7.9 Statistical differences between experimental and control dog groups

The only statistical significant result in the difference before and after interaction between the experimental and control dog groups, was oxytocin (p = 0,01). The increase in oxytocin was higher in the experimental group where people interacted with their own dogs.

7.10 Physiological changes in humans and dogs

This section is seen as the main support for the hypothesis stated and it also represents the largest number of subjects (n = 36). The previous sections compared owners and non-owners, but this one compares the physiology of positive interspecies interaction in a direct manner, between human and dog. Similar physiological reactions in both species can thus support human-animal theories and if similar to intraspecies physiological changes, supporting those interaction theories, an inclusive interaction theory can be proposed.

7.10.1 Changes in MAP

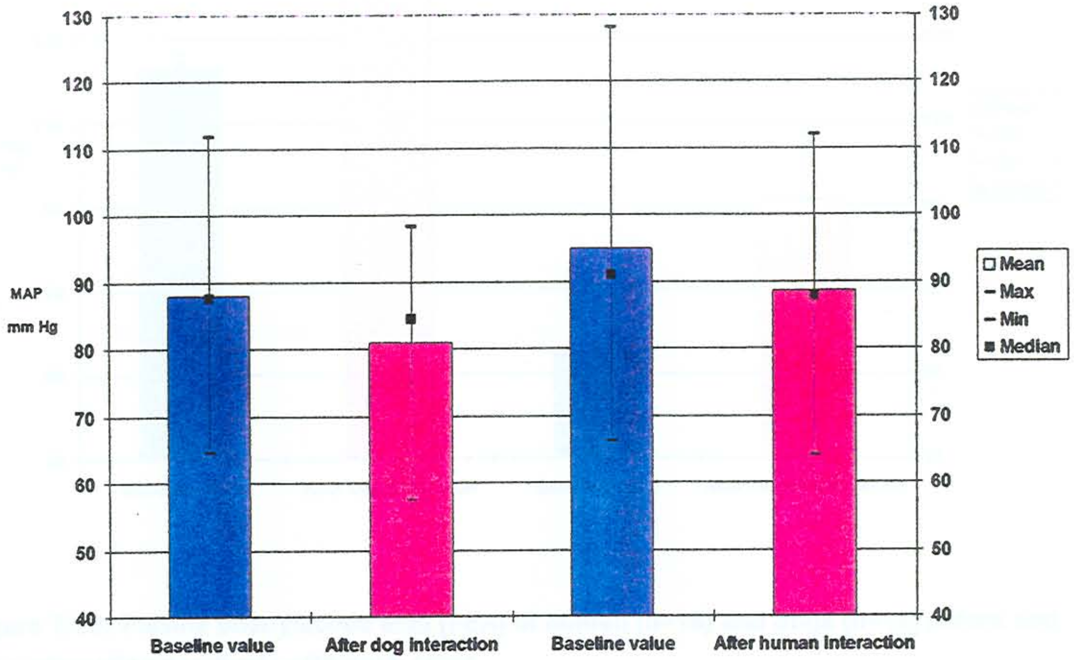

Figure 7.17: Mean arterial blood pressure (MAP) of humans (n = 18) and dogs (n = 18) before and after interacting positively with each other

Table 7.20: Mean arterial blood pressure (mmHg/ℓ) of humans (n = 18) and dogs (n = 18) interacting positively with each other

MAP (humans)	Before	After	p-value	MAP (dogs)	Before	After	p-value
Mean	87,9	80,9	-	Mean	94,8	88,6	-
Standard deviation	12,7	11,8	-	Standard deviation	18,4	15,2	-
Median	87,6	84,4	-	Median	91,0	87,7	-
Significance	-	-	0,00	Significance	-	-	0,00

The time taken for MAP to decrease sufficiently for blood collection as five to 24 minutes for humans and five to 23 minutes for dogs. The tendency in both species was to show a decrease in MAP during positive interaction.

7.10.2 Changes in plasma neurotransmitters

7.10.2.1 Phenylacetic acid as metabolite of phenylethylamine

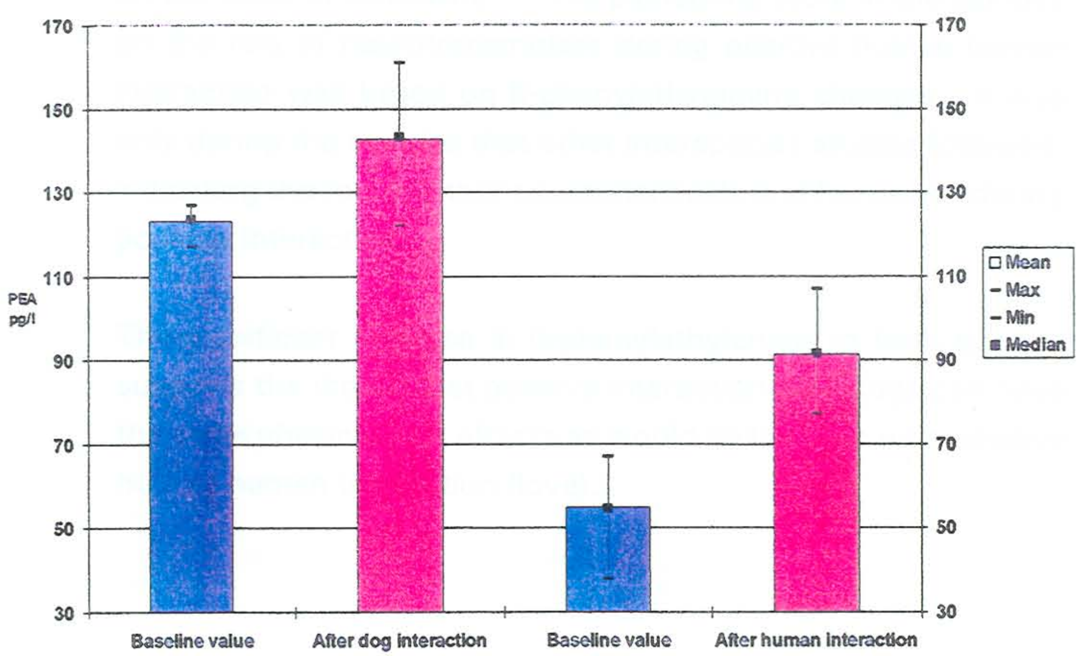

Figure 7.18: Plasma phenylacetic acid (PEA) of human (n=18) and dogs (n=18) before and after interacting positively with each other

Table 7.21: Concentrations of phenylacetic acid (pg/ℓ) in the plasma of humans (n = 18) and dogs (n = 18) interacting positively with each other

PAA (humans)	Before	After	p-value	PAA (dogs)	Before	After	p-value
Mean	122,9	142,4	-	Mean	54,6	91,2	-
Standard deviation	2,9	9,7	-	Standard deviation	7,9	7,5	-
Median	123,5	143,0	-	Median	54,5	91,5	-
Significance	-	-	0,00	Significance	-	-	0,00

The tendency in both species was to show a significant increase ($p<0,05$) in ß-phenylethylamine during positive interaction.

This was a very important measurement in the context of this study, because the basis of the theory that the physiological changes interspecies will be the same as intraspecies, was built on the work of Liebowitz.[153] His pioneering work in the eighties on the role of neurotransmitters during positive human-human interaction was based on ß-phenylethylamine changes. It was only during the nineties that other interspecies studies followed, indicating the role of other neurochemicals and hormones during positive interaction.

