FUNCTIONS OF FAST REFLEXION IN BIPOLAR CHOICE

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INTRODUCTION

Our view of "reflexion" has been essentially broadened during the last twenty years. Traditionally we have considered it to consist of the conscious constructing of images of the self and others by human beings. Now we have evidence that there is a reflexion of another nature as well. It is as if an inborn informational processor is built in into human psyche whose function is to *automatically* create these images together with their subjective domains. This processor generates a specific specter of human responses not controlled consciously and running extremely fast (one-two milliseconds). This type of reflexion, as distinct from the traditional concept is called *fast reflexion* (Lefebvre, 1987). In this paper we will decipher the mathematical laws governing the automatic functioning of this inborn processor and show how they reveal themselves in human behavior (Adams-Webber, 1996a). The result of this analysis will be a formal model of the subject with fast reflexion.

Ideally, global theoretical models ought to possess two properties: integrity and uniformity. Integrity means that the model must be able to reflect simultaneously the subject's perception, behavior, and inner domain. Uniformity requires that different aspects of the subject's activity must be described in terms of the same theoretical language. The general method for attaining these two properties is to represent the subject as a *composition of mathematical functions*. Various elements of this composition are interpreted as "inputs" and "outputs" and as images of the self and of other subjects. These images can have their own inner domain containing images of the next order. As a result, we succeed in producing a unified functional description of the subject's inner and external activity. A composition of mathematical functions is also a function. It describes the subject's behavior. Therefore, the composition's structure reflects not only the subject's inner domain, but also the macrostructure of a computational process generating behavior. In the simplest cases, when the "global" function of behavior is known in advance, information about the mental domain can be obtained from a purely mathematical analysis of the properties of the function.

INTRODUCTION OF THE CONCEPT OF REFLEXION INTO PSYCHOLOGY

It is no accident that early steps in this direction were taken in Russia, where the dominance of behaviorism has been historically less oppressive than in America. These preliminary steps were related to a discovery of a sudden interruption of subjects' automatized processes in experimental games. Typical laboratory experiments included two phases. In the first phase, a computer program playing the role of an opponent "taught" subjects a particular mode of behavior which was advantageous for them. Then, in the second phase, the program suddenly changed its tactics in such a way that the same mode of behavior became disadvantageous. In these experiments, it was discovered that the subjects would alter their behavior abruptly. No evidence of gradual retraining was observed (Lefebvre, 1967; 1969; 1972; 1977a; Baranov & Trudoliubov, 1969a,b; Lepsky, 1969).

The abrupt change from a previous automatized activity was often accompanied by some "insight" or "realization": the subjects suddenly "understood" that their opponent had, during the first phase of the experiment, deliberately misled them. Under this operational interpretation, the concept of "realization" acquired a functional meaning. It was believed to be connected, if not with the reorganization of human automatized activity, then at least with its instant blocking. Nonetheless, the use of terms such as "realization," "understanding," "intention," whose meanings depend significantly on the context, threatened a return to pre-behaviorist "mentalism" and abandonment of the commitment to the scientific falsification of hypotheses.

An alternative approach was to construct simple formal models of subjects in the framework of which concepts reflecting the human subjective domain could acquire clear and unambiguous meaning. This approach led to the construction of several particular models of the subject with reflexion. In this paper we shall limit our consideration to one line of the development of such models associated with studying the bipolar choice (Lefebvre, 1977b; 1980; 1982; 1992; V.A.Lefebvre, V.D.Lefebvre, Adams-Webber, 1986; Krylov, 1994; Miller & Sulcoski, 1999). This theoretical model gave rise to many new methodological problems which have been addressed in an extensive literature (Adams-Webber, 1987; 1995; Batchelder, 1987; Kauffman, 1990; Lefebvre, 1987; 1995; Levitin, 1987; Popper, 1992; Rapoport, 1990; Schreider, 1994; 1998; Townsend, 1983; 1990; Wheeler, 1987; Zajonc, 1987).

MECHANISM FOR GENERATING IMAGES OF THE SELF AND OTHERS

The hypothesis of existence of the inner processor for generating fast reflexion can be described as follows (Lefebvre, 1985):

(1) A person possesses an inner formal mechanism for modeling the self and others. This mechanism is universal and does not depend on the particular culture to which a person belongs.

(2) The models of the self and other are reflexive; that is, these models may themselves contain models of the self and other, and so on.

