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A Cognitive Model for the Red Baron: a Perspective Taking into Account Emotions

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Abstract
Emotions play an important role in the decision making process, as coherent behavior is impossible if they are not considered as a basic element in that process. In this paper we develop a cognitive model that takes into consideration the emotions of a fighter pilot and how they relate to specific behavioral actions of the Red Baron in combat situations. To accomplish this we follow a procedure in order to get a cognitive model. We implement a cognitive structure of emotions based on the theory of Ortony, Clore, and Collins, in order to create the emotional model. Finally, the two models, cognitive and emotional, are combined in a single model, which we will call the EmoCog model. In the last part, we present a representation of knowledge using fuzzy cognitive maps. This representation permits a validation of the EmoCog model, using hypothetical scenarios that simulate the Red Baron's behavior in combat situations. The principal goal is get a model that can include emotions like part of the environment evaluation. Later make possible the inclusion of emotions in the decision making-process.

Keywords: *emotions; decision making process, fuzzy cognitive maps, cognitive model, behavior cognitive task analysis.*

1. Introduction
According to Ortony, Clore, and Collins [10], emotion is one of the central and omnipresent aspects of human experience. Normal people experience a wide range of emotions, from the calm satisfaction of completing a relatively trivial task to mourning the death of a loved one.

Moreover, while emotions add color, depth, and richness to humane experience, they can also cause spectacular rifts between judgment and action. Such rifts can have profound, and sometimes terrible, consequences for individuals and society such as crimes of passion, suicide, and mental illness.

Emotion is a relatively short lasting affective state of synchronized responses based on an assessment of internal or external events. Emotions are balanced affective states focused on: events, agents, or objects. Emotions are real and intense, and originate in cognitive interpretations imposed on external reality, and not directly from reality per se, for which reason, contrary to widespread belief, these authors see emotions as having an essential and profound cognitive foundation.

Until quite recently, emotions were not considered by investigators in the decision making process. Decision making process was seen as a cognitive process, a matter of estimating which of several alternative courses of action offered the greatest positive consequences. In recent years we have witnessed an explosion of enquiry into the role emotions play in the decision making process. The research conducted has shown that 1) even incidental emotions, in other words those that have no relationship with decision making at the moment in question, are capable of having a significant impact on judgment, and choice; 2) the emotional deficit at a given time, whether natural or experientially induced, can degrade the quality of the decision making process; and 3) the inclusion of emotions in decision making models can increase their explanatory power. Therefore, contemporary research on decision making process is characterized by an intense focus on emotion [9].

Because emotions are a force that plays a fundamental role in human life, they cannot be overlooked when simulating aspects of human behavior, such as the decision making process. Contexts are diverse, and may include: video games or simulators.

Most of the air combat behaviors of the *Red Baron*, whose real name was Manfred Albrecht Freiherr von Richthofen, have been inferred from his book *The Red Fighter Pilot* [14] and the German army's air combat manual from the First World War [1, 11, 13]. Other *Red Baron's* behaviors were inferred from combat narratives by his opponents and comrades in arms. Thus, inspired by the science fiction short story *Wings Out of Shadow* by [12], and in the spirit of replicating his behavior in an unmanned aircraft controlled only by a program that executes air combat behavior simulating the *Red Baron*'s personality. We have been able to analyze and design a behavior to emulate the actions of an artificial fighter pilot. In this paper we describe two of the most representative scenarios of this combat behavior.

The Article is divided as follows. Section ***two*** describes the process of obtaining the cognitive model through its parts, then, in section ***five*** we explain its relationship with the emotional model of the *Red Baron*. Section ***three*** describes the structure of goals based on the mental model of the *Red Baron*. In section ***four*** we describe eighteen elements of the emotional behavior of a pilot in a combat situation and design a causal matrix that connects the related elements. Section ***five*** offers a brief description of the fundamentals of fuzzy cognitive maps, as a means of representing behavior and its relationship with the causal matrix. In section ***six*** we exemplify and interpret two combat scenarios, which we consider the most representative. Finally, we present our conclusions.

