ($[S]_{so}$), the substrate concentration in sink ($[S]_{si}$), and the net profit of the ensemble (np_e) of source and sink.
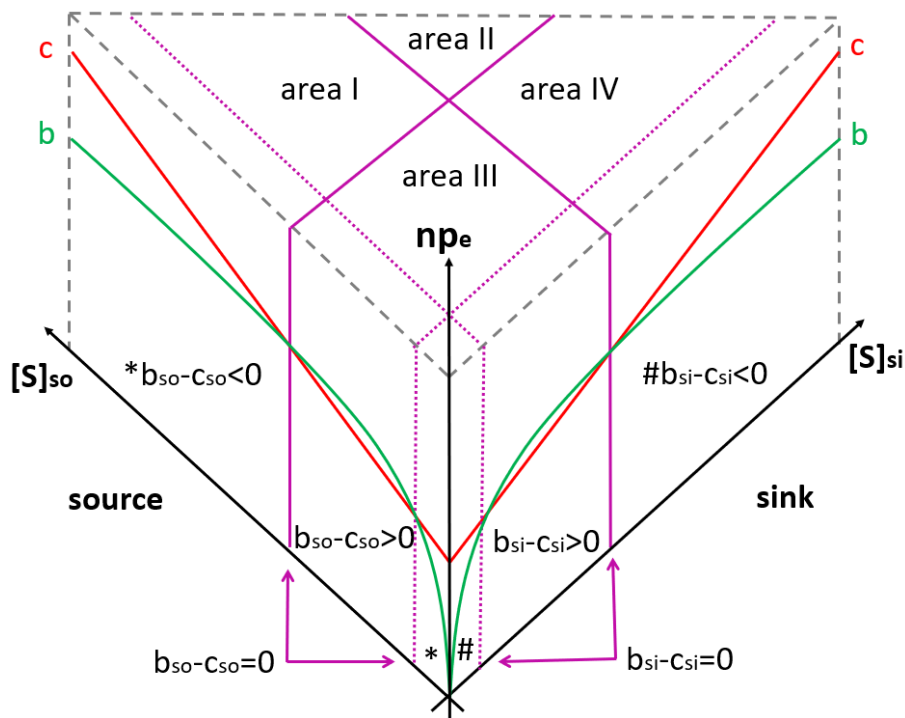
Figure 2

Figure 2
The coordinates of the prism shaped transfer space are the substrate concentrations [S] in source and sink and the net profit of the ensemble of both, np_e. In the presence of a fixed cost, we observe 4 borders where b-c=0 (dotted and solid purple lines).

An active ensemble transfers substrate. The substrate concentration in source is decreased in the benefit and cost function and increased in sink by the same amount (conservation law). An inactive ensemble does not transfer substrate. The absence of transfer serves as reference with simple additivity; $np_e = np_{so} + np_{si}$. Superadditivity is achieved when transfer results in a larger net profit than in the case of no transfer; $np_e > np_{so} + np_{si}$. Transfer is a reasonable action. Subadditivity is an outcome when transfer results in a smaller net profit than no transfer; $np_e < np_{so} + np_{si}$. Transfer is not a reasonable action.

An active ensemble may have a negative net profit. But if the net profit of the inactive ensemble is even more negative, we observe superadditivity. The net profit of an active ensemble may be positive but if the net profit of an inactive ensemble is even larger this would be subadditivity.

In area I, a peaceful transfer at free will is performed. Source is loaded with

substrate producing a negative net profit while in sink this substrate would produce a positive net profit; both gain after a transfer. The ensemble is voluntarily active only when b<c in source and b>c in sink! A win-win situation. The transfer stops at the limit b-c=0. Superadditivity for the ensemble is the result. There may be a master but he is peaceful and serves as an honest broker.

Area IV is an irrational area where only an external master can force or deceive the ensemble (both, source and sink) to be active and only subadditivity for the ensemble will be a result. Source is forced or deceived to give a substrate with a positive net profit and sink is forced or deceived to take that substrate though it will result in a negative net profit.

Area II and area III are transitional areas. They are only accessible by force and deception, too. But this time against the interest of only one party. The master acts in coalition with the other party or this party is the master. Here, one side will lose while the other side gains net profit. The question is whether the overall balance of the ensemble is super- or subadditive.
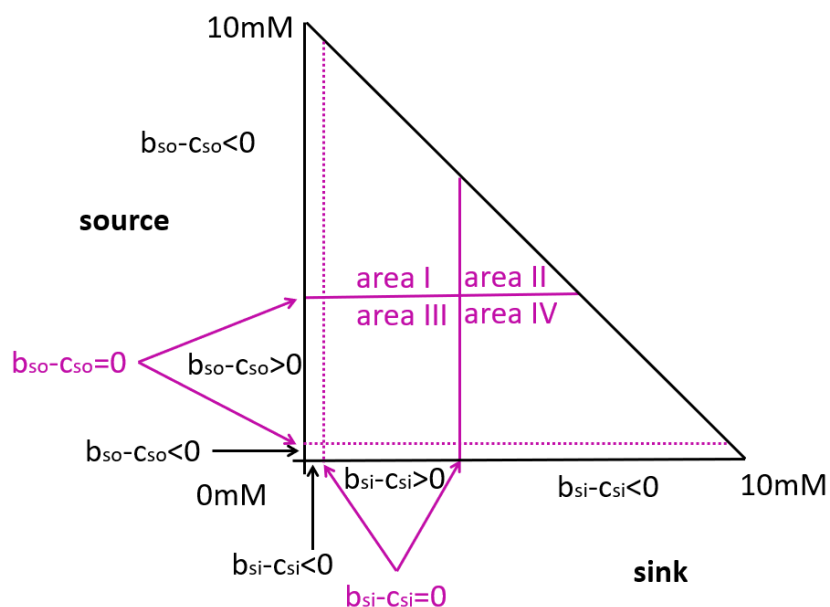
Figure 3

Figure 3
Here we look top down onto figure 2 in the presence of a fixed cost. This is the view of the results in figure 4 to 9. Standard is: [S] = 0mM to 10mM, K_m = 0.5mM, V_{max} = 5µmol/min, bf = 1b min/µmol, cf = 5/3 c/mM in symmetric ensembles.

Results and discussion

In figure 4 I observe a peaceful ensemble without an external or internal master. The ensemble is completely symmetric in source and sink. The ensemble is active only in area I with two important exceptions. All transfers are at free will and offer both sides an advantage.
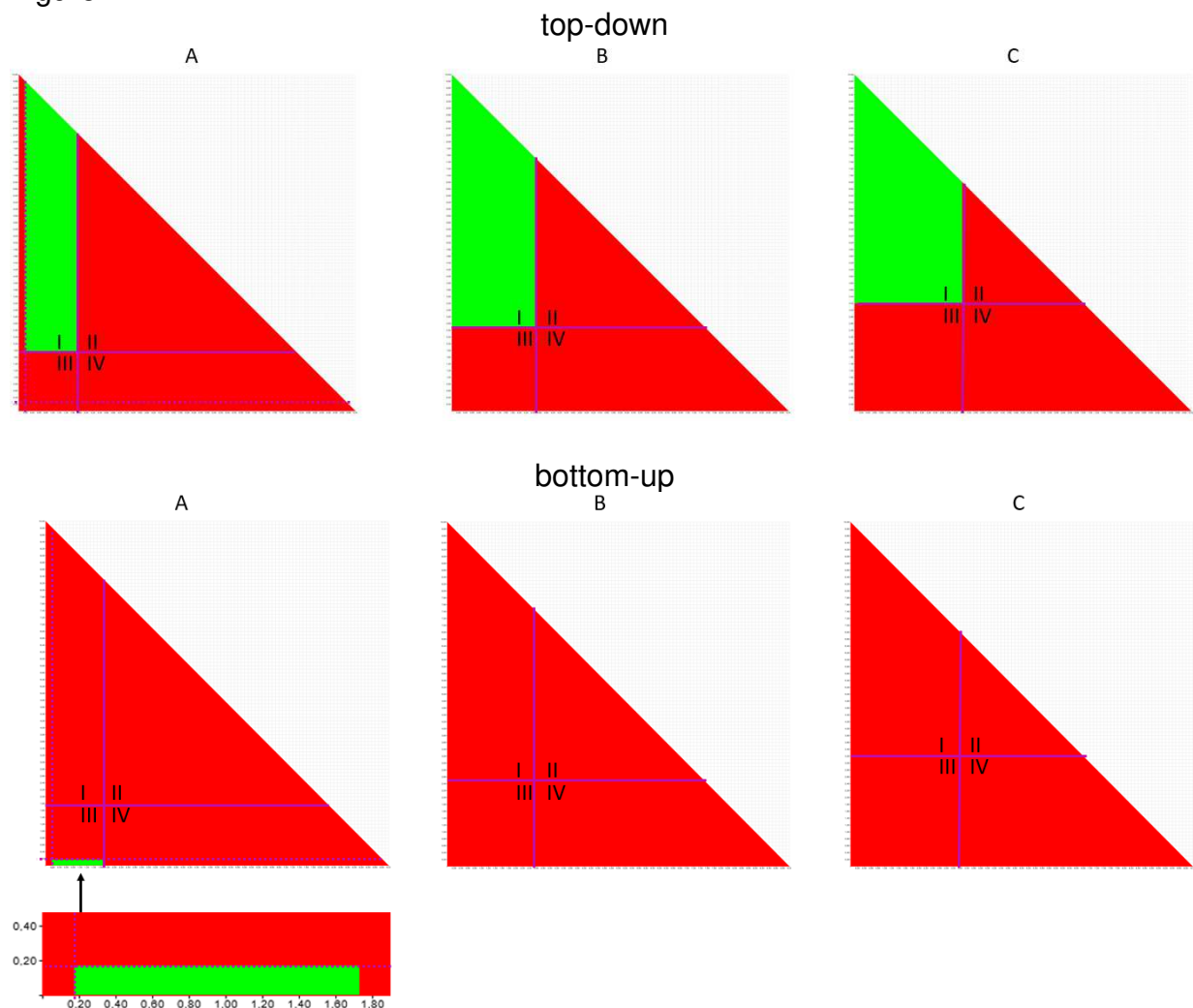
Figure 4

Figure 4
Source and sink form a peaceful, symmetric ensemble with respect to Km, Vmax, bf, cf, and fixed cost or free substrate. In A the fixed cost is 1, no fixed cost in B, and in C 1mM substrate is free. Red indicates the net profit of an inactive ensemble. Green indicates an active ensemble. There, source (b-c<0) transfers at free will substrate to sink and sink (b-c>0) takes the substrate at free will, resulting in superadditivity (green surface above red surface, with exception A, bottom-up). There, the transfer is at free will but subadditive (green below red)! A fixed cost leads to an activity outside of area I at free will and inactivity in area I (A, top down, left side).

The <u>behaviour</u> of this simple model is not based on a net profit evaluation! Net profit is important for the assessment of the result of the behaviour and the success of the ensemble. A simple ensemble has two simple components; source and sink. They separately monitor benefit and cost. In benefit domination only the benefit is visible. Here, more is better. In cost domination only the cost is visible. Here, less is better. Both parties are limited according to their actions. Source only can give, sink only can take. Both parties see an advantage for them in area I. The advantage to source is to get rid of cost domination (b<c). The advantage to sink is to gain benefit domination (b>c). Source gives at free will substrate to reduce benefit domination. Sink takes the substrate at free will as the substrate there will increase benefit. This is the basic situation in area I.