(3) The inner formal mechanism for modeling includes a computational process, which is automatic and does not depend on conscious will. This process predetermines a person's responses in a situation of choice between "good" and "bad", and it also generates his inner feelings, such as guilt and condemnation.

(4) The models of the self and of the other also have this computational ability, which allows a person to model automatically his own and his partner's inner feelings, providing information that is unavailable to direct observation.

Let us mention further that this human modeling mechanism is not a chain of verbal reasoning such as "I think that he thinks that I think," etc. Such chains are purely linguistic structures. In contrast, we are concerned with the direct computational modeling of the self and other which proceeds automatically and independently of inner speech (Lefebvre, 1985, pp.291-292.)

This hypothesis was published sixteen years ago as more than a methodological declaration. It contained a detailed description of a possible mechanism for cognitive computations; however, experimental evidence in its favor began to appear only recently. For example, Hughes and Cutting (1999) demonstrated that children's ability to reproduce other persons' inner domains operates automatically and does not depend on verbal development.

The mechanism for the automated generation of images of the self and others described in this section lies outside the framework of the traditional understanding of reflexion as a human conscious constructive activity connected with his will and desire. While constructing one's own image consciously a person may provide it with many features of his own choice. Unlike this "creative" activity, the processor under consideration is inseparable from the human being itself. The subject in a normal state does not sense its presence. One cannot eliminate the control of this processor by an effort of will, which is similar to the impossibility of intentionally ceasing to understand words in one's own native language. We have called the automatic process of generating the images *fast reflexion*, in order to avoid confusion with a conscious process of comprehending the self and others.

REFLEXIVE MODEL OF BIPOLAR CHOICE

The model represents a subject facing the choice between two alternatives, A and B. One of them, A, plays the role of the positive pole, and the other that of the negative pole (Lefebvre, 1977b; 1980; 1995; 1997). In the simplest case, when the subject's inner world does not contain the images of other subjects, his choice can be described by the function $X_1=f(x_1,x_2,x_3)$, where all variables take their values from the interval [0,1] (see Appendix). The value of x_3 is the subject's *intention* to choose the positive pole. The greater x_3, the more the "desire" to make this choice. The value of X_1 is interpreted as the *probability* with which the subject is *ready* to choose the positive pole, A, in reality. The value of x_1 is the world's *pressure* toward the positive alternative A at the *precise moment* of choice. The value of x_2 is the world's *pressure* toward A which is *expected* by the subject based on prior experience. We can consider the values of x_1 and $(1\text{-}x_1)$ as normalized utility-measures of the alternatives A and B at the moment of choice, and the values of x_2 and $(1\text{-}x_2)$ as normalized expected utility-measures.

A mathematical analysis of the function $X_1=f(x_1,x_2,x_3)$ of three variables demonstrates that it can be represented as a composition of one particular function of two variables, $F(x,y)$, and that such a representation is unique; that is, $X_1=F(x_1,F(x_2,x_3))$. Function $X_2=F(x_2,x_3)$ is interpreted as the *image of the self* possessed by the subject. Under this interpretation the subject has a functionally correct image of the self, since the same function, $F(x,y)$, describes him from both his own perspective and external points of view. The first variable in this function, x, represents perceptual input, and the second variable, y, is a mental image of the self. Therefore, in considering the function $F(x_2,x_3)$, which plays the role of an image of the self, we have to interpret the variable x_2 as an image of the input, and the variable x_3 as the subject's mental representation of his image's image of the self. To avoid confusion, we call this secondary image a *model of the self*. The variable x_3 now takes on an additional meaning: it represents not only the subject's intention, but also his model of the self. As a result we obtain a formal analogue of the macro-structure of the subject's inner domain. This analogue is a structure of composition $F(x_1,F(x_2,x_3))$. At the same time, this structure describes the process involved in the cognitive computation of X_1: first, $X_2=F(x_2,x_3)$ is computed, and then $X_1=F(x_1,X_2)$.

The subject's intention may depend on factors distinct from x_1 and x_2, and, in principle, can take on any value from [0,1]. In cases in which the intention depends only on x_1 and x_2, we assume that the subject's cognitive mechanism coordinates both the subjective intention, x_3, and an objective readiness, X_1, in such a way that $X_1=x_3$ (Lefebvre, 1992). This equation corresponds to the statement that the subject has a correct model of the self.