The significant increase in ß-phenylethylamine in both species supports the theory that positive interaction with dogs can have the same physiological effects as would be the case with positive human-human interaction (love).

7.10.2.2 Dopamine

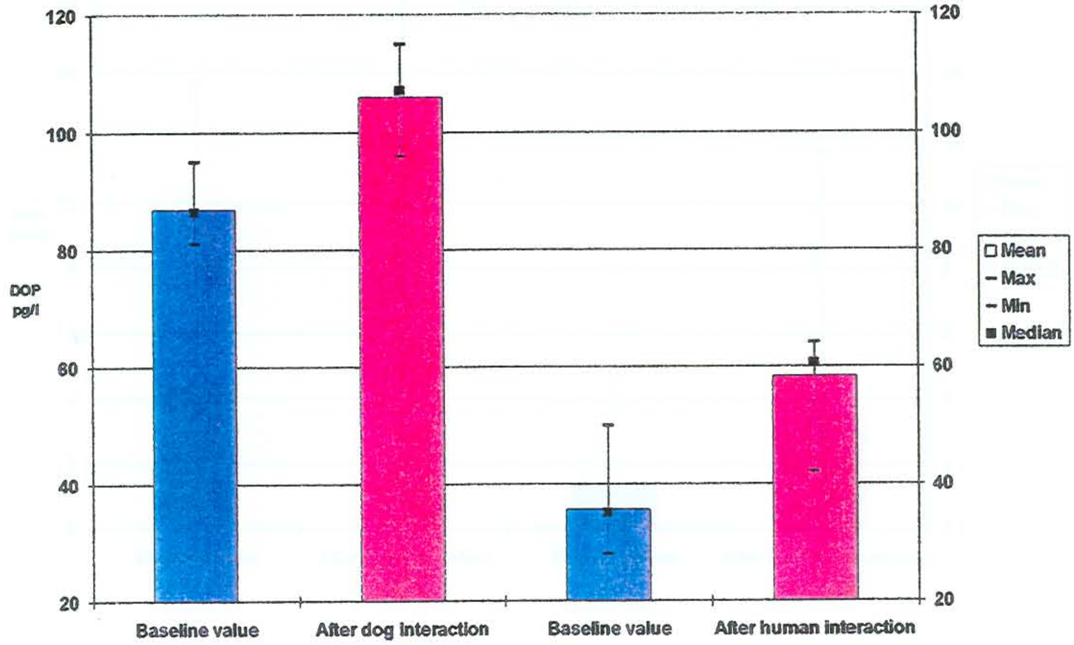

Figure 7.19: Plasma dopamine (DOP) of humans (n=18) and dogs (n=18) before and after interacting positively with each other

Table 7.22: Concentrations of dopamine (pg/ℓ) in the plasma of humans (n = 18) and dogs (n = 18) interacting positively with each other

DOP (humans)	Before	After	p-value	DOP (dogs)	Before	After	p-value
Mean	86,7	105,8	-	Mean	35,5	58,2	-
Standard deviation	4,6	5,4	-	Standard deviation	5,9	5,5	-
Median	86,5	107,0	-	Median	35,0	60,5	-
Significance	-	-	0,00	Significance	-	-	0,00

Both species showed a significant increase ($p < 0,05$) in dopamine during positive interaction.

7.10.2.3 ß-endorphin

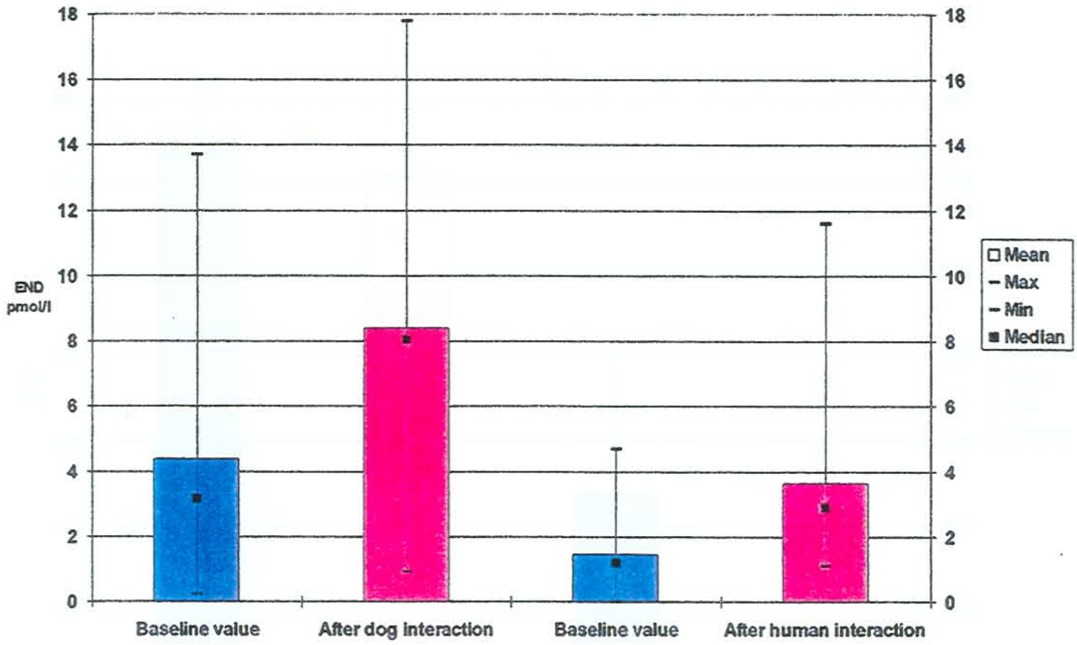

Figure 7.20: Plasma beta-endorphin (END) of humans (n=18) and dogs (n=18) before and after interacting positively with each other

Table 7.23: Concentrations of ß-endorphin (pmol/ℓ) in the plasma of humans (n = 18) and dogs (n = 18) interacting positively with each other

END (humans)	Before	After	p-value	END (dogs)	Before	After	p-value
Mean	4,3	8.3	-	Mean	1,4	3,6	-
Standard deviation	3,9	4,9	-	Standard deviation	1,1	2,7	-
Median	3,1	8,0	-	Median	1,2	2,8	-
Significance	-	-	0,00	Significance	-	-	0,00

Both species showed a significant increase in ß-endorphin during positive interaction.