2. The cognitive model of The Red Baron

According to [4, 5, 6], cognitive models have been used successfully: 1) to analyze mastery; 2) to model reactive conduct; 3) in solving problems to represent how the novice migrates toward expertise; 4) as part of a comprehensive model which, in addition to learning cognitive abilities, includes affective, motivational, and social skills [8] and 5) in curricular design. Laureano-Cruces, De Arriaga & García-Alegre [4, 5, 6] propose a procedure to develop a cognitive model. Revisiting their methodology, we started by developing a behavior cognitive task analysis (BCTA), the aim of which is to elucidate the components necessary to simulate behaviors. BCTA is a recursive analysis, which proceeds by analyzing the behavioral process involved and taking abilities into consideration; behavior is recursively divided into increasingly specific sub-behaviors. This allows us to more accurately identify its component elements. These sub-behaviors are related to their respective underlying mental models. Structures and processes that interact, make up mental models and the strategies involved, performing each step in the behavior.

The cognitive model was used to formalize behaviors that will represent the actions of the *Red Baron,* and will help us in conducting a more in-depth analysis to identify other elements that may be relevant for affective states. For more information, consult the references cited.

The behavior chosen corresponds to a fighter pilot who searches for, recognizes, and attacks an enemy in a combat scenario. The cognitive model is described below through mental models of the Red Baron's combat behavior (Figures 1-4), and behavioral analysis of its different component actions.

```
BEGIN
    Take off                                      STEP 1
    IF (good weather)
        WHILE (combat situation)
            REPEAT
                Watch flanks                      STEP 2
                Look for enemy                    STEP 3
                Identify enemy                    STEP 4
                IF (at advantage)
                    Frame enemy                   STEP 5
                    IF (there is ammunition)
                        Attack enemy              STEP 6
                    ELSE
                        Attack enemy without weapons   STEP 7
                    ENDIF
                ENDIF
                IF (under enemy attack)
                    Evade enemy                   STEP 8
                ENDIF
            UNTIL (aircraft conditions are not good OR
            Fuel is insufficient OR no good weather)
        ENDWHILE
        Return to base                            STEP 9
        Land                                      STEP 10
    ENDIF
END
```

Figure 1. Mental Model of the Red Baron's Combat Behavior

```
                BLOCK Attack enemy (STEP 6)
BEGIN
    IF (there are enemy aircraft)
        IF (there is a free enemy aircraft)
            Attack enemy aircraft                 STEP 6.1
        ELSE
            Seek enemy aircraft                   STEP 6.2
        ENDIF
    ELSE
        Attack enemy lines on land                STEP 6.3
    ENDIF
END
```

Figure 2. Mental Model of Enemy Attack

```
    BLOCK Attack enemy without weapons (STEP 7)
BEGIN
    IF (there are enemy aircraft)
        IF (there are free enemy aircraft)
            IF (there is an enemy aircraft in range)
                Destroy tail of enemy aircraft        STEP 7.1
            ELSE
                Destroy wings of enemy aircraft       STEP 7.2
            ENDIF
        ENDIF
    ELSE
        Strafing run over enemy lines on land         STEP 7.3
    ENDIF
END
```

Figure 3. Mental Model of Enemy Attack without weapons

```
BLOCK Evade enemy (STEP 8)
BEGIN
  IF (at advantage)
    Inverted loop maneuver           STEP 8.1
    Attack enemy                     STEP 6
  ELSE
    Reduce speed                     STEP 8.2
    Attack enemy without weapons     STEP 7
  ENDIF
END
```

Figure 4. Mental Model of Evading the Enemy

The tables 1-4 show in summary the different BCTAs for the various actions, related to the steps in the mental models. They indicate type of knowledge: factual, conceptual, procedural, strategic, and tactical.

Table 1. Red Baron's combat BCTA

Development Steps	Content Steps
Take off (Step 1)	Procedural
Watch flanks (Step 2)	Procedural & tactical
Look for enemy (Step 3)	Procedural & strategic
Identify enemy (Step 4)	Factual
frame the enemy (Step 5)	Procedural & tactical
Attack enemy (Step 6)	Procedural & tactical
Attack enemy without weapons (Step 7)	Procedural & tactical
Evade enemy (Step 8)	Procedural & tactical
Return to base (Step 1)	Procedural
Land (Step1)	Procedural

