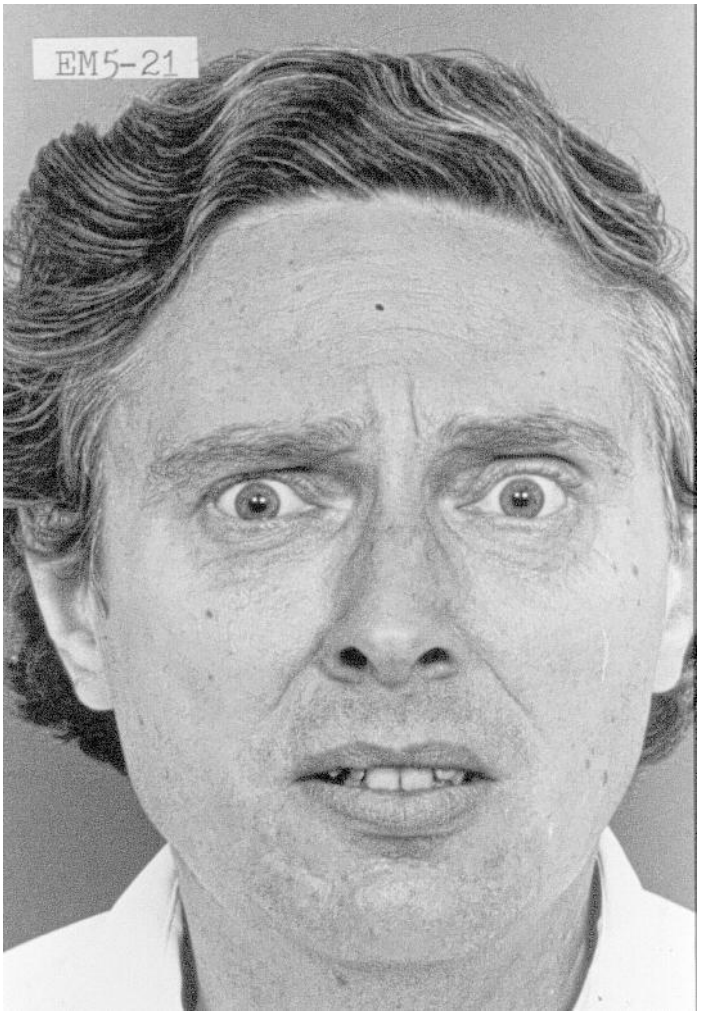
Processing emotional stimuli in the visual system using the low road

Daniël Heikoop



Bachelorthesis, Cognitieve Kunstmatige Intelligentie,

University of Utrecht

Contents

Abstract

The brain contains a "high road" and a "low road" for processing of visual stimuli. The high road is assumed to process all visual stimuli whereas the low road is thought to be specialized in processing danger cues, allowing a reflex "fight or flight"-response. However, many studies coined an extra term, namely *freeze* to accompany the term "fight or flight", which could influence reaction times involving emotional perception in the visual system. Given that the low road and high road differ in length and therefore processing speed, and the low road specializes in emotional processing, we were interested in the difference in processing speed between different stimuli. Therefore, we decided to test three different conditions, all having the focus on the difference in reaction speed between neutral and emotional stimuli. In our first experiment we showed each subject pictures of persons containing neutral or emotional expressions. In the second we first showed them a cue face, then a target face. The third experiment first showed both a cue face and a distraction, supposed to make the cue face invisible for the subject. The idea behind these three experiments was to try to test three different components in the visual system. The first experiment was thought to be the lifelike experiment, where the second pre-focused the low road and the third cancelled the high road altogether, giving different processing speeds per experiment. The three experiments showed no significant differences between emotion-rich and emotion-less faces, raising the question whether there is a difference in processing speed in emotion perception or something else.

1. Introduction

The "high road" and "low road" in the visual system has been common knowledge for several years now (LeDoux, 1996). Differences in processing speed have been found between those two roads and have been ascribed great importance in basal "fight or flight"-like behavior, first described by Walter Bradford Cannon in the early twentieth century[1]. This behavior is thought to be a primal response to dangerous situations, providing us with a reflex-like reaction to such situations allowing us to survive more easily. Although the name refers to actions like fight and flight, several studies have claimed another action caused by fear, namely *freeze* (e.g. Johnson, 2003) which raised several questions. This reaction freezes one in place, disabling movement altogether (like a deer caught in the headlights). Therefore it is

sometimes also called the "fight-or-flight-or-freeze response" (Bracha et al., 2004). According to James McGaugh, fear is not learned in the amygdala (Vazdarjanova & McGaugh, 1998), whereas basic understanding of the amygdala show us definite processing of emotions, fear being one of them. This newfound understanding of emotional learning gives raise to interesting questions regarding the high- and low road in the visual system. Where those roads are found to be involved in processing of emotionally laden responses, these seem to be more important than just being a connection between parts of the brain.