7.10.2.4 Norepinephrine

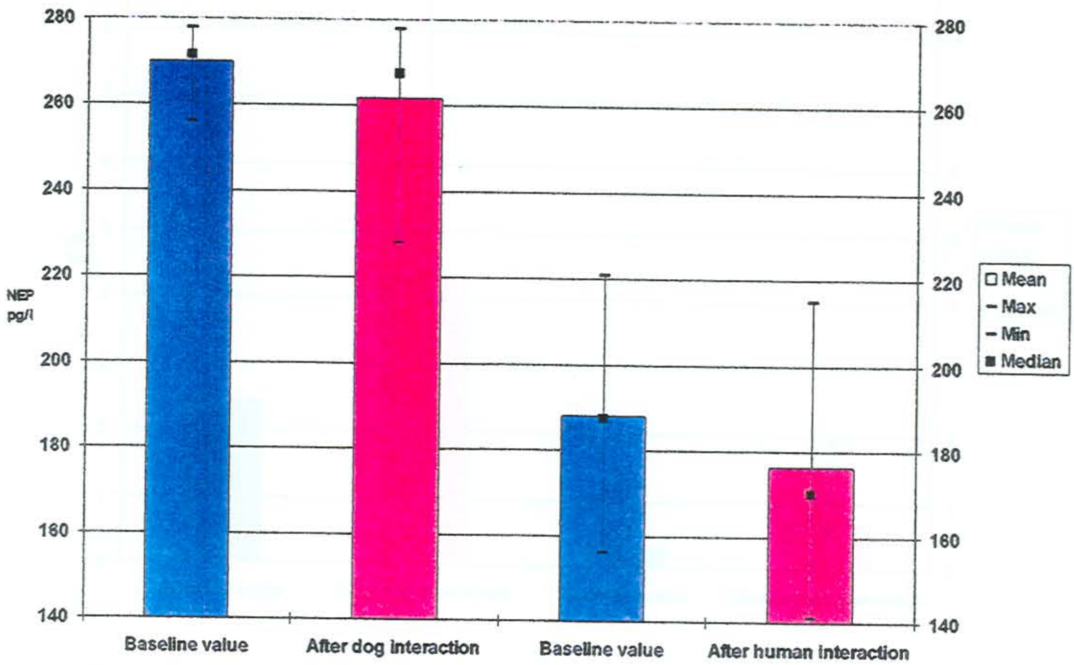

Figure 7.21: Plasma norepinephrine (NEP) of humans (n = 18) and dogs (n = 18) before and after interacting positively with each other

Table 7.24: Concentrations of norepinephrine (pg/ℓ) in the plasma of humans (n = 18) and dogs (n = 18) interacting positively with each other

NEP (humans)	Before	After	p-value	NEP (dogs)	Before	After	p-value
Mean	269,7	261,5	-	Mean	187,8	176,2	-
Standard deviation	5,8	14,4	-	Standard deviation	20,5	18,0	-
Median	271,5	267,5	-	Median	187,5	170,0	-
Significance	-	-	0,07	Significance	-	-	0,00

The norepinephrine decreased in both species, but for humans the decrease was not statistically significant.

7.10.2.5 Oxytocin

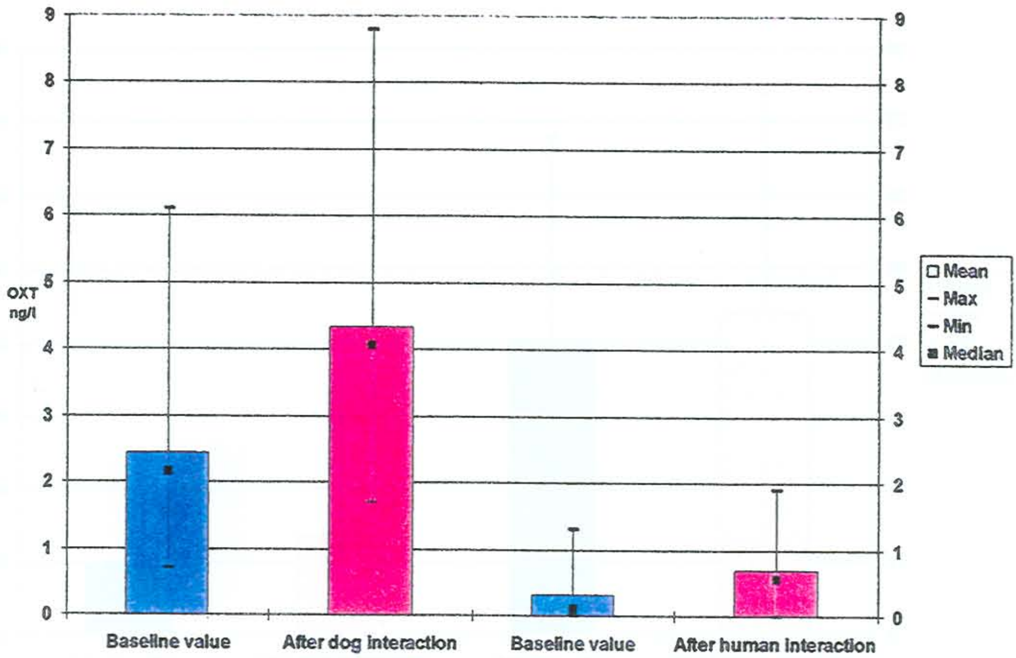

Figure 7.22: Plasma oxytocin (OXT) of humans (n=18) and dogs (n=18) before and after interacting positively with each other

Table 7.25: Concentrations of oxytocin (ng/ℓ) in the plasma of humans (n = 18) and dogs (n = 18) interacting positively with each other

OXT (humans)	Before	After	p-value	OXT (dogs)	Before	After	p-value
Mean	2,4	4,3	-	Mean	0,3	0,6	-
Standard deviation	1,5	1,6	-	Standard deviation	0,4	0,6	-
Median	2,1	4,0	-	Median	0,1	0,5	-
Significance	-	-	0,00	Significance	-	-	0,00

Both species showed a significant increase in oxytocin during positive interaction.

7.10.2.6 Prolactin

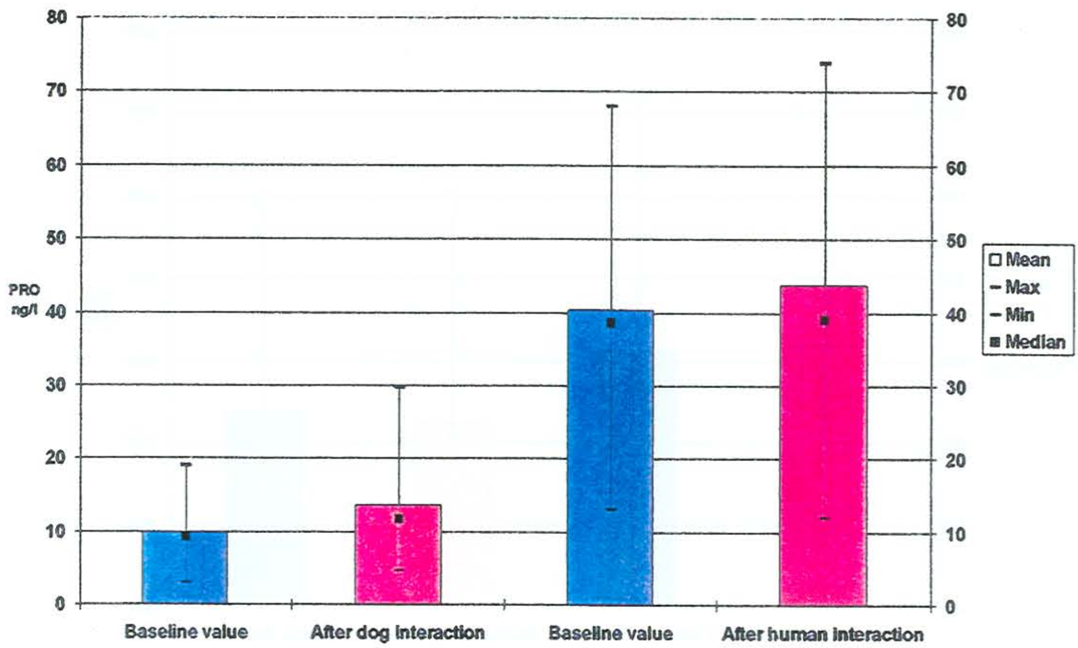

Figure 7.23: Plasma prolactin (PRO) of humans (n=18) and dogs (n=18) before and after interacting positively with each other

Table 7.26: Concentrations of prolactin (ng/ℓ) in the plasma of humans (n = 18) and dogs (n = 18) interacting positively with each other

PRO (humans)	Before	After	p-value	PRO (dogs)	Before	After	p-value
Mean	9,7	13,5	-	Mean	40,1	43,6	-
Standard deviation	5,0	6,4	-	Standard deviation	20,6	22,7	-
Median	9,2	11,6	-	Median	38,5	39,0	-
Significance	-	-	0,00	Significance	-	-	0,01

Both species showed a significant increase in prolactin during positive interaction.

