ON THE PSYCHOLOGICAL BASIS OF ECONOMICS AND SOCIAL PSYCHOLOGY

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> The very idea of a borderland of causal connections between the great branches of learning is typically dismissed by social theorists and philosophers as reductionistic. This diagnosis is of course quite correct. But consider this: Reduction and the consilience it implies are the key to the success of the natural sciences. Why should the same not be true of other kinds of knowledge? Because mind and culture are material processes, there is every reason to suppose, and none compelling enough to deny, that the social sciences and humanities will be strengthened by assimilation of the borderland disciplines. (Wilson 1998).

SUMMARY

The emotive equation in conjunction with the expectational constraints, comprising a mathematical formulation of the individual's expectational plan, is applied to elementary cases in economics and social psychology thereby uniting psychology, social psychology, and economics within one analytic methodology. This canonical formulation represents the individual's conscious experience with the advance of real time in the absence of surprise, accounting for emotive discounting of expected instantaneous utility and expected uncertainty. In a departure from neoclassical (economic) theory, expected intertemporal utility is mapped onto a real-time datum as anticipatory pleasure. Following surprise (e.g., by a creative thought), of the several candidate expectational plans that the individual may consider, that which provides the greatest pleasure of anticipation is chosen. This (operative) plan guides behavior until negated by surprise. The theory is applied to an elementary example of capital function, and to two cases of economically interacting individuals, the latter case accounting for an imposed stereotypic bias on the expected productivity of one of the agents. The effect of this bias on the welfare of the cooperating agents, and on the capital versus finished good exchange price, is addressed. Inasmuch as the emotive equation acquires empirical substantiation from neuropsychological investigations, it may be concluded that a unifying connection between the human and natural sciences has been realized.

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I. INTRODUCTION

It could be expected that a synthesis of related sciences would be impeded, if not precluded altogether, by a false foundation. This would appear to be the case in the social sciences. A fateful error occurred in the development of economic theory during the so-called "marginal revolution" of the late Nineteenth Century. Principally Walras, in the formulation of his celebrated general equilibrium theory (1874-77), but also Jevons (1871) and Menger ((1871) 1950), variously identified utility (satisfaction) directly with the commodities that serve needs rather than do so imputatively, having first identified *instantaneous* utility—pleasure—exclusively with the process-of-knowing (P-O-N) attending mental and physical activity.[1] A result of this error was to strengthen an already prominent "separate and inexact" character of the discipline (Hausman 1992).

Had Walras been familiar with Gossen's utility theory published about twenty years earlier (1854) he may have avoided the mistake. In his single publication after two decades of solitary study, Gossen postulated the exclusive direct identification of utility with (mental and physical) activity, and offered utility laws or rules: e.g., decrease of instantaneous utility (pleasure) with time; recurrence of wants (refreshment of instantaneous utility after a lapse of time); and maximization of total intertemporal utility (total time-integrated pleasure) as the behavioral rule. For a period of years following the discovery of his book, leading economists, including Walras and Jevons (see Walras 1885), praised Gossen's work (Jaffe 1973). But the advantage of Walras's already published equilibrium theory, in conjunction with its elementary (algebraic) mathematics, weighed against Gossen's utility theory succeeding as an approach to (economic) behavior. Economists adopted Walras's ill-founded equilibrium theory as the core of the emergent neoclassical school, and the latter has dominated economic theory up to the present day.[2]

In contrast with the "physics-like" tenor of the Walrasian-based neoclassical theory, the *Austrian tradition* has developed the subjective understanding of behavior: The Austrian tradition…

> is that which particularly emphasizes: the purposefulness of individual action; the role of knowledge in economic choice; the subjectivity of the phenomena that interest economists; the

> competitive-entrepreneurial character of the market process; and the *ex ante* role in which time affects economic activity. (Kirzner 1981, p. 115)

This understanding, which accords with the present formulation of expectational plans, is the product of "..the evolution of subjectivism from Menger through Mises to Shackle as an evolution from a subjectivism of given wants through one of given ends to that of the active mind (Lachmann 1981, p. 39)".

While the Austrian School was correct in its subjective approach, it did not recognize the neoclassical theory as fundamentally incorrect: "[The Austrian] perspective sees the edifice of modern neoclassical economics as built upon essentially sound foundations (Kirzner 1981, p. 111)". Later in the same article, reference is made to "..the essentially healthy elements in modern neoclassical economics" and "..the basically sound ideas fundamental to it (p. 112)". It is noteworthy in this regard that the Austrian methodology has not (until now) received a substantive mathematical formulation, an apparent consequence of its intent to effect a "..reconstruction of the [neoclassical] edifice" on what is now recognized as an unsound utility theory. And so it may be concluded that the early marginalist's misstep affected the evolution of economic theory beyond the neoclassical paradigm.

Just as the early marginalist's mistake in directly identifying utility with commodities impeded the convergence of the several schools of thought in economics, so it may be concluded that the same effect has obtained regarding the unification of the human sciences. In this regard, preferences in standard economic theory are, as has been observed (note 2), exogenously determined—in accordance with the direct assignment of utility to consumables. That is, preferences have been taken as given (rather than determined by the operative plan, as is held in the present contribution).[3] In sociology the reverse tends to be true:

> Many sociologists view preferences as *results* of enduring exchanges and social contracts, not as rationales for initiating them. Preferences are endogenous, because people seek consistency between their conduct and creeds and because they tend to conform to the values and expectations of others. (Baron and Hannan 1994, p. 1117)

This disagreement at the essential level may be judged significantly responsible for the separation of economics from the greater body of social science. In this regard:

> It is a fact that ever since the Eighteenth Century both groups have grown steadily apart until by now the modal economists and the modal sociologists know little and care less about what the other does. (Joseph Schumpeter, circa 1940s, as quoted in Baron and Hannan, p. 1112).

Citation data show little change over the intervening years since Schumpeter's observation (Ibid., p. 1112). The marginalist's error is the central factor in the isolation of economic theory. Inasmuch as the present theory—returning to the insightful work of Gossen, and assimilating the contributions of numerous researchers over the past century[4]—reverses this error, it may be concluded that the road to unification has been opened.[5]

In the present paper the principal intent is to address interactive behavior. In particular, two examples of group-behavior are considered: (1) the economic interdependency of two individuals in isolation; and (2) an extension of this example to accommodate social psychology (in a preliminary way). In preparation for these treatments, a review of basic theory—the emotive equation and attending constraints—is provided, along with a simplified formulation of the two production function model of capital for the isolated individual.[6]

II. BASIC THEORY: Emotive Equation

In recent years researchers in the natural sciences have increasingly entered the borderland between the scientific and literary cultures:

- Cognitive neuroscientists are using an arsenal of new techniques to map the physical basis of mental events;
- Behavioral geneticists have started to characterize and even pinpoint genes that affect mental activity, from drug addition and mood to cognitive operations;
- Evolutionary biologists … are reconstructing the origins of human social behavior with special reference to evolution by natural selection;
- Environmental scientists … are more precisely defining the arena in which our species arose.

(Wilson 1998)

Additionally, "…scholars have traditionally drawn sharp distinctions between the great branches of learning , and particularly between the natural sciences as opposed to the social sciences and humanities." However, "…growing evidence exists that the boundary is not a line at all, but a broad, mostly unexplored domain of causally linked phenomena awaiting cooperative exploration from both sides." The present work contributes to the "cooperative exploration":

With its empirical attributes from neuropsychological investigation, the emotive equation reaches from the *human sciences* to meet the natural sciences.

The emotive equation may be written:[7]

$$\text{(1a)} \qquad E^i_k = \sum_{w=1,\infty} [f^i_{kw} \int_0^\infty \lambda^i_{kw}(.,.,\ldots,t)\, P^i_{kw}(.,.,\ldots,t)\, dt]$$

where the pleasure E^i_k is experienced by individual i in anticipation of expectational plan k.[8] The expectational plan, accounting for all expectational uncertainty[9] and the (emotive) discounting of expected (pleasure/pain) experience, is implicit within equation (1a), in conjunction with the expectational constraints on the individual's purposeful behavior:[10]

$$\text{(1b)} \qquad \Phi^{ic}_{kw} = 0, \qquad c(w) = 1, \infty$$

In equations (1a) and (1b), kw refers to worldline w of expectational plan k, and, in (1b), c signifies the accountable entity (e.g., imaginary time, or a dated element of capital or consumable). The individual, in his or her purposeful behavior, seeks to maximize E^i_k (by setting $dE^i_k=0$), where this is done, first, by maximizing E^i_k for each of the contending expectational plans, and, second, by choosing, thereby rendering immediately operational, the plan that provides the greatest anticipatory pleasure.[11] Further explanation of the emotive equation, including term definitions, is provided in the following discussion.