However, in the presence of a fixed cost, a small red stripe appears on the source (left) side of the triangle in area I (figure 4A, top down). In this stripe the ensemble is inactive because sink (!) is inactive (figure 3, $b_{si}<c_{si}$). Sink is cost dominated. A cost dominated sink does not take. As neither source nor sink are internal masters, nor is an external master present, the ensemble is inactive.

A green stripe (4A, bottom up) appears on the sink side of the triangle. This is a transfer at free will in area III. In this small stripe source is cost dominated (figure 3) and sink is benefit dominated. However, area III is an area where consensual transfers in the absence of a fixed cost do not happen. The result of this transfer is subadditive (green below red surface) as the loss in source is larger than the gain in sink. A transfer at free will resulting in subadditivity is an irrational behaviour for the ensemble, although every single party gains here. In the lower and right part of area III transfers by force and deception also result in subadditivity for the ensemble (see figure 5 and 6).

Superadditivity or subadditivity and activity or inactivity are opposing feature pairs but not necessarily coupled. The fixed cost related inactive region in area I can be superadditive (figure 5A, with force) and the active region in area III (figure 4A, bottom up) is subadditive. In the absence of a fixed cost or in the presence of substrate for free only superadditivity in area I is present. Activities outside of area I are not observed (4B, 4C).

Now I want to investigate symmetric ensembles with a master. An external master is a third party. An internal master would be a dominating source or sink. An internal master will never cross his own limits. A master-source will only force a sink to take beyond the limit b-c=0 of the sink (area II) and a master-sink will only force a source to give beyond the limit b-c=0 of the source (area III). An internal master will never enter area IV. Area IV is protected by the master´s limit b=c.

Two types of external masters exist. A peaceful honest broker (indistinguishable from figure 4 and 7) or a master using force and deception. There, two subtypes exist. A conditionally violent and deceptive master or an unconditionally violent and deceptive master. The conditional type will not be active (use violence and deception to enforce a transfer) when source and sink will transfer at free will (area I). This type of master will be only active when the ensemble is inactive.

In figure 5 a conditionally violent and deceptive external master is in control of the ensemble. Whenever the ensemble is inactive, he forces or deceives (blue colour code) the ensemble to transfer 1mM of substrate.

The external master forces or deceives the ensemble to be active in all 4 areas. Parts of area II, III, and all of area IV are subadditive (blue surface below red surface).
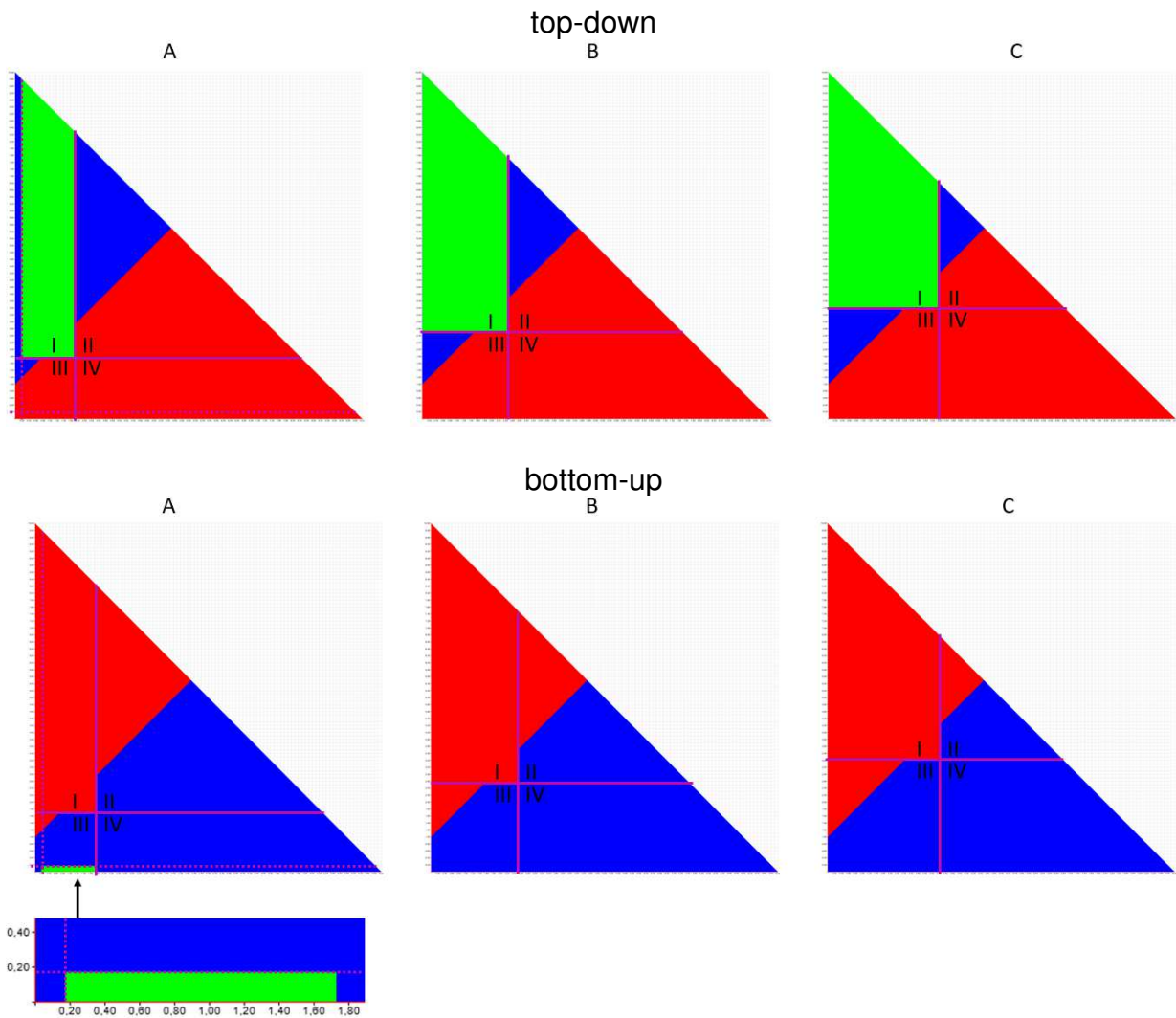
Figure 5

Figure 5
Source and sink are controlled by an external, conditionally violent and deceptive master. They form a symmetric ensemble identical to figure 4. This master always transfers 1mM substrate from source to sink in every concentration pair where source and sink do not transfer substrate at free will (green). The net profit of the inactive ensemble is in red. When the concentration in source is below 1mM the residual amount is transferred. In the bottom up view it becomes obvious that this is subadditive for large parts of the concentration range (blue below red, bottom up). In A the subadditivity of the green small stripe is still present as this is a transfer at free will.

The large green area is superadditive (green surface over red, area I) and at free will. Force is used also in area I where the fixed cost prohibited activity in the ensemble of figure 4. Thus, the red stripe (4A) turns blue (5A top-down). Parts of the blue area (force and deception) are superadditive

(top-down, blue over red, area II and III) and parts are subadditive (bottom-up, red over blue, area II and III). This is the transitional nature of area II and III. All of area IV is subadditive (red over blue).

Again, in figure 5A a green area appears in the bottom-up perspective (area III). There, source (b-c<0) gives substrate at free will to sink and sink (b-c>0) takes it at free will. The result is still subadditive in this symmetric ensemble. As the ensemble is active, the master does not interfere with this behaviour. This is irrational from the perspective of the master and the ensemble as a whole. Obviously, we are dealing here also with a very simple external master as he does not stop this behaviour.

In the absence of a fixed cost or in the presence of free substrate, the green area changes the location of the green corner along the edge between blue and red. The width of the green area changes as more substrate is beneficial but no additional phenomena appear.

Figure 6 shows an unconditionally violent and deceptive master and his ensemble. He always forces the ensemble to transfer 1mM, including area I. He does not respect any inner limit (b-c=0) of the ensemble.

The shape of the super- and subadditive areas reminds of the conditionally violent master. A small subadditive corner (inwards into the blue surface, top down) appears where a superadditive region at free will (green, outwards) in figure 5 was located; additional subadditivity is created here. All green areas, transfers at free will, are lost.

Figure 6
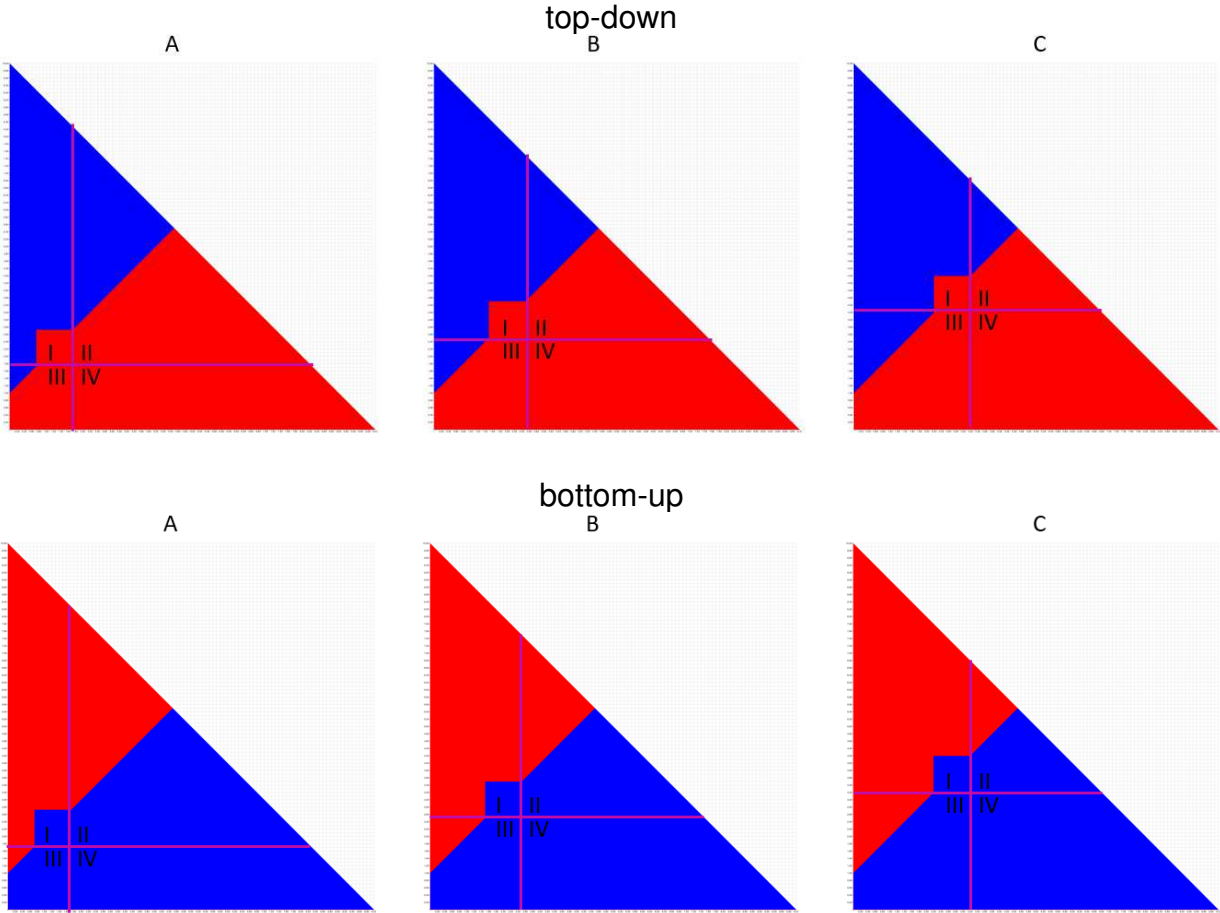
Figure 6
Source and sink are controlled by an external, unconditionally violent and deceptive master. They form a symmetric ensemble with respect to Km, Vmax, bf, cf, and fixed cost or free substrate. The conditions A, B, and C are identical to figure 4. The unconditionally violent and deceptive master always transfers 1mM substrate from source to sink in every concentration pair. He does not respect the limits of source and sink. Below concentrations of 1mM in source the residual amount is transferred to sink.