7.10.2.7 Cortisol

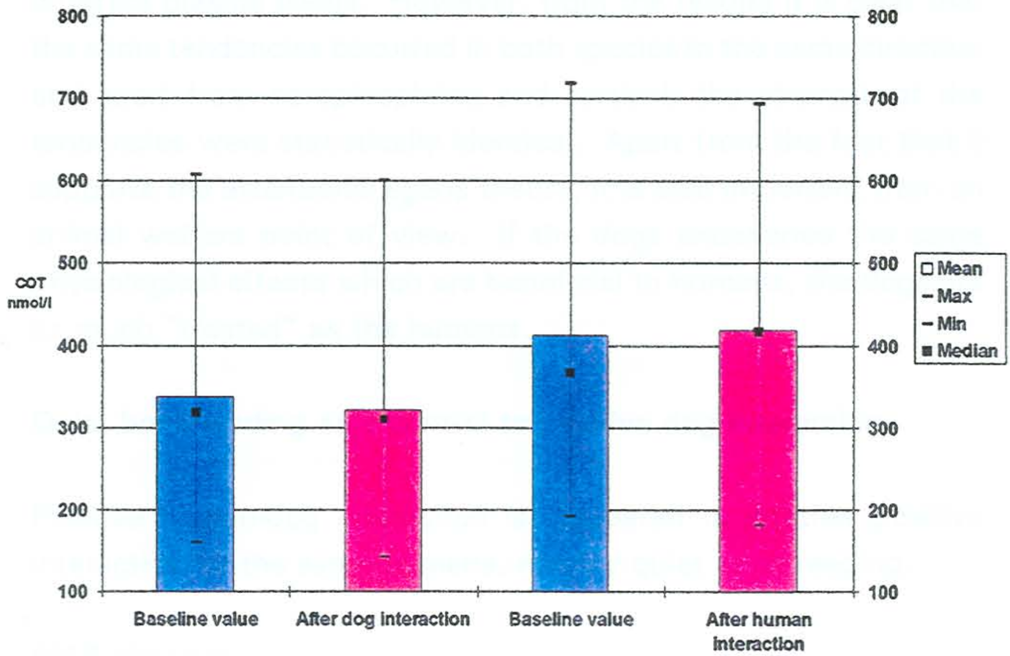

Figure 7.24: Plasma cortisol (COT) of humans (n=18) and dogs (n=18) before and after interacting positively with each other

Table 7.27: Concentrations of cortisol (nmol/ℓ) in the plasma of humans (n = 18) and dogs (n = 18) interacting positively with each other

COR (humans)	Before	After	p-value	COR (dogs)	Before	After	p-value
Mean	337,3	320,4	-	Mean	411,8	416,8	-
Standard deviation	151,0	143,5	-	Standard deviation	161,4	158,2	-
Median	317,0	309,0	-	Median	366,5	416,0	-
Significance	-	-	0,00	Significance	-	-	0,30

Cortisol decreased in both species, but in dogs the decrease was not statistically significant.

7.11 Statistical differences between humans and dogs

It was not possible to compare the two species' results statistically, because of possible species differences in the chemistry and different plasma levels. However, from the results it is clear that the same tendencies occurred in both species in the same direction and apart from norepinephrine and cortisol, the strength of the tendencies were statistically identical. Apart from the fact that it supports the *attentionis egens* theory, it is also important from an animal welfare point of view. If the dogs experience the same physiological effects which are beneficial to humans, the dogs are as much "treated" as the humans.

7.12 Quiet book-reading as a control to positive dog interaction

Positive human-dog interaction is compared to another positive interaction by the same humans, namely quiet book-reading.

7.12.1 MAP changes

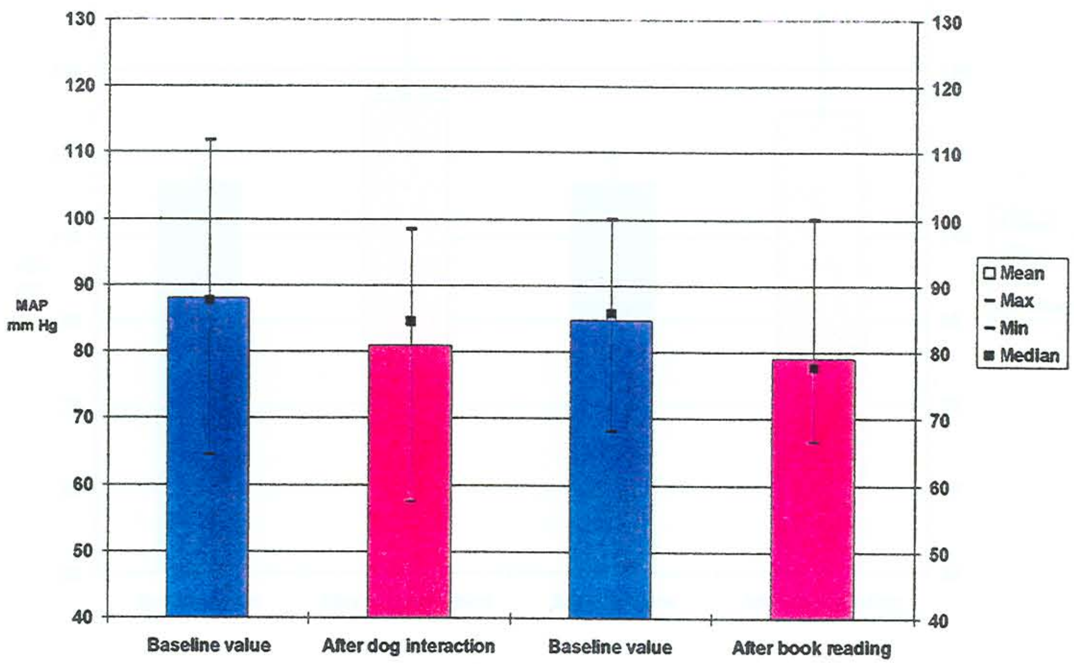

Figure 7.25: Mean arterial blood pressure (MAP) of humans before and after interacting positively with dogs and quiet book-reading (n = 18)

Table 7.28: Mean arterial blood pressure (mmHg/ℓ) of humans reading a book quietly (n = 18)

MAP	Before	After	p-value
Mean	84,6	79,0	-
Standard deviation	8,7	8,8	-
Median	85,7	77,6	-
Significance	-	-	0,00

Time taken for MAP to decrease sufficiently before blood collection was five to 24 minutes for dog interaction and four to 10 minutes for quite book-reading.