FUNCTIONAL ROLE OF THE IMAGE OF THE SELF

Theoretical models may assist in conducting thought experiments. With the help of such an experiment we will clarify the role which the subject's image of the self plays in his activity. Let the subject face a moral choice. In his value system, alternative A is a good act, and alternative B a bad one. Suppose that on the basis of the previous experience the subject sees the world as pressing him toward choosing the positive pole, that is, $x_2=1$. Let the subject have the intention of choosing the positive pole, that is, $x_3=1$. With these data we find the value of the image of the self: $X_2=F(1,1)=1$ (see Appendix). Thus, the subject "sees" himself performing a good deed. Suppose that at the moment of choice, the world exerts pressure on the subject to choose the negative pole, which means $x_1=0$. Then the subject's real choice will correspond to the value of the function $X_1=F(0,F(1,1))=0$, i.e., in reality the subject carries out a bad action. The next time a similar situation arises, the subject will expect the world to press him toward the negative pole, which means that the value of x_2 is changed from 1 to 0. If the subject's intention is still positive ($x_3=1$), the value of his image of the self becomes $X_2=F(0,1)=0$, and if the world keeps pressing toward a bad action ($x_1=0$), his real choice will correspond to the value $X_1=F(0,F(0,1))=1$, that is, the subject will choose the positive pole. In the first case, the subject sees himself as "good" but commits a bad action ($X_1=0$); in the second case, the subject sees himself as "bad" but performs a good action ($X_1=1$). The image of the self plays the role the subject's "conscience": seeing oneself as "bad" prevents one from choosing the negative pole. It follows from the formal model that when the value of $X_2=0$, then the value of X_1 / 1. Therefore, a possible function of the image of the self is to block some of the subject's actions. If at $x_1=0$ the value of an image of the self suddenly changes from $X_2=1$ to $X_2=0$, we can describe this change in standard introspective language as follows: "the world presses the subject toward evil, but the subject imagines himself as being ready to commit a bad act, then feels a prick of conscience and refuses to obey the pressure of the world."

THE DIFFERENCE BETWEEN AUTOMATIZED AND DELIBERATE CHOICE

A distinction between automated and deliberate choice is traditionally based on the notion that a person sometimes consciously plans and then performs an actions as planned, while other times the phase of conscious planning is absent (Bargh & Chartrand, 1999). The reflexive model allows us to make a clear distinction between these two cases: the variable x_3 represents the subject's will (intention, desire); and the variable X_1 represents his behavior. Only behavior which does not depend on a subject's will can be called "automatic"; that is, the value of X_1 does not depend on the value of x_3. Similarly, a subject's behavior can be called "deliberate" only if the identity X_1 / x_3 holds, i.e., it is entirely determined by his will. Finally, mixed cases are possible in which intention x_3 influences X_1, but does not entirely determine it.

AUTOMATIC CHOICE

An automatic choice is possible only in such pairs x_1=*a* and x_2=*b* for which the value of the function $X_1=f(a,b,x_3)$ does not depend on the value of x_3 (see Appendix). As an illustration we will consider an experiment described in Wegner and Wheatley (1999). Their subjects were asked to attempt to read the unconscious muscle movement of a participant confederate whose fingers were placed on top of their own on "yes" and "no" response keys. Then a subject heard a trivial question of the type, "Is the capital of the USA Washington, D.C.?". In reality, the confederate did not hear the questions and so his finger movements could not depend on their content. Nevertheless, the subjects pushed the correct button 87% of the times. In 63% of the cases they thought that they were acting according to their own will, and in 37% they believed that they felt a slight movement of the confederate's fingers. In commenting on this experiment the authors write:

"They answered correctly, in other words, but did not have a strong sense of willfully having done so and instead thought the confederate had played a significant part. The pattern of findings across six experiments suggests that the correct answers are produced automatically." (Wegner & Wheatley, 1999, p.457.)

This conclusion corresponds to the mechanism which is represented in the formal model. Certainly, the majority of the subjects did not have any doubts that Washington, D.C. is the capital of the USA. The pressure of the external world was a social "demand characteristic" directed toward the positive pole "tell the truth," in the given case, "yes," so x_1=1. After the first question the subjects expected the other questions to be of the same type: they anticipated pressure toward true answers; that is, x_2=1. As shown in the Appendix, under such conditions choice is automatic, that is, it does not depend on intention x_3.

