The Terms and Relations of Comparison, Referential, and Relative Processes

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ABSTRACT

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This paper develops the mathematical foundations of comparison, referential, and relative (CRR) processes. The key ingredients are: (1) three kinds of terms; and (2) two kinds of relations. Combining the three terms – absolute amount, relative amount, and relative rank – with the two kinds of relations – functions of one variable and functions of two variables – produces a set of six fundamental CRR processes. The paper analyzes the appropriate general functions for each of the six basic CRR processes, and explores the theoretical criteria for specific functions. The paper takes three further steps. First, it links the six basic types of CRR processes to the three fundamental sociobehavioral forces in the recently proposed new unified theory, which also links the forces to identity and to happiness. Second, following the new unified theory, the paper shows how change over time in the fundamental sociobehavioral outcomes provides new manifestations of CRR processes. Third, the paper describes how the primordial sociobehavioral outcomes, like their change over time, operate as explanatory factors that generate rich new phenomena, including new emergent subgroups and new inequalities.

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0. FOREWORD

KARL-DIETER OPP: A PASSION FOR PRECISION

    Karl-Dieter Opp has a passion for precision. This passion for precision shines through all his contributions – theoretical, empirical, methodological. And it animates every undertaking and every collaboration. To honor Karl-Dieter Opp and celebrate his contributions to social science, I take his spirit to the realms in which I am currently working and attempt to render more precise some words we use every day.

1. INTRODUCTION

        Mirror, mirror on the wall,

        Who is fairest of them all?

                The Stepmother in Snow White

    Vanity was the beginning and the end of Sir Walter Elliot's character;

    vanity of person and of situation. . . . . He considered the blessing of beauty

    as inferior only to the blessing of a baronetcy; and the Sir Walter Elliot, who

    united these gifts, was the constant object of his warmest respect and devotion.

                Jane Austen, Persuasion

    [Our self-feeling] is determined by the ratio of our actualities to our

    supposed potentialities; a fraction of which our pretensions are the

    denominator and the numerator our success; thus, Self-esteem =

    Success/Pretensions. Such a fraction may be increased as well by

    diminishing the denominator as by increasing the numerator. To give up

    pretensions is as blessed a relief as to get them gratified. . . .

                William James, Principles of Psychology

The last will be first, and the first last.

Matthew 19:30

A large class of measurement operations and substantive relations in social science focus on the individual's reflections about personal characteristics. These reflections take many forms and play many parts, as illustrated in the epigraphs. For example, the individual may locate herself in her country's wealth hierarchy, thereupon reflecting on two distinct aspects of her social standing: her relative rank in the wealth hierarchy and her relative amount of wealth. Though both relative rank and relative amount require a group or population for their definition, they differ in important ways. One measure is based on magnitudes, the other on ranks. Relative rank ranges between zero and one, while relative amount occupies the entire positive halfline. Further, some reflections do not require a group at all, as when the individual compares his current wealth to his wealth a year earlier. And some reflections appear in seemingly compound form, as when the individual starts with his relative rank on the horsemanship hierarchy and then compares it to his desired relative rank.

As these brief remarks indicate, humans, in company with social scientists, whose goal it is to understand human behavior, routinely handle and experience a wide variety of terms and relations which involve some kind of comparison, referential, or relative assessment. A brief list of terms would include, besides relative rank and relative amount, the absolute amount, together with some recurring words, such as reference group, reference individual, reference point, referent, and standard. And a brief list of relations would include status, power, and the comparison relations (also known as reference-point relations), including relative deprivation, self-esteem, and the sense of justice.

Not surprisingly, it is sometimes difficult to discern from human speech the precise nature of the reflection that animates a certain individual or ignites a certain situation. And not surprisingly, the literature includes seeming confusions of two types: first, using the same word

2

to label different terms or relations; and, second, using different words to label the same term or relation.

This paper develops a framework for systematically clarifying all the terms and relations involved in comparison, referential, and relative processes (henceforth CRR processes). Precise understanding of the exact mathematical structure of the terms and relations enables sharp analysis of important sociobehavioral phenomena, providing checklists, as it were, for discerning the underlying reality and as well providing a theoretical apparatus for deriving implications concerning what each process requires and what it forbids.

The framework begins with three sets of elements, and from these builds up a tightly integrated and coherent system. The three fundamental elements are: (1) **personal quantitative characteristics** – such as wealth, beauty, intelligence, heroism, skills; (2) **personal qualitative characteristics** – such as gender and ethnicity; and (3) the outcomes they generate, including **primordial sociobehavioral outcomes** (PSOs) – such as status, power, and justice.[1] In the archetypical relation, the outcome Y is a function of a personal quantitative characteristic X, possibly in a group defined by a qualitative characteristic.

At the outset, we make four key distinctions. First, we distinguish between **operations on single X variables** and **relations among X and Y variables**. Second, we distinguish between three kinds of X terms, the absolute amount, the relative amount, and the relative rank. Third, we distinguish between variables which represent the individual's actual amount or level of a personal quantitative characteristic – called the **actual holding** – and variables which represent a desired or expected counterpart – called the **comparison holding**; the actual holding is of the character, "what I have," and the comparison holding is of the character, "what I would like to have." Fourth, we distinguish between **functions of one variable** and **functions of two variables**; functions of one variable are always functions of the actual holding, and functions of

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[1] The distinction between qualitative and quantitative characteristics, long appreciated in mathematics (e.g., Allen 1938:10-11) and in statistics and econometrics, has since the pioneering work of Blau (1974, 1977ab) come to be seen as structuring behavioral and social phenomena in a fundamental way.

two variables are always functions of both the actual holding and the comparison holding.

As noted, the actual holdings and comparison holdings of quantitative characteristics may be represented in three ways – in their raw form, as well as by the relative amount and the relative rank. Thus, the combination of three types of terms and two types of relations (functions of one variable and functions of two variables) generates a matrix of six basic types of CRR processes.

As will be seen, some of the operations on single variables require a group or population, called a **reference group**. Moreover, a comparison holding is a **reference point**. Thus, there are two distinct kinds of referential processes, one involving terms and the other involving relations. These two distinct kinds of referential processes sometimes occur together, but they may also occur separately. For example, some processes have a reference group but no reference point, and some processes have a reference point but no reference group. Examples of the first include functions of relative rank, and examples of the second include functions of actual income and income a year ago. The framework developed in this paper simplifies and clarifies the variety of referential processes and links them to relative and comparison processes.