In figures 7 to 9 asymmetric ensembles with a fixed cost are investigated. In figure 7 again a peaceful ensemble without a master (or with an honest broker) is investigated. All 6 surfaces are a variation of only figure 4A.

Figure 7

Figure 7
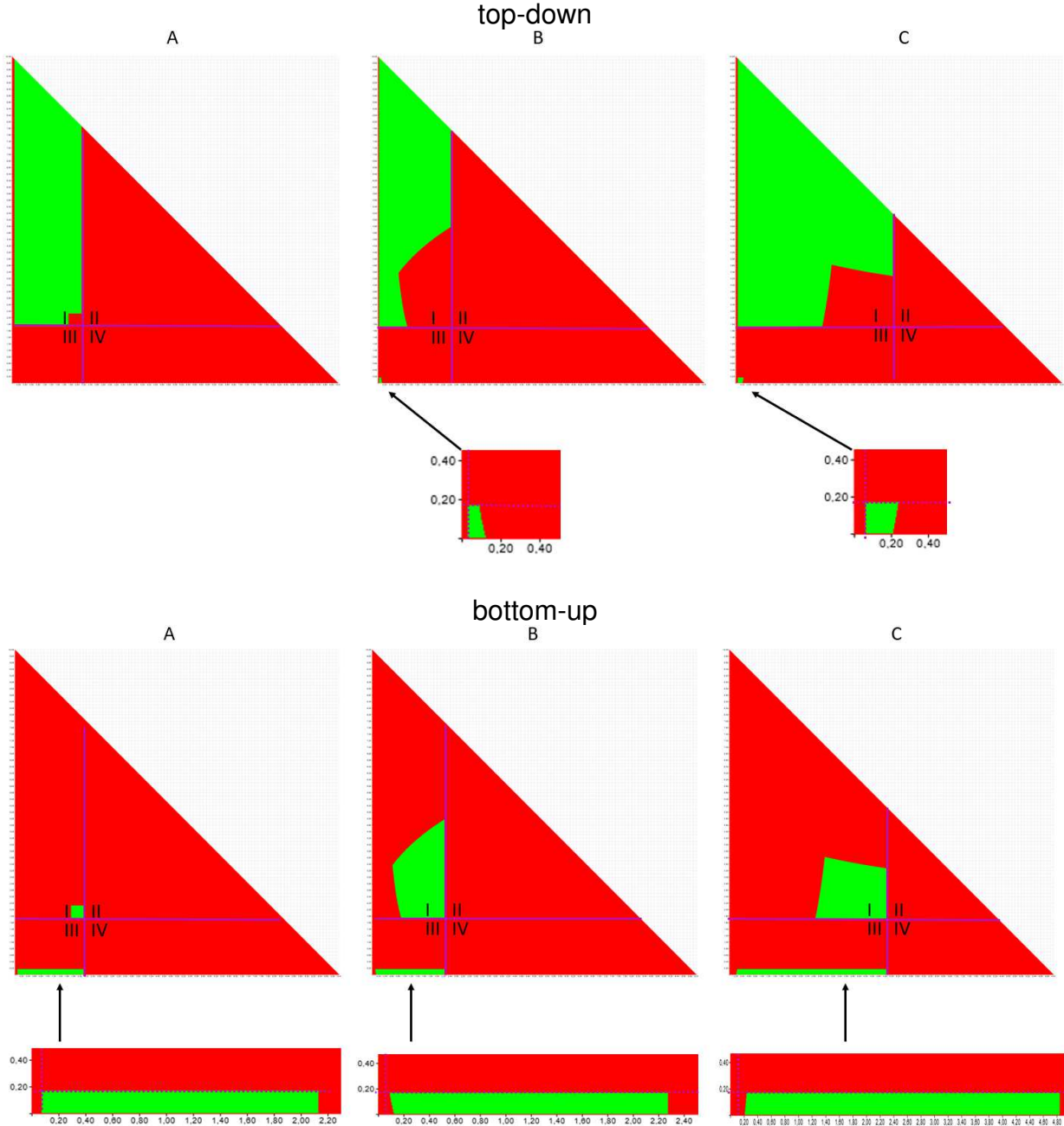Source and sink form a peaceful, asymmetric ensemble with respect to A: fixed cost (source 1, sink 0.5) or B: Km (source 0.5mM, sink 0.1mM) or C: Vmax (source 5µmol/min, sink 10µmol/min). In B and C top-down a tiny new superadditive surface appears at very low concentrations (inset). This is only a small part of the total area of a transfer at free will in this area. The biggest part stays subadditive (bottom-up, insets).

The asymmetry of the ensemble has a specific structure. Sink is better suited for production as fixed cost there is lower (A) or Km is lower (B, higher affinity to the substrate) or Vmax is higher (C, faster reaction). I call this a strong asymmetric ensemble. Weak asymmetric ensembles show additional subadditivity in area I. Due to the specific asymmetries here, the inactive red stripe on the source side is decreased and the subadditive green stripe on the source side of the triangle in area III caused by the fixed cost is increased (7A, 7B, and 7C all bottom up). In addition, the asymmetry makes part of the small, green stripe on the sink side superadditive (insets top down, figure 7B and 7C). However, additional subadditivity appears (centre 7A, 7B, and 7C). The biochemical asymmetries (Km, Vmax) drastically distort the quadratic shape (7A, bottom up) of the subadditive small green area. Km and Vmax are part of the nonlinear benefit function.

Now I want to investigate asymmetric ensembles with a master.

In figure 8 I observe a conditionally violent and deceptive external master acting on asymmetric ensembles. The green area in the insets of the bottom-up view shows that there is again irrational transfer at free will in area III. This transfer does not result in superadditivity but in subadditivity (8A) or only in a little superadditivity (8B, 8C). He is also active where fixed cost was prohibitive.

The green, superadditive and subadditive areas stay unchanged in comparison to figure 7. The transfer of an additional 1mM of substrate outside of area I in source and sink results in additional superadditivity coloured in blue (top down). However, there is more additional subadditivity (bottom up, blue) by force or deception.

Figure 8

Figure 8
Source and sink are controlled by a conditionally violent and deceptive external master.
The ensemble is asymmetric with respect to A: fixed cost (source 1, sink 0.5) or B: Km
(source 0.5mM, sink 0.1mM) or C: Vmax (source 5µmol/min, sink 10µmol/min). In B and
C parts of the subadditive area at free will in area III becomes superadditive (insets, top
down). The reason is a higher affinity (decreased Km in B) or higher reaction velocity
(increased Vmax in C). All conditions are a variation of only figure 5A.

Finally, there is the unconditionally violent and deceptive master. He does not have two different behaviours (accept transfers at free will or enforce them). He immediately forces the system to transfer an amount he sets. The target transfer size is 1mM in every concentration pair (figure 9) or less if the concentration in source is too low.
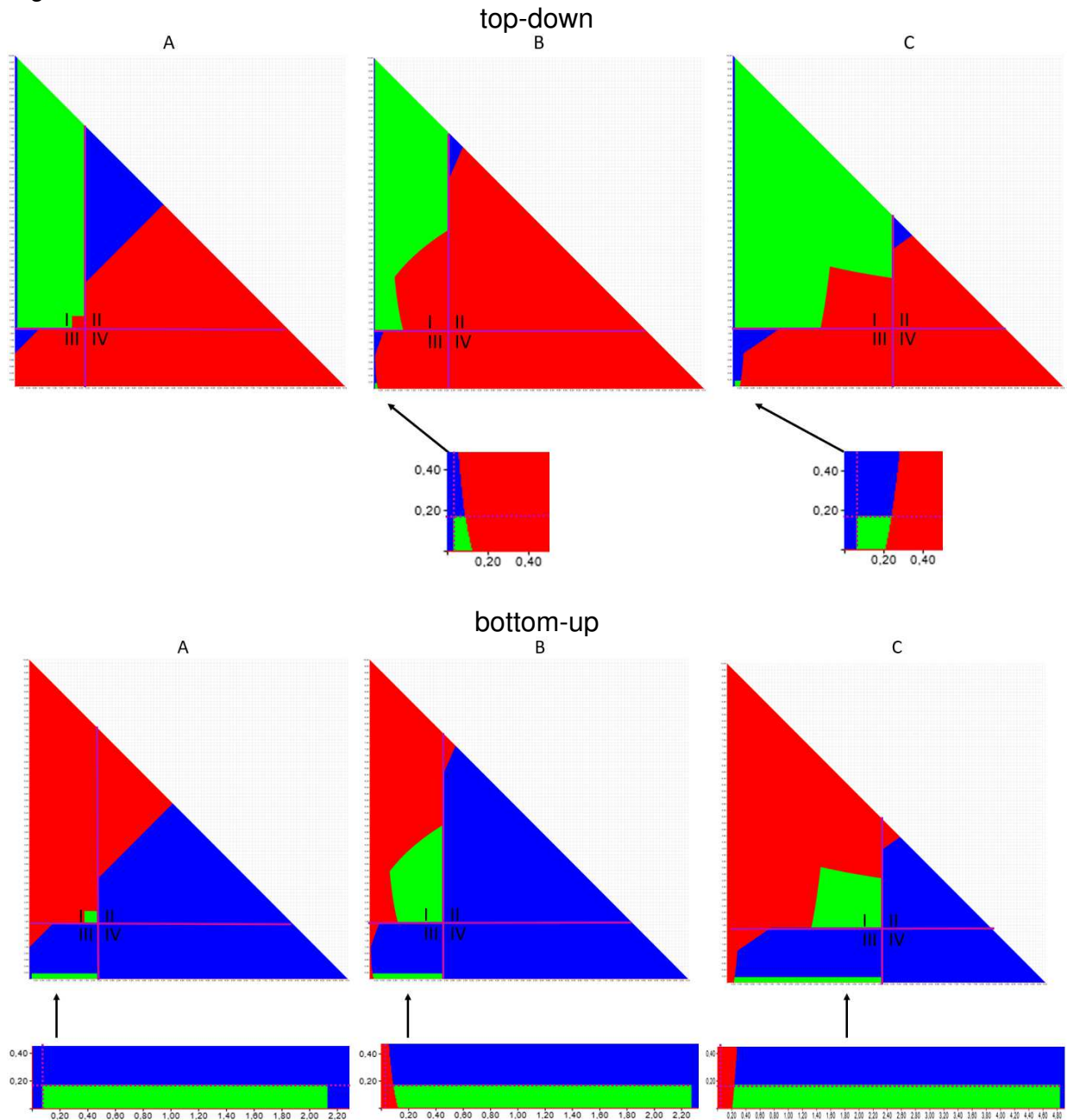
Figure 9
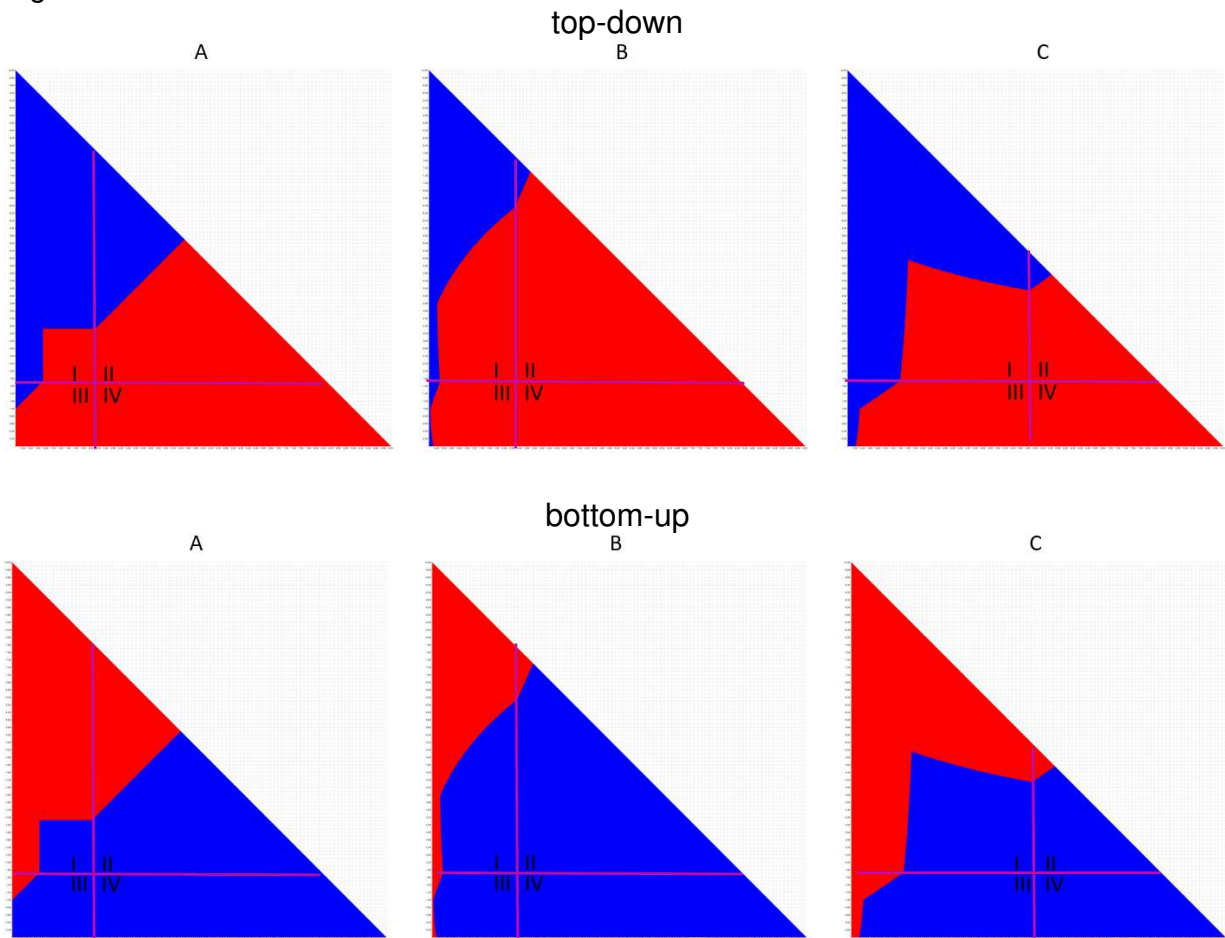
Figure 9
Source and sink are controlled by an unconditionally violent and deceptive master. The ensemble is asymmetric with respect to A: fixed cost (source 1, sink 0.5) or B: Km (source 0.5mM, sink 0.1mM) or C: Vmax (source 5μmol/min, sink 10μmol/min). All conditions are a variation of only figure 6A.