DELIBERATE CHOICE

In this case the intention, x_3, predetermines entirely the subject's readiness, X_1. In accordance with the model, this is possible only if both x_1=0 and x_2=0 simultaneously, that is, in the situation in which the world presses the subject to choose the negative pole (x_1=0) and the subject's expectation is the same (x_2=0). Under this condition, X_1 / x_3, that is, any subject's intention turns into his readiness, X_1. At first glance it seems that such a representation of deliberate or "free" choice is bound up with a particular problem, since real people even when they know the correct answers, may exhibit willfulness and answer incorrectly. To clarify this situation we return to Wegner and Weatney's experiment (1999), in which the subjects heard questions of the type, "Is the capital of the USA Washington, D.C.?" As we demonstrated earlier, the correct answers to these questions are automatic. But many social psychologists who conduct surveys encounter subjects' "rebellion," especially during a series of monotonous trivial questions. Doesn't this fact contradict the model's predictions? In fact, the formal model explains the psychological mechanism underlying such rebellion. As we already have demonstrated, in experiments of the Wegner-Weatney type the subject takes on values x_1=1 and x_2=1. Suppose that after he answers a number of trivial questions, his "value system" suddenly changes: the positive pole, the choice of "tell the truth", becomes negative and the negative pole, the choice of "lie," becomes positive. The social imperative "tell the truth" did not disappear, but now it is directed toward the negative pole. A pressure toward the new positive pole is equal to zero. So, x_1=0 and x_2=0, and the subject's choice becomes deliberate. Thus, the inversion of the poles stops the automatic mode of activity.

THE GOLDEN SECTION AND OTHER CONSTANT

An important impetus for the development of this model in the United States was a series of experiments based on bipolar dimensions of judgment represented by pairs of antonymous adjectives (such as strong-weak), within the framework of Kelly's (1955) personal construct theory, summarized by Adams-Webber (1996b). In the early 1970s an unexpected finding was obtained repeatedly (Adams-Webber & Benjafield, 1973; Benjafield & Adams-Webber, 1976): experimental subjects, on average, assigned their personal acquaintances to the positive poles of dimensions with a relative frequency of 0.62. Benjafield and Adams-Webber (1976) conjectured that the theoretical value of this constant might be the golden section ($\frac{\sqrt{5}-1}{2}=0.618\ldots$).

The first attempt to explain the underlying psychological mechanism and specify the conditions for the appearance of the golden section in such experiments was formulated with the help of the reflexive model (Lefebvre, 1985). In accordance with this model, the golden section appears under two conditions:

(1) The subject does not have an operational criterion for determining whether a given object actually possesses the quality the presence of absence of which he must judge.

(2) The act of ascribing this quality to the object plays the role of the positive pole and the act of rejecting it that of the negative pole.

Let us clarify condition (2). It is not important that a given quality is positive or negative in its essence; the important factor is the subject's evaluation of ascribing this quality to the object. For example, suppose someone bought a defective watch; in evaluating this purchase in terms of the construct "failure-success" we have to consider "failure" to be the positive pole and "success" to be the negative pole. To test the model's predictions, we need to analyze data from experiments in which both conditions specified above were satisfied. Several experiments conducted within the framework of the investigation of "mere exposure" (Zajonc, 1968) meet the criterion, especially those requiring subjects to choose between two patterns, one of which had been previously presented with an extremely short exposure time of 1-3 milliseconds (Kunst-Wilson & Zajonc, 1980). As shown in previous experiments, this time is inadequate for the subjects to memorize a pattern consciously, however, the "old" alternative, that is the one shown previously, was chosen by the subjects more often (Kunst-Wilson & Zajonc, 1980). We might reason that the prior exposure of patterns orients the pairs shown in the second phase of these experiments. Each "old" pattern assumes the role of the positive alternative, and its "new" counterpart that of the negative alternative. If we take this assumption into consideration, then in accordance with the reflexive model, the "old" alternative must be chosen not just "more often," but with the relative frequency of 0.62. We analyzed all of the available data from similar experiments (Lefebvre, 1995) and obtained the following results:

Kunst-Wilson & Zajonc (1980)	0.60;
Seamon, Brody & Kanff (1983)	0.61;
Mandler, Nakamura & Van Zandt (1987)	0.62;
Bonano & Stillings (1986)	0.66, 0.63, 0.62, 0.61, 0.63, 0.62.

The last line contains six results because the authors conducted six independent experiments. We see that the data cluster around the value 0.62, which is exactly what the reflexive model predicts.