Also as will be seen, there are two distinct kinds of relative processes, one involving relative terms (the relative amount and the relative rank) and the other involving relative relations (as in relative deprivation). These turn out to be exactly equivalent to referential processes: relative terms are reference-group terms, and relative relations are reference-point relations.

Accordingly, each of the six types of CRR processes can be represented by a general function and labeled according to whether it is a comparison, referential, and/or relative process.

Next, we establish the connections between the framework of CRR processes and the recently proposed theory which unifies the three fundamental sociobehavioral forces – comparison, power, and status (Jasso 2007, in press). The theory provides the requisite guidance for specific functions, thus sharpening the relations in the CRR framework. A key feature of the new unified theory is that it incorporates rates of change, thus making it possible to distinguish among the three PSOs. For example, both status and power are increasing functions of wealth,

4

but they differ in their rates of change. Attentiveness to the second derivatives of the status and power functions decisively overcomes the danger of confusing status with power.

Continuing, we observe that both individuals and theories go a step further and contrast PSOs at two points in time. Though human reflections may be couched in words like "compare", these contrasts are not comparison processes, for the two terms in the contrast are not actual and comparison holdings of quantitative characteristics but rather magnitudes of PSOs.

Finally, we consider PSOs and changes in PSOs as explanatory factors triggering a wide range of further individual and social phenomena. We briefly discuss two examples, in which (1) new subgroups are generated, and (2) new social inequalities are generated.

A short note concludes the paper.

2. THE TERMS AND RELATIONS IN CRR PROCESSES

2.1. The Terms in CRR Processes

2.1.1. The Actual Holdings of Goods and Bads

Consider an individual. The individual has quantitative characteristics and qualitative characteristics. Among the quantitative characteristics, cardinal characteristics (such as wealth or land) are each represented by the individual's **absolute amount**, denoted x. The absolute amount is the first basic term of CRR processes.[2]

Meanwhile, the individual's qualitative characteristics generate a variety of groupings to which the individual belongs. For example, gender leads to two groupings, men and women; and residence and location characteristics lead to potentially all-encompassing groupings, such as all residents of Germany or all citizens of Italy. Each such grouping consists of N persons, and is called a **group** or **population**. For simplicity and convenience, in what follows we discuss the generic "population," but it should be remembered that the individual mentally manipulates many populations, even in the course of a single day, thinking of the population formed by all

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[2] As customary, the upper-case letter X is used to denote a variable and the lower-case letter x to denote the variable's realized values.

Catholics in the world at one moment and at the next of the population formed by all residents of Leipzig, and so on (Merton 1957:235, 239; Berger, Zelditch, Anderson, and Cohen 1972:135-137; Jasso 1980:7-10; Jasso 2000:335).

Continuing, in the population there are N absolute amounts of the focal quantitative-cardinal characteristic, and these form a **distribution**, which like all distributions can be characterized by its parameters, such as the mean, the minimum, and the maximum. The second basic term in CRR processes is the **relative amount**, defined as the ratio of the absolute amount to the arithmetic mean:

$$\text{relative amount} = \frac{x}{\mu}, \tag{1}$$

where μ denotes the arithmetic mean. Note that the relative amount is equivalent to, but easier to use than, the **relative share** (the absolute amount expressed as a share of the total amount $x/N\mu$).

If the N absolute amounts are arranged in ascending order, they generate the N absolute ranks, denoted i and represented by the integers from 1 to N. In this ordering, the absolute amounts are called the order statistics, and the absolute ranks are called the rank-order statistics. The absolute rank combines with N to produce the third basic term in CRR processes, the **relative rank**, denoted r:

$$\text{relative rank} = \frac{i}{N+1}. \tag{2}$$

The relative ranks have several appealing properties. First, their arithmetic mean is exactly one-half. Second, the first and Nth relative ranks are equidistant from 0 and 1, respectively, and also from the mean. Third, the elements of each subrange pair (e.g., 2 and N-1) are equidistant from 0 and 1, respectively, and also from the mean. The formula for the relative rank in (2) provides an estimate of the relative rank r in a group of any size, including large populations of size N tending to infinity.

As can be seen from the foregoing, the three basic terms – absolute amount, relative amount, and relative rank – are tightly linked to each other. Importantly, the absolute amount is a

standalone quantity, but the relative amount and the relative rank require a group or population –

usually called the reference group. Thus, the relative amount and the relative rank are not only

relative terms, they are also **referential terms**, more specifically, **reference-group terms**.[3]

We can go a step further and link the three basic terms via the parts they play in

mathematically specified distributions, especially in two of the basic associated functions of

probability distributions, the cumulative distribution function (CDF), denoted $F(x)$, and its

inverse, the quantile function (QF), denoted $Q(\alpha)$. In somewhat loose language, the CDF

provides the probability α that the variable is less than or equal to a given amount x; and the QF

provides the absolute amount corresponding to the probability, which can be interpreted as a

relative rank. Indeed, among continuous distributions with strictly increasing CDF, these two

functions are related to each other and to the two basic elements by the simple relations:

$$F[Q(\alpha)] = \alpha$$
$$Q[F(x)] = x .$$

(3)

Finally, note that if the distribution is divided through by the arithmetic mean μ, the

relations in (3) continue to hold, with the absolute amount x in the second equation replaced by

the relative amount.

To this point we have focused on quantitative characteristics of the cardinal type and

qualitative characteristics. The first basic term -- the absolute amount -- is generated from the

quantitative characteristic alone; the second and third basic terms – the relative amount and

relative rank – require as well a qualitative characteristic. But what about quantitative

characteristics of the ordinal type, such characteristics as beauty and intelligence and heroism?

For ordinal characteristics we adopt the measurement rule introduced in Jasso (1980) and

represent them by relative ranks. Accordingly, ordinal characteristics can only be represented by

relative ranks, not by absolute amounts or relative amounts, and their representation always

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[3] The foundation for studying referential processes was laid by Merton (1949, 1957) and
Merton and Kitt (1950). For an overview, see Jasso (2000).

requires a population provided by a qualitative characteristic. Thus, ordinal characteristics are represented by relative terms, which, as we saw above, are also referential terms, more specifically, reference-group terms.