Table 2. Attack enemy BCTA

Development Steps	Content Steps
Attack enemy aircraft (Step 6.1)	Procedural
Seek enemy aircraft (Step 6.2)	Procedural
Attack enemy lines on land (Step 6.3)	Procedural

Table 3. Attack enemy without weapons BCTA

Development Steps	Content Steps
Destroy tail of enemy aircraft (Step 7.1)	Procedural
Destroy wings of enemy aircraft (Step 7.2)	Procedural
Strafing run over enemy lines on land (Step 7.3)	Procedural

Table 4. Evading the enemy BCTA

Development Steps	Content Steps
Inverted loop maneuver (Step 8.1)	Procedural
Reduce speed (Step 8.2)	Procedural

The above results serve as a starting point to develop an emotional structure based on goals, to in turn create a cognitive structure that allows us to assign values to them [10].

3. Goal oriented structure using the mental model of The Red Baron

The model of emotional behavior displayed by the *Red Baron* and proposed in this paper is based on the OCC theory [10]. In the following section this theory is explained in general terms, for greater detail consult the reference cited. This theory explains emotional behavior in relation to a macrostructure of valuation of: *goals, norms, and individual attitudes*, based on which we propose an emotional structure that indicates goals and subgoals, as hierarchically related nodes. In this hierarchical and complex structure, the principal goal is *take off* in order to begin the combat behavior. With this in mind we design a *macro-structure of the Red Baron's goals* (Figure 5); that gives the clues to get the principal goal. In other words the last is constituted by partial goals.

The nodes have input and output connections with other nodes, except the nodes at the top and bottom ends. These connections or links establish causal relations from the more specific nodes to the more general nodes. An explanation of the different types of goals is presented below.

Active pursuit goals (A): Goals one wants to have achieved. They include goals of *procurement* that get certain things, *entertainment* goals that seek enjoyment, *instrumental* goals that further the pursuit of other goals, and *crisis* goals that manage crises when goals of *preservation* are threatened.

Goals of *interest* (I): Things one wants to happen. They are not active because one does not believe one can influence them. They include goals of *preservation* (which preserve states).

Filler goals (F): Attainable goals that are not discarded. They include goals of *satisfaction* (that satisfy physiological needs). They are cyclical and routine goals such as eating, sleeping, etc.

The interaction of goals allows goals of *active pursuit to create goals of interest and vice-versa.* Also, they can *create filler goals*.

Goals *I or A* can be achieved: 1) fully, 2) not at all or partially, 3) sometimes only fully or not at all, and 4) other times only partially.

Links may be disjunctive (input) or conjunctive (input and output), and also sufficient (S), which means that when there are several subgoals, it will suffice for one of them to be fulfilled to achieve the goal with greater hierarchy; and necessary (N). Links can also be facilitating (F) or inhibiting (I), which means that they indicate when a goal may facilitate another or the consequences of a goal prevent the fulfillment of another.

The Red Baron's combat situations are basically two: *Attack enemy and Evade enemy*. This structure shows the different goals involved in combat behavior and the different links that indicate the causal flow between them.

For the *Red Baron*, the reason to act was to engage in combat and remain there; consequently, one of the higher level (general) goals is to *continue in combat*, whereas the lower level (specific) goals are represented by minimal conditions to take off and continue in combat: *aircraft in good condition*, *enough fuel* and *good weather*. Figure 5 establishes the macro-structure of the Red Baron's goals, based on the design of the cognitive model obtained in section 2.