It may first be observed that the expression is similar to Strotz's (1956) "utility functional," as provided in his footnote on page 168. In this regard, the process-of-knowing pleasure P^i_{kw} is identical to Strotz's "instantaneous utility"—i.e., *pleasure* (with dimension [PLEASURE]). The indices of P^i_{kw} refer, to reiterate, to worldline w of expectational plan k of individual i (worldlines are discussed below). An expected P-O-N pleasure/displeasure is concomitant with each intertemporal mental and physical activity. "t" is imaginary time with an expectational character, this character being true of the entire expression to the right of the equal sign. (Anticipatory pleasure E has a real-time, rather than expectational, character.) λ^i_{kw}, the "emotive mapping function," corresponds to Strotz's "weight or discount function."[12] This parameter has the effect of discounting the expected pleasure (or pain) of an intertemporal activity relative to its expected magnitude in the immediate future. However, whereas the parameter's magnitude is autonomically determined in both Strotz's and the present work, its meaning herein is radically different. In particular, it is postulated that λ^i_{kw}, with dimension [TIME^{-1}] (versus the dimensionless character of λ in Strotz's work), effects the mapping of intertemporal utility (dt seconds of $P^i_{kw}(t)$ pleasure = differential utility with dimensions [PLEASURExTIME]) into a corresponding real-time pleasure of anticipation with dimension [PLEASURE][13]. f^i_{kw}, referred to as expectational uncertainty herein,[14] is inappropriately subsumed within Strotz's instantaneous utility function—a not uncommon step in mathematical economics that fails to recognize that expected pleasure is that which the individual actually expects to experience, and not a pleasure discounted by previously extinguished expectational uncertainty. Because f^i_{kw} occurs outside of the integrand in the present work, it permits the *worldline* to be introduced—an imaginary curve through parameter space, including space-time, on which an expectedly possible sequence of worldstates is recognized.[15] All expected experience, including expectational uncertainty, is represented by an infinity[16] of worldlines, each with a corresponding time-integral of (emotively) discounted expectational P-O-N pleasure from present real-time to the worldline terminus (taken to be infinity, for mathematical completion and convenience).[17,18] Mortality risk—an essential cause (along with emotive mapping) of the discounting of expected P-O-N pleasure/pain (see Blaug 1968, p. 505-507)—will be addressed in a later contribution.

Note that since surprise is, by definition, absent from the expectational plan, the individual has perfect expectational foresight along each worldline to its terminus, including perfect foresight of all expected activity having the intent of acquiring substantive knowledge—i.e., (previously uncertain) knowledge that has the effect of reducing expectational uncertainty. Perfect expectational foresight includes our preferences. Accordingly, "..if we foresee our situation, we can also see how we will act. There is nothing left to consider, no occasion for judgment: perfect foresight empties choice (See Schick 1979, p. 273)".[19] In addition to attaining knowledge encompassed by the expectational plan, the individual also acquires *unexpected knowledge* due to surprise.

A few additional comments of a more general nature are appropriate. In this regard, it is significant that each of the elements of the emotive equation has its basis in the literature (note 4). Furthermore, the Gossenian approach (on which (1a,b) is largely founded) has been shown to substantively represent economic behavior.[20] And the theory not only has an empirical foundation, but, not coincidentally, is subject to empirical validation, or refutation.[21]

It is, as has been previously noted, an essential feature of the emotive equation that utility is directly, or originally, identified only with the individual's process-of-knowing attending (actual and expected) mental and physical activity—i.e., utility is not directly identified with the goods and services that the individual consumes, as has been the unsound practice of standard theory for over 120 years. Nevertheless, following Gossen ((1854) 1983) and Menger ((1871) 1950), commodities—and, moreover, entities of every conceivable kind—receive *imputed* utility—or, more fundamentally, imputed *anticipatory pleasure*, with utility as an ancillary concept—as part of the solution methodology. [22] In particular, the imputed *anticipatory pleasure* of an entity—its perceived value in the individual's mind—is the difference in anticipatory pleasure obtained from the most desirable expectational plans with and without the entity.[23] This understanding of value is the foundation for a new theory of market prices—one based on assigned (but theoretically *learnable*) P-O-N pleasure, rather than on prescribed consumable utility.

Expectation, as defined in note 8 and formulated in (1a,b), may transcend natural law. As an example, the individual, if sufficiently unsound (e.g., intoxicated) may believe with certainty that he or she can fly to the moon, and prepare a corresponding plan of action. The emotive equation would fully represent this expectational plan, and all other aspects of the individual's intentions, realistic or not. Of course, the individual would experience surprise when he or she fails in the attempted flight—due to the failure to recognize gravity, among other considerations, as a virtual constraint.

The emotive equation, as seen above, is a coherent (internally consistent) representation of the individual's expectational plan, in contrast to standard theory's incoherent character.[24] The equation also has an empirical foundation—both pleasure (Rolls 1975) and intentional/expectational planning (Snyder, et. al. 1997) are measurable—and neuropsychological research has indicated that feeling accompanies and supports practical thought and rational decisions (Damasio 1994; Bechara, et. al. 1997). Further substantiation by way of original contributions has been provided (see note 20). A simplified formulation of one of these contributions—the two production function model of capital (as given in the WEAI paper)—will now be presented.

IIIa. APPLIED THEORY—Economics

Two Production Function Model of Capital

The two production function model of capital (following Lange 1936) is particularly meaningful in its representation of the individual's productive and consumptive activities in relation to the material world. In this regard, one's (incremental) *labor activity* increase in the production of capital, rather than the incremental sacrifice—"cost"—of a finished good, may be recognized as the investment, with the resulting decrease in labor activity in the production of a fixed amount of the finished good as the return-on-investment.

In the considered two production function model of capital, the isolated individual expectationally prepares a daily regimen involving consecutive appliance (capital) and food production activities, immediately followed by food consumption, with rest concluding the 24 hour day.[25] In prescribing the activity durations throughout the intertemporal period, subject to the constraints, the individual's expectational calculus seeks a balance of marginal anticipatory-pleasures of all expected activities. (Additionally, in the general case, he or she would account for expectational worldline-uncertainty and the discounting of intertemporal pleasure/pain—essential elements of expectational planning that are not substantively addressed in this simplified example.) After formulation of the expectational plan for present case, a study of the interest rate (at an elementary level) will be given.

The first step in addressing this problem is to rewrite the emotive equation in terms of recurring day-to-day time:

(2) $$E^I_k = \sum_{w(k)=1,\infty} f^I_{kw} \left(\sum_{d=1,\infty} \left[\int_0^\tau \lambda^I_{kw}([d-1]\tau+t^*)\, P^I_{kw}([d-1]\tau+t^*)\, dt^* \right] \right)$$

where it is seen that the arguments of λ and P are expressed in terms of day d and length-of-day τ, in addition to imaginary time t*.[26] The integration limits are correspondingly changed from $0\rightarrow\infty$ to $0\rightarrow\tau$. Note that the superscript is changed to upper case I, this being the adopted convention for the isolated individual case. Assuming λ to be independent of time within each worldline-day allows (2) to be written:[27]

(3) $$E^I_k = \sum_{w(k)=1,\infty} f^I_{kw} \left(\sum_{d=1,\infty} \left[\underline{\lambda}^I_{kwd} \int_0^\tau P^I_{kw}([d-1]\tau+t^*)\, dt^* \right] \right)$$

$$= \sum_{w(k)=1,\infty} f^I_{kw} \left(\sum_{d=1,\infty} \left[\underline{\lambda}^I_{kwd}\, u^I_{kwd}(\langle L_{wd1}, L_{wd2}, C_{wd}, R_{wd}\rangle^I_k) \right] \right)$$

where, for the individual I and expectational plan k,

L_{wd1} = labor duration in day d of worldline w in the production of appliance (capital)
L_{wd2} = labor duration in day d of worldline w in the production of food
C_{wd} = food consumption duration in day d of worldline w
R_{wd} = rest (leisure) duration in day d of worldline w

with the sum of the sequential activities filling the entire day. u^I_{kwd}—representing the total utility expected to be received in the indicated worldline-day of the individual's plan—is written:

(4) $$u^I_{kwd}(\langle L_1, L_2, C, R\rangle^I_{kwd}) = \int_0^{L1} \langle p_{L_1}(t^*)\rangle^I_{kwd} dt^* + \int_0^{L2} \langle p_{L_2}(t^*)\rangle^I_{kwd} dt^*$$
$$+ \int_0^{C} \langle p_C(t^*)\rangle^I_{kwd} dt^* + \int_0^{R} \langle p_R(t^*)\rangle^I_{kwd} dt^*$$

In this equation, P^I_{kw} has been replaced by activity-specific P-O-N pleasure functions, e.g. $\langle p_{L_1}(t^*)\rangle^I_{kwd}$. It is postulated that $p_{L_i}<0$ for i=1,2 (productive displeasure expected). Also, $p_C>0$ and $p_R>0$ (positive consumptive and rest pleasure expected to be experienced). Furthermore, the time derivatives of all four functions are negative (Gossen's first law (1854) 1983, p. 6).[28] Note that the activity initial-pleasure, e.g. $p_C(0)$ is restored from day to day, in (idealized) accordance with Gossen's law of recurrence of wants [Ibid., 41]. It is seen from the above conditions that (neglecting the indices):

$$\partial u/\partial x<0, \qquad x=L_1, L_2$$
$$\partial u/\partial x>0, \qquad x=C, R \text{ and } \partial^2u/\partial x^2<0, x= C, R$$

In the present application we are interested in the individual's operative expectational plan for the single day—the 24 hour period to immediately commence. (It is postulated that he or she does not recognize experience in day 2 or beyond.) There is no uncertainty in the expectation, and one worldline accordingly exists. For this set of conditions, (3) becomes, dropping I, k, w, and d as understood:

$$E = \underline{\lambda}\ u(L_1, L_2, C, R) \tag{5}$$

The individual must, with the requisite "sense of realism," account for the expected constraints in seeking the optimal activity regimen thereby maximizing his or her anticipatory pleasure for the day. In the present problem, the constraints account for elapsed time, food consumption versus production, and appliance production:

Expected Constraints**:**

(6a) $\Phi^{Time} = \tau - (L_1 + L_2 + C + R) = 0$ Time

(6b) $\Phi^{Appl} = F^A(L_1) - Q^A = 0$ Appliance

$\partial F^A/\partial L_1 >0, \partial^2F^A/\partial[L_1]^2<0$ (Capital)

(6c) $\Phi^{Food} = F^F(L_2,Q^A) - a\,C = 0$ Food

$\partial F^F/\partial L_2 >0, \partial^2F^F/\partial[L_2]^2<0$

$\partial F^F/\partial Q^A >0, \partial^2F^F/\partial[Q^A]^2<0$

where the production functions are seen to exhibit the usually assumed economic condition of diminishing returns (e.g., $\partial^2F^F/\partial[L_2]^2<0$).