In early twentieth century social science, there were discussions concerning whether the behaviorally relevant quantities are amounts or ranks (e.g., Homans 1967:66-67; see also Jasso 2007). There will be more to say when we examine the relations of CRR processes, but at this juncture it is clear that (1) humans care about both cardinal and ordinal things, and hence both amounts and ranks are behaviorally relevant, and (2) in situations involving cardinal goods and bads, discussion shifts to which of the three basic elements are behaviorally relevant.

To summarize, the individual's cardinal characteristics can be described and represented by the absolute amount, the relative amount, and the relative rank, and the individual's ordinal characteristics can be described and represented by the relative rank. Representation by the relative amount and the relative rank requires a qualitative characteristic or, equivalently, a group or population. This group or population is often called the reference group. Thus, the relative amount and the relative rank are outcomes simultaneously of relative processes and of referential processes.

All these descriptions and representations of the individual's quantitative characteristics are collectively called **actual holdings**, denoted A. Quantitative characteristics of which more is preferred to less are called **goods**, and quantitative characteristics of which less is preferred to more are called **bads**.[4]

2.1.2. The Comparison Holdings of Goods and Bads

Corresponding to every actual holding, there potentially exists an alternate, possibly imaginary, representation of the good or bad called the **comparison holding**, denoted C. The

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[4] The observer decides whether to regard a thing as a good or as a bad. For simplicity, in this paper we use as examples of goods things which are regarded by most observers as goods, and similarly for bads. But it should not be forgotten that there exist contrarian individuals, who march to the beat of a different drummer and who may regard as bads the things that most of their fellows regard as goods, and conversely. As Lucretius observed and Milton Friedman reminds us, "one man's food is another's poison."

actual holding is of the form, "what I have," and the comparison holding is of the form, "what I would like to have."

If I have three pigs, I may dream of having seven pigs; if I have a worn-out winter coat, I may dream of a Gogolian overcoat; if I hear that a noted athlete earns three million dollars a year, I may judge her grossly underpaid and proclaim ten million dollars her rightful salary; if my relative amount of income is 1.5, I may judge myself eternally blessed, thinking a relative amount of 1 is all I deserve; if I am the weakest athlete in my classroom and always picked last in the sports teams, I may wish I were at least the median athlete; if I hear that the trader in the cubicle next to mine received a bonus of half a million dollars, my bonus of fifty thousand dollars is humiliating; if my relative rank is .95, I may dream of raising it to .99; when the government releases income data, I am dismayed to be below the mean. In all these examples, note that the underlying dimension is the same for both the actual and the comparison holding – pigs or dollars or athletic skill – and that comparison holdings are of the same three forms as actual holdings: absolute amount, relative amount, and relative rank.

The hallmark of a comparison holding is that its effect on the outcome is opposite that of the actual holding. For example, in the case of goods, as the actual holding increases, the outcome increases, but as the comparison holding increases, the outcome decreases.

Two classics of social science highlight a comparison process, and as we get a fix on the comparison holding it is illuminating to recall their words. The first is from Marx who, in <u>Wage Labour and Capital</u>, a treatise based on lectures delivered in December 1847, begins with the celebrated thought-experiment on the hut and the palace ([1849]1968:84):

> A house may be large or small; as long as the surrounding houses are
> equally small it satisfies all social demands for a dwelling. But let a palace
> arise beside the little house, and it shrinks from a little house to a hut. The
> little house shows now that its owner has only very slight or no demands
> to make; and however high it may shoot up in the course of civilisation, if
> the neighboring palace grows to an equal or even greater extent, the

9

occupant of the relatively small house will feel more and more

uncomfortable, dissatisfied and cramped within its four walls.

Marx proceeds to observe that recent changes in the distribution of material goods are

precisely such as to differentially affect workers' and capitalists' holdings and that, therefore, the

social satisfaction of workers has fallen ([1849]1968:84-85):

A noticeable increase in wages presupposes a rapid growth in productive

capital. The rapid growth of productive capital brings about an equally

rapid growth of wealth, luxury, social wants, social enjoyments. Thus,

although the enjoyments of the worker have risen, the social satisfaction

that they give has fallen in comparison with the increased enjoyments of

the capitalist, which are inaccessible to the worker, in comparison with the

state of development of society in general. Our desires and pleasures

spring from society; we measure them, therefore, by society and not by the

objects which serve for their satisfaction. Because they are of a social

nature, they are of a relative nature.

In this remarkable passage, Marx isolates the operation of the actual holding and the comparison

holding in the production of satisfaction.

The second – given in the epigraph – is from William James, who in the famous tenth

chapter of Principles of Psychology, titled "The Consciousness of the Self," analyzes the

production of self-esteem ([1891]1952:200). In this passage, no less remarkable than Marx's,

James, working in a quite different tradition, arrives at a similar proposition, isolating the effects

of an individual's actual holding and comparison holding on self-esteem.

These examples suggest that it may be useful to make a taxonomy of all the possible

sources of the comparison holding. Accordingly, we identify six major classes of sources of the

comparison holding, shown in Table 1, and list here the main kinds within each of the six major

classes:

– Table 1 about here –

10

1. Directly selected. I just want seven pigs, don't ask me why, maybe I just like the number seven.

2. (A function of) own actual holding.

2.1. (A function of) own current actual holding. She should be earning twice what she earns.

2.2. (A function of) own previous actual holding. He should be earning twice his starting salary ten years ago.

3. (A function of) other's actual holding.

3.1. (A function of) another's actual holding.

3.1.1. (A function of) another's current actual holding. She should be earning twice her teammate.

3.1.1.1. (A function of) the current actual holding of the person who ranks immediately above.

3.1.1.2. (A function of) the current actual holding of the person who ranks immediately below.

3.1.2. (A function of) another's previous actual holding. He should be earning half of what Willie Mays earned.

3.1.2.1. (A function of) the current actual holding of the person who ranks immediately above.

3.1.2.2. (A function of) the current actual holding of the person who ranks immediately below.

3.2. (A function of) everyone's actual holdings.

3.2.1. (A function of) everyone's current actual holding

3.2.2. (A function of) everyone's previous actual holding.