The blue superadditive surfaces (top down) and blue subadditive surfaces (bottom up) show that the unconditionally violent and deceptive master seems to shift the output of the ensemble to even less superadditivity.

Again, when the linear component (cost) is manipulated the borders between super- and subadditivity stay linear and they become curved, when the non-linear component of the net profit is manipulated.

The above depictions give a general, qualitative, and spatial impression of the distribution of superadditivity and subadditivity within the transfer space. But it is also possible to quantify superadditivity and subadditivity as the volume between the active and inactive ensemble (volume integral, total net profit with transfer minus total net profit without transfer). The unit of the volume (super- or subadditive) is: $np*mM^2$. The results are collected in table 1 to 4 The conditions are basically the conditions of figures 4A, 5A, 6A, 7, 8, and 9.

Table 1, completely symmetric ensemble (figure 4A, 5A, 6A)

	independent ensemble	conditionally violent master	unconditionally violent master
superadditivity, free will	8.0594	8.0594	
subadditivity, free will	-0.1461	-0.1461	
superadditivity, forced		4.7686	14.3978
subadditivity, forced		-32.5311	-32.9267

Table 2, asymmetric ensemble with respect to fixed cost (fig. 7A, 8A, 9A)

	independent ensemble	conditionally violent master	unconditionally violent master
superadditivity, free will	11.5489	11.5489	
subadditivity, free will	-0.197	-0.197	
superadditivity, forced		2.4626	14.6653
subadditivity, forced		-32.3748	-33.1653

Table 3, asymmetric ensemble with respect to Km (fig. 7B, 8B, 9B)

	independent ensemble	conditionally violent master	unconditionally violent master
superadditivity, free will	5.4237	5.4237	
subadditivity, free will	-0.4492	-0.4492	
superadditivity, forced		1.1641	5.5526
subadditivity, forced		-35.0871	-38.1614

Table 4, asymmetric ensemble with respect to Vmax (fig. 7C, 8C, 9C)

	independent ensemble	conditionally violent master	unconditionally violent master
superadditivity, free will	33.4868	33.4868	
subadditivity, free will	-0.6326	-0.6326	
superadditivity, forced		4.3941	33.4834
subadditivity, forced		-28.0076	-32.4596

It is clearly visible that under the chosen conditions a conditionally and an unconditionally violent and deceptive external master with no internal limits (active in all possible concentration pairs) is in sum producing less superadditivity than an honest broker (peaceful master) or an independent, peaceful ensemble.

In an older paper (4, figures 7-10 there) this was investigated more deeply. There I showed that violent and deceptive masters, when not deviating too much from the internal limit b-c=0 into area II and III, can have an advantage over the peaceful master with the same ensemble. They are even dominant when the peaceful master has a small outside support.

At the internal limit b-c=0 source stops to give and does not enter $b_{so}-c_{so}>0$ by giving additional substrate and sink stops to take and does not enter $b_{si}-c_{si}<0$ by taking additional substrate. Both parties are only active in area I. However, in proximity to this limit (area II and area III) additional superadditivity is achievable. In case a master sets a new limit not too far away from b-c=0, he may harvest additional superadditivity for the price of only a small amount of subadditivity and some investment into force and deception. But this implies that the master is able to organize different amounts of substrate to be transferred. All transfers end at the newly set limit no matter how far the starting concentration pair is away from that limit. In a concentration pair source:sink 10mM:0mM he may transfer 5.5mM and in a concentration pair 6mM:4mM he will transfer only 1.5mM substrate. This complex ability is not active in the master here.

An honest broker as master may be viewed as a peaceful and friendly way to success. However, very often in the real world, both, source and sink, are either cost dominated (area II) or benefit dominated (area III). Only a conditionally or an unconditionally violent and deceptive master are able to produce superadditivity there. This will make additional investments (force, deception) necessary and a new type of cost appears: subadditivity.

Evolutionary fate of a net profit accumulator strategy, a substrate transfer strategy, and a combination of both strategies

In the investigation above a large range of concentration pairs have been simultaneously observed in an ensemble. The main idea was to see what happens in many different start conditions to an ensemble when no transfer is performed (inactive) in comparison to when a transfer is performed (active). The main observation was that transfers of some concentration pairs are superadditive. They create a better result when transfers are performed. In some cases, the outcome was subadditive. Here, no transfer would create a better outcome for the ensemble. To me, it is a clear and observable fact in nature that the overall benefit (b) of an organism must be larger than the overall cost (c) for this organism (b>c) to keep him alive and kicking. Superadditivity refers to better efficiency. Better efficiency will result in an advantage in mutual competition of ensembles. The unit of super- and subadditivity as a global result over the whole available concentration pairs is $np*mM^2$. The unit of a local case (a single concentration pair) is super- or subadditive net profit. The superadditivity harvested from the ensemble is a benefit to the master. His direct cost is an investment into force and deception. An honest broker as a peaceful master will have transfer and information costs to connect source and sink.

Now I want to investigate the strategic alternatives of an unconditionally violent and deceptive master:

- the master controls the ensemble completely
- the master has no knowledge of internal limits (b-c=0)
- the master harvests super- and subadditivity as his net profit
- the ensemble has a very unequal distribution of substrate
- the ensemble does not change over the generations of masters
- the ensemble is completely symmetric
- the ensemble has a fixed cost of 1
- the transfers are small compared to the fixed cost

The master follows blindly one of three different, very simple strategies:

A. Transfer strategy (figure 10)

The master with this strategy blindly transfers substrate. A limited set of concentration pairs is observed (start condition in source: 2mM to 4mM in 0.1mM steps; 0.1mM in sink). The master will transfer once in every generation a certain amount of substrate from source to sink. He can´t measure the size of the transfer or compare the present size to the past size. His success is dependent on the size of this transfer. 100 masters start with an initial transfer of 0.1mM. After that the transfer size of every master is mutated randomly and normally distributed up to a ±0.1mM increase or decrease. The different masters transfer now different amounts of substrate. This results in different amounts of net profit. The average net profit is plotted against the generation time. The data points are coloured in red. The upper ten percent of masters (largest transfers) will have a single offspring, each. The lower ten percent masters (smallest transfer size) are lost. The next generation starts with a new mutational step.

B. Positive net profit strategy (figure 11)

With this strategy the master looks only for a positive net profit (superadditivity of the ensemble). A limited set of concentration pairs

is observed (start condition in source: 2mM to 4mM in 0.1mM steps; 0.1mM in sink). The master is not able to monitor the absolute size or the course of his net profit. He will transfer once in a generation in a limited set of concentration pairs and checks whether his net profit is positive (b>c, np>0). In case the net profit is negative he will pause for 9 further generations and then try again. His success is dependent on the size of the positive net profit. 100 masters start with the same very small initial transfer. After that the transfer size of every master is mutated randomly. The different masters transfer now different amounts of substrate. They will have different sizes of net profit. The average of this net profit is plotted against the generation time. The data points are coloured in black. The upper ten percent (largest net profit) will have a single offspring, each. The lowest ten percent of the masters (smallest net profit) are lost. The next generation starts with a mutational step. The initial transfer size is 0.1mM. The maximal variation by mutation of the transfer size is ±0.1mM, normally distributed.

C. Combination of A and B (figure 12)

The masters start either with strategy A or B (50A, 50B). Again 100 masters are observed in a limited set of concentration pairs (start condition in source: 2mM to 3.3mM in 0.1mM steps; 0.1mM in sink). All strategies are judged according to their net profit! The ten percent of the largest net profits will reproduce. The ten percent of the smallest net profits are eliminated. The single master who has just avoided to be eliminated will change his strategy. The changed strategy will always start at the transfer size of the previous strategy. The average of the net profit of the 100 masters is plotted against the generation time (blue). In a second graph the percentage of the

applied strategy (transfer strategy in red; positive net profit strategy in black) is plotted over the generation time.