During quiet book-reading the MAP decreased significantly in the same way as during positive dog interaction.

7.12.2 Changes in plasma neurotransmitters

7.12.2.1 Phenylacetic acid as metabolite of phenylethylamine

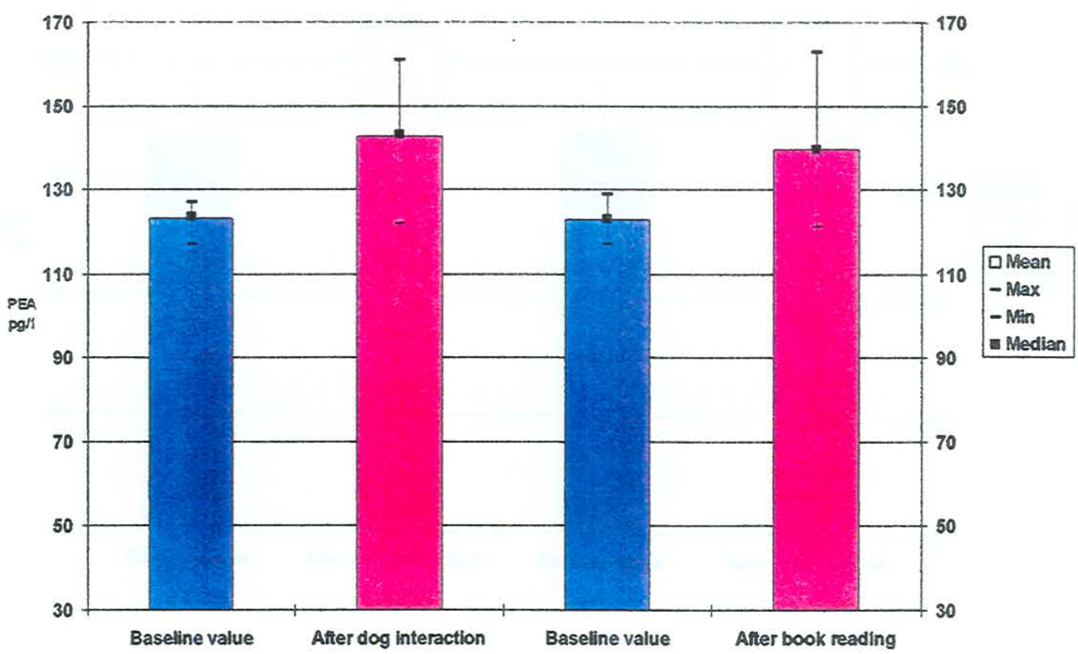

Figure 7.26: Plasma phenylacetic (PEA) of humans before and after interacting positively with dogs and quiet book-reading (n=18)

Table 7.29: Concentrations of phenylacetic acid (pg/ℓ) in the plasma of humans reading a book quietly (n = 18)

PAA	Before	After	p-value
Mean	122,7	139,6	-
Standard deviation	3,2	15,1	-
Median	123,0	139,5	-
Significance	-	-	0,00

During quiet book-reading, the changes observed in the plasma neuropeptides and hormones, were all similar to those seen with positive human-dog interaction. It may be possible to describe book-reading as a positive self-interaction with a similar effect to that of positive interaction with others.

7.12.2.2 Dopamine

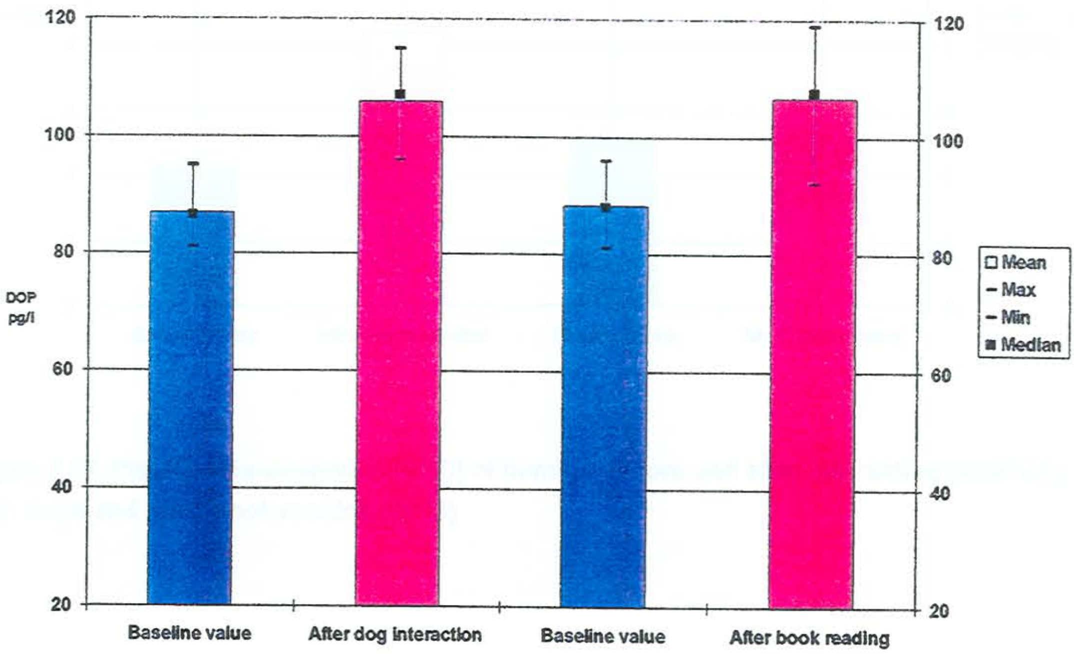

Figure 7.27: Plasma dopamine (DOP) of humans before and after interacting positively with dogs and quiet book-reading (n=18)

Table 7.30: Concentrations of dopamine (pg/ℓ) in the plasma for humans reading a book quietly (n = 18)

DOP	Before	After	p-value
Mean	88,1	106,5	-
Standard deviation	5,0	7,1	-
Median	88,0	107,5	-
Significance	-	-	0,00