4. (A function of) a parameter of a distribution in a group

4.1. (A function of) a location parameter of a distribution in a group

4.1.1. {A function of) the mean

4.1.2. (A function of) the minimum

4.1.3. (A function of) the maximum

4.1.4. (A function of) the median

4.2. (A function of) a relative rank

5. (A function of) a parameter of a subdistribution in a subgroup

5.1. (A function of) a location parameter of a subdistribution in a subgroup

5.1.1. {A function of) the mean

5.1.2. (A function of) the minimum

5.1.3. (A function of) the maximum

5.1.4. (A function of) the median

5.2. (A function of) a relative rank

5.3. In which subgroup

5.3.1. Based on qualitative characteristic (race, gender, etc.)

5.3.2. Based on quantitative characteristic corresponding to actual holding

5.3.2.1. Based on everyone above self

5.3.2.2. Based on everyone below self

5.3.2.3. Based on everyone with holdings equal to own holding plus or minus a set amount

5.3.2.4. Based on everyone with relative ranks equal to own relative rank plus or minus a set number of percentage points.

6. A function of personal characteristics. The best example is the just reward function, which expresses the observer's idea of the just reward for a rewardee as a function of the rewardee's characteristics. The just reward function was introduced by Jasso (1983a) as a mathematization of the referential structure postulated by Berger, Zelditch, Anderson, and Cohen (1972) and is thus sometimes called the BZAC function.

Note that the individual has many choices to make, besides, obviously, the good or bad to reflect about. If the comparison holding is a function of another's holdings, then a key question

12

is which others are selected. If the comparison holding arises from a distribution, then a key

question is which group is selected. And so on.

There is an interesting connection between the relative amount introduced in the previous

section (2.1.1) and the comparison holding based on a parameter of a distribution. When the

comparison holding is the arithmetic mean in a population, the ratio of the actual holding to the

comparison holding is identical to the relative amount, and there is a danger of confusion. The

key, as will be seen below, to avoiding confusion is to examine the function representing

determination of the outcome of interest – such as status or self-esteem – to see whether the

outcome is a function of one or of two variables (or, equivalently, to see whether the comparison

holding is constant or variable).

Finally, note that some comparison holdings require a reference group while others do

not. For example, comparison holdings arising from a parameter of a distribution in a group

obviously require a reference group; in contrast, comparison holdings arising as functions of own

current or previous actual holding do not require a reference group.

2.2. The Relations in CRR Processes

The outcomes of interest, including the primordial sociobehavioral outcomes, are

functions of actual holdings of personal quantitative characteristics. In the case of goods, such as

wealth, beauty, or skill, the outcomes are increasing functions of the actual holding; in the case of

bads, such as taxes, fines, or liabilities, the outcomes are decreasing functions of the actual

holding. But the precise representation of the personal quantitative characteristics may differ,

and so, too, the precise functional form.

The outcome may be a function of a single variable, or it may be a function of two

variables.

If the outcome is a function of a single variable, it is a function of the actual holding only.

If the outcome is a function of two variables, the two variables are the actual holding and

the comparison holding, and the process is a comparison process. The arguments in a

comparison process may be either of the three types of representations, but they must be the same

13

representation for both the actual holding *A* and the comparison holding *C*. For example, both *A* and *C* may be actual amounts, or both may be relative amounts, or both may be relative ranks.

As already discussed, because the comparison holding is a reference point, a comparison process is also a referential process, more specifically, a **reference-point relation**. Moreover, because the comparison holding is the standard in a relative relation such as relative deprivation, a comparison process is also a relative process (as discussed in the passage by Marx), more specifically, a **relative-relation**. And as will be seen below, comparison processes comprise one of the three fundamental sociobehavioral forces.

The hallmark of a comparison process is that the actual and comparison holdings have opposite effects on the outcome. In a comparison process involving a good, as the actual holding increases, the outcome increases, and as the comparison holding increases, the outcome decreases. In a comparison process involving a bad, as the actual holding increases, the outcome decreases, and as the comparison holding increases, the outcome increases.

2.3. <u>Combining the Terms and Relations in CRR Processes</u>

As we have seen, the argument(s) of the CRR function may be either an absolute amount, a relative amount, or a relative rank, and the outcome may be a function of one variable or of two variables. Table 2 presents the six types of relations obtained by combining the three types of terms and the two types of relations. The notation in Table 2 follows the notation introduced in section 2.1.

– Table 2 about here –

As noted in the preceding section, all the relations in the righthand column – that is, all the functions of two variables – are both comparison processes, referential processes of the reference-point kind, and relative processes of the relative-relation kind. Now we note that all the terms in the second and third rows are relative terms, and, because, as previously discussed, they are formed by reference-group operations, all the relations in the second and third rows are also both relative processes of the relative-term kind and referential processes of the reference-group kind.

14

Note that the comparison holding in the upper-righthand cell may, but need not, require a reference group, as discussed in Section 2.1.2. For example, the comparison holding may be the median income, in which case a reference group is required, or it may be income ten years ago, in which case a reference group is not required.

Note also that the equations in Table 2 are general functions, as the CRR framework does not by itself provide guidance for specific functions. Such guidance will have to come from theory.

To further clarify the terms and relations of CRR processes, we present in Table 3 the same matrix as in Table 2, indicating in each cell whether the process involves either a reference-group term or a reference-point relation. Several conclusions follow immediately:

– Table 3 about here –

1. Three of the six possible relations – the three functions of two variables in the righthand column -- are reference-point relations, and they are the only reference-point relations in the matrix. These three are thus simultaneously comparison processes, referential processes, and relative processes.

2. Four of the six possible relations – those in the second and third rows – always contain reference-group terms; a fifth, in the upper-righthand cell, sometimes does so as well. These four, or sometimes five, are thus simultaneously referential processes and relative processes.

3. One of the six possible relations – that in the upper-lefthand cell – has neither a reference group nor a reference point. It is thus the null case, neither a comparison process nor a referential process nor a relative process.

4. Two of the six possible relations – those in the cells in the second and third rows of the righthand column – and sometimes a third, that in the upper-righthand cell, embed both a reference group and a reference point. These two, and sometimes three, relations are thus doubly-referential processes and, equivalently, doubly-relative processes.

Table 4 summarizes the foregoing by repeating the matrix shown in Tables 1 and 2, replacing the cell contents by the label for type of CRR process represented in the cell.