In general, the mutation of the transfer size is always smaller than the fixed cost. More complex strategies are imaginable. Net profit as well as transfer size could be compared between a previous and a present period. This would be a strategy of a much higher complexity with the necessity to remember. However, I want to keep everything as simple as possible. The large number of ensembles not affected by the selection process serves as a reservoir. The harvested superadditivity is interpreted as the master´s net profit to simplify matters. The fixed cost appears within the ensemble. To change the strategy at the border to extinction may appear as a complex behaviour. But it is known in biology that contact with a dangerous environment not immediately leading to death activates pre-existing defence mechanisms (5). A simple switch between existing strategies after an appropriate stimulus. As both strategies already exist separately, it is easily imaginable to fuse them together by a simple combination of both "genes" and use an appropriate switch.

In figure 10 the transfer strategy starts at negative net profits due to the fixed cost. The average of the masters jumps a little upwards and then steadily increases further. After about 2200 generations a positive net profit is achieved. The increase flattens, declines, and after about 6200 generations the net profit starts to become negative again. This result is not only the average of 100 masters but also the average of different concentration steps of 0.1mM between the upper and lower limit. Not all other possible concentrations show this result. A feature of an unconditionally violent master on his ensemble is the increase in subadditivity in other concentration pairs (see figure 9 and literature 6).
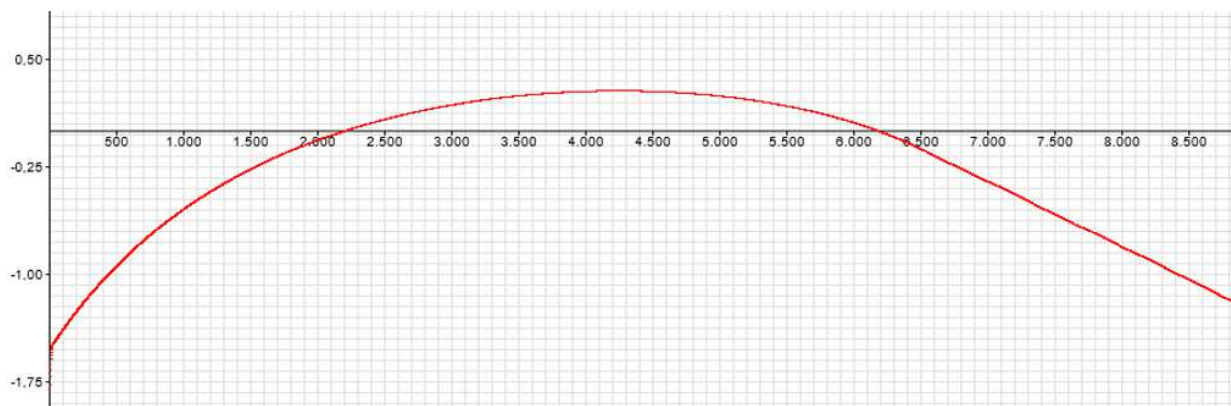
Figure 10

Figure 10
The master follows a transfer size strategy (A). The red dots show the development of the net profit over 8500 generations.

In contrast to the transfer strategy A, the pure positive net profit strategy B is tied up in inactivity. Only a few random steps lead upwards but fail to reach a positive net profit within 8500 generations (figure 11).
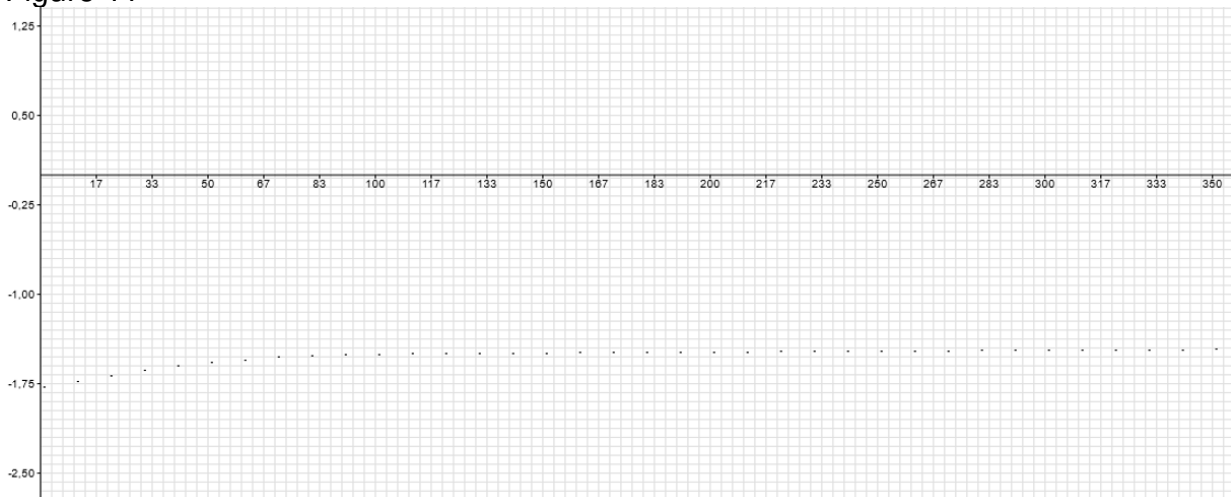
Figure 11

Figure 11
The master follows a positive net profit strategy (B). The black dots show a random small increase. Only a small section (350 generations) is shown. The ensemble never reaches a positive net profit in the long run. The dots are distanced by 9 generations as the masters pause again and again.

In figure 12 the masters are able to switch between the two strategies. The master at position 90 of the net profit ranking is at the border to be eliminated. This will make him change his actual strategy to the alternative strategy. However, he keeps the transfer size of the previous strategy.

Figure 12

Figure 12
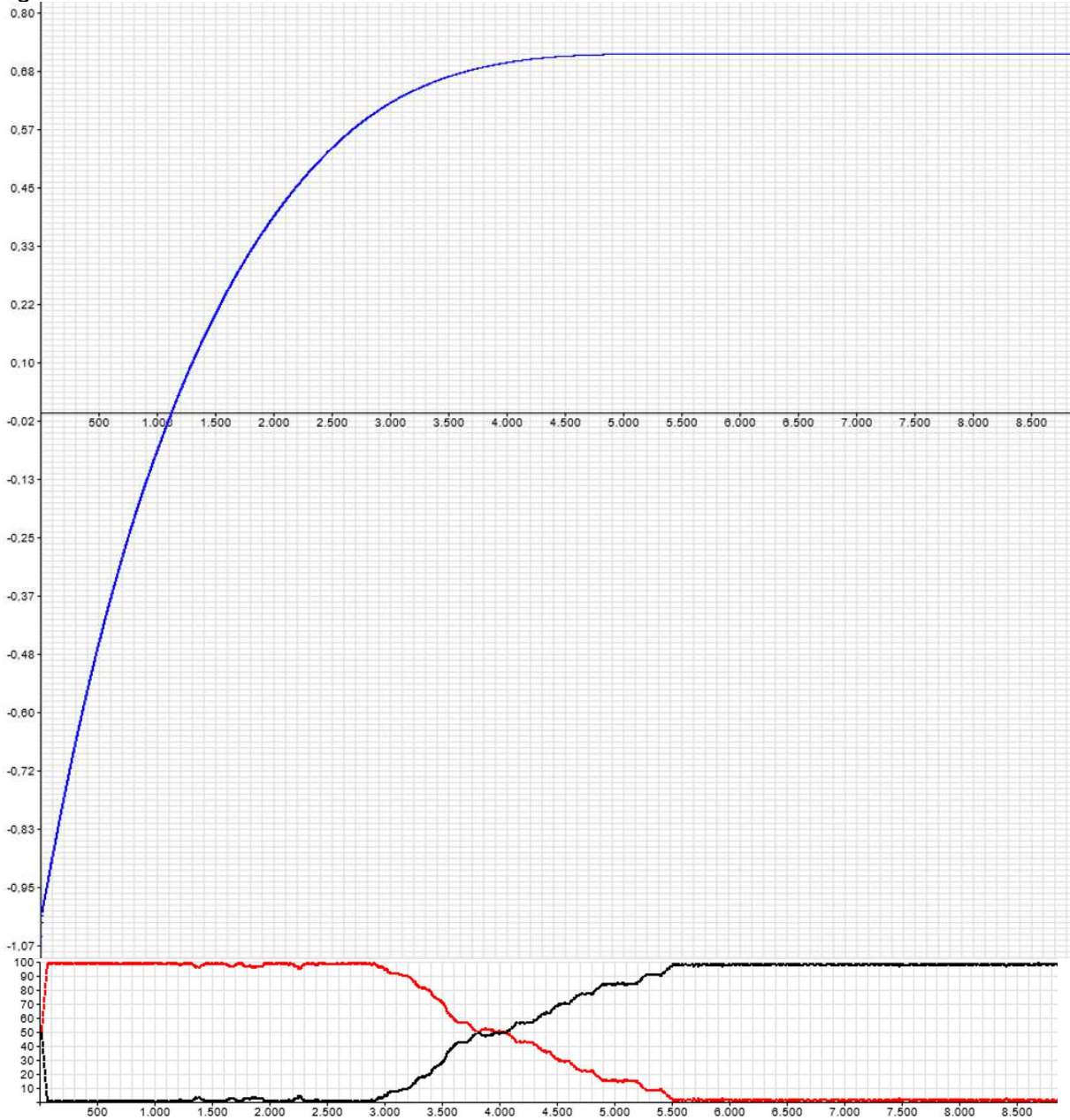The masters follow a mixed strategy. 50 masters start with a transfer strategy (red) and 50 masters start with a positive net profit strategy (black). Both are able by a single step to switch between the two different strategies. The blue curve is the average net profit of the 100 masters with two alternative strategies and a limited set of concentration pairs (2mM to 3.3mM in 0.1mM steps in source and 0.1mM in sink).

It is obvious that the average net profit rises from negative values to the first positive average net profit within about 1100 generations. The net profit rises further and stays constant after 4500 to 5000 generations (blue curve, figure 12). The black and red curves explain what happens to the distribution of the two alternative strategies. In the beginning, the positive net profit strategy quickly vanishes. This strategy reappears, surprisingly not very successful, within the range of small positive average net profits. However, near the maximal average positive net profit the positive net profit strategy pushes through within 2500 generations (generation time 3000 to 5500). Then the positive net profit strategy stays dominant and the transfer strategy disappears. The reason is that further increased transfers will result again in smaller net profits (figure 10) and therefore this strategy is eliminated by the selection process.

The effect of a wrong assumption of entanglement

In the previous section I have demonstrated the success of rational and ideology free behaviour in the presence of a fixed cost. Nevertheless, it is observable that rational entities fail. There may be a lack of knowledge, wrong information, insufficient evaluation of correct information, and the impossible ability to predict the future. In addition, there may also be a new source of error which is the mistaken assumption of entanglement.

Entanglement within the transfer space connects source and sink beyond the flow of substrate (7, 8). Source and sink are additionally connected by genes or shares. Therefore, source and sink participate mutually in gain and loss. Due to the conservation of mass and energy and good scientific practice double counting is forbidden. I have tried in an earlier attempt to address the problem of double counting in the case of entanglement (7).

There, I assumed, that strangers invest in themselves and do not transfer. The other party has no genetic relation. Both parties end after their lifespan. The maximal net profit of such an inactive ensemble is the maximal net profit of each single party. An ensemble of parent and offspring has a much longer duration. It extends into the future. I showed in the basic paper (7) that a simultaneous consideration of quantity and shared quality was superior to the best result self-investment could achieve.