If these findings are in fact correct, processing speeds may vary given the stimulus, i.e. neutral or emotional, resulting in a reaction, i.e. fight, flight or freeze. Therefore, the non-learning low road will be under the scope, hoping to find definite differences between neutral (emotion-less) stimuli and fearful/frightful stimuli. Given the understanding that the low road will give a quicker response than the high road, the low road must be involved in emotional processing, ergo it will only process emotional stimuli. Our experiment we described in this article will answer the question "*Is there a difference in reaction speed in the low road of the visual system and if so, what differences are there?*". There are two hypotheses about this question. The first is that there will be a quicker response to emotional stimuli, therefore a shorter reaction time than for neutral stimuli. This is due to the fact that the emotional stimuli will be using the faster low road, which causes one to fight or flight and the neutral stimuli the slower high road –which we won't be examining. The other, perhaps even more interesting hypothesis is raised by the possibility of freezing during the presentation of the emotional stimuli, which might inflict an impairment of performing the task and therefore increasing the reaction time, perhaps even beyond the reaction time to neutral stimuli. Since many publications mention the freezing reaction as if it were common, one might expect this reaction to emerge in the task. Once the reaction time to both stimuli is similar to each other, one of two possible explanations might be the case: either the freezing action impairs one's movement capability or the presentation of an emotional stimulus does not infer a quicker response in the low road of the visual system.

In our experiment we will use a technique called *continuous flash suppression (CFS)* which should make a presented cue disappear to conscious vision. The reason we try this technique is that we thereby try to avoid processing visual input through the high road, giving us the quickest reaction speeds possible and hopefully giving us the biggest difference between neutral and emotional stimuli. This is because the neutral stimuli should theoretically only be processed by the high road, and elimination of using the high road should prolong processing speeds of neutral stimuli and not of emotional stimuli.

2. Methods

In the experiment we performed we were particularly interested in the low road in the visual system. Therefore we, in one case, used a masking technique called *continuous flash suppression (CFS),* thereby suppressing or sometimes even entirely eliminating the use of the high road during the task (Tsuchiya & Koch, 2005)[2].

2.1 Observers

Fourteen subjects with normal or corrected-to-normal vision, whereof eleven males and three females, took part in this experiment. All subjects took part in all three experiments.

2.2 Procedure

Before each of the three experiments, the subjects were instructed on what to do during each experiment. The experiments were run in a dark, closed room where the subjects were facing a computer screen (LaCie electron blue IV). The subjects were told to look through a device containing a set of mirrors and a chinrest which was placed on a fixed distance to the screen. The screen presented two red fixation crosses, which should fuse together into one while looking through the device. The distance between the crosses was set at α=12.7 deg (x=12.8 cm, y=57 cm), given that this distance should be most effective for fusing the two crosses together. The background luminance was set at 29.9 cd/cm^2. The screen dimensions were 1024x768, with refresh rate = 100 Hz.

Before the experiments begun the subjects were asked if they knew which eye was their dominant eye. If they didn't knew they were asked to perform a simple test to determine which eye was their dominant eye. They were asked to make a look through-circle of their index finger and thumb and look through it with both eyes opened and fixate on a random point. Then they were asked to close one eye and then the other. On the situation where the fixation point did not change, the eye which was open at that time was the dominant eye.

Then the experiments could begin. First the subjects were asked to look through the device, saying whether they saw the two crosses as one. The subjects were then told they would be shown pictures of faces each time they pressed the spacebar. They were asked to respond to the last picture on each trial, responding to whether the picture showed a male or a female, pressing the left or right arrow on the keyboard respectively. Once the spacebar was

pressed, the red fixation cross would become a green cross for 0.5 seconds which would be followed by either a rectangular cue made up of static grey noise or a cue face, shown for 0.2 seconds, which was the size of the target faces, shown for 0.2 seconds. Then varied by a stimulus-onset asynchrony (SOA) the target face would appear between 1.2 and 1.7 seconds after the cue, which would be shown for a maximum of 3 seconds[3]. The SOA was implemented to avoid a gambling behavior[4], which might influence the reaction times. After each Cue-Target-loop the red fixation cross reappeared, and the subject should have pressed the spacebar again to start the next presentation.