The parameter definitions are as follows: To reiterate some of the earlier discussion, the individual's expected regimen consists of four sequential activities: L_1 hours of labor in producing appliance; L_2 hours of appliance-assisted labor in producing food; C hours of food consumption; and R hours of rest, thereby completing the day of length τ (e.g., 24 hours). No appliance is expectedly on hand at the start of the day, and the appliance production function F^A

is accordingly dependent only on the productive activity duration L_1. Q^A is the quantity of produced appliance, and this enters the food production function F^F along with the duration of food production labor L_2. The resulting food (implicit in the mathematics) is consumed at the constant rate "a" per unit food consumption time. As has been noted, expected pleasure/pain experience beyond day 2 is discounted to zero as a simplification.

Given the function and coefficient definitions, and recognizing that conditions permitting a solution must be satisfied, the emotive equation (5) subject to the above constraint equations may be solved for the five unknowns (four activity durations and the appliance quantity). In applying the method of Lagrange multipliers, the three constraint equations, each with a multiplier (of unknown value), is appended to (5) resulting in:

$$\text{(7)} \qquad E = \underline{\lambda}\, u(L_1, L_2, C, R) + l^T \Phi^{Time} + l^A \Phi^{Appl} + l^F \Phi^{Food}$$

where l^T, l^A, and l^F are the Lagrange multipliers. The solution procedure is to take the partial derivative of E with respect to the eight unknowns in turn, including the three multipliers, setting each expression equal to zero. Accordingly, where it is seen that the process-of-knowing instantaneous-utility functions re-emerge:

<u>Subsidiary Relations</u>:

$$\text{(8a)} \quad L_1: \quad \underline{\lambda}\, p_{L1}(L_1) - l^T + l^A\, \partial F^A(L_1)/\partial L_1 = 0$$

$$\text{(8b)} \quad L_2: \quad \underline{\lambda}\, p_{L2}(L_2) - l^T + l^F\, \partial F^F(L_2, Q^A)/\partial L_2 = 0$$

$$\text{(8c)} \quad C: \quad \underline{\lambda}\, p_C(C) - l^T - a\, l^F = 0$$

$$\text{(8d)} \quad R: \quad \underline{\lambda}\, p_R(R) - l^T = 0$$

$$\text{(8e)} \quad Q^A: \quad - l^A + l^F\, \partial F^F(L_2, Q^A)/\partial Q^A = 0$$

$$\text{(8f)} \quad l^T: \quad \tau - (L_1 + L_2 + C + R) = 0$$

$$\text{(8g)} \quad l^A: \quad F^A(L_1) - Q^A = 0$$

(8h) l^F: $F^F(L_2, Q^A) - a\,C = 0$

The solution of this set of algebraic equations determines the individual's expected activity regimen for the day. That is, the solution determines the duration of the individual's expected effort in making the food-producing appliance (L_1); the duration of the immediately following expected effort in using the appliance to produce food (L_2); the duration of the expected pleasure in consuming the produced food (C); and the duration of the expected pleasure in resting at the conclusion of the day (R)—all subject to the individual's common knowledge of the world (as inherent within the emotive equation and associated constraints). Should there be no surprises during the day, this solution represents the individual's actual experience as real-time gradually eclipses imaginary, intertemporal time. (Surprise due to a creative thought initiates a new plan, inasmuch as unexpected knowledge is obtained by the experience. Similarly, a lapse of memory would occasion surprise, and a new plan, unless, of course, it was recognized and accommodated as a possibility in the operative expectational plan.)

It appears advantageous at this point to reiterate an essential principle of the present theory—i.e., uncertainty is a relentless property of the future into which the individual proceeds. Accordingly, the single worldline in the present study is a fiction serving the current illustrative purpose. In reality, an infinite number of worldlines opens into the future in every expectational plan (e.g., the exact placement of footsteps can't be known), and the individual's experience with advancing real time will be represented by one of these worldlines.

Having prepared a determinate formulation (when properly posed) of the isolated individual's expected regimen, the basis exists to address the corresponding *net marginal return on investment over investment* (NMRetI/I)—i.e., the real interest rate (when elapsed time is assigned).

The real interest rate is defined in physical terms, while its determination (in the present case) is understood in subjective terms. Physically, the real interest rate in the present case can be understood to represent the expected "mechanical advantage" of capital-production labor over food-production labor in expectedly producing the final increment (or *marginal* amount) of food. In particular, the individual, in his or her expectational planning, recognizes (for a positive real interest rate) that an extra minute (say) of capital production is more effective in producing food than an extra minute of food production. The reason is that the incremental capital (δQ^A) in conjunction with the "baseline" food production duration (L_2) (expectedly) produces a greater amount of marginal food than the baseline amount of capital (Q^A) in conjunction with the incremental increase (i.e., one minute) in the food production interval (δL_2).

Continuing to address the physical basis, one may postulate that the investment is a marginal amount of labor in producing capital, rather than the "cost" of a quantity of finished good (as postulated by Lange 1936), with the return being a greater change (reduction) in the labor duration directly producing the finished good. In particular (for the considered case), the individual could imagine that the amount of food that is produced is held constant when capital-producing labor is incrementally increased (δL_1) and that the imagined food production interval necessary to produce the fixed amount of food is correspondingly decreased (δL_2). On this basis, the real interest rate is the negative of the net marginal change (reduction) of the total labor in the day (capital production plus food production) divided by the marginal labor increase in producing capital, or:

$$\text{NMRetI/I} = -(\delta L_2 + \delta L_1)/\delta L_1 \tag{9}$$

where

NMRetI/I = real interest rate (nondimensional—time lapse understood)
δL_1 = incremental increase in capital production duration
δL_2 = incremental increase in food production duration (having negative value)

The incremental change in the food production duration δL_2 may be given the following expression:

$$\delta L_2 = -[\partial F^A(L_1)/\partial L_1]\ \{\delta L_1\}\ [\partial F^F(L_2, Q^A)/\partial Q^A] / [\partial F^F(L_2, Q^A)/\partial L_2]$$

Substituting into (9) and simplifying gives:

$$\text{NMRetI/I} = [\partial F^A(L_1)/\partial L_1]\ [\partial F^F(L_2, Q^A)/\partial Q^A] / [\partial F^F(L_2, Q^A)/\partial L_2] - 1 \tag{10}$$

This expression for the real interest rate is (functionally) identical to Lange's [1936] relation (and the basically equivalent earlier definition by Wicksell (1935)), despite the different character of investment (labor time versus cost of the finished product—food). Through use of equations (8a), (8b), (8d), and (8e), (10) becomes:

$$(11) \qquad \text{NMRetI/I} \;=\; \frac{\underline{\lambda}\,[\text{p}_{\text{L}_1}(\text{L}_1) - \text{p}_{\text{R}}(\text{R}_1)]}{\underline{\lambda}\,[\text{p}_{\text{L}_2}(\text{L}_2) - \text{p}_{\text{R}}(\text{R}_1)]} \;-\; 1$$

$$=\; \frac{\text{p}_{\text{L}_1}(\text{L}_1) - \text{p}_{\text{R}}(\text{R}_1)}{\text{p}_{\text{L}_2}(\text{L}_2) - \text{p}_{\text{R}}(\text{R}_1)} \;-\; 1$$

While (10) is an established relation in economic theory (as noted above), (11) is a new result in that the interest rate is expressed in neuropsychological parameters.

At the heart of (11) is the expectational balancing of <u>net</u> instantaneous-utility (productive minus leisure) at the margins of the two productive intervals, L_1 and L_2. In particular, combining (9) and (11) gives (again, setting aside the mapping coefficients):

$$\delta\text{L}_1\,[\text{p}_{\text{L}_1}(\text{L}_1) - \text{p}_{\text{R}}(\text{R}_1)] + \delta\text{L}_2\,[\text{p}_{\text{L}_2}(\text{L}_2) - \text{p}_{\text{R}}(\text{R}_1)] \;=\; 0$$

This may be considered another new result, demonstrating how the mind adjusts the intended activity durations in capital function to maximize expected intertemporal-utility or, equivalently, expectationally balance net marginal instantaneous-utility (recognizing, again, that only when emotive mapping/discounting is assumed "flat" or uniform in an intertemporal period can one rigorously refer to the maximization of intertemporal utility).