The essence of entanglement is the simultaneous observation of a quantity balance (net profit) of source and sink and a quality balance of source and sink. Source and sink as well as quantity and quality are independent of each other and therefore orthogonal to each other. Quality is a complex concept as quality is a feature. Quantity is just a number. Both exist in connection but are independent (orthogonal). In many instances high quality is connected to longevity and durability (*e.g.,* in cars and other consumer products). The same is true for parent and offspring. A parent (source, here, now) invests into offspring (sink, there, then) with an expected longer lifespan than the parent. Exceptions with opposite investment strategies seem to contradict this idea. In ants and bees, offspring (workers) invest into a parent (queen). There, however, the short-lived offspring invests into the long living mother or sister.

Before I go on, I want to admit that it is bold to compare entangled and not entangled parties. Let us assume we observe a source and a sink consisting of 10000 genes each. The action of these 10000 genes results in one final saturating benefit function and one final linear cost function in both parties. In the unrelated case we observe a total of 20000 different genes. In the case of parent and offspring we have 2*5000 unrelated genes and 2*5000 pairwise identical genes. We look at only 15000 different genes. The content of information in both cases is different and entangled ensembles extend further into the future.

The entanglement of source and sink is achieved in the model as follows:

Inactive ensemble:

$$\left((b_{so}-c_{so})*ef_{so} + (b_{si}-c_{si})*ef_{si}\right)_{so}*sf_{so}^{noT} + \left((b_{so}-c_{so})*ef_{so} + (b_{si}-c_{si})*ef_{si}\right)_{si}*sf_{si}^{noT}$$

Active ensemble:

$$\left((b_{so}-c_{so})*ef_{so} + (b_{si}-c_{si})*ef_{si}\right)_{so}*sf_{so}^{T} + \left((b_{so}-c_{so})*ef_{so} + (b_{si}-c_{si})*ef_{si}\right)_{si}*sf_{si}^{T}$$

b=benefit of source (so) or sink (si), c=cost of source (so) or sink (si), ef=entanglement factor with source (so) or sink (si). The entanglement of a party with itself is one (so-so, si-si), the entanglement with the other party is between one and zero (so-si, si-so). One would be a clone, zero would be a complete stranger. Offspring in mammals, for example, has an entanglement of 0.5 with the parent and *vice versa*. sf=success factor of source (so) or sink (si) with transfer (T) or without transfer (noT). The success factor after a transfer may *e.g.,* increase in sink and decrease in source (parent feeds offspring). But the success factor after a transfer may also possibly decrease in sink and increase in source (transfer of a burden). The success factor is a tool to take into account the future success of a party. The difference of an inactive (noT) and an active ensemble (T) again calculates the superadditivity or the subadditivity of the transfer. The factors ef and sf have not been visible in the initial version of my model because ef with the other party (so-si, si-so) was zero and sf was set to be one and self-entanglement (so-so, si-si) was also one. An offspring and a parent share 50% (ef0.5) of the genes in mammals (not considering the information content of the mitochondrial genome). For simplicity it is assumed that parent and offspring as well as two strangers have identical benefit functions and cost functions. They are completely symmetric. The standard biochemical values here are: [S]=0mM to 10mM, Km=0.5mM, Vmax=5μmol/min, bf=1b min/μmol, cf=5/3 c/mM in symmetric ensembles.

Masters are able to use force and deception but the master himself may also be forced or deceived to act on his ensemble in a specific way. This may harm or help the outcome (superadditivity or subadditivity) he may harvest from the ensemble. According to my model two basic sources of error for a master are possible: a. misjudgement of the degree of entanglement of source and sink (ef_{so}, ef_{si}). b. misjudgement of the success of a transfer (sf_{so}^{T}, sf_{si}^{T}) or of no transfer (sf_{so}^{noT}, sf_{si}^{noT}).

An accurate judgment depends on information. Information can be deliberately manipulated to influence the behaviour. This may be the case for the entanglement factor arising from a conjunct or not conjunct past. The success factor may also be twisted by deliberately wrong information about the future success but is also influenced by random processes. However, I will investigate the success factor from a different angle, later.

In figure 13 I compare the superadditive net profit of an ensemble of two strangers controlled by an unconditionally violent master with the ensemble of a parent and an offspring (ef0.5) also controlled by an unconditionally violent master. In both ensembles this master imposes a transfer of 0.001mM in all concentration pairs along a diagonal from 1.4495mM in source and 0mM in sink to 1.4495mM in sink and 0mM in source. This diagonal cuts through the maximum when no transfer is performed. The ensemble of two strangers (orange curve) is inferior to many concentration pairs where entangled parties share quantity and quality. However, in case the master wrongly assumes entanglement of the strangers, he will be disappointed in a lot of concentrations as quality is not shared. This changes on the very right side of figure 13 where the not entangled ensemble is performing better (more superadditive net profit than the entangled ensemble).

Figure 13
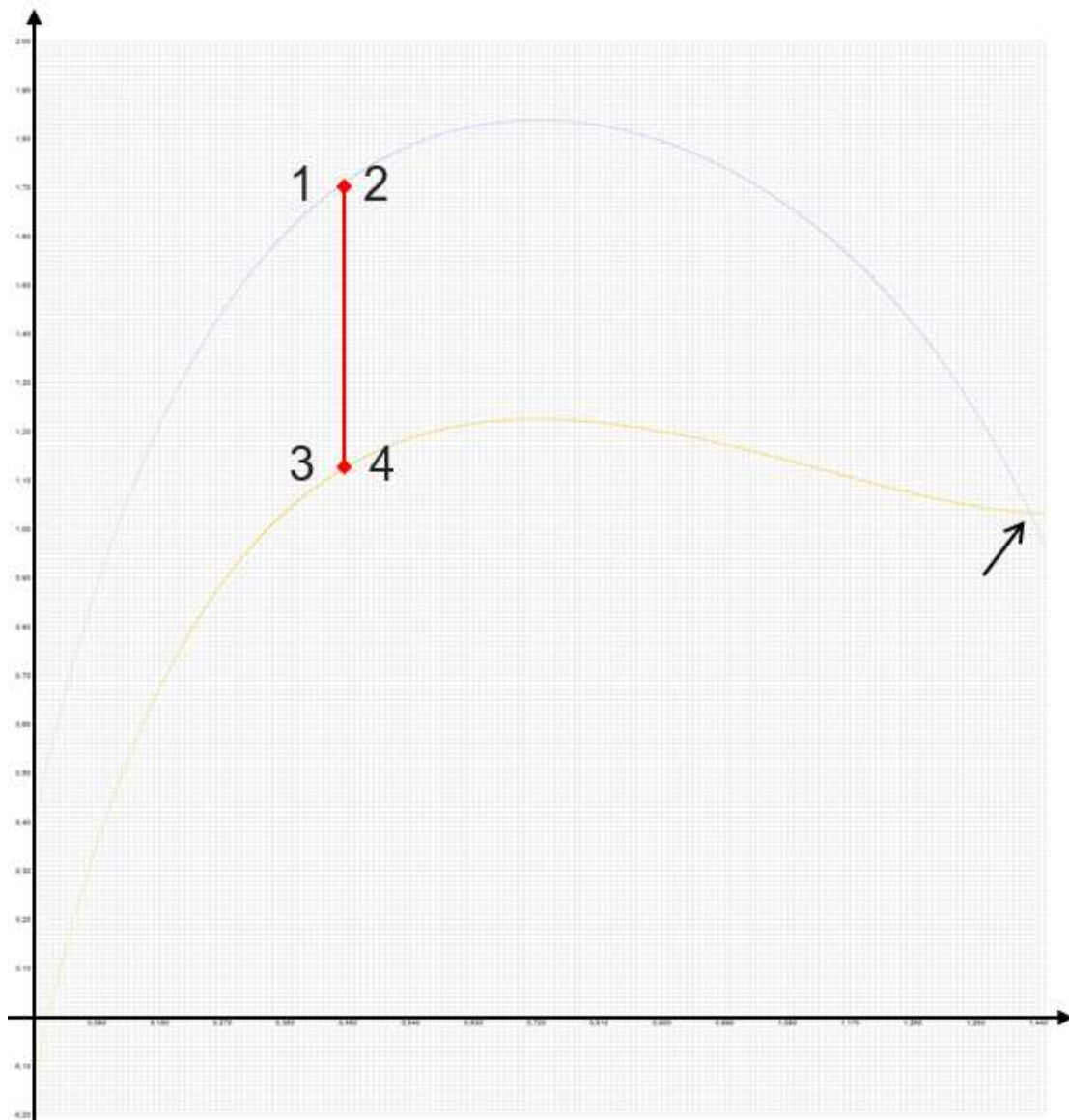
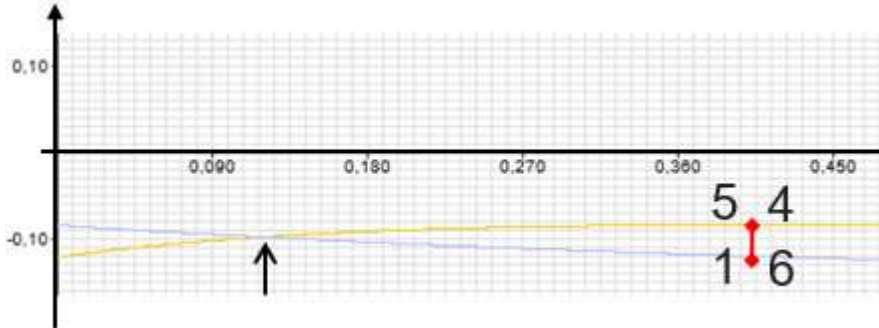|	conviction: entangled	conviction: not entangled
fact: entangled	1 expected result	2 better result
fact: not entangled	3 worse result	4 expected result

Figure 13
The blue curve represents the entangled ensemble, the orange curve represents the ensemble of strangers (x axis, superadditive net profit quantity and quality; y axis, substrate concentration in sink). The depiction is a cross section of the transfer space between 1.4495mM in source (0mM in sink) and 1.4495mM in sink (0mM in source) on a diagonal line leading through the maximum at 0.7247mM in source and sink (symmetric ensemble). A fixed cost is not considered. The following success factors were used for both ensembles: $sf_{so}^{T}=0.9$; $sf_{si}^{T}=1$; $sf_{so}^{noT}=1$; $sf_{si}^{noT}=0.2$. The entanglement factor for parent and offspring is ef0.5 or strangers is ef0. The transfer enforced by the unconditionally violent master in all concentration pairs along the diagonal was only 0.001mM. The arrow marks the equivalence concentration where entangled and not entangled parties have the same superadditive net profit.

In the next figure (figure 14) the success factor of a sink without a transfer is increased from 0.2 to 0.95. It is very likely now for the sink to survive without a transfer. Here, in most of the cases, no transfer of substrate will result in a better outcome for the non-entangled strangers. However, better is to be understood as less subadditivity as the results are negative superadditivity. This time a transfer enforced by the master under the wrong assumption of entanglement at the identical concentrations in source and sink like figure 13 will result in a better outcome than expected.

Entangled parties share quantity and quality. In case the quantity is low this will be shared also by the entangled party, lowering the combined quantity and quality balance. The crossing point of the blue and yellow curve shifts from right (figure 13, high concentrations in sink) to left (figure 14, low concentrations in sink).

Figure 14

	conviction: entangled	conviction: not entangled
fact: entangled	1 expected result	6 worse result
fact: not entangled	5 better result	4 expected result

Figure 14
The legend of this figure is identical to figure 13. The following values have been changed: $sf_{so}^T=0.9$; $sf_{si}^T=1$; $sf_{so}^{noT}=1$; $sf_{si}^{noT}=0.95$.