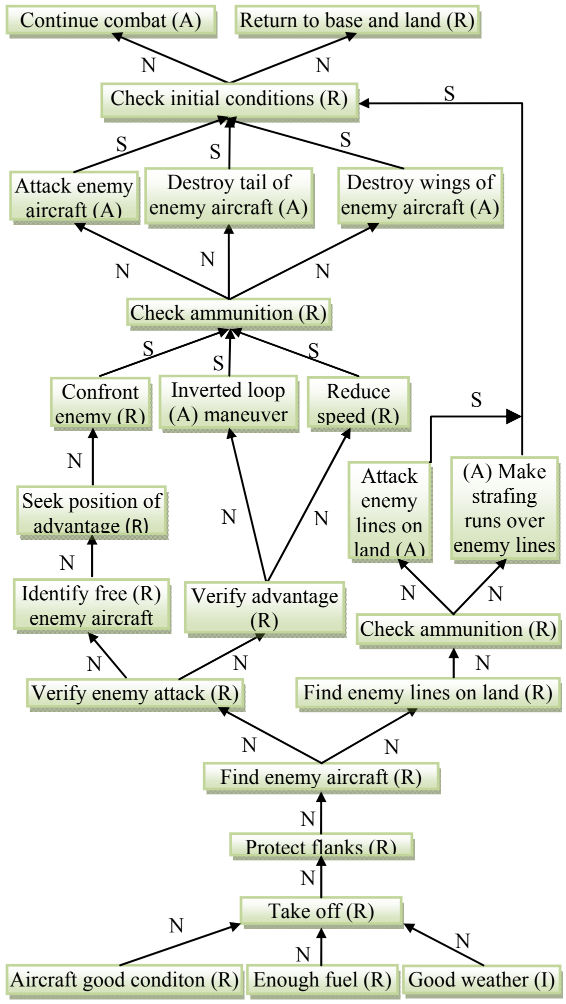

Figure 5. Macrostructure of Red Baron's goals in action

4. Description of the elements of the emotional model of a pilot in a combat situation

Based on the air combat manual and the experience of one of the authors who is a pilot, we extracted the following *eighteen* elements that are part of the emotional model of a pilot in a combat situation [13, 14]. These elements are the emotions we have considered for our EmoCog model.

Emotions that make up the emotional model.

The elements considered necessary in combat behavior are described below, and consist of: emotions and actions-events. With this model we try to emulate the combat behavior, that reacts to the environment events taking into account also the emotions. Their choice is based on a theoretical investigation of the personality of: 1) The *Red Baron,* 2) the air combat manual, and 3) the pilot's supposed psychological state during combat. Also, information was obtained from the experience of one of the authors as a pilot. Based on this analysis we conclude that the following elements can appear: before, during, and at the end of an air combat.

Temerity (1), appears during the combat situation when an enemy attacks the pilot. To some extent, there is an obnubilation of the emotion of self preservation.

Aggressiveness (2), appears during the combat situation when the pilot is attacked by the enemy and tries to defend himself using the available weapons. It is the expected, default response of a fighter pilot.

Self preservation (3), appears during the combat situation when the pilot is attacked by the enemy and tries to defend himself without being injured. This emotion is also activated when the aircraft is damaged and the pilot jumps in a parachute.

Victory (4), appears during the combat situation when the pilot is attacked by the enemy reinforcing self preservation.

Desire (5), appears in the period preceding a combat situation reinforcing anxiety.

Dexterity (6), appears during the combat situation when the pilot is attacked by the enemy and reacts reinforcing aggressiveness and adrenaline as a defense mechanism.

Adrenaline (7), appears during the combat situation then the pilot is attacked by the enemy and responds physiologically to the threat or enemy attack.

Fear (8), appears in the period preceding a combat situation when the pilot does not feel capable to confront the enemy.

Glory (9), appears during the combat situation when the enemy attacks the pilot and reinforcing victory.

Anxiety (10), appears in the period preceding a combat situation when the pilot expects to sight the enemy and engage in combat.

Emotionality (11), appears during the combat situation when the enemy attacks the pilot. Victory and desire are reinforcing. Also appears when the aircraft malfunctions or is damaged and the pilot has to abort the mission.

Self-control (12), appears during the combat situation when the enemy attacks the pilot and desperation is not produced.

Synchronization (13), appears during the combat situation when the enemy attacks the pilot and reacts automatically reinforcing comradeship.

Superiority (14), appears during the combat situation the enemy attacks the pilot and judges him to be less skilled than the pilot.