The actual task for the subjects was, as mentioned above, to respond to whether they saw a male or female picture. Before each experiment they were told to do it as accurately and as quickly as possible.

The first experiment contained 36 trials, the second and third 432 trials. Because of the length of these trials the subjects were given breaks between experiments. When several subjects arrived on the location together, when the first subject completed an experiment, the second took the same experiment right after and when the last subject completed an experiment, the first subject continued with the next experiment, thereby maximally eliminating fatigue. Unfortunately not every subject arrived together, but every subject got a sufficient break between experiments nonetheless.

2.3 Stimuli

All the stimuli had a height of 4 cm (α=4º) and the width was resized according. They all came from the Eckman set. Every experiment contained six different grey faces, three men and three women. All of these showed three different emotions: angry, afraid or neutral (figure 1). Every combination was shown twice.

Figure 1. The three different emotions presented by the pictures in the experiment. From left to right: afraid, angry and neutral.

2.3.1 No Cue

The first experiment contained 36 trials: 18 different trials for each eye. The 18 different trials were made up by 3 different emotions (angry, afraid and neutral), 2 different sexes (male and female) and 3 different faces per sex. Once the spacebar was pressed a rectangular static grey noise was shown briefly, followed by a short period of no stimulus, followed by another short presentation of the static grey noise, followed by the target face (figure 2).

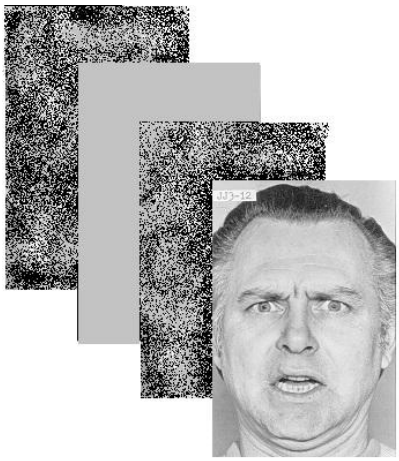


Figure 2. The sequence of presentation for each trial.

2.3.2 Cue Visible

The second experiment was similar to the No Cue-experiment, apart from having a cue stimulus instead of a noise rectangle (figure 3). Here we are interested in the difference in reaction time depending on cued emotions. Therefore we used every computation of emotion of cue versus emotion of target, which gives us 3x3 different computations. The other variables were sex of cue, sex of target and identity, which gave us 2x2x6 different computations, giving us a total of 9x24=216 trials. Also, because we presented all trials to each eye, this resulted in 432 trials.

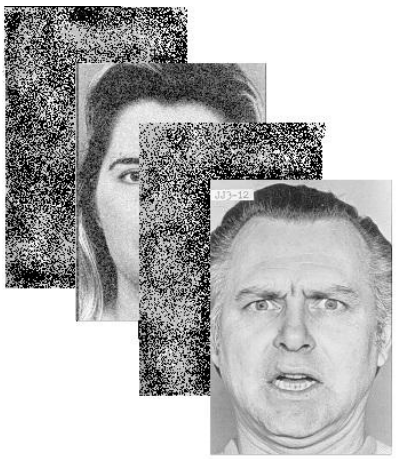


Figure 3. Sequence for the Cue Visible-experiment.

2.3.3 Cue Invisible

The final experiment actually used the difference in dominance between the two eyes because here we use a technique called *continuous flash suppression (CFS).* This technique uses a field (8x8 cm) of rapidly overlapping (10 per second) black and white rectangles (maximally 2x2 cm, minimally 1x1 cm) used to make the other picture, presented to the other eye, invisible (figure 4). While testing this technique we discovered that if the pattern was displayed in the non-dominant eye, ergo the cue face in the dominant eye, the cue would pop out of the CFS, making the cue visible after all. If we presented the CFS in the dominant eye the cue would almost always and sometimes even entirely be invisible to the subject. Therefore, prior to the experiment, we made sure all the faces were presented to the non-dominant eye. To be sure the examiner stayed for a few trials asking whether they saw the cue face. Once the subject did not seem to notice the cue (or see at most part of the faces), the examiner left the room to avoid distraction of the subject.