15

3. CRR PROCESSES AND

THE NEW UNIFIED THEORY OF SOCIOBEHAVIORAL FORCES

Building on the great advances of twentieth century sociology, Jasso (in press) recently proposed a new unified theory of sociobehavioral forces (see also Jasso 2007). The unified theory begins with the idea that the basic sociobehavioral forces involve a primordial sociobehavioral outcome generated by a quantitative characteristic. In the case of goods, the PSOs are increasing functions of the quantitative characteristic; in the case of bads, the PSOs are decreasing functions of the quantitative characteristic. For simplicity restricting attention to goods, if all PSOs are increasing functions of quantitative characteristics, then, given that there are only three possible rates of change – increasing, decreasing, and constant – there must be three (classes of) PSOs. Fortuitously, the literature suggests three main candidates for sociobehavioral forces – justice (and its sibling comparison processes), status, and power – and further suggests that the comparison outcomes increase at a decreasing rate and status increases at an increasing rate. Thus, if power is a sociobehavioral force and distinct from comparison and status, it must increase at a constant rate.

Jasso (in press) further argues that each operation of a sociobehavioral force also generates, besides a magnitude of the PSO which gives the force its name, an identity and a magnitude of happiness. To illustrate, at a particular moment a person may derive status from his or her rank on wealth within a particular group, and at that moment the combination of quantitative characteristic, qualitative characteristic, and PSO constitutes the personal identity. Each identity is labeled to indicate the trio of elements, for example, "horsemanship/sex/status" or "wealth/country/self-esteem." Consistent with all versions of identity theory, the individual may be viewed as a collection of identities. And the collection of identities can in turn be mapped onto the individual's happiness profile. Of course, happiness can also be generated outside the sociobehavioral world, for example, by a sunset or the nuts or figs on a tree.

A payoff of this approach is that it clarifies previous discrepancies in specifications of happiness: all the specifications (as a comparison process or not; as concave, convex, or linear) are correct, each corresponding to one of the component PSOs, each with its own periods of salience and latency.

In this section, we examine the three sociobehavioral forces in the unified theory, looking closely at the terms and relations embedded in them, so that they may be linked to the CRR framework presented in the previous section.

3.1. The Status Force

The mathematical foundation for the status function was laid by Goode (1978) and Sørensen (1979). Goode (1978) argued that status increases at an increasing rate with the actual holding (implicitly of a good), and Sørensen (1979) proposed a mathematical form for the status of occupations in which the actual holding is represented by the relative rank. Noting that the function proposed by Sørensen (1979) satisfies Goode's (1978) convexity condition, Jasso (2001c) applied it to the status of individuals:

$$S = \ln\left(\frac{1}{1-r}\right), \quad 0 < r < 1, \tag{4}$$

where S denotes status and, as before, r denotes the individual's relative rank on a quantitative characteristic.[5]

Thus, the current understanding of status is that (1) status is a function of one variable, the actual holding, (2) the actual holding is represented by the relative rank, and (3) status increases at an increasing rate with the relative rank.

Accordingly, the status force is a relative process, and, in virtue of the requirement for a

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[5] The mathematical foundation for studying status when it is generated by two or more quantitative characteristics had been laid earlier by Berger, Cohen, and Zelditch (1966:44), who noted that negatively associated characteristics would reduce status inequality (a relation subsequently established for small groups by Humphreys and Berger (1981)), and by Berger, Fisek, Norman, and Zelditch (1977:126-127), who proposed the principle of organized subsets for dealing with multiple negatively associated characteristics. For analysis of the multiple-good case and derivation of the new probability distributions to which it leads, see Jasso (2001c) and Jasso and Kotz (in press).

reference group, it is also a referential process.

3.2. <u>The Comparison Force</u>

As discussed above, comparison processes pertain to a function of two variables, an actual holding A and a comparison holding C, with A and C having opposite effects on the outcome, denoted Z. The classical tradition discussing comparison processes and the major special cases – such as self-esteem and the sense of justice – suggests that a comparison function should satisfy two desiderata: It should be scale-invariant, so that the outcome is the same whether the holdings are measured in, say, dollars or yen; and it should be additive, in the sense that the effect of A on Z is independent of the magnitude of C, and the effect of C on Z is independent of the magnitude of A. Jasso (1990) showed that the only function which satisfies both scale-invariance and additivity is the function:

$$Z = \theta \ln\left(\frac{A}{C}\right), \tag{5}$$

where θ is the signature constant whose sign is positive for goods and negative for bads and whose absolute value measures the observer's expressiveness.

The log-ratio comparison function has several appealing properties. First, it provides an exact mapping from combinations of A and C to the comparison outcome Z, with zero representing a neutral point, positive numbers representing positive self-esteem or overreward in the justice case, and negative numbers representing negative self-esteem or underreward in the justice case. Second, it embodies the property that deficiency is felt more keenly than comparable excess, the vaunted deficiency aversion and loss aversion. Third, as noted, the function is the only function which satisfies two other desirable conditions, additivity (the effect of A on Z is independent of the magnitude of C, and the effect of C on Z is independent of the magnitude of A) and scale invariance (expressing A and C in different units – say, yen instead of dollars – does not alter Z). Fourth, the function is symmetric; that is, if the actual holding A and the comparison holding C trade places, the outcome is the negative of Z. Fifth, the function integrates rival conceptions of comparison processes as a difference and as a ratio. Sixth, the

18

log-ratio form is the limiting form of the difference between two power functions, integrating log and power approaches and further strengthening integration of difference and ratio approaches. Recently, as noted above, another (almost magical) property has come to light, linking the comparison function and the Golden Number, $(\sqrt{5}-1)/2$.[6]

As noted above, the actual holding and the comparison holding may be either actual amounts, relative amounts, or relative ranks; of course, the actual holding and the comparison holding must be of the same form, for example, both relative amounts or both actual amounts.

Thus, the current understanding of comparison is that (1) the comparison outcome is a function of two variables, the actual holding and the comparison holding, (2) the actual and comparison holdings may be represented by the absolute amount, the relative amount, or the relative rank, and (3) the comparison outcome increases at an decreasing rate with the actual holding.

Accordingly, the comparison force is always a comparison process; in virtue of the reference-point nature of the comparison holding, it is also a referential process, and because it is a relative relation, it is also a relative process. Moreover, when the arguments are relative terms, the comparison force is doubly relative and doubly referential.