The reflexive model yields numerical predictions also for cases in which, prior to the beginning of an experiment, the subjects develop the intention to evaluate objects only positively or only negatively. In the first case, x_3=1, and the model predicts that the subjects will make positive evaluations with the probability X_1=2/3; in the second case, x_3=0, the model predicts that the probability of positive evaluations be X_1=1/2.

Special experiments with bipolar constructs in which the subjects' intentions were determined, have shown that with positive intentions the frequency of choosing positive adjectives was equal to 0.67; and with negative intentions this frequency was 0.5 (Adams-Webber, 1997; Adams-Webber & Rodney, 1983). Therefore, the reflexive model also passed this test.

CONCLUSION

We have described and analyzed the simplest possible model of the subject with fast reflexion, which does not contain images of others. In more complicated models, the analysis begins not by writing a function describing the subject's choice, but by constructing a reflexive structure as a basis for the function describing behavior.

It is important to keep in mind that reflexive models are not limited to the analysis of the subject's fixed states. From the very beginning of the development of the reflexive approach, it has employed *dynamic models* (Lefebvre, Baranov, and Lepsky, 1969), which are now widely used in modeling various psychological phenomena (see Barton, 1994; Kelso, 1995). A recent use of the dynamic model of the reflexive subject has led to the hypothesis that one of the fundamental functions of self-awareness consists of fighting against chaos, which appears in the series of sequential cognitive computations (Lefebvre, 1999, 2001).

Finally, mathematical methods have been used successfully in modeling behavior, memory, learning, perception, and thinking. Their use in constructing models of a subject capable of being aware of the self and performing deliberate actions is a natural direction for the development of psychology.

APPENDIX

1. The Main Equation

The function $X_1=f(x_1,x_2,x_3)$, which describes the subject's readiness to choose the positive pole, is

$$X_1 = x_1 + (1 - x_1)(1 - x_2)x_3, \tag{1}$$

where $x_1,x_2,x_3 \in [0,1]$ (Lefebvre, 1991; 1992b).

2. A Theorem on Reflexion

The functional equation $K(x_1,K(x_2,x_3)) = x_1+(1-x_1)(1-x_2)x_3$, where x_1,x_2,x_3 are any numbers from [0,1] and all values of $K(x_2,x_3)$ belong to [0,1] has only one solution: $K(x,y) = 1-y+xy=F(x,y)$ (the proof is given in Lefebvre, 1992). It follows from this theorem that the subject can be represented as

$$X_1 = F(x_1,F(x_2,x_3)). \tag{2}$$

The following function corresponds to the image of the self:

$$X_2 = F(x_2,x_3) = 1 - x_3 + x_2x_3 . \tag{3}$$

3. The Correct Model of the Self

Correctness means that $X_1=x_3$. It follows from (1) that the following function corresponds to the subject with the correct model of the self:

$$X_1 = \begin{cases} \dfrac{x_1}{x_1 + x_2 - x\ x_2}, & \text{if } x_1 + x_2 > 0 \\ \text{any number from } [0,1], & \text{if } x_1=0 \text{ and } x_2=0\ . \end{cases} \qquad (4)$$

4. Automatic Choice

A choice is called *automatic*, if the values $x_1=a$, $x_2=b$ are such that $f(a,b,x_3) / \text{const}$, where x_3 is any number from [0,1]. It follows from (1) that choice is automatic if at least one of the variables (x_1,x_2) is equal to 1.

5. Deliberate Choice

A choice is called *deliberate*, if the values $x_1=a$, $x_2=b$ are such that function $f(a,b,x_3) / x_3$, where x_3 is any number from [0,1]. It follows from (1) that the choice is deliberate only if $x_1=x_2=0$.

6. Golden Section and Other Constants

We assume that (a) the world's pressure toward the positive and negative poles is the same, $x_1=1/2$; (b) the subject's expectation of the pressure toward the positive pole is equal to his readiness to choose it, $x_2=X_1$. It follows from (1) that under these conditions

$$X_1 = \frac{1+x_3}{2+x_3}\ . \qquad (5)$$

If the subject's intention has not been determined in advance, the subject has a correct model of the self, $X_1=x_3$; then (5) transforms into the equation $X_1^2+X_1-1=0$, whose solution is $\frac{\sqrt{5}-1}{2}=0.618\ldots$ If the subject's intention has been predetermined, $X_1=2/3$ at $x_3=1$, and $X_1=1/2$ at $x_3=0$, as follows from (5).

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