Comradeship (15), appears during the combat situation when the enemy attacks the pilot and joins with comrades to organize defense.
Abort (16), appears during the combat situation the enemy attacks the pilot and the aircraft malfunctions or is damaged rendering it inoperable.
Error (17), appears during the combat situation when the enemy attacks the pilot and judges his abilities and weaknesses erroneously.
Rebelliousness (18), appears during the combat situation when the enemy attacks the pilot and implements new forms of joining combat; is a symbol of mastery in flight.
Table 5 shows the different relationships between elements of the model of emotions and the different behavioral actions resulting from the CBA (Tables 1-4), in order to interpret the different behaviors (understanding behavior as a combination of different actions) in different scenarios.
After obtaining the EmoCog model of the behavior we want to represent, we need to use a representative technique that takes into consideration the uncertainty inherent in the decision making process implicit in the unfolding of the *Red Baron*'s air combat behavior.
The *fuzzy cognitive maps* introduced by Bart Kosko [2, 3] are chosen precisely for their characteristic of managing uncertainty in complex processes like the decision making process. Also this kind of representation makes possible a parallel and distributed reasoning; where all elements and their reciprocal influence are considered. For more detail consult the references cited [7, 8].

5. Fuzzy cognitive maps

In the field of artificial intelligence, cognitive maps encode knowledge relating to causal events and how it is activated. Modeling cognitive maps using fuzzy logic seems natural, due to the inherent uncertainty found in real world data and knowledge bases. These have been used successfully to model the behavior of expert systems in different topics [7, 8].
Fuzzy cognitive maps (FCMs) are represented by a digraph, in which the nodes are concepts that describe the system's principal characteristics and the arrows between nodes represent causal relationships (positive or negative) between concepts. This graphic representation (Figure 6) illustrates the influence each concept has over the others.
A graphic illustration of an FCM is shown below. The concepts in an FCM are events, whose values change over time. Concepts take values in the interval [0, 1], and the interconnection weights, *pij*, take values in the interval [-1,1]. As the graph shows, the value corresponding to the edge between concepts *i* and *j* is represented by *pij*. Then *pij* = 0 indicates the absence of a relationship between the concepts *i* and *j*, and *pij* > 0 indicates a positive causality, which means that an increase in concept *i* translates into an increase

Table 5. EmoCog model relationships between emotions and behavior

Behavioral concepts	Steps of development	Elements of the emotions model
Take off	STEP 1	Temerity(1), Aggressiveness (2), Victory(4), Desire(5), Adrenaline(7), Anxiety(10)
Verify good weather	Boolean	Self preservation(3)
Combat situation	Boolean	Temerity(1), Aggressiveness(2), Victory(4), Desire(5), Adrenaline(7), Glory(9), Anxiety(10), Synchronization(13), Superiority(14), Comradeship (15)
Identify enemy	STEP 4	Aggressiveness(2), Dexterity(6), Self control(12)
Look for enemy	STEP 3	Temerity(1), Aggressiveness(2), Victory(4), Superiority(14)
Watch flanks	STEP 2	Self preservation(3), Fear(8)
There is no advantage	Boolean	Dexterity(6), Fear(8)
Attack enemy without weapons	STEP 7	Temerity(1), Aggressiveness(2), Victory(4), Glory(9), Superiority(14)
Destroy tail of enemy aircraft	STEP 7.1	Temerity(1), Aggressiveness(2), Adrenaline(7), Emotivity(11)
Destroy wings of enemy aircraft	STEP 7.2	Temerity(1), Aggressiveness(2), Adrenaline(7), Emotivity(11), Superiority(14)
Strafing run over enemy lines on land	STEP 7.3	Temerity(1), Aggressiveness(2), Adrenaline(7), Superiority(14)
There are advantage	Boolean	Superiority(14)
Frame the enemy	STEP 5	Victory(4), Desire(5), Glory(9)
Attack enemy	STEP 6	Synchronization(13), Superiority(14), Comradeship(15)
Attack enemy aircraft	STEP 6.1	Synchronization(13), Superiority(14), Comradeship(15)
Seek enemy aircraft	STEP 6.2	Temerity(1), Aggressiveness(2), Victory(4), Synchronization(13), Superiority(14)
Attack enemy lines on land	STEP 6.3	Temerity(1), Aggressiveness(2), Desire (5), Dexterity(6), Adrenaline(7), Superiority(14), Comradeship(15)
There are enemy attack	Boolean	Self preservation(3), Fear(8), Rebelliousness(18)
Evade the enemy	STEP 8	Temerity(1), Aggressiveness(2), Self preservation(3), Desire (5), Dexterity(6)
Inverted loop maneuver	STEP 8.1	Dexterity(6)
Reduce speed	STEP 8.2	Self preservation(3), Dexterity(6)
Return to base	STEP 9	Victory(4), Self control(12), Abort(16), Error(17)
Land	STEP 10	Victory(4), Abort(16), Error(17), Rebelliousness(18)

in concept *j* or that a reduction in concept *i* translates into a reduction in concept *j*. If *pij* <0, there is a negative causality, which means that an increase in concept *i* produces a reduction in concept *j* or that a reduction in concept *i* produces an increase in concept *j*.