A reference to the significance of the foregoing treatment of the economic behavior of the isolated individual appears advantageous before proceeding to the interactive agents case. As Marshall observed over a century ago, "The element of time is the centre of the chief difficulty of almost every economic problem (1990)". While the early marginalists rejected time as a basic theoretical parameter by directly identifying utility with commodities, in the present theory time is restored to its crucial role in behavioral theory. In this step, economic analysis is raised to a new level—e.g., in the study of capital function, liquidity preference, growth/decline, nature of value, and price determination. Relatedly, preferences are now endogenously rather than exogenously determined. Among the important consequences (with specific reference to endogenous preferences) is a possibly greater prominence given to the interactive development of individuals and institutions:

> By institutions, individuals are not merely constrained and influenced. Jointly with our natural environment and our biotic inheritance, as social beings we are *constituted* by institutions. They are given by history and constitute our socio-economic flesh and blood. This proposition must cohabit with the more widely accepted—and equally valid—notion that institutions, knowingly or unknowingly, are formed and changed by individuals. (Hodgson 1998)

Beyond the institutions resides the remainder of social science, which can now be assimilated on the basis of the emotive equation. Later in the present note, social psychology, albeit at an elementary level, will be addressed. But first, the economic system of two interactive agents is formulated and discussed.

In the treatment of two economically-interactive agents in isolation, one agent manufactures a food-producing appliance (capital) but is constrained, for an unspecified reason, from using it to produce food. The other agent produces food, but not appliance. Trading of food for capital is expected to mutual benefit. In addressing the social psychological relationship of the cooperating agents in the later study, it will be seen that only minor changes are introduced in the interactive-agents formulation to follow.

Economic Interaction of Two Agents in Isolation

The two-agent formulation is an elementary extension of the isolated individual treatment given above. At the core of the model is the same two-step process for producing food, except that one individual—Agent 1—is expected to make the food-producing appliance and the second individual—Agent 2—is expected to use the appliance to produce food. It is part of their joint, negotiated plan that Agent 2 is expected to "purchase" all of the produced appliance for an agreed amount of food during the one-day intertemporal period (the transfers not concurrent). Note that their cooperation necessitates different activity regimens. Besides the difference in production activities—one individual produces appliance and the other food—is the overall arrangement or sequence of activities. The essential consideration here is that Agent 2 cannot produce food while Agent 1 is producing appliance, inasmuch as the latter is required for the former. Accordingly, Agent 2 will rest for at least as long as Agent 1 is at work. Thereafter, Agent 1 will rest until after

Agent 2 finishes producing food. They are both then free, after food transfer to Agent 1, to dine for the remainder of the day. Subject to these restrictions the agents will define their respective activity durations to maximize plan anticipatory pleasure. (Of course, the problem definition must permit an analytic solution.)

In formulating the problem, it is postulated, in accordance with the preceding discussion, that Agent 1 expects to begin the day laboring to produce appliance, then to rest, and finally to conclude the day consuming food. Agent 2 expects to begin the day resting, then to produce food, and to conclude with food consumption. Within the context of these concurrent regimens, Agent 2 expects to receive a quantity of appliance at the conclusion of its production and to return a quantity of food as payment at the conclusion of her food production activity. Note that Agent 2 food production will not necessarily commence upon receipt of appliance, nor that Agent 1 food consumption will immediately begin upon receipt of food.

Another part of their coordinated plan is that neither appliance nor food is expected to survive from one day to the next (for an unspecified reason), so planning does not extend into day 2 and beyond.

Note that there are no explicit provisions in the model for activities other than appliance/food production, food consumption, and rest.[29] Of course, the agents need to spend some time planning the next day's activity, but this may be understood to occur during the common activity of food consumption at the end of the day.

Explanation of the analytic procedure for determining the food and appliance specific marginal anticipatory-pleasures—i.e., each in terms of the imputed marginal anticipatory-pleasure per unit amount of entity—is a primary objective in the development to follow. It is recognized that the standard plots or graphs (Marshallian: see Rima (1991), p. 326]) of commodity supply and demand versus price may be determined—where the intersection point of the two curves gives the price. This approach differs from standard neoclassical theory by determining specific marginal anticipatory-pleasure (value) as part of the solution, whereas standard theory directly assigns utility to commodities, and only consumables.[30]

In the usual procedure, each agent is first assigned a corresponding emotive equation. Accordingly, extending (7):

AGENT 1 Emotive Equation (Appliance production only):

$$(12) \qquad E^{indiv=1} = \underline{\lambda}^1\, u^1(L^1_1, R^1, C^1) + l^{1T}\Phi^{1T} + l^{1A}\Phi^{1A} + l^{1F}\Phi^{1F} + l^{1E}\Phi^{1E}$$

AGENT 2 Emotive Equation (Food production only):

$$(13) \qquad E^{indiv=2} = \underline{\lambda}^2\, u^2(R^2, L^2_2, C^2) + l^{2T}\Phi^{2T} + l^{2F}\Phi^{2F} + l^{2E}\Phi^{2E}$$

Φ^{1E} and Φ^{2E} are new constraints accounting for the exchange of food and appliance. As noted earlier, since Agent 2 does not produce appliance the equation is absent from her constraints. Agent 1 retains the food constraint, however, inasmuch as food consumption is represented.

Agent 1 constraints and subsidiary relations. The constraint equations for Agent 1 may be written:

Expected Constraints /AGENT 1:

(14a)	$\Phi^{[indiv=1]\underline{T}ime} = \tau - (L^1_1 + R^1 + C^1)$	$= 0$	Time
(14b)	$\Phi^{[indiv=1]\underline{A}ppl} = F^{1A}(L^1_1) + \Delta Q^{1A}$ $\partial F^{1A}/\partial L^1_1 > 0,\ \partial^2 F^{1A}/\partial[L^1_1]^2 < 0$ $\partial F^{1F}/\partial Q^{1A} > 0,\ \partial^2 F^{1F}/\partial[Q^{1A}]^2 < 0$	$= 0$	Appliance (Capital)
(14c)	$\Phi^{[indiv=1]\underline{F}ood} = Q^{1F} - a^1 C^1$	$= 0$	Food
(14d)	$\Phi^{[indiv=1]\underline{E}xch} = \underline{P}\,\Delta Q^{1A} + Q^{1F}$	$= 0$	Exchange

In comparing with the isolated individual constraints (equations (6a-6c)), the new exchange constraint is apparent. This equation (14d) represents the exchange of food and appliance between the two agents at the ratio (i.e., price) $\underline{P}$. Each of the exchange quantities occurs elsewhere in the constraint relations—Q^{1F} in the food constraint and ΔQ^{1A} in the appliance constraint.[31] It is seen that only labor duration L^1_1 is evident, since the individual does not expect to produce food.

The corresponding subsidiary relations are obtained by taking the partial derivatives of the relevant emotive equation (12) with respect to the individual-specific unknowns (i.e., all except the exchange price $\underline{P}$), including the multipliers. Accordingly, making use of (4) in a contracted form,

$$u^I(L^1_1, \ldots, C^1, R^1) = \int_0^{L1} p_{L^1{}_1}(t^*)dt^* + \quad \ldots$$
$$+ \int_0^{C} p_{C^1}(t^*)dt^* + \int_0^{R} p_{R^1}(t^*)dt^*$$

there results:

<u>Subsidiary Relations</u> / <u>AGENT 1</u>:

(15a) L^1_1: $\underline{\lambda}^1\, p_L{}^1{}_1(L^1_1) - l^{1T} + l^{1A}\, \partial F^{1A}(L^1_1)/\partial L^1_1 = 0$

(15b) C^1: $\underline{\lambda}^1\, p_C{}^1(C^1) - l^{1T} - l^{1F}\, a^1 = 0$

(15c) R^1: $\underline{\lambda}^1\, p_R{}^1(R^1) - l^{1T} = 0$

(15d) ΔQ^{1A}: $l^{1A} + \underline{P}\, l^{1E} = 0$

(15e) Q^{1F}: $l^{1F} + l^{1E} = 0$

(15f) l^{1T}: $\Phi^{[\text{indiv}=1]\underline{T}\text{ime}} = \tau - (L^1_1 + R^1 + C^1) = 0$ Time

(15g) l^{1A}: $\Phi^{[\text{indiv}=1]\underline{A}\text{ppl}} = F^{1A}(L^1_1) + \Delta Q^{1A} = 0$ Appliance (Capital)

(15h) l^{1F}: $\Phi^{[\text{indiv}=1]\underline{F}\text{ood}} = Q^{1F} - a^1\, C^1 = 0$ Food

(15i) l^{1E}: $\Phi^{[\text{indiv}=1]\underline{E}\text{xch}} = \underline{P}\, \Delta Q^{1A} + Q^{1F} = 0$ Exchange

including the four constraint equations, (14a)-(14d).