3.3. The Power Force

Power, the third PSO, is an increasing function of personal quantitative characteristics. The research record to date is sparse with respect to its arguments and the form of the function (Webster 2006). Jasso (2006a, in press) argues that if power is truly distinct from status and from comparison processes, then power must increase at a constant rate with the actual holding. Provisionally, Jasso (in press) suggests that both cardinal and ordinal characteristics play a part in the power force, and represents them, respectively, by the relative amount and the relative rank.

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[6] The mathematical foundation for multiple-good comparison processes was laid by Jasso (1980:6, 10-11, 14, 30), who proposed multi-good justice evaluations and reported multi-good justice evaluation distributions for the case of independent goods, and by Jasso (1983b:264), who added the case of negatively associated goods. Further detail on properties of the comparison function is found in Jasso (1978, 1990, 2006b, 2007). The theory of the comparison force is summarized in Jasso (2001a, 2006b).

If it turns out that the argument in the power function can be represented exclusively by relative amounts and relative ranks, then the power force is also always both a relative process and a referential process. However, if the argument in the power function can be an absolute amount, then in this case the power force is neither a comparison nor a referential nor a relative process.

Here we remain agnostic, permitting power to be a function of an absolute amount of cardinal quantitative characteristics.

3.4. <u>Summary</u>

Table 5 presents the specific functions corresponding to the three sociobehavioral forces in the new unified theory, separately by cardinal and ordinal quantitative characteristics and expressed in two versions, for small groups and large populations. The combination of distinctive sociobehavioral force and attentiveness to cardinal versus ordinal characteristics yields a set of five possible societies, evoking Plato's (<u>Republic</u>, Book VIII) idea that there are five basic types of societies.

– Table 5 about here –

Note that when the arguments of the small-group formula for the comparison function in the case of a cardinal good are relative amounts, the mean, being the same for both A and C, disappears.

Note also that theory provides the guidance for the specific functions in Table 5, sharpening the general functions in Table 2.

Table 6 returns to the matrix formed by the three types of terms and the two types of functions, and locates each of the three sociobehavioral forces in the corresponding cells of the matrix. As shown, the comparison force occupies three cells and is their sole occupant; the power force occupies two cells, one of which is shared with the status force, and may occupy a third; the status force occupies only one cell, and shares it with the power force.

– Table 6 about here –

Finally, Table 7 directly connects the three sociobehavioral forces and the three CRR

20

processes, separately for cardinal and ordinal quantitative characteristics and distinguishing between the reference-group and reference-point members of the referential family and, similarly, between the relative-term and relative-relation members of the relative family.

– Table 7 about here –

4. CHANGE IN PSO OVER TIME

With each turn of the sociobehavioral wheel, a trio of quantitative characteristic, qualitative characteristic, and sociobehavioral force is activated and a PSO generated, together with an identity and a magnitude of happiness. All this happens at a moment in time. Thus, for given configuration of quantitative characteristic, qualitative characteristic, and sociobehavioral force, the individual's magnitude of the PSO may change over time. For example, the individual's actual holding may change – that is, the absolute amount, relative amount, and/or relative rank may change. Similarly, the group may change, as may the group size, etc.

The new unified theory, as its component theories, yields many testable predictions for behavioral and social phenomena, expressing the long reach of the processes it subsumes. One special technique for deriving implications focuses on the change in PSO. Called the micromodel, it investigates the change in PSO from Time 1 to Time 2 for given changes in the inputs of the PSO function. The general form, with Y denoting any of the three PSOs and subscripts denoting the time period, is given by:

$$CY = Y_2 - Y_1,\qquad(6)$$

where CY denotes change in Y. If CY is zero, then whatever transpired between the two time periods has had no effect on the individual; if, however, CY is negative, then the individual has become worse-off, and, if positive, better-off (Jasso 2004, 2006b, in press).

It may be convenient to ascribe to the formulas for the change in PSO the CRR properties of the component PSOs. Accordingly, the formula for the change in status is, like its status PSO components, both a relative process and a referential process, based on the relative terms and the requisite reference group; and the formula for the change in the comparison outcome is, like its

21

comparison PSO components, a referential process and also a relative process, based on the reference-point and relative-relation it embeds. Note that the CRR labels do not refer to the relation in the change function but rather to the terms and relations in the component PSOs.

For computational purposes, it is useful to obtain equivalent expressions for the change in PSO formulas. In the case of status, the CS formula can be easily expressed in terms of the individual's absolute rank and group size (Jasso 2004). In the case of comparison, derivation of the CZ formula is facilitated by using an additional postulate of comparison theory, a postulate known as the identity representation of the comparison holding, in which the comparison holding is replaced by an identically equal expression, which in the case of cardinal goods includes the group size, the group's total amount of the good, and an individual-specific parameter representing the idiosyncratic component of the comparison holding (Jasso 2006b).

Table 8 presents the computational formulas for the change in PSO, for the three sociobehavioral forces, and separately by cardinal or ordinal good. The formulas have proved useful in generating a wide range of predictions. For example, the formulas for the change in the comparison function have been used to generate predictions for theft (Jasso 1988, 2001b), gifts (Jasso 1993b), disasters (Jasso 1993a), and workplace hiring (Jasso 2006b); and the formula for the change in the status function has been used to generate predictions for workplace hiring (Jasso 2004), in this case enabling contrast between regimes dominated by comparison and regimes dominated by status.

– Table 8 about here –

Predictions obtained in this way include: (1) Parents of non-twin children will spend more of their toy budget at an annual giftgiving occasion than at the children's birthdays; (2) The gain from theft is greater when stealing from a fellow group member than when stealing from an outsider; (3) The insider-theft premium is greater in poor groups than in rich groups; (4) The propensity to posttraumatic stress syndrome is greater among veterans of wars fought away from home than among veterans of wars fought on home soil; and (5) If the parent who dies first leaves no bequest to the children, then in periods when wives tend to predecease husbands (e.g.,

22

because of death in childbirth), mothers will be mourned more than fathers; however, in periods when husbands tend to predecease wives (e.g., because of war), fathers will be mourned more than mothers.[7]

5. PSOs AND CHANGE IN PSOs AS EXPLANATORY FACTORS

In the preceding section, we saw that the change in PSO generates rich implications for behavior. More broadly, the PSO also generates an abundance of implications. Thus, both PSO and change in PSO operate as fundamental explanatory factors, useful in both theoretical and empirical analysis.