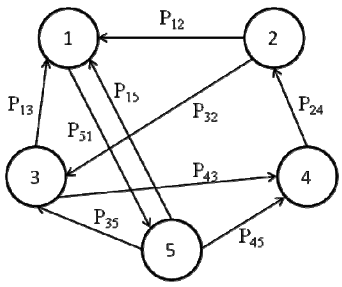

Figure 6. Fuzzy Cognitive Map

In this paper we will refer to FCMs as causal representations between knowledge/data to represent their relationships, and which are also part of events. For example the aggressiveness shown by the *Red Baron* during combat produces a rise in his adrenaline, in the case of other types of knowledge representation this type of causality could not be described due to limitations when attempting to describe relationships of causality.

Causal Matrix

An adjacency matrix, *p*, is used to represent the cause-effect relationships between nodes. The value of each of the concepts at instant *t+1* is determined by the present value of the concept and matrix *p*. One of the forms used most recently to quantify each node's effect on the other elements is as follows:

$$C_i(t+1) = f\left[\ \sum_{k=1}^{n} p_{ki}(t_n)C_k(t_n)\ \right] \qquad (1)$$

Where C_i represents the quantification of the total effect of node *i* (concept *i*) on the other elements, *f* represents a non-linear threshold function applied individually on the components of the product of the matrix. The non-linear function allows us to define the distribution of output values, in other words the FCM is equipped with a self evaluation, in the sense of knowing how well it reasons in relation to the design of links in the adjacency matrix. We must bear in mind that the inclusion of non-linearity sometimes forces the FCM to be recycled through the states.

Various functions can be used as a threshold function. The first proposed was f(x)=max{*lb*, min(1,x)}, where *lb* is the lower limit of the values of the vertices; if the interval of values for the concepts is [0,1] we propose using $f(x) = 1 / (1 + e^{-x})$ or $f(x) = 1 / (1 + e^{-cx})$, where *c* is a positive real number other than 1; *c* = 5 has been suggested, because it is the value that has reported the best results, see [7, 8]. The choice of threshold function depends on the method used to describe the concepts which, as we can see, are two: *the first* introduces two opposite concepts in the same FCM, where the values of the concepts must be in the interval [0,1], where 0 represents the absence of the concept and 1 means the presence of the concept, and *the second*, where the concepts take values in the interval [-1,1], which means that if there is a concept called *decision*, which can take negative values to describe a *wrong decision* and positive values to describe a *correct decision*. Then *f* is a threshold function used to assign the value of the concept in a standardized interval. The proper choice of *f* is also very important, as the choice of *f* affects the system.

The FCM is activated assigning the number 1 to one or more concepts, and is applied iteratively, multiplying the vector by the matrix of causality. If the result is less than -1 or greater than 1, they are standardized to -1 or 1, respectively. A limit state is achieved when: 1) a new state is equal to one already found, 2) a limit of the cycle, 3) when the last states are equal to the others found previously (a pattern of states).

Table 6. Causal matrix of elements that intervene in a combat situation

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0
2	1	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0
3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	-1
4	1	0	0	0	1	0	1	-1	1	0	0	1	1	1	0	-1	-1	0
5	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0
6	0	0	0	0	1	0	0	-1	1	0	0	0	0	0	0	0	0	0
7	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
8	0	0	1	-1	0	-1	-1	0	0	-1	0	0	0	0	0	0	0	0
9	-1	0	0	0	1	0	1	0	-1	0	0	1	1	0	0	0	0	0
10	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
11	0	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0
12	0	0	0	0	1	0	0	0	0	1	0	1	0	1	0	0	0	0
13	-1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0
14	-1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
15	-1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
16	-1	0	1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	1
17	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	1	0
18	1	0	0	-1	0	0	0	0	-1	0	0	0	-1	-1	-1	-1	0	1

In the study case we propose that the cognitive structure of emotions affects the decision making process, which will be reflected in actions, in other words affect the cognitive conduct. This generates a causal matrix for the eighteen elements in the model of emotions, which is related to the different behavioral elements (Table 5). These are the relationships that give meaning to the trial scenarios and allow us to assign an interpretation to the different behaviors.