Agent 2 constraints and subsidiary relations. The constraint equations for Agent 2 are:

<u>Expected Constraints</u> /<u>AGENT 2</u>:

(16a) $\Phi^{[\underline{i}\text{ndiv}=2]\underline{T}\text{ime}} = \tau - (R^2 + L^2_2 + C^2) = 0$ Time

(16b) $\Phi^{[\underline{i}\text{ndiv}=2]\underline{F}\text{ood}} = F^{2F}(L^2_2, Q^{2A}) + \Delta Q^{2F} - a^2\, C^2 = 0$ Food

$$\partial F^{2F}/\partial L^2_2 > 0,\ \partial^2 F^{2F}/\partial [L^2_2]^2 < 0$$
$$\partial F^{2F}/\partial Q^{2A} > 0,\ \partial^2 F^{2F}/\partial [Q^{2A}]^2 < 0$$

(16c) $\Phi^{[\underline{i}ndiv=2]\underline{E}xch} = \underline{P}\ Q^{2A} + \Delta Q^{2F} = 0$ Exchange

The major difference between this set of equations and that for Agent 1 is the absence of the appliance constraint. Note that $F^{2F}(L^2_2, 0) = 0$ in (16b), i.e. the individual expects to require appliance to produce food.

As before, taking the partial derivatives of the relevant emotive equation (13) with respect to the Agent 2 individual-specific unknowns produces the corresponding subsidiary relations:

<u>Subsidiary Relations</u> / <u>AGENT 2</u>

(17a)	L^2_2:	$\underline{\lambda}^2\ pL^2_2(L^2_2) - l^{2T} + l^{2F}\ \partial F^{2F}(L^2_2, Q^{2A})/\partial L^2_2$	$= 0$	
(17b)	C^2:	$\underline{\lambda}^2\ pc^2(C^2) - l^{2T} - l^{2F}\ a^2$	$= 0$	
(17c)	R^2:	$\underline{\lambda}^2\ pR^2(R^2) - l^{2T}$	$= 0$	
(17d)	Q^{2A}:	$l^{2F}\ \partial F^{2F}(L^2_2, Q^{2A})/\partial Q^{2A} + \underline{P}\ l^{2E}$	$= 0$	
(17e)	ΔQ^{2F}:	$l^{2F} + l^{2E}$	$= 0$	
(17f)	l^{2T}	$\Phi^{[\underline{i}ndiv=2]\underline{T}ime} = \tau - (R^2 + L^2_2 + C^2)$	$= 0$	Time
(17g)	l^{2F}	$\Phi^{[\underline{i}ndiv=2]\underline{F}ood} = F^{2F}(L^2_2, Q^{2A}) + \Delta Q^{2F} - a^2\, C^2$	$= 0$	Food
(17h)	l^{2E}	$\Phi^{[\underline{i}ndiv=2]\underline{E}xch} = \underline{P}\ Q^{2A} + \Delta Q^{2F}$	$= 0$	Exchange

Equations (15a-15i) and (17a-17h) comprise seventeen expressions for the equal number of individual-specific unknowns—including the seven Lagrange multipliers. The remaining unknown is the exchange ratio or price $\underline{P}$. One additional equation is accordingly needed, and this is provided by requiring commodity "conservation." In particular, it is required that the quantity of appliance transferred by Agent 1 to Agent 2 be received by Agent 2:

(18) $$\Delta Q^{1A} + Q^{2A} = 0$$

Equations (15a-i), (17a-h), and (18) comprise the determinate set for a solution—when the functions and coefficients are properly specified. Note that a similar requirement for food exchange would be superfluous inasmuch as (18) in conjunction with (15i) and (17h) require $Q^{1F} + \Delta Q^{2F} = 0$.

As the initial comment in a brief discussion of the foregoing, it is instructive to recognize that each of the individual-specific sets of relations—i.e., (15a-i) for Agent 1 and (17a-h) for Agent 2—can be solved for a given price $\underline{P}$. In general, however, (18) will not be satisfied. In other words, an arbitrary exchange price will not yield an agreement on the quantity of food to be exchanged per unit of appliance. The individuals negotiate (in their cooperative expectational planning) until they agree. This process—implicit in the above formulation—reflects a prominent basis for real-world price determination. In this regard it is interesting that the present intertemporal instantaneous-utility basis for determining (expectational) supply versus demand yields the corresponding Marshallian cross-plot (as noted earlier). In both cases, the intersection of the supply and demand curves gives the exchange price.

While a complete solution is not obtained in the present work, the price of appliance in terms of (numeraire) food may be derived. From (15d) and (15e) of Agent 1's subsidiary relations an initial expression for the appliance price may be written:

$$\underline{P} = l^{1A}/l^{1F} \tag{19}$$

In this equation l^{1A}—the Lagrange multiplier for the appliance constraint—represents the anticipatory pleasure expectedly imputed to the corresponding marginal unit-amount of appliance by the individual for the operative expectational plan. The multiplier l^{1F} is similarly understood. The ratio accordingly gives the relative value—i.e., price of appliance in terms of food in the present treatment. For example, l^{1A} could be quantified as three units of anticipatory pleasure per unit appliance while l^{1F} could be quantified as two such units per unit of food. The ratio gives the price of appliance in the interactive individuals' economic relationship: 1.5 units of food as the cost for one unit of appliance.

A more explicit expression for the price is obtained through application of (15a) - (15c). Solving (15a) for l^{1A} and (15b) for l^{1F}, making use of (15c), and substituting into (19) yields:

$$\underline{P} = \frac{-\underline{\lambda}^1 \{p_L{}^1{}_1(L^1{}_1) - p_R{}^1(R^1)\}/[\partial F^{1A}(L^1{}_1)/\partial L^1{}_1]}{\underline{\lambda}^1 \{p_C{}^1(C^1) - p_R{}^1(R^1)\}/a^1}$$

$$= -\frac{a^1}{\partial F^{1A}(L^1{}_1)/\partial L^1{}_1} \times \frac{p_L{}^1{}_1(L^1{}_1) - p_R{}^1(R^1)}{p_C{}^1(C^1) - p_R{}^1(R^1)}$$

In this (expectational) expression, the ratio of the individual's marginal rate of food consumption to his marginal rate of appliance production is in product with the ratio of net appliance-production pleasure at the margin to the same for food. It may be seen how the individual's expected celerity in appliance production enters the determination of the exchange price. In particular, were the individual to expect a greater difficulty in appliance production—i.e., a decreased $\partial F^{1A}(L^1{}_1)/\partial L^1{}_1$—the appliance's price would tend to increase, in accordance with intuition. (A more substantive discussion is provided in the next section.) The same result obtains should greater food consumption per unit time be expected (i.e., increased a^1).

Inspection of Agent 2's subsidiary relations allows a second expression for the appliance price. Solving (17d) and (17e) for $\underline{P}$ gives:

$$\underline{P} = \partial F^{2F}(L^2{}_2, Q^{2A})/\partial Q^{2A}$$

This relation states that the exchange ratio (price)—in terms of units of food (numeraire) for each unit of appliance—is given by the marginal productivity of appliance. Note that the evidently mechanistic determination of price is illusory inasmuch as subjectivity determines the individual's labor duration $L^2{}_2$ and acquired capital Q^{2A}: Unlike standard theory, preferences for entities are endogenously determined.

To briefly reflect on the immediately preceding point, the 2-agent problem considered above illustrates the plan-dependent character of negotiated prices. In particular, were a different plan agreed to—e.g., where each individual produces both food and appliance but exchanges for optimality—supply versus demand would result in a different price. Standard theory ignores this proper etiology of production and exchange based on expectational planning: As has been stated, utility is directly assigned to products (consumables only) thereby yielding the basically unsound equilibrium theory.

IIIb. APPLIED THEORY—Social Psychology

In the following discussion, the preceding 2-agent treatment is extended to account for *stereotyping*:

> …a fundamental and probably universal bias in perception which has important and far-reaching consequences for behavior ranging from relatively harmless assumptions about people to gross practices such as genocide. It is a central component of prejudice and intergroup relations, and its study is inextricable from the study of intergroup behavior. (Hogg and Abrams 1988, p. 66.)

Of specific interest is an 'accentuation effect (Tajfel 1957)' attending categorization. Tajfel's *accentuation principle* holds that "…the superposition of a systematic classification of stimuli into two categories on a continuously distributed judgmental dimension results in the perceptual exaggeration of similarities within and differences between categories (Ibid., p. 71)". In economics such exaggeration could affect the prices of goods (e.g., yield an erroneous assessment of product-amount versus package size),[32] and socioeconomic status/employability (e.g., bias in assessing the attributes of foreign nationals (Tajfel, et. al. 1964; See also Hogg and Abrams 1988, p. 72)). One such affect is addressed below—the influence of stereotypic bias on the expected economic performance and income of the cooperative agents, and on the commodity exchange ratio. It will be seen that the mathematical formulations (i.e., emotive equations and corresponding constraints) are basically the same as that of the preceding study, except for the introduction of a celerity factor in the Agent 2 food production and P-O-N utility (and pleasure) functions.