Two examples will suffice: First, operation of the three sociobehavioral forces – comparison, status, and power – triggers formation of new subgroups. The new subgroups include not only rather straightforward new subgroups – such as, in the case of the justice PSO, new subgroups consisting of those who judge themselves justly rewarded, those who judge themselves unjustly underrewarded, and those who judge themselves unjustly overrewarded – but also rich new kinds of subgroups – such as subsets loyal to self (called Selfistas), subsets loyal to pre-existing subgroups based on, say, race or gender (called Subgroupistas), and subsets loyal to the entire group (called Groupistas). The proportions in each of these new types of subgroups have been shown to differ systematically depending on the sociobehavioral force, the distributional form of the valued personal quantitative characteristics, and the proportions in the pre-existing subgroups. For example, when status is the dominant sociobehavioral force, Subgroupistas command a majority in the society, a majority whose exact size varies with the proportions in the pre-existing subgroups. However, when justice is the dominant sociobehavioral force, Subgroupistas can be in the majority or in the minority, depending on (1) whether the valued good is cardinal or ordinal, (2) the distributional form of valued cardinal

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[7] The micromodel is one of four techniques for theoretical derivation used in the new unified theory. The others are the macromodel, the mesomodel, and the matrixmodel. They were initially developed for deriving implications in comparison theory, and subsequently found to be equally applicable and useful in status theory (e.g., Jasso 2001c, in press).

goods, and (3) the proportions in the pre-existing subgroups. For further results, see Jasso (2001c, in press).

Second, each sociobehavioral force generates a new measure of inequality – inequality in the PSO. For example, when income generates status, there are two distinct kinds of social inequality in play, income inequality and status inequality. New questions arise, such as the conditions under which PSO inequality is less than or greater than inequality in the quantitative characteristic generating the PSO. These questions are explored by Jasso and Kotz (in press).

6. TOWARD GREATER PRECISION:
WHAT HAVE WE LEARNED?

To achieve greater clarity and simplicity, we developed a framework that first and foremost distinguishes between (1) terms and (2) relations among terms. We made a further distinction between (1) relations which can be represented as functions of one variable and (2) relations which can be represented as functions of two variables. The two variables in functions of two variables are an actual holding and a comparison holding, such as the actual earnings and the just earnings. From this simple beginning, it was possible to establish the following:

1. <u>Comparison Processes</u>. Comparison processes are relations which are represented by functions of two variables, the actual holding and the comparison holding. The hallmark of a comparison process is that the actual holding and the comparison holding have opposite effects on the outcome.

2. <u>Referential Processes</u>. Referential processes are processes which include either reference-group terms or reference-point relations. Reference-group terms require a reference group. Reference-point relations include a reference point which operates as comparison holding and thus are functions of two variables.

3. <u>Relative Processes</u>. Relative processes are processes which include either relative terms or relative relations. Relative terms are of two main kinds, the relative amount and the relative rank. Relative relations are functions of two variables, the actual holding and the

comparison holding; the quintessential relative relation is relative deprivation.

4. <u>Fundamental Equivalences</u>.

4.1. <u>Equivalence of Reference-Group Terms and Relative Terms</u>. All relative terms (the relative amount and the relative rank) require a reference group and are thus reference-group terms.

4.2. <u>Equivalence of Reference-Point Relations, Relative Relations, and Comparison Processes</u>. Reference-point relations, relative relations, and comparison processes are functions of two variables, the actual holding and the comparison holding, and possess the signature feature -- opposite effects of the actual holding and the comparison holding on the outcome.

5. <u>Doubly Referential Processes</u>. Processes with both reference-group terms and reference-point relations are doubly referential processes.

6. <u>Doubly Relative Processes</u>. Processes with both relative terms and relative relations are doubly relative processes.

7. <u>Equivalence of Doubly Referential Processes and Doubly Relative Processes</u>. It follows from the fundamental equivalences in 4.1 and 4.2 that doubly referential processes and doubly relative processes are equivalent.

8. <u>Some Comparison Processes Are Doubly Referential or, Equivalently, Doubly Relative</u>. When the terms in a comparison process are relative terms (or, equivalently, reference-group terms), the comparison process is doubly referential or, equivalently, doubly relative.

Both the referential terminology and the relative terminology have rich histories, and it is likely that both will remain in regular use. The keys to avoiding confusion are not so much about distinguishing between referential things and relative things but rather about distinguishing between terms and relations, and within relations, between functions of one variable and functions of two variables. Accordingly, it may be useful in future to avoid the terms, "referential term" and "referential relation," replacing the first by "reference-group term" and the second by "reference-point relation." Comparison processes always refer to relations and are always functions of two variables, so that there is no danger of confusion.

The paper took three further steps. First, we introduced into the discussion the three fundamental sociobehavioral forces, noting especially that the associated unified theory provides further direction on specification of the functions in comparison, referential, and relative processes. In particular, the unified theory proposes that the three forces have distinctive rates of change. For example, in the case of goods, the three primordial sociobehavioral outcomes which give each force its name increase with the actual holding, but they have distinctive rates of change – comparison outcomes increase at a decreasing rate, status increases at an increasing rate, and power increases at a constant rate. The unified theory also links the sociobehavioral forces to identity and to happiness.

Second, following theoretical development in comparison theory and status theory, the unified theory highlights the change over time in the primordial sociobehavioral outcomes, and this change over time – especially change between two points in time – provides a new manifestation of comparison, referential, and relative processes.

Third, building further, we saw that the primordial sociobehavioral outcomes of the three fundamental sociobehavioral forces, like their change over time, operate as explanatory factors that generate rich new testable implications. We looked briefly at the emergence of new subgroups and the emergence of new social inequalities.

Analysis of the mathematical foundations of comparison, referential, and relative processes provides new simplicity and clarity to these processes and the terms and relations embedded in them, thus sharpening the tools for theoretical and empirical work. Moreover, the exact correspondence we established between CRR processes and the three fundamental sociobehavioral forces in the recently proposed new unified theory further opens the door to richer and more rigorous theoretical and empirical analysis of individual and social phenomena. It is not difficult to imagine bold new questions and rich new answers.