Table 6 shows the causal matrix corresponding to the eighteen elements mentioned in A of section 4. This table shows the relationships, positive, negative, and neutral, between the eighteen elements.

The graph in Figure 7 shows the causal relationships between the different emotions that a pilot experiences in a combat situation and the Red Baron's combat behavior, which explains the personality *configuration* that made him so efficient.

1.Temerity	7. Adrenaline	13. Synchronization
2.Aggressiveness	8. Fear	14. Superiority
3.Self preservation	9. Glory	15. Comradeship
4.Victory	10. Anxiety	16. Abort
5.Desire	11. Emotionality	17. Error
6.Dexterity	12. Self control	18. Rebelliousness

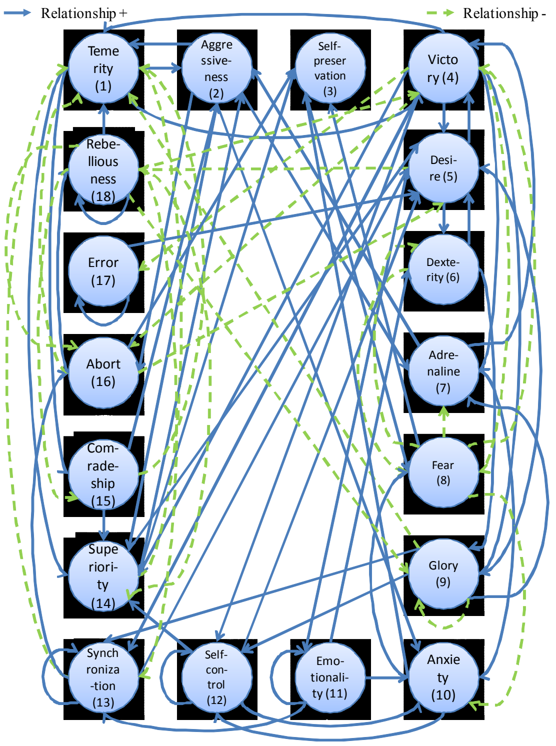

Figure 7. Causal graph of emotional model of a pilot in combat situations

6. Description and interpretation of two possible air combat scenarios for The Red Baron

The next section offers an explanation of the most representative scenarios in a combat situation. The first scenario is represented by Table 7.

Positive behavioral elements activated in the input vector: Temerity(1), Aggressiveness(2), Desire(5), Adrenaline(7), and Superiority(14).

Table 7. Combat scenario without negative behavioral elements

Negative behavioral elements activated in the input vector: [None].

This scenario represents the optimum psychological state of a fighter pilot just before engaging an enemy in combat. It also shows that he has no indisposition to face the enemy.

Positive behavioral elements activated in the output vector: Self preservation(3), Victory(4), Dexterity(6), Anxiety(10), Emotionality (11), Self control(12), Synchronization(13), Superiority(14), and Rebelliousness(18).

The output scenario represents a pilot who has defeated his enemy, with absolute self confidence and a touch of arrogance and satisfaction in having done a good job, who also is difficult to overcome. It shows an ace of aces of the air. The second scenario is represented by Table 8.