In the study to follow it is assumed that the categorization process has already had its effect on the two cooperating individuals, e.g. within the context of society. In particular, *food production per unit time*—the "focal dimension"—receives a biased assessment (categorization) on the basis of *physical stature or height*—the "peripheral dimension." To be specific, both individuals recognize that one, the relatively small Agent 2, is expected to perform at a reduced level of celerity in the production of food (per unit time).[33]

The modification of the two-interactives formulation such that it accommodates the stereotypic reduction of Agent 2's food productivity is the assignment of a food-production celerity factor Λ^2_2 to Agent 2. This factor will be seen to arise, as noted above, in the P-O-N utility function (or, alternatively, P-O-N pleasure function) and the food-production function. The effect of this factor is to cause both individuals to expectedly adjust their rates of production and consumption in order to continue to maximize intertemporal utility (or, more fundamentally, expectational plan anticipatory pleasure).

Proceeding now to the formulation, it is reiterated that the emotive equations and corresponding constraints for the two interactives exhibit the same general form as in the previous section, but with the explicit representation of the celerity factor in the formulation for Agent 2.

AGENT 1 Emotive Equation **(**Appliance production only):

(20)
$$E^{\underline{i}ndiv=1} = \underline{\lambda}^1 u^1(L^1_1, R^1, C^1)$$
$$+ l^{1T}\Phi^{1T} + l^{1A}\Phi^{1A} + l^{1F}\Phi^{1F} + l^{1E}\Phi^{1E}$$

$$\partial u^1/\partial x<0, \qquad x= L^1_1$$
$$\partial u^1/\partial x>0, \qquad x= R^1, C^1; \partial^2 u^1/\partial[x]^2<0, x= R^1, C^1$$

The constraint equations also take the same form as before:

Expected Constraints /AGENT 1:

(21a) $\Phi^{[\underline{i}ndiv=1]\underline{T}ime} = \tau - (L^1_1 + R^1 + C^1) = 0$ Time

(21b) $\Phi^{[\underline{i}ndiv=1]\underline{A}ppl} = F^{1A}(L^1_1) + \Delta Q^{1A} = 0$ Appliance (Capital)
$\partial F^{1A}/\partial L^1_1 >0, \partial^2 F^{1A}/\partial[L^1_1]^2 <0$

(21c) $\Phi^{[\underline{i}ndiv=1]\underline{F}ood} = Q^{1F} - a^1 C^1 = 0$ Food

(21d) $\Phi^{[\underline{i}ndiv=1]\underline{E}xch} = \underline{P}\,\Delta Q^{1A} + Q^{1F} = 0$ Exchange

Similarly for Agent 2:

AGENT 2 Emotive Equation (Food production only):

$$(22) \qquad E^{indiv=2} = \underline{\lambda}^2 u^2(R^2, [\Lambda^2_2, L^2_2], C^2) + l^{2T}\Phi^{2T} + l^{2F}\Phi^{2F} + l^{2E}\Phi^{2E}$$

$\partial u^2/\partial x<0, \quad x = L^2_2$

$\partial u^2/\partial x>0, \quad x = R^2, C^2$; and $\partial^2 u^2/\partial[x]^2 < 0,\ x = R^2, C^2$

$\partial u^2/\partial\Lambda^2_2 < 0,$ (i.e., $\partial p_L{}^2_2(\Lambda^2_2, L^2_2)/\partial\Lambda^2_2 < 0$)

where Λ^2_2 is the agent's celerity factor in producing food. (Brackets in the utility function argument enclose the closely related parameters.) The constraint relations retain the same general form as (16a) – (16c):

Expected Constraints / AGENT 2:

(23a) $\Phi^{[indiv-2]Time} = \tau - (R^2 + L^2_2 + C^2) = 0$ Time

(23b) $\Phi^{[indiv-2]Food} = F^{2F}([\Lambda^2_2, L^2_2], Q^{2A}) + \Delta Q^{2F} - a^2 C^2 = 0$ Food

$\partial F^{2F}/\partial L^2_2 \geq 0,\ \partial^2 F^{2F}/\partial[L^2_2]^2<0,\ \partial F^{2F}/\partial\Lambda^2_2 >0$

(23c) $\Phi^{[indiv-2]Exch} = \underline{P}\, Q^{2A} + \Delta Q^{2F} = 0$ Exchange

Following the usual Lagrangian process, and reverting to the P-O-N pleasure functions (e.g., $p_L{}^1_1(L^1_1)$) rather than utility functions (e.g., $u^1(L^1_1, R^1, C^1)$), the subsidiary relations emerge as:

Subsidiary Relations /AGENT 1:

(24a) L^1_1: $\underline{\lambda}^1 p_L{}^1_1(L^1_1) - l^{1T} + l^{1A}\,\partial F^{1A}(L^1_1)/\partial L^1_1 = 0$

(24b) C^1: $\underline{\lambda}^1 p_C{}^1(C^1) - l^{1T} - l^{1F} a^1 = 0$

(24c) R^1: $\underline{\lambda}^1 p_R{}^1(R) - l^{1T} = 0$

(24d) ΔQ^{1A}: $l^{1A} + \underline{P}\, l^{1E} = 0$

(24e) Q^{1F}: $l^{1F} + l^{1E} = 0$

(24f) l^{1T}: $\Phi^{[\underline{i}ndiv\text{-}1]\underline{T}ime} = \tau - (L^1{}_1 + R^1 + C^1) = 0$ Time

(24g) l^{1A}: $\Phi^{[\underline{i}ndiv\text{-}1]\underline{A}ppl} = F^{1A}(L^1{}_1) + \Delta Q^{1A} = 0$ Appliance (Capital)

(24h) l^{1F}: $\Phi^{[\underline{i}ndiv\text{-}1]\underline{F}ood} = Q^{1F} - a^1 C^1 = 0$ Food

(24i) l^{1E}: $\Phi^{[\underline{i}ndiv\text{-}1]\underline{E}xch} = \underline{P}\, \Delta Q^{1A} + Q^{1F} = 0$ Exchange

<u>Subsidiary Relations</u> /<u>AGENT 2</u>:

(25a) $L^2{}_2$: $\underline{\lambda}^2\, p_L{}^2{}_2(\Lambda^2{}_2, L^2{}_2) - l^{2T} + l^{2F}\, \partial F^{2F}([\Lambda^2{}_2, L^2{}_2], Q^{2A})/\partial L^2{}_2 = 0$

(25b) C^2: $\underline{\lambda}^2\, p_C{}^2(C^2) - l^{2T} - l^{2F} a^2 = 0$

(25c) R^2: $\underline{\lambda}^2\, p_R{}^2(R^2) - l^{2T} = 0$

(25d) Q^{2A}: $l^{2F}\, \partial F^{2F}([\Lambda^2{}_2, L^2{}_2], Q^{2A})/\partial Q^{2A} + \underline{P}\, l^{2E} = 0$

(25e) ΔQ^{2F}: $l^{2F} + l^{2E} = 0$

(25f) l^{2T}: $\Phi^{[\underline{i}ndiv\text{-}2]\underline{T}ime} = \tau - (R^2 + L^2{}_2 + C^2) = 0$ Time

(25g) l^{2F}: $\Phi^{[\underline{i}ndiv\text{-}2]\underline{F}ood} = F^{2F}([\Lambda^2{}_2, L^2{}_2], Q^{2A}) + \Delta Q^{2F} - a^2 C^2 = 0$ Food

(25h) l^{2E}: $\Phi^{[\underline{i}ndiv\text{-}2]\underline{E}xch} = \underline{P}\, Q^{2A} + \Delta Q^{2F} = 0$ Exchange

As before, an exchange constraint must be recognized to obtain closure. Accordingly,

$$\Delta Q^{1A} + Q^{2A} = 0$$

For the eighteen unknowns, including the exchange price <u>P</u>, there are an equal number of equations, and the formulation may be solved when properly defined.

To summarize, the preceding formulation represents the expectational plan of two interactive individuals, accounting for a psychologically imposed bias in the expected performance of one the individuals (Agent 2). Each has an expected three-activity regimen for the ensuing day—production, consumption, and rest (not in this order)—but with Agent 1 expectedly limited to making (a food producing) appliance and Agent 2 limited to using the appliance to produce food. Early in the day it is expected that all of the produced appliance will be transferred to Agent 2, with part of the subsequently produced food shared with Agent 1 as compensation. Since neither appliance nor food expectedly survives beyond day 1, no account of day 2 intertemporal experience is recognized in the coordinated expectational planning. In the only mathematical departure from the 2-agent case addressed earlier in the paper, Agent 2 is represented as having a stereotypically biased (reduced) celerity in her rate of food production, mathematically represented by the addition of a celerity factor in the instantaneous-utility function and food-production function (see, e.g., (25a)). While a complete solution will not be obtained herein, the formulation will be used to study the effect of stereotypic bias on the negotiated expectational plan.

Psychology's importance to the development of substantive economic theory has previously been established (WEAI article), and we can now by way of the above formulation begin to accommodate social psychology within this union. In doing so, it may first be observed that "just as we categorize objects, experiences, and other people, *we also categorize ourselves* (Hogg and Abrams 1988, p. 21; see Turner 1981, 1982, 1985; Turner, et. al. 1987)". (Emphasis added.) Furthermore, "…the outcome of this process of self categorization is an accentuation of similarities between self and other ingroupers and differences between self and outgroupers, that is self-stereotyping." In this regard:

> …self-categorization at once accomplishes two things: it causes one to perceive oneself as "identical" to, to have the same social identity as, other members of the category…; and it generates category-congruent behavior.. (Ibid., p. 21)

"*Generates category-congruent behavior*." This is the salient aspect in the present study of the effect of stereotyping on economic behavior and commodity exchange ratio. It is understood that while Agent 2 recognizes her ability to function at a higher level of productivity, she conforms to the stereotypic bias by reducing food production per unit time.[34,35] The task now is to assess the effect of the considered stereotyping on the individual's food production for the day, and the systemically related food versus appliance exchange ratio.