7.12.2.3 ß-endorphin

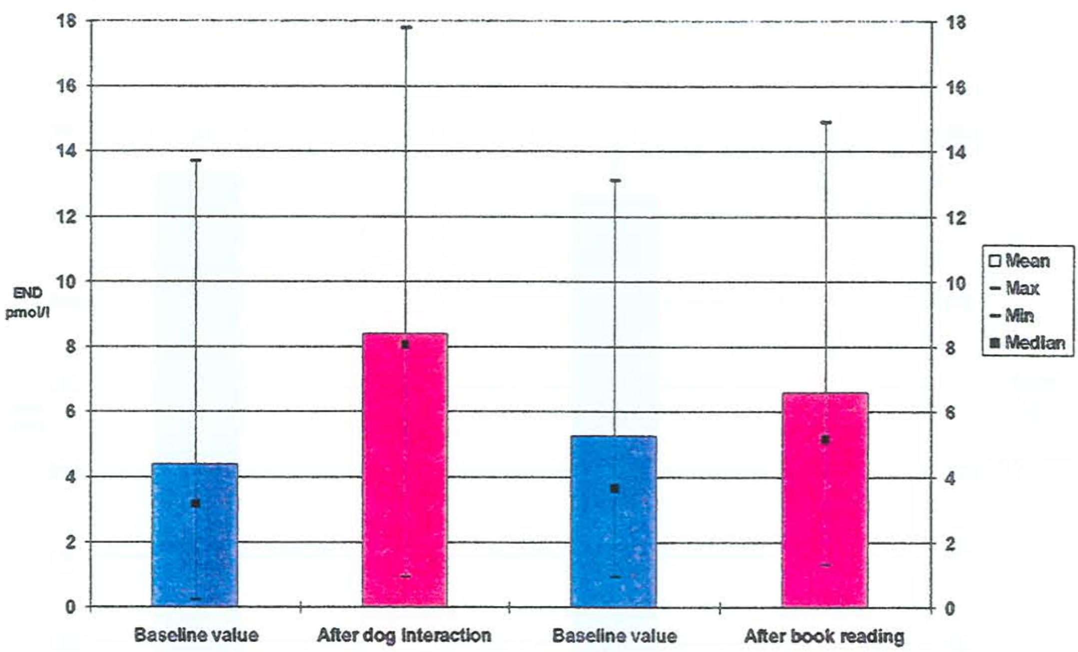

Figure 7.28: Plasma beta-endorphin (END) of humans before and after interacting positively with dogs and quiet book-reading (n=18)

Table 7.31: Concentrations of ß-endorphin (pmol/ℓ) in the plasma for humans reading a book quietly (n = 18)

END	Before	After	p-value
Mean	5,2	6,5	-
Standard deviation	4,1	4,1	-
Median	3,5	5,1	-
Significance	-	-	0,00

7.12.2.4 Norepinephrine

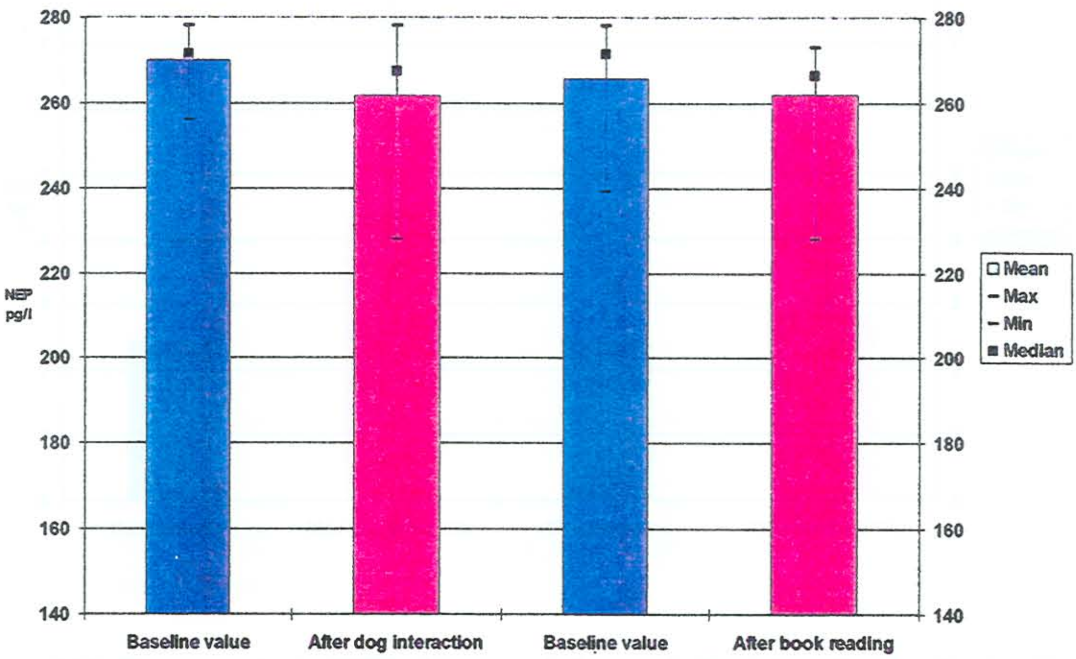

Figure 7.29: Plasma norepenephrine (NEP) of humans before and after interacting positively with dogs and quiet book-reading (n=18)

Table 7.32: Concentrations of norepenephrine (pg/ℓ) in the plasma for humans reading a book quietly (n = 18)

NEP	Before	After	p-value
Mean	265,6	261,7	-
Standard deviation	12,7	11,4	-
Median	271,5	266,5	-
Significance	-	-	0,05

7.12.2.5 Oxytocin

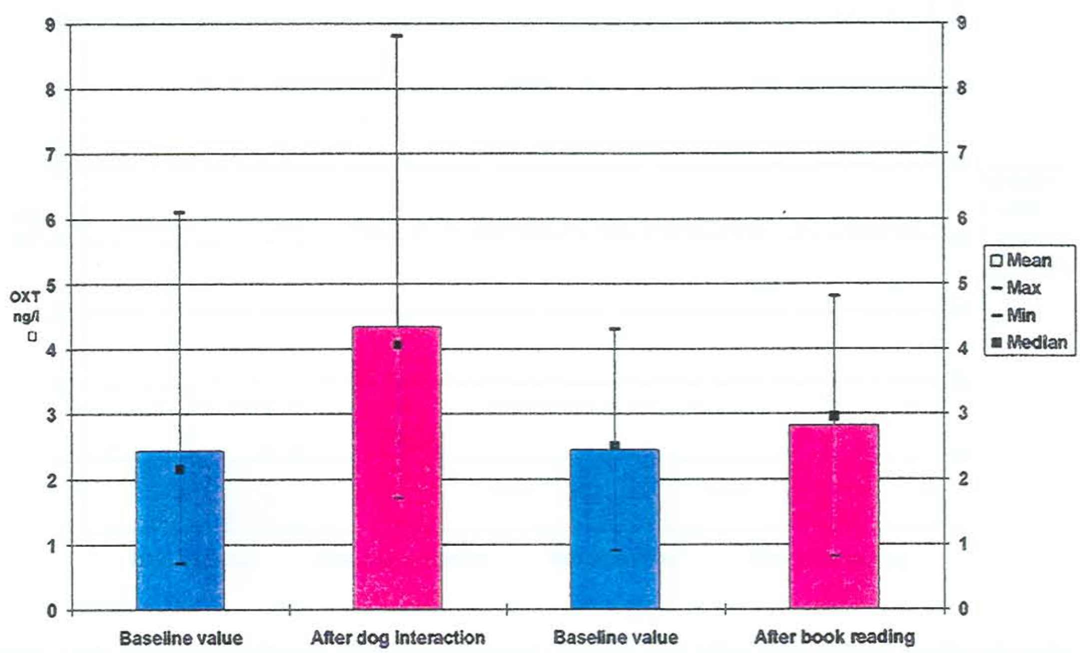

Figure 7.30: Plasma oxytocin (OXT) of humans before and after interacting positively with dogs and quiet book-reading (n=18)

Table 7.33: Concentrations of oxytocin (ng/ℓ) in the plasma for of humans reading a book quietly (n = 18)