Table8. Combat scenario with negative behavioral elements

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	-1	-1	-1	-1	-1	-1	0	1	-1	0	0	-1	-1	-1	0	0	1	0
2	0.9	0.0	0.5	0	0	0.0	0	0.9	0.0	0	0.0	0	0	0	0.0	0.00	0.9	0.9
3	0.9	0.9	0.9	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.5	0.5	0.0	0.5	0.5	0.00	0.9	0.9
4	0.9	0.9	0.9	0.0	0.5	0.1	0.6	0.9	0.0	0.9	0.9	0.9	0.1	0.9	0.6	0.58	0.9	0.4
5	0.0	1	1	0.9	0.9	0.9	0.5	0.9	0.1	0.9	0.9	1	0.9	1	0.9	0.96	0.9	0.5
6	0.0	0.9	1	0.5	1	0.9	0.9	0.6	0.9	0.9	0.9	1	0.9	1	0.0	0.91	0.5	0.9
7	0.0	0.9	1	0.9	1	0.9	0.9	0.9	0.1	1	0.9	1	0.9	0.9	0.0	0.95	0.5	0.9
8	0.3	0.9	1	0.6	1	0.9	0.9	0.6	0.9	1	0.9	1	0.9	0.9	0.0	0.63	0.1	0.9
9	0.0	0.9	1	0.9	1	0.9	0.9	0.8	0.1	1	0.9	1	0.9	0.9	0.0	0.88	0.0	0.9
10	0.3	0.9	1	0.7	1	0.9	0.9	0.5	0.9	1	0.9	1	0.9	0.9	0.0	0.59	0.0	0.9
11	0.0	0.9	1	0.9	1	0.9	0.9	0.8	0.2	1	0.9	1	0.9	0.9	0.0	0.82	0.0	0.9
12	0.3	0.9	1	0.7	1	0.9	0.9	0.5	0.9	1	0.9	1	0.9	0.9	0.0	0.58	0.0	0.9
13	0.0	0.9	1	0.9	1	0.9	0.9	0.7	0.2	1	0.9	1	0.9	0.9	0.0	0.77	0.0	0.9
14	0.3	0.9	1	0.8	1	0.9	0.9	0.5	0.9		0.9	1	0.9	0.9	0.0	0.58	0.0	0.9

Positive behavioral elements activated in the input vector: Fear(8) and Error(17).

Negative behavioral elements activated in the input vector: Temerity(1), Aggressiveness(2), Self preservation(3), Victory(4), Desire(5), Dexterity(6), Glory(9), Self control(12), Synchronization(13), and Superiority(14).

This scenario represents a pilot who is very prone to failure and may not return to his base alive and may die in combat due to the positive behavioral elements activated, with negative elements confirming a deplorable psychological state. A fighter pilot with these psychological characteristics should not be allowed to fly under any circumstances.

Positive behavioral elements activated in the output vector (iteration number 20): Aggressiveness(2), Self preservation(3), Victory(4), Desire(5), Dexterity(6), Adrenaline(7), Glory(9), Anxiety(10), Emotionality(11), Self control(12), Synchronization(13), and Superiority(14) and Rebelliousness (18).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
2	0.5	1	0.9	1	0.9	0.9	0.9	0.5	0.5	0.9	0.9	0.5	0.5	0.9	0.9	0.9	0.5	0.5
3	0.0	1	1	0.9	1	0.9	0.9	0.5	0.9	1	0.9	1	0.9	1	0.5	0.5	0.0	0.9
4	0.0	0.9	1	0.9	1	0.9	0.9	0.5	0.6	1	0.9	1	1	0.9	0.0	0.6	0.0	0.9
5	0.1	0.9	1	0.9	1	0.9	0.9	0.5	0.9	1	0.9	1	0.9	0.9	0.0	0.7	0.0	0.9
6	0.0	0.9	1	0.9	1	0.9	0.9	0.5	0.6	1	0.9	1	1	0.9	0.0	0.6	0.0	0.9

The output scenario represents a pilot who has emerged victorious from his confrontation with the enemy, despite the unfavorable input scenario. This is unquestionably due to his personality configuration. This is what makes this study of the *Red Baron*'s personality truly valuable (Figure 5), given that, based on his biography and prior studies, this configuration of emotions represents the optimum personality to be programmed into an unmanned combat aircraft [12].

7. Conclusions

One of the goals of this paper is to show how actions at a given time are related with emotions and how this example allows us to visualize this phenomenon. We developed an analysis and design of the *Red Baron*'s behavior with emphasis on combat behavior. We have shown that this fighter pilot's personality structure is decisive in his success in two of the most representative air combat scenarios. We have established relationships between emotions and actions. Is very important take into account the expert interpretation of the output vector. The continuation of this line of research, allows for implementation, if possible, in an unmanned fighter aircraft or in a flight simulator or a video game where the gamer can choose the opponent's personality. We have developed software that can use to test this and others causal matrices (http://delfosis.uam.mx/~ana/ You look for it in *docencia* and *inteligencia artificial*)

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