It may first be observed that the decreased food production celerity imposed on Agent 2 not only reduces her food production for the day (see (23b)), but also the amount of appliance produced by Agent 1—a consequence of less food being provided by Agent 2 in trade.[36] Accordingly, both individuals in their cooperative activity experience a diminished welfare due to the stereotypic bias (assuming their behaviors conform to the agreed plan—i.e., no surprises).

Turning to the effect of the celerity bias on the exchange of food for appliance, the first step is to obtain expressions for the corresponding price $\underline{P}$. Following the procedure used in the earlier treatment of the economic interaction of isolated interactive individuals, (24d) and (24e) for Agent 1 are first solved for $\underline{P}$. Then (24a,b,c) allow,

(26)
$$\underline{P} = l^{1A}/l^{1F}$$
$$= \frac{-\underline{\lambda}^1 \{p_L{}^1{}_1(L^1{}_1) - p_R{}^1(R^1)\}/[\partial F^{1A}(L^1{}_1)/\partial L^1{}_1]}{\underline{\lambda}^1 \{p_C{}^1(C^1) - p_R{}^1(R^1)\}/a^1}$$
$$= -\frac{a^1}{\partial F^{1A}(L^1{}_1)/\partial L^1{}_1} \times \frac{p_L{}^1{}_1(L^1{}_1) - p_R{}^1(R^1)}{p_C{}^1(C^1) - p_R{}^1(R^1)}$$

Solving (25d) and (25e) gives $\underline{P}$ in Agent 2 parameters:

(27)
$$\underline{P} = \partial F^{2F}([\Lambda^2{}_2, L^2{}_2], Q^{2A})/\partial Q^{2A}$$

Addressing (27) first, it is recalled that the appliance price in the considered example is simply the marginal productivity of appliance. The immediate intent is to assess the effect of a reduction of Agent 2's celerity $\Lambda^2{}_2$ on the marginal productivity of appliance, and hence on the value of $\underline{P}$. In this regard, it is noted that food production is a function of $L^2{}_2$ and Q^{2A}, in addition to $\Lambda^2{}_2$. (As an aside, this multi-parameter dependency points to an advantage of mathematical expression, to be demonstrated below: The mathematical approach can penetrate complexity to achieve insight.)[37]

In addressing the effect of Agent 2's celerity on the exchange ratio $\underline{P}$, the first step is to express the incremental change of price $\delta\underline{P}$ in terms of an incremental change in celerity $\delta\Lambda^2{}_2$. Equation (27) allows:

$$\delta\underline{P} = [\partial\underline{P}/\partial\Lambda^2{}_2]\,\delta\Lambda^2{}_2 \;=\; \{\overset{[1]}{\partial(\partial F^{2F}/\partial Q^{2A})/\partial\Lambda^2{}_2} + \overset{[2]}{\partial(\partial F^{2F}/\partial Q^{2A})/\partial L^2{}_2\ [\partial L^2{}_2/\partial\Lambda^2{}_2]}$$

$$+ \overset{[3]}{\partial^2 F^{2F}/\partial[Q^{2A}]^2\ [\partial Q^{2A}/\partial\Lambda^2{}_2]}\}\,\delta\Lambda^2{}_2 \quad + \ \text{H.O.T.}$$

Recalling that the marginal productivity of capital (appliance) is positive by definition (increased capital amount increases output), it may be ascertained that :

- Term [1] has positive value:
  Increased celerity increases output;
- Term [2] has negative value:
  The product of positive valued $\partial(\partial F^{2F}/\partial Q^{2A})/\partial L^2{}_2$ (positive effect of increased labor duration on the marginal productivity of appliance) and negatively valued $\partial L^2{}_2/\partial\Lambda^2{}_2$ (increased discomfort attending increased productive effort reduces the effort duration) is positive;
- Term [3] has negative value:
  Diminishing marginal productivity of capital in product with generally increased output (increased food production bringing more appliance in trade) produces a negative result.

Depending on the relative magnitude of term [1] vis-à-vis the sum of [2] and [3], $\underline{P}$ could increase or decrease with the imposed reduction of $\Lambda^2{}_2$. Note that $\underline{P}$ in Agent 1 terms (equation (26)) must, of course, accommodate (for a properly formulated problem).

It is seen from the foregoing how stereotypic bias can affect economic behavior. In the present case this influence entered through the expectational process-of-knowing utility and production functions of one of the interactive agents. In general, of course, all individuals are affected by bias to a finite degree—and the present methodology will accommodate by means of comprehensive formulation. Beyond this consideration is the much greater landscape of social-psychological behavior that the present approach can address. Institutionalized bias, for example, may be represented in the constraints, and P-O-N instantaneous utility can acknowledge prejudicial attitude. Furthermore, because the approach is substantively temporal, the evolution of intragroup and intergroup relations (social psychological, economic, etc.) over time is amenable to representation.

As a note on the general significance of the preceding study, by accommodating stereotypic bias in the economic behavior of interacting agents two advances have been achieved: (1) It has been demonstrated that social psychology is amenable to mathematical formulation; and, arguably of greater importance, (2) Social psychology has been analytically joined or united with economics and the basic human science, psychology. In the latter regard, it does appear that mathematical integration of the human sciences has a transcending character: Whatever benefits or advantages that occur from the mathematical formulation of diverse scientific departments are amplified by their coherent unification within an encompassing mathematical system.

IV. CONCLUSION

While social psychology has been the principle concern of the present contribution, significant attention has been devoted to the economic interaction of two individuals in isolation. This treatment provided the conceptual and mathematical framework for addressing social psychology, and, in particular, the effect of stereotypic bias on the economic performance of the cooperating individuals. Psychology has also been addressed in the form of the canonical emotive equation—the essential basis or foundation for the economic and social psychology studies that followed. The present work, demonstrating an economic effect of stereotypic bias, has initiated mathematical modeling in social psychology by extending thereto the already established formulations within psychology and economics (Chamberlain 1997; 1998).

Just as the laws and theories of physics are instrumental in integrating the diverse branches of the natural sciences, it could be expected that the social sciences will be similarly united. A further development would be the consilience of the natural and human sciences as the interfacial domain is entered from both sides (Wilson 1998). In this regard, quite remarkable advances have been made in recent years in the empirical investigation of brain function—e.g., the measurement of pleasure (Rolls 1975); the essential role of feeling in supporting cognitive function (Damasio 1994; Bechara, et. al. 1997); and the measurement of intention (Snyder, et. al. 1997). These advances impart an empirical basis, and hence scientific character, to the presently offered formulation of the individual's expectational plan—the *emotive equation*. Inasmuch as this basically psychological theory, with established applications in economics and social psychology, has received empirical attributes from the natural sciences, it could be concluded that a connection across the interfacial domain between the human and natural sciences has been realized.

NOTES

[1] Menger "attributed"—i.e., imputed—"importance" to consumables based on benefit to "our lives and well-being (Ibid., p. 152)". "Goods of higher order," i.e. factors of production, then acquired utility by further imputation. By initially imputing utility (importance) only to consumables, Menger made, in effect, a direct assignment. This focus on consumption as the salient consideration in economics reflected a prominent philosophical perspective of the time: "..the theory of Economics must begin with a correct theory of consumption (Jevons 1971, p. 40)".

[2] Prominent in this regard is the exogenous determination of preferences explicit in Walras's equilibrium theory (a consequence of his consumable-based utility theory). The opposite is true—preferences, as noted in this article, are expectational-plan dependent, i.e. endogenously determined.

[3] However, consistent with present theory, movement towards the endogenous determination of preferences is in progress. (See Bowles 1998; Hodgson 1998; Rabin 1998). In this regard, there have been attempts in recent years to modify standard utility theory to accommodate endogenous preferences—"childhood and other experiences, social interactions, and cultural influences (Becker 1996, p. 3)". However, a (time independent) meta-preference function is assumed, so the approach cannot be considered substantive (See also Hodgson 1998, p. 8fn).

[4] Refer to the appendix in the WEAI paper (Chamberlain 1997).

[5] It may be of interest that a copy of Gossen's book (1983) was not acquired until November 1994, after completion of the theory in 1993. The conviction that utility should be originally and exclusively identified with the process of knowing attending mental and physical activity was realized in September 1991. The writer first became aware of Gossen's work in Georgescu-Roegen's "UTILITY" in the *International Encyclopedia of the Social Sciences* (1968) in April 1989.

[6] The present treatment of the two production function model of capital is a contraction of the more comprehensive study presented at the WEAI conference in 1997 (Chamberlain 1997).

[7] The discussion of the emotive equation is largely taken from a paper presented at the 1997 WEAI annual conference in Seattle (Chamberlain 1997). A derivation from the basic principle P=dU/dt and essential concepts was presented at the AAAS conference (Pacific Division) in 1998 June (Chamberlain 1998). The reader may also refer to articles and discussions posted on the Internet during ‘95-’96, if available.