OXT	Before	After	p-value
Mean	2,4	2,8	-
Standard deviation	1,1	1,1	-
Median	2,5	2,9	-
Significance	-	-	0,01

7.12.2.6 Prolactin

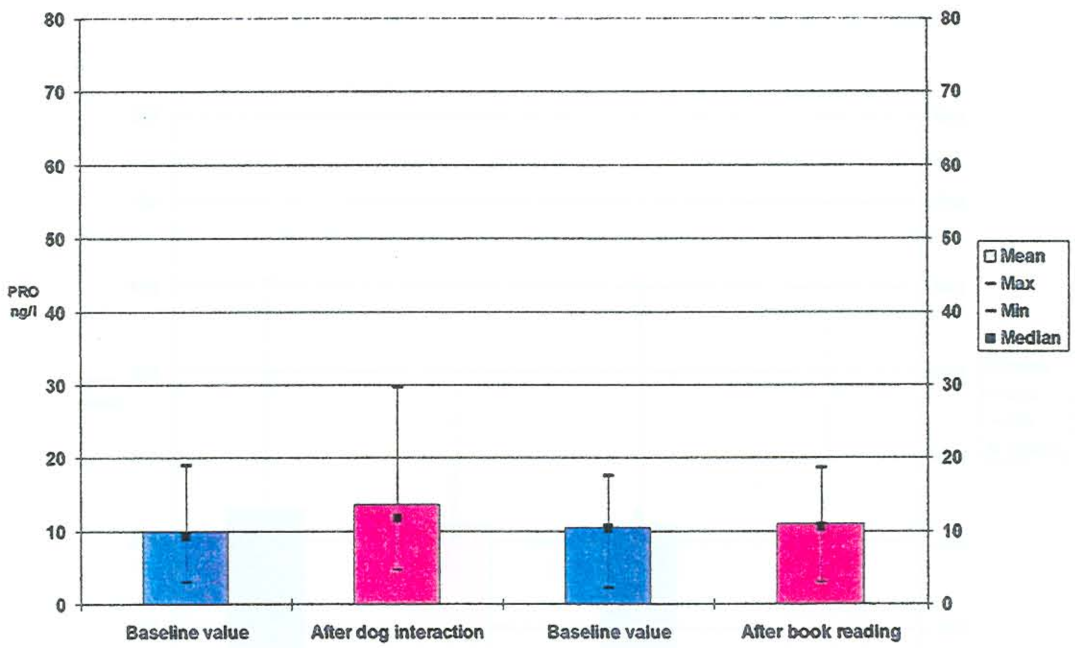

Figure 7.31: Plasma prolactin (PRO) of humans before and after interacting positively with dogs and quiet book-reading (n=18)

Table 7.34: Concentrations of prolactin (ng/ℓ) in the plasma for humans reading a book quietly (n = 18)

PRO	Before	After	p-value
Mean	10,4	10,9	-
Standard deviation	4,6	4,5	-
Median	10,2	10,4	-
Significance	-	-	0,00

7.12.2.7 Cortisol

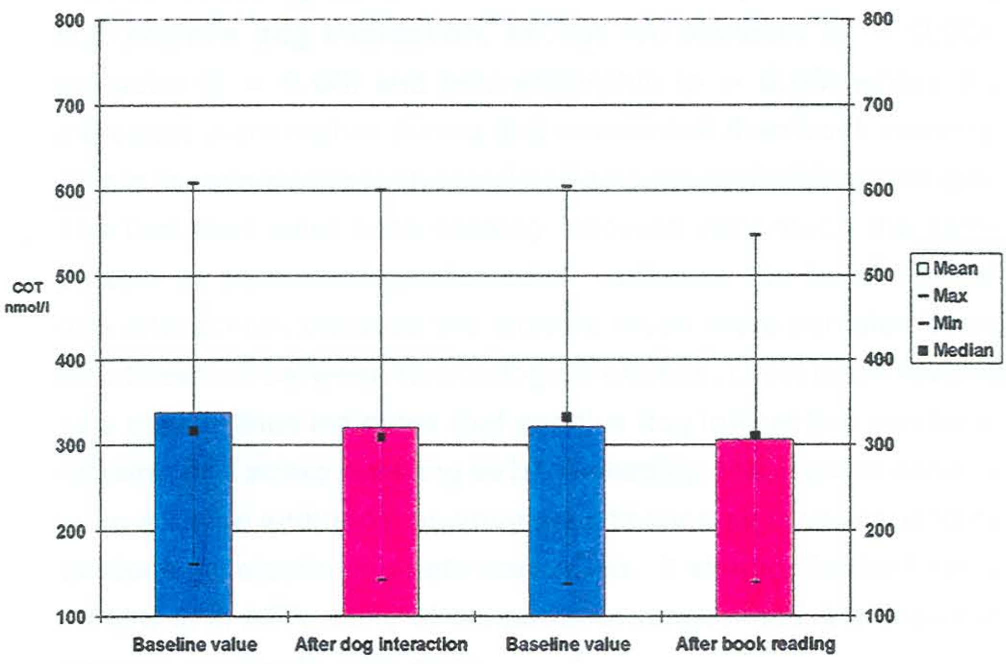

Figure 7.32: Plasma cortisol (COT) of humans before and after interacting positively with dogs and quiet book-reading (n=18)

Table 7.35: Concentrations of cortisol (nmol/ℓ) in the plasma for humans reading a book quietly (n = 18)

COR	Before	After	p-value
Mean	321,5	305,9	-
Standard deviation	144,6	135,0	-
Median	332,5	309,5	-
Significance	-	-	0,00

7.13 Statistical differences between quiet book-reading and positive dog interaction

There were no significant differences between quiet book-reading and positive dog interaction, except for oxytocin (p = 0,00), prolactin (p = 0,00) and beta-endorphin (p = 0,00) where the increases were higher during dog interaction than book-reading. This is in accordance with social bonding neurochemical changes. The fact that quiet book-reading followed very much the same pattern as positive dog interaction, indicates the true effect of dog interaction, because the latter is much more complex being an interaction between two biological entities. Quiet book-reading as a control thus indicates that positive dog interaction can be as relaxing and stress relieving as book-reading and in some aspects even achieve additional positive effects such as those caused by oxytocin, prolactin and beta-endorphin. It should also be kept in mind that in AFP, many of the patients cannot read, but they can interact positively with dogs.

7.14 Discussion

The results of this experiment strongly supports the theoretical basis for animal-facilitated psychotherapy. Once the physiology is known, i.e. the role that neurochemicals and hormones might play during positive interaction, it is possible to use this information as a rationale for using animals in psychotherapy. The research thus supports the hypothesis stated in 1.3.