Figure 4. Presentation for both eyes in the Cue Invisible-experiment. In the dominant eye the field of black and white rectangles were displayed, occluding (almost always and sometimes even entirely) the cue face.

3. Results

Each experiment was examined separately to determine whether there was a significant difference in reaction time between the emotional faces (angry and afraid) and neutral faces. The main result was that there has not been found a significant difference in reaction time.

3.1 No Cue

All data from the fourteen subjects were gathered and categorized into three categories:
- mean reaction time on a frightened target (mbang),
- mean reaction time on an angry target (mboos),
- mean reaction time on a neutral target (mneut).

These reaction times were put into SPSS and then we performed a Repeated Measures ANOVA (RMA), with Bonferroni correction. These led to the conclusion that there was no significant difference between the reaction times (figure 5).

The No Cue-experiment showed $F(2,26)=0,807$, $p=0,457$ as values[5].

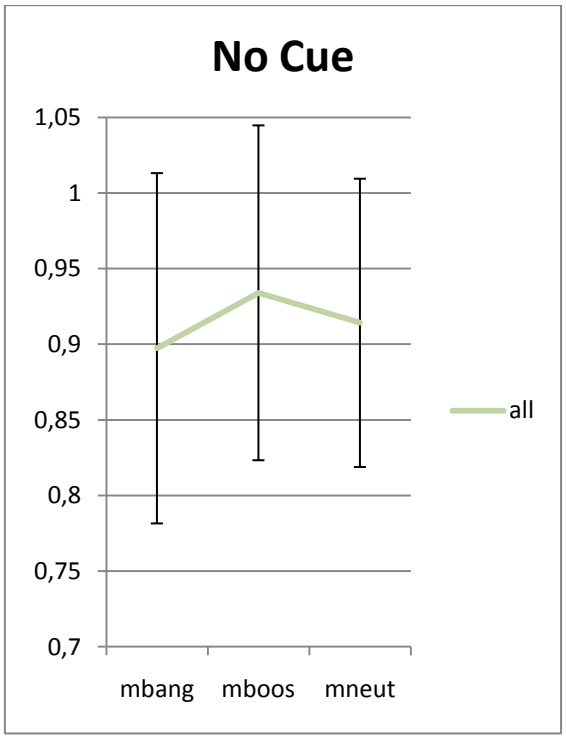


Figure 5. Mean reaction times of the different categories, showing no significant difference.

3.2 Cue Visible

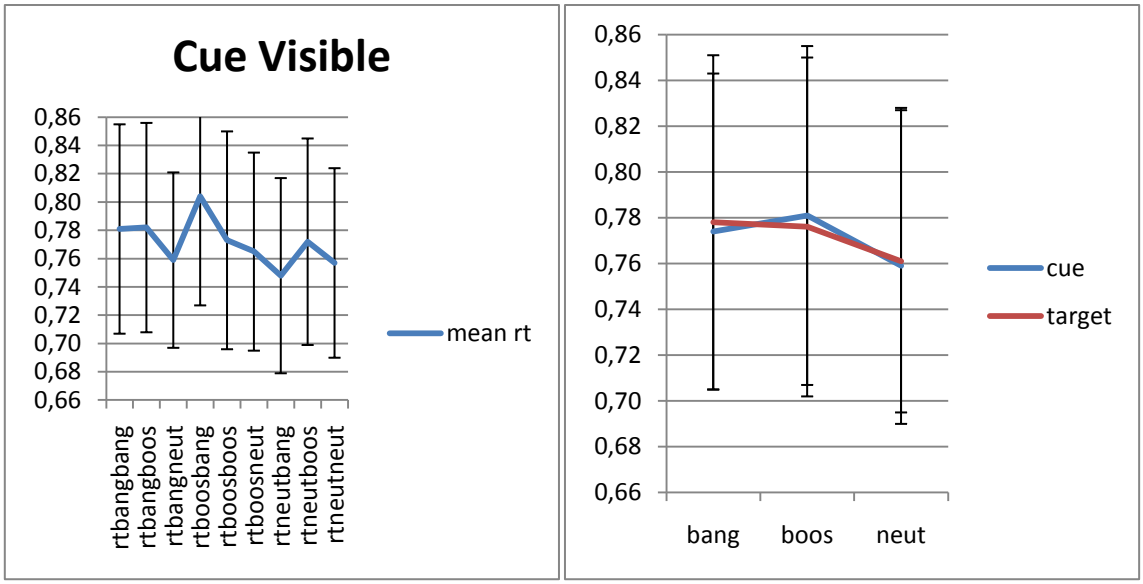
The second experiment was scaled into nine different categories, because every form of emotion was presented as cue and as target, resulting in 3x3 permutations. These categories are:
- mean reaction time on a frightened cue and a frightened target (rtbangbang),
- mean reaction time on a frightened cue and an angry target (rtbangboos),
- mean reaction time on a frightened cue and a neutral target (rtbangneut),