Errors due to a mistaken assumption of entanglement are a new type of error. The disappointing experience about the result of a forced transfer in good faith and the conviction of a brotherly connection, but in the absence of true entanglement, will be repeated over and over again. Many other reasons for the failure will be surmised as long as the true nature of the error is not acknowledged.

Entanglement of source and sink adds an advantage to such ensembles. Why then do we observe investment into strangers?

Investment into strangers is not common in nature outside of area I. A general reason for investment into strangers outside of area I could be that an implicit benefit of a higher instance is increased (an implicit cost is decreased) or the overall success probability is increased. I interpret that as an increase of a success factor. A success factor existing in the absence of entanglement.

In the following section I investigate an investment when the success factor for the investment into the stranger is better than the success factor for the investment into an entangled party. The calculation of the superadditive net profit (x-axis) is identical to figures 13 and 14; *i.e.,* under the influence of an unconditional violent and deceptive master. A master unaware of any of the ensemble´s inner limits. The y-axis is the substrate concentration in sink between 0mM and 1.4495mM; identical to figure 13.

This time the following success factors are used:

a. entangled: $ef = 0.5$; $sf_{so}^{T} = 0.2$; $sf_{si}^{T} = 0.30$; $sf_{so}^{noT} = 0.2$; $sf_{si}^{noT} = 0.2$
b. not entangled: $ef = 0.0$; $sf_{so}^{T} = 0.2$; $sf_{si}^{T} = 0.30$; $sf_{so}^{noT} = 0.2$; $sf_{si}^{noT} = 0.2$
c. not entangled: $ef = 0.0$; $sf_{so}^{T} = 0.2$; $sf_{si}^{T} = 0.45$; $sf_{so}^{noT} = 0.2$; $sf_{si}^{noT} = 0.2$
d. not entangled: $ef = 0.0$; $sf_{so}^{T} = 0.2$; $sf_{si}^{T} = 0.90$; $sf_{so}^{noT} = 0.2$; $sf_{si}^{noT} = 0.2$

The success factor of the source in all four cases is low, maybe it is even the same source. This party is not expecting a successful future. But after a transfer the success factor does not decrease significantly, either. The source seems to be at the end of a vast plain. However, the entangled sink (a) not only has a low success factor, too, but the sink responds weakly to a transfer. In contrast, the not entangled sink strongly and positively responds to a transfer (d, sf0.9) or slightly better (c, sf0.45) or identical (b, sf0.3). Could the first case (a, sf0.3 of the entangled sink) be a blueprint of a disinherit and the largest value (d, sf0.9 for the not entangled sink) be the result of a donation to a foundation? No, not with a simple biochemical model! Nevertheless, a case with above values is investigated in figure 15.
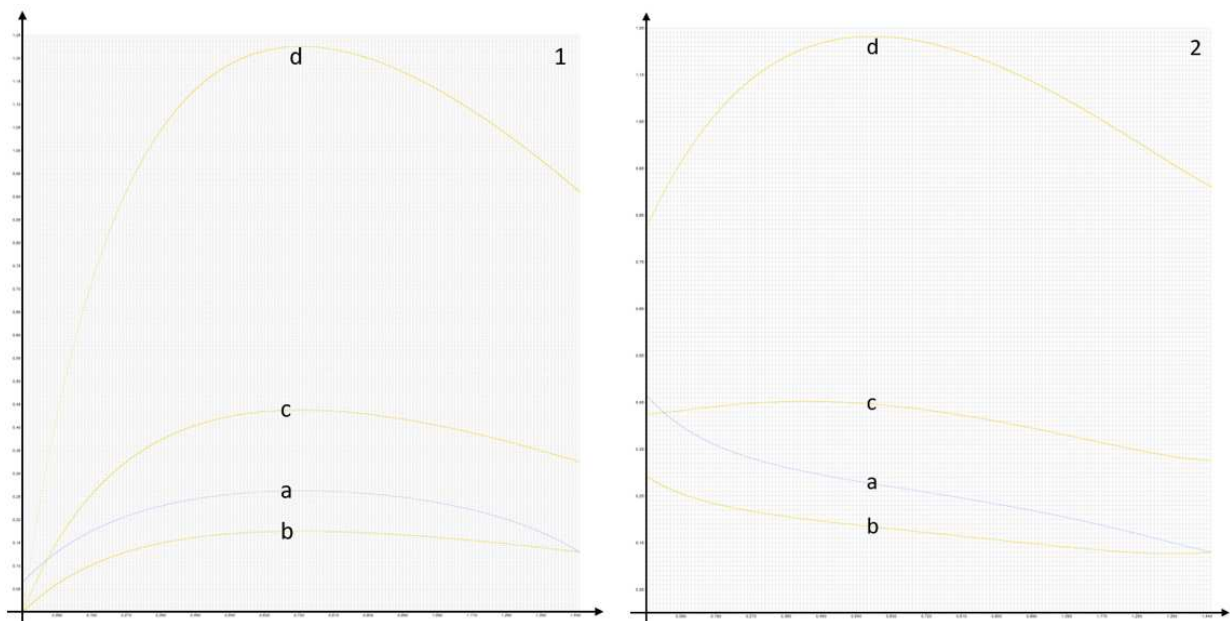
Figure 15

Figure 15
The legend of this figure is identical to figure 13 with the following values: blue curve entangled: a. $ef = 0.5$; $sf_{so}^T = 0.2$; $sf_{si}^T = 0.3$; $sf_{so}^{noT} = 0.2$; $sf_{si}^{noT} = 0.2$. orange curves not entangled: b. $ef = 0$; $sf_{so}^T = 0.2$; $sf_{si}^T = 0.3$; $sf_{so}^{noT} = 0.2$; $sf_{si}^{noT} = 0.2$. c. $ef = 0$; $sf_{so}^T = 0.2$; $sf_{si}^T = 0.45$; $sf_{so}^{noT} = 0.2$; $sf_{si}^{noT} = 0.2$. d. $ef = 0$; $sf_{so}^T = 0.2$; $sf_{si}^T = 0.9$; $sf_{so}^{noT} = 0.2$; $sf_{si}^{noT} = 0.2$.
1: Source transfers 0.000001mM of the available substrate. 2: Source transfers 10% of the available substrate.

Superadditivity corresponds to the success of an ensemble. The more superadditivity an ensemble is capable to produce, the more successful it will be in a competition with a second ensemble. The message of figure 15 is clear. Genetic tradition (entanglement) may be a sufficient condition but not a necessary condition for the success of an ensemble. Genetic entanglement only reduces the necessity of a high success factor for an ensemble to succeed. Genetic tradition of source and sink is irrelevant, as long as there are sources and sinks in every generation available and the success factor is sufficient. This condition met, non-entangled ensembles can be more successful than entangled ensembles (figure 15, compare a with c and d).

In the above depiction we learn that a high success factor (c, d) can compensate for the absence of entanglement. At higher transfers (*e.g.,* 90% of the substrate, data not shown) even b becomes better in many concentrations than a. Entangled parties share both, advantages and disadvantages.

Considering the observation of figure 15, it is reasonable to also assume that an increased success factor by a little bit can compensate for a little less entanglement. From this statement the following question can be derived and answered: Why do organisms invest into sexual reproduction? A clone (ef=1) has a higher entanglement than an offspring from mating (ef=0.5).

In figure 16 it is assumed that the new combination of genes through sexual reproduction (ef0.5) confers a strong advantage to the offspring (sf1) in comparison to the clone (ef1, sf0.3; identical to the origin of the clone).
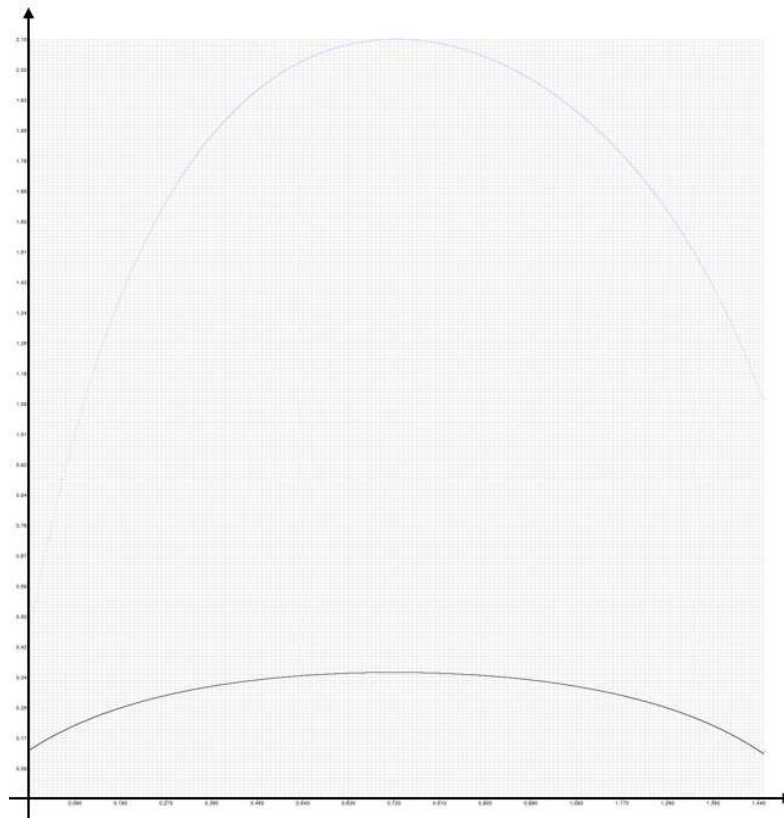
Figure 16

Figure 16
The legend of this figure is identical to figure 13 with the following values: blue curve, offspring: $ef =0.5$; $sf_{so}^{T} =0.3$; $sf_{si}^{T} =1$; $sf_{so}^{noT} =0.4$; $sf_{si}^{noT} =0.1$. Black curve, clone: $ef =1$; $sf_{so}^{T} =0.3$; $sf_{si}^{T} =0.3$; $sf_{so}^{noT} =0.4$; $sf_{si}^{noT} =0.1$. Source transfers 0.001mM of the available substrate.

Sexual reproduction is costly. The main reasons are: a. recombination disrupts coadapted clusters of genes; b. the finding of mating partners may be costly; c. males are not directly productive with respect to offspring quantity. Therefore, it is generally assumed that sexual reproduction confers an advantage overcompensating the reduced entanglement between parent and offspring.

Now it would be interesting to understand how much better a not entangled ensemble has to be to outcompete an entangled ensemble. Or, let me frame it this way: At what size relation of the success factors and entanglement factors is the production of superadditivity equal? The answer to this question is, however, not simple. The size of the transfer can´t be

made negligible. The net profit in source is different from the net profit in sink in most of the imaginable cases in a non-linear way. In addition, there may be biochemical asymmetries in source and sink. A lower cost, a higher Vmax (higher productivity), or a smaller Km (higher affinity) in sink may compensate for a smaller success probability (sf_{si}). Or a very large success factor of sink may compensate for a higher cost, a higher Km, or a lower Vmax in sink. The answer has to be calculated in every single case. The non-linear benefit function $b=bf*Vmax*[S]/([S]+Km)$ and the linear cost function $c=cf*[S]$ are both a function of the substrate concentration: $b-c = np = f([S])$.