7.14.1 Results in perspective

From the results the following aspects should be considered:

- a significant decrease in blood pressure and thus all the other physiological effects can be achieved between five and 24 minutes of positive dog interaction. This information is important in therapy. After allowing a short period to get familiar with the contact situation, ± 10 minutes, the actual contact need not be long. In practical terms it means that in a AFP contact session should be rather repeated more often than for a very long period of time. For example, rather three 15-20 minute sessions per day than one 60 minute session;

- this is the first time that *attentionis egens* (affiliation behaviour, positive interaction) is described on the neurochemical level and on an interspecies basis. The importance of the measurements in both species is that, during AFP, the dog experiences the same physiological effects as the patient. These physiological changes may be linked to a feeling of well-being and the facilitator is thus being "treated" as much as the patient. This is exactly what the *attentionis egens* theory proposes;

- the theory that a decrease in blood pressure could be an indicator of concurrent biochemical changes is supported by the results. If biochemistry is not available, a much simpler measurement such as blood pressure could be a valid indicator whether the interaction has the necessary physiological effects;

- the controls proved to be valuable. The questionnaire which reflects the state of anxiety of participants, indicated that a "healthy feeling" could be linked to a "healthy physiological" status. The latter was indicated by the participants' health reports and normal blood pressure. Baseline values for every participant was also valuable. This control ensured that physiological changes could be individualized and that the range for healthy adult participants could be established. The control between humans with their own dogs (experiment group) and those with unfamiliar dogs (control group) was valuable in the sense that long term bonding appears to have some additional advantages because of the effects of oxytocin, prolactin and ß-endorphin. Lastly, to use another intervention (book-reading) which could also contributes to relaxation proved that positive dog interaction, although much more complicated, could have the same physiological advantages. Dog interaction can also have more advantages with regard to the effects of bonding, which is only possible with other live interaction;

- the observations are new in veterinary physiology, because the baseline values for the neurochemicals as well as the response thereof on positive interaction have not been analysed before. The analyses of the dog neuropeptides and hormones posed a challenge to the Laboratory, despite the fact that the human analyses had been done as part of their routine work. Species differences, even on the molecular level, were found to occur. Specific adaptations had to be made to cater for these subtle differences, especially with regard to preparing a standard against which the dog sera could be measured. Comments were made earlier with regard to the ß-endorphin and prolactin measurements;

- physiological parameters used during the experiment are not seen as causes of any process. They are regarded as effects of a complex biological interaction and in a sense the physiological changes are results of the phenomenon of human-dog interaction.

7.14.2 Placebo effect

It is possible that AFP was not generally accepted by physicians as a valid medical approach, because it was seen as a placebo effect.

In their significant contribution on this subject Shapiro and Shapiro[226] discussed the placebo effect in depth in their book "The Powerful Placebo". They defined a placebo as follows:

> "any treatment that is used for its ameliorative effect on a system or disease but that actually is ineffective or is not specifically effective for the condition being treated".[226]

Until recently (the fifties) the history of medical treatment was essentially the history of the placebo effect. Developments that have decreased the placebo effect include the use of scientific method, controls and the double blind method. However, not all problems were eliminated, using these approaches.[226]

This experiment complied with the methodological safeguards suggested by Shapiro and Shapiro.[226] The main criticism of the use of animals in psychotherapy is that it could be non-specific. Shapiro and Shapiro[226] suggested that measurement of plasma variables is the best method to ensure accurate and specific changes. Furthermore, they agreed that there is consensus that psychotherapy is beneficial for many patients, but additional studies are needed before it can be said with certainty that such therapy is more than a placebo. This study provided such additional physiological information. The authors concluded their book by indicating that the underlying mechanisms of the body (physiology) that control and maintain health still elude us:

> "If the nonspecificity of the placebo effect can be rendered specific and its strength can be unleashed, the terms *placebo* and *placebo effect* can appropriately disappear into medical history".[226]

The results of this study attempted to do just that with regard to AFP.

7.14.3 Neurochemical profile of human-dog interaction

Based on the results of this study, a decreased blood pressure could be sufficient as indicator of neurochemical changes. However, if a profile of neurochemicals is necessary to measure effect or to determine rationale, the following proposal is made:

Humans:	phenylethylamine	Dogs:	phenylethylamine
	dopamine		dopamine
	oxytocin		oxytocin
	ß-endorphin		
	prolactin		

Norepinephrine concentrations in plasma might be affected by the process of venipuncture and cortisol concentrations showed too much variation. Until problems with the measurement of ß-endorphin and prolactin in dogs can be solved, it is suggested that these parameters not be included in the profile.

It was reported that the role of oxytocin on behaviour could be extensive. Repeated oxytocin injections in rats caused lowered blood pressure and decreased cortisol plasma levels, forming an anti-stress pattern.[227] These links were also found in this study. Oxytocin has been shown to influence a variety of behaviour, it promotes sexual, maternal and social behaviour, probably playing an important role in *attentionis egens* needs, because the same effects were recorded after the rats were stroked for five minutes on their abdomens.[227] It was also found that oxytocin stimulates prolactin release, another link which was also recorded in this study.[163,164,167,227] Keeping this in mind, prolactin may be removed from the neurochemical list for humans, because it follows an increase of oxytocin plasma levels.

From a psychotherapy point of view, it was stated that ß-phenylethylamine has recently been implicated in the aetiology of affective disorders[228] (*attentionis egens* disorders) and this neurotransmitter together with oxytocin, could thus be the minimum neurochemical profile to measure positive interaction.

7.14.4 Measurement of emotions

Joseph le Doux[229] is a leading authority in the field of neural science and his book "The Emotional Brain" published in 1998, has relevancy. Critical questions often asked about the results of the physiology involving emotions are, how reliable and valid are they. With regard to internal validity, this must be high because of all the controls built into the experimental design. The question rather has bearing on the external validity (generalisation) which may go hand in hand with reliability (repeatability).

Le Doux[229] described emotions as biological functions (physiology) of the nervous system. The measurement of neurochemicals can be helpful in understanding emotions and this approach contrasts with the more typical approach to understand emotions as psychological states, independent of the underlying brain mechanisms. Although psychological research has been extremely valuable, brain function is far more powerful in understanding emotions. There are specific classes of emotions and some of them are universal among vertebrate, despite the fact that there are also species differences. Emotional responses are for the most part, generated unconsciously and feelings often follow on physiological changes. He then made this very important statement which reflects on the results of this study:

> "If, indeed, emotional feelings and emotional responses are effects caused by the activity of a common underlying system, we can then use the objectively measurable emotional responses to investigate the underlying mechanism, and, at the same time, illuminate the system that is primarily responsible for the generation of the conscious feeling. And since the brain system that generates emotional responses is similar in animals and people, studies of how the brain controls these responses in animals are a pivotal step towards understanding the mechanisms that generate emotional feelings in people".[229]

People have little direct control over their emotions and they often set up situations as external events (such as positive dog interaction) so that the stimuli that automatically trigger emotions will be present. While conscious control over emotions is weak, emotions can flood consciousness, because the brain connections from the emotional systems to the cognitive systems are stronger than the connections from the cognitive systems to the emotional systems. Once emotions occur, they become powerful motivators of future behaviour. Mental health is maintained by emotional hygiene. Mental problems to a large extent reflect a breakdown of emotional order and emotions can have both useful and pathological consequences.[229]

From this it is clear that what was measured in this experiment, is part of "universal physiology" in the sense that results should be (within normal ranges) repeatable and have external validity, despite the relative small number of participating subjects. Variations in normal physiological responses are attributed to genetic potential. The transmitters that neurons produce or can respond to, are genetically specified. In fact, most characteristics of individual neurons such as their size, shape and amalgamation with other neurons to form specific brain parts, are largely determined by genes. Certain patterns of neural circuitry are also specified by genes.[229]

The next chapter will discuss other human-animal interaction theories.