- mean reaction time on an angry cue and a frightened target (rtboosbang),
- mean reaction time on an angry cue and an angry target (rtboosboos),
- mean reaction time on an angry cue and a neutral target (rtboosneut),
- mean reaction time on a neutral cue and a frightened target (rtneutbang),
- mean reaction time on a neutral cue and an angry target (rtneutboos),
- mean reaction time on a neutral cue and a neutral target (rtneutneut).

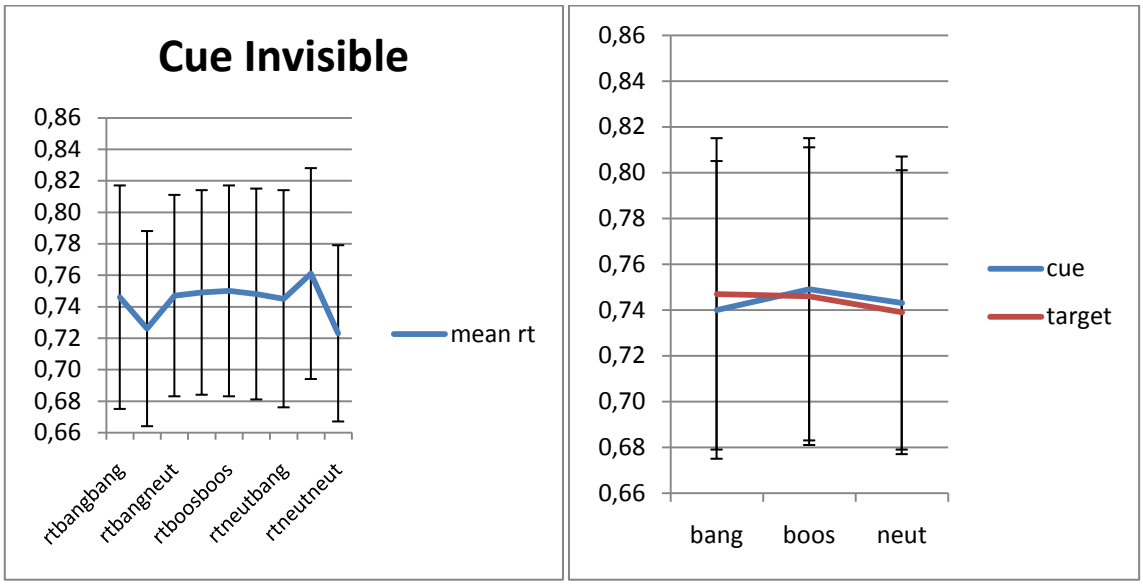
Following the same calculations as for the previous experiment, this also led to the conclusion that there is no significant difference in reaction times (figures 6&7). The Cue Visible-experiment did not show any significant difference either. The statistics for the cue gave us $F(2,26)=2,057$, $p=0,148$. The target values were $F(2,26)=1,372$, $p=0,271$ and the two combined (cue*target) $F(4,52)=2,154$, $p=0,087$[5].

3.3 Cue Invisible

Previously thought to be the most promising experiment for proving different reaction times, the third experiment was scaled the same as the second, resulting in the same nine categories as in the Cue Visible-experiment. Also these were measured by a RMA, giving us the conclusion that here as well no significance has been found (figures 8&9).
No combination of cue and target differed significantly from another.
Cue values were $F(2,26)=0,950$, $p=0,400$, target values were $F(2,26)=0,459$, $p=0,637$. The two combined $F(4,52)=2,043$, $p=0,102$[5].



Figures 6&7. Left: Mean reaction times of the different categories for the Cue