If "s" is the total substrate concentration (10mM), "t" the amount to be transferred, and "x" is the substrate amount in sink, then the following can be stated:

before transfer: $(b-c)_{so} = np_{so}\, f([S]) = bf*Vmax*[s-x]/([s-x]+Km - c=cf*[s-x];$

$$(b-c)_{si} = np_{si}\, f([S]) = bf*Vmax*[x]/([x]+Km - c=cf*[x]$$

after transfer: $(b-c)_{so}= np_{so}\, f([S]) = bf*Vmax*[s-x-t]/([s-x-t]+Km - c=cf*[s-x-t]$

$$(b-c)_{si}= np_{si}\, f([S]) = bf*Vmax*[x+t]/([x+t]+Km - c=cf*[x+t]$$

And the complete equation comparing an entangled ensemble (ef0.5) and an ensemble of two strangers (ef0):

$(np_{so}\, f(10-x-t)*1+np_{si}\, f(x+t)*0.5)*sf_{so}^{T}+(np_{so}\, f(10-x-t)*0.5+np_{si}\, f(x+t)*1)\, *sf_{si}^{T})$ **-**

$(np_{so}\, f(10-x)*1+np_{si}\, f(x)*0.5)*sf_{so}^{noT}+(np_{so}\, f(10-x)*0.5+np_{si}\, f(x)*1)*sf_{si}^{noT})$

= $np_{so}\, f(10-x-t)*sf_{so}^{T} + np_{si}\, f(x+t)*sf_{si}^{T} - (np_{so}\, f(10-x)*\, sf_{so}^{noT} +np_{si}\, f(x)*sf_{si}^{noT})$

After substituting the function term for the net profit into the formula and subsequent simplification, there arise polynomials of third degree in x and t. This cannot easily be solved for x and we cannot retrieve a simple relationship between the success factors, the entanglement, and x.

Final discussion

The model "transfer space" is based on the size comparison of a benefit and a cost, both with the same physical unit. Benefit is a preferable feature, cost not. But both are inseparable connected and vary depending on the local conditions. A source wants to decrease cost until b=c, a sink wants to increase benefit until b=c. Both parties can be forced or deceived to behave otherwise. The difference of benefit and cost is called net profit. When two parties compete, the size of the net profit is deciding. When two ensembles compete, the size of the superadditive net profit is deciding.

Now the question is whether net profit or transfer size is a better and more honest or true criterion for the evaluation of a successful single party or an ensemble? This is regrettably also a political question. In biology the net profit of the "whole" must be positive (b-c>0) to sustain life in general (growth, repair, offspring production, etc). The benefit of an action must be larger than the cost of the action. The gain in ATP must be larger than the cost in ATP. The energetic net profit of some metabolic steps may be negative, but the overall balance of all benefits and costs must be positive. The whole bill is paid by the sun´s energy.

Superadditivity and subadditivity are the possible outcomes of "transfer" in comparison to "no transfer" in an ensemble. The size-difference of superadditivity and subadditivity between two ensembles (locally, a single concentration pair or globally, all possible concentration pairs) decide their success in mutual competition (9). In ensembles of ensembles super- and subadditivity of a lower-level entity is the benefit of a higher-level entity (2). The same is true for economies on any scale in societies (many ensembles of ensembles, deeply tiered and nested). Subadditivity and superadditivity may appear side by side in different places of the concentration range (figures 4 to 9, table 1 to 4). Here, the discussion is more complex as there is often no consensus how much subadditivity will be tolerable in a society

to achieve superadditivity elsewhere. In addition, it should not be forgotten that in ensembles some kind of master may be present. The performance of the ensemble could be the evaluation criterion of competing masters and finally the size of their bonus or malus. Some masters appreciate transfer size and others positive net profit. This leads to two contradicting economic ideas. There may be a feedback mechanism between the master and his ensemble favouring transfer size over net profit. However, transfer size may be a function of net profit as net profit is a function of the transfer size. In addition, extreme net profit achievement in one party may possibly be accompanied by subadditivity of the ensemble and may be punished - in case there is no connection between the master and the party extracting the extreme net profit. Different ensembles and their masters compete on the basis of superadditivity. The master has costs, too. He invests into force and deception or he has travel expenses or information costs as an honest broker.

Within my model I show that in the presence of a fixed cost the transfer strategy and the positive net profit strategy are successful only in combination. In the real world, fixed cost is the default setting. The transfer strategy sets the ensemble on its way as an active ensemble. This strategy acts as a pathfinder. The positive net profit strategy takes over in the range of positive net profit and selection stabilizes the optimum (figure 10, 11, 12). The latter finding is very important. Selection and removal of underperforming entities is an important part of the mechanism but originates outside of the ensemble. Although the force within the single parties is due to the attractor $b-c=0$, the maximization of net profit comes from an external instance. The driving force within the transfer space is the size relation of benefit and cost. Source only gives when $b<c$ and sink only takes when $b>c$ in the absence of an external force. Maximization of net profit is not an aim at this stage. Maximization of net profit appears when

single parties compete. Maximization of superadditivity is a later level when ensembles compete. To qualitatively compare the size relation of the outgoing cost (expenditure) and the incoming benefit (revenue) is a simple task. At slowly increasing concentrations, the benefit will suddenly change into a cost. This sudden change is easily detectable if you are a simple organism - a true *Homo Economicus* - and not an organism with beliefs and ideology. In contrast, net profit changes gradually. You have to remember and compare the size of two differences (b_1-c_1 versus b_2-c_2); a complex achievement. The acquisition of this ability is not a necessity for simple life. It is a feature of the world the organism lives in. The change in strategy from A to B (figure 12) makes the system sensitive towards the outside world, here a model world, where the benchmark is better net profit (superadditivity).

I want to emphasize that naïve transfers with a non-justified hope for the future are futile. Strategy C is no warranty for future success and positive net profit. But for competing ensembles, less subadditivity may be already an achievement. On top of that it is easy to understand that neither observing increasing cost only (pessimistic view) nor increasing benefit only (optimistic view) is a good advice to monitor progress. A combination of naïve investment (transfer in the absence of positive net profit) and fixation of the optimal transfer size seems a good and easy to understand strategy. The starting point for a transfer may be the real or assumed entanglement of source and sink.

Entanglement

I might also have used the word "bonding". Entanglement here is not to be understood in the line of the Copenhagen interpretation of entanglement in quantum physics as nonlocality. An old and rejected interpretation in

quantum physics was the idea of a hidden variable. But this is my interpretation of entanglement here. The hidden variable is the fact that source and sink share *a-priori* information (DNA). Both parties share quality. In case the quantity in the sink is increased, the quality in the source is also increased (ef0.5). But to do so the quantity in source has to be decreased, decreasing also the quality in sink (ef0.5). Despite this symmetry, superadditivity is possible due to the non-linear nature of the benefit function. The effect of the transfer is moderated by a success factor. The idea that quantity may transit into quality is a Marxist idea (10). Though Marxism is not a natural science it is an interesting idea. The additional aspect of my model is that quality can in reverse turn into quantity. Parents not investing into offspring number (quantity) but into offspring care (quality) may increase the number (quantity) of surviving offspring in comparison to other strategies within the same species. I am convinced that the quantitative aspect of an investment is a transfer of substrate into the benefit but also the cost function of sink. This will automatically result in a change of quality of the party entangled by information (DNA). A qualitative aspect of an investment would be related to an investment of substrate into a modification of the success factor of sink. The success factor may also be a function of the substrate concentration with non-linear and linear terms. This quality, a higher success probability, then will in return result in a higher quantity, *i.e.,* more surviving offspring.

True altruism, the willingness to do things that bring advantages to others, even if it results in disadvantage for yourself, does not exist. Even parents are investors, not altruists. The sink shares 50% of the genes and is a longer lasting, partially identical copy. "Altruism" is a fraudulent concept invented in successful human societies. It is applied to extract benefits or get rid of costs without the necessity to use expensive and (self-)harming force. Limited fraud can easily create additional superadditivity near the

internal limit b-c=0 (figure 2 and 3). In area II sink is cheated to take a burden, in area III source is cheated to give a value. The cost is the investment into deceiving information and, as an emergent new cost, a little bit subadditivity. The superadditivity is the upside and the subadditivity is the downside of the "noble lie" (Plato, The Republic). The balance sheet decides the success. The fraudulent concept of altruism, regrettably, has confused models in biology.

Entanglement could be interpreted as a judgment of a conjunct past. The perception of entanglement can easily be manipulated. A prolonged contact or an ideology/religion may induce the feeling or belief of entanglement without a factual entanglement. This may be induced in all parties: source, sink, and master. This is indicated by the use of salutations like comrade (soldiers sharing the same room), sister, brother, mother, and father. Comparable observations are made in animals participating in the reciprocity network of eusocial insects. The intruder often acquires the smell of the hive during an initial phase of proximity to become accepted as a member of the hive. However, this is an area of an intensive arms race (11, 12). The intruder is usually successful with already weakened targets. In a successful case the not entangled source or sink behaves as if there was entanglement. This behaviour harms the not entangled source of benefit or sink of cost. The mistake can only be corrected, when the true nature of the error is understood. However, the error is either not detected (simple life forms) or attributed to other causes to spare the good conviction.

Successful single parties have offspring to continue the germline. Successful ensembles need not to be entangled. This may be different in fully integrated ensembles. Genetic tradition is not important to recreate source and sink when consumed. Source or sink consumed by exploitation can also be replaced by a not entangled party. Entanglement only reduces the necessity for a high success factor. Investment into strangers is based

on the size of the quantitative aspect of superadditive net profit; not it´s quality. If the success factor of the not entangled sink exceeds the success factor of the entangled sink sufficiently, entanglement is no longer important (figure 15). This not antagonistic but complementing role of sf and ef helps to understand the evolution of integration and disintegration of ensembles or the shift between sexual (ef0.5) and asexual reproduction (ef1). The cost of sexual reproduction is overcompensated by far through the increased success factor of recombinant offspring (figure 16) to escape a rapidly evolving parasite (13). My simple model is able to recreate the advantage of recombination by modification of only the success factor in comparison to the clone. The success factor is able to compensate for a smaller or absent entanglement as, in reverse, entanglement can compensate a smaller success factor, but not limitless. For very similar or identical success factors in two different sinks, entanglement will always be crucial to the behaviour of the same source. However, the wrong assumption of entanglement is a new type of error (figure 13, 14).

This seems to be a result within the limits of my model. But: What is a stranger? According to the Cambridge Dictionary a stranger is: "someone not known or not familiar". "Not known" refers to information. The word "familiar" has roots in Latin and comes from *familiaris*: "domestic, private, belonging to a family, of a household". A stranger is non-kin. A stranger is not part of a family, he has no identical genetic information. Parent and offspring share identical sequences of DNA; *i.e.,* genes. As all living things share the same origin, the question "what is a stranger" adds a philosophical dimension. It is a continuum. Nevertheless, different genetic distances between individuals exist. This is especially important for full siblings. The average relation here is 50% but, for statistical reasons, it may vary between 0% to 100% in diploid organisms (not considering

mitochondria). This may be a starting point for green beard genes and discriminatory behaviour (14).

I combine a lot of orthogonal property pairs: "source and sink", "quantity and quality", "here and there", and "now and then". "Now and then" adds a time dimension. However, there is no time dimension in the transfer space originally. The transfer space is a three-dimensional space and not a four-dimensional space-time. Therefore, I have to combine source (parent) and sink (offspring) with the pair quantity (parent, here, now) and quality (offspring, there, then) in one depiction. I could have chosen to use two separate depictions; one being empty for strangers. The assumption of entanglement looks into the past - a past connection. Besides the wrong assumption of a shared past, there may also be the wrong assumption of a successful future. This time direction can be a source of errors, too. As they say: "Prediction is very difficult, especially about the future." But this is a very common and already well-known problem. The entanglement factor and the success factor introduce a time dimension into the model transfer space.

Literature

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