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28

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Table 1. Major Classes of Sources of the Comparison Holding

1. Directly selected

2. (A function of) own actual holding

3. (A function of) other's actual holding

4. (A function of) a parameter of a distribution in a group

5. (A function of) a parameter of a subdistribution in a subgroup

6. A function of personal characteristics

Notes: See text for the many specific sources of the comparison holding within each major class.

Table 2. Three Types of Terms and Two Types of Functions

	Function of Actual Holding	**Function of Actual and Comparison Holdings**
Absolute Amount	$Y = Y(x_A)$	$Y = Y(x_A, x_C)$
Relative Amount	$Y = Y\left[\left(\dfrac{x}{\mu}\right)_A\right]$	$Y = Y\left[\left(\dfrac{x}{\mu}\right)_A, \left(\dfrac{x}{\mu}\right)_C\right]$
Relative Rank	$Y = Y(r_A)$	$Y = Y(r_A, r_C)$

Notes: In these formulas, x denotes the absolute amount of a cardinal characteristic, μ denotes the arithmetic mean, and r denotes the relative rank. The actual holding is denoted by A and the comparison holding by C.

Table 3. Reference-Group Terms and Reference-Point Relations in the Matrix of Three Types of Terms and Two Types of Functions

	Function of Actual Holding	Function of Actual and Comparison Holdings
Absolute Amount	neither reference group nor reference point	reference point always; reference-group sometimes
Relative Amount	reference group only	both reference group and reference point
Relative Rank	reference group only	both reference group and reference point

Notes: General functions for the six types of relations are shown in Table 2.

Table 4. Comparison, Referential, and Relative Processes in the Matrix of Three Types of Terms and Two Types of Functions

	Function of Actual Holding	**Function of Actual and Comparison Holdings**
Absolute Amount	---	Comparison Reference-Point Relation Relative Relation Possibly Doubly Referential Possibly Doubly Relative
Relative Amount	Reference-Group Term Relative Term	Comparison Doubly Referential Doubly Relative
Relative Rank	Reference-Group Term Relative Term	Comparison Doubly Referential Doubly Relative

Notes: General functions for the six types of relations are shown in Table 2.

Table 5. Specific Formulas for Sociobehavioral Forces in the New Unified Theory, by Cardinal or Ordinal Good, and Small Group or Large Population

Sociobehavioral Forces					
Comparison		Status		Power	
Cardinal Good	Ordinal Good			Cardinal Good	Ordinal Good
A. Small Groups					
$Z = \theta \ln\left(\dfrac{x_A}{x_C}\right)$	$Z = \theta \ln\left(\dfrac{i_A}{i_C}\right)$	$S = \ln\left(\dfrac{N+1}{N+1-i_A}\right)$		$P = \left(\dfrac{x}{\mu}\right)_A$	$P = \dfrac{i_A}{N+1}$
B. Large Populations					
$Z = \theta \ln\left(\dfrac{x_A}{x_C}\right)$	$Z = \theta \ln\left(\dfrac{\alpha_A}{\alpha_C}\right)$	$S = \ln\left(\dfrac{1}{1-\alpha_A}\right)$		$P = \left(\dfrac{x}{\mu}\right)_A$	$P = \alpha_A$

Notes: All formulas are for the case of a good; formulas for bads are straightforwardly derived. Formulas for status and for the ordinal cases of the comparison and power forces are expressed in terms of the raw rank i and the population size N; definitional formulas expressed in terms of the relative rank are given in the text. The subscripts A and C denote the actual and comparison holdings, respectively. While the comparison function is a function of two inputs (the actual and comparison holdings), the status and power functions are functions of a single input (the actual holding). Status theory does not distinguish between cardinal and ordinal characteristics. The comparison outcome Z increases at a decreasing rate with the actual holding (x in the cardinal case, the relative rank α in the ordinal case); status S increases at an increasing rate with the relative rank α; power P increases at a constant rate with the actual holding (the relative amount in the cardinal case, the relative rank α in the ordinal case). Note also that, in the case of cardinal goods, power P may also turn out to be a function of the absolute amount x.

Table 6. Basic Sociobehavioral Forces in the Matrix of Three Types of Terms and Two Types of Functions

	Function of Actual Holding	Function of Actual and Comparison Holdings
Absolute Amount	Power	Comparison
Relative Amount	Power	Comparison
Relative Rank	Power Status	Comparison

Table 7. Correspondence Between CRR Processes and Sociobehavioral Forces, by Cardinal or Ordinal Holding

CRR Processes	Sociobehavioral Forces				
	Comparison		Status	Power	
	Cardinal Holding	Ordinal Holding		Cardinal Holding	Ordinal Holding
Comparison	✔	✔	✘	✘	✘
Referential					
Reference-Group	Possibly	✔	✔	Possibly	✔
Reference-Point	✔	✔	✘	✘	✘
Relative					
Relative-Term	Possibly	✔	✔	Possibly	✔
Relative-Relation	✔	✔	✘	✘	✘

Table 8. Change in PSO, by Sociobehavioral Force and Cardinal or Ordinal Good

Sociobehavioral Forces					
Comparison		Status		Power	
Cardinal Good	Ordinal Good			Cardinal Good	Ordinal Good
$ln\left(\dfrac{x_2 N_2 T_1 \varphi_1}{x_1 N_1 T_2 \varphi_2}\right)$	$\ln\dfrac{i_2(N_1+1)\varphi_1}{i_1(N_2+1)\varphi_2}$	$\ln\left[\dfrac{(N_2+1)(N_1+1-i_1)}{(N_1+1)(N_2+1-i_2)}\right]$		$\dfrac{x_2 N_2}{T_2}-\dfrac{x_1 N_1}{T_1}$	$\dfrac{i_2}{N_2+1}-\dfrac{i_1}{N_1+1}$

Notes: The change in PSO is obtained by subtracting the PSO formula for Time 1 from the PSO formula for Time 2 (Table 4). In these expressions x denotes the individual's own amount of the cardinal-good (say, income or wealth), T denotes the total amount of the cardinal good in the collectivity, N denotes the population size, φ denotes the individual-specific parameter capturing idiosyncratic elements in the individual's idea of the comparison holding for him/herself, and i denotes the individual's rank in the ordinal good.. [A note to avoid confusion: In published expositions and analyses of comparison theory, the total amount of the cardinal good has always been denoted by S; in the new world of the unified theory, S denotes status, and thus the total amount of the cardinal good is now denoted by T.]