[8] The definition of expectation may be stated as follows: An expected experience is imagined—“without a sense of unrealism (Shackle (1958) 1967, p. 41-42)"—as it would actually be experienced. Regarding the relationship between expectation and surprise, if an actual, i.e. real-time, occurrence causes surprise, then the occurrence was

categorically absent from the individual's expectation; Alternatively, if the individual can state with a sense of realism that an occurrence did not cause surprise, then the occurrence was encompassed by the individual's expectation.

[9] The writer recognizes the modern understanding of (subjective) uncertainty, wherein "…each individual is able to represent his *beliefs* as to the likelihood of different states of the world (e.g., as to whether Nature will choose rain or shine) by a "subjective" probability distribution (Fisher 1912, ch. 16; Savage 1954). That is, an assignment to each state of a number between zero and one (end-points not excluded) whose sum equals unity. Subjective certainty would be represented by attaching the full probabilistic weight of unity to only one of the outcomes. The degree of subjective uncertainty is reflected in the dispersion of probability weights over the possible states (Hirshleifer 1989, p. 15)".

[10] An alternative formulation of the emotive equation exhibits Lagrange multiplier terms (See equation (7)). Multiplier terms are each of zero-value at the solution point, and hence have no effect on the objective function or solution. The advantage in appending multiplier terms to the objective function is that this highlights the considerable "suitability" of the Lagrangian method for modeling *sensibly periodic* economic behavior. In this regard, the multipliers are germane to the *marginal* valuation of certain types of entities throughout the intertemporal period (i.e., entities—such as sugar, salt, and water—that are, in effect, infinitely divisible).

[11] Strotz (1956, p. 173] understood that "To-day it will be rational for a man to jettison his optimal plan of yesterday, not because his tastes have changed, but because today he is a different person with a new discount function—the old one shifted forward in time." (Emphasis added.) The present writer disagrees. It is understood that the individual who recognizes the potential "intertemporal tussle" in his expectational calculus will, with his *sense of realism* (Shackle (1958) 1967, p. 41-42), prepare an expectational plan that recognizes or accommodates the forward shifting of the discount function. (Otherwise the individual could prepare an expected activity scenario that he or she knows will not be followed—i.e., a plan prepared without the requisite sense of realism.)

[12] It is understood that P and λ have functional dependencies (in addition to imaginary time)—e.g., one's health or emotional state—and learned factors—e.g., experienced pleasure/pain, and knowledge imparted by education and advertising. Note that while diverse parameters may enter the integrand functions, the integrand is exclusively additive with respect to imaginary time—in particular, the additive dependence does not extend to consumables, as has been erroneously postulated in standard theory.

[13] This postulate extends the work of Shackle ((1958) 1967, p. 41-42). It is noteworthy that the supporting theoretical contribution of Ehrenfels ((1896) 1982; see Fabian and Simon 1986, p. 72-74), along with the empirical/theoretical contributions of Damasio (1994) and Bechara (1997), were not obtained until after finalization of the emotive equation, including the emotive mapping function.

[14] It is recognized that subjective probabilities can always be assigned to conceivable events. (See Vriend 1995, p. 267.)

[15] The worldline here corresponds to the world line in physics. However, whereas the latter refers to the geodesic curve through space-time per se, in the present work the worldline is understood to be a locus of points through expectational-plan parameter space, including space-time. At the time of plan origination all worldlines are coincident, and those that haven't been extinguished by the advance of real-time into the future—such being due to real-time's inexorable eclipsing of expectational uncertainty—remain coincident. The worldline ensemble for a given expectational plan is seen, therefore, to resemble an (infinitesimally thin) tree, where all worldlines expectedly divide, like branches, with height (imaginary time) above the ground.

[16] The footfalls along one expectational worldline of a great trek can differentially depart from those of another worldline. Attention to this level of detail permits the canonical formulation, on which basis analyses and modeling can be fruitfully developed.

[17] An internet correspondent noted that "..the subjective a priori probability belief (the "prior") in a Bayesian formulation is a natural fit to your approach since it combines experience (frequency) with intuition (subjective expectation), plus learning". It can be added that the present approach goes beyond traditional Bayesian theory in that it accommodates or recognizes that "other factors than utilities of outcomes determine the value of the alternatives (Gardenfors and Sahlin 1988, p. 14)".

[18] Expectational uncertainty—and surprise—attending interaction with other conscious agents is accommodated by the theory.

[19] It is in this sense that nature, exclusive of the individual's judgment, determines how expectational uncertainty is extinguished with the advance of real time. (The individual retains, however, his or her *creativity*—occasioning, thereby, surprise, and new plans—and so avoids an automaton-like existence.)

[20] The approach has been employed to mathematically demonstrate, as original contributions, how expectation serves to determine the rate of real (i.e., non-monetary) interest—this being accomplished for two historically prominent models of capital: the two production function model (Lange 1936), and the costless conversion model (introduced by Clark (1899); see also Solow (1965, p. 28-31)). The effect of expectation on economic growth for a prescribed real interest rate has also been demonstrated (crusonia plant model (Jevons 1871); see also Knight (1944)). These advances were presented on the internet in 1996. The two production function model of capital was further developed in the WEAI paper.

[21] In addition to the developing research programs involving the neural-electrical measurements of intention (planning; see Snyder, et. al. 1997) and the neurobiological relationship between feeling and practical thought/behavior (Damasio 1994), one can employ the theory to predict (infer) and correlate intentional activity of humans and animals under controlled conditions.

[22] Menger first, however, imputed utility exclusively to consumables and then to "goods of higher order," whereas in the present approach all entities receive imputed utility (or, more fundamentally, anticipatory pleasure) on an equal basis. Regarding Gossen, his method of imputing the utility of consumption to a product, in conjunction with the corresponding utility/disutility in its production (Ch. 2), is not in accord with the present approach.

[23] Note that the entity—and eye, for example—can belong to someone other than the individual forming the expectational plans. In this case, the value of the entity, on an empathetic basis or otherwise, is similarly determined.

[24] In standard theory, utility is not uncommonly identified with consumables on the consumption side—ignoring consumption activity—and with the P-O-N of labor activity on the production side. This arrangement is conceptually and mathematically (dimensionally) inconsistent.

[25] This model departs from Lange's in several respects, including: (1) the production of a (assumed infinitely divisible) farming appliance as capital instead of axes; (2) the production of food rather than wood as the finished product; and (3) the addition of two activities—food consumption and rest. The present model also accounts for the individual's expectational calculus, which was not addressed in Lange's treatment.

[26] It is noted that λ was unnecessarily replaced by M in the WEAI paper (Chamberlain 1997). In the present work and the AAAS paper, λ is retained.

[27] The "nested" index convention—e.g. $\langle L_{wd1}\rangle^{I}_{k}$ and, later, $\langle pL_1(t)\rangle^{I}_{kwd}$—has been introduced (invented) to deal with the considerable diversity of economic parameters.

[28] In general the partial derivative would be employed, e.g. $\partial pL_{1i}/\partial t<0$, reflecting the multi-parameter dependency of the pleasure function. In the present simplified case, (imaginary) time is the only parameter in the argument, and the ordinary derivative is used.

[29] Any activity of the individual may be explicitly modeled in the present methodology. It is advantageous, however, to represent only the salient activities of the considered problem.

[30] Standard theory has struggled to understand price determination since Walras's general equilibrium theory (Walras 1874-77). Of course, in response to changes in market prices people change their economic plans. This, in turn, changes the utility (or, more fundamentally, anticipatory pleasure) imputed to commodities—consumables and factors alike. Standard theory short-circuits this process by directly assigning utility to consumables.

[31] Note that the amount of appliance Q^{1A} is implicit in the formulation, as will also be the case for the amount of food Q^{2F} in the Agent 2 formulation.

[32] In an analogous case, an experiment by Bruner and Goodman (1947) demonstrated that subjects erroneously identified greater sizes with higher valued coins, and conversely.

[33] Of course, it may be that the food production activity is sufficiently demanding that the smaller person must, realistically, have a lower productivity (than, say, agent 1 would have). Of interest in the present treatment, however, is a psychologically imposed lower level of food production per unit time.

[34] The self-categorization process within the social context could be of such character as to cause the individual to subliminally discount abilities. From the analytical perspective, this condition would be represented by the interactive individuals formulation of Section IIIa.

[35] For Λ^2_2 having the nominal value of 1 (say) in the absence of bias, $F^{2F}([\Lambda^2_2=1,\ L^2_2],\ Q^{2A})$ of the present formulation has the same functional dependence on L^2_2 and Q^{2A} as $F^{2F}(L^2_2,\ Q^{2A})$ of the earlier study of the economic

system of two-interactives (zero bias assumed). The effect of the considered mode of stereotyping is, then, to cause Agent 2 to reduce $\Lambda^2{}_2$ below 1 thereby effecting a lower expected productive celerity.

[36] It is assumed here that the increased duration of food-production effort attending the diminished labor displeasure is relatively ineffective—i.e., it does not produce a net increase in produced food.

[37] Another demonstration of the value of the substantive mathematical approach in *human science* was provided in the WEAI paper (Chamberlain 1997), wherein the effects of subjective uncertainty, emotive discounting, and liquidity preference on expectational planning were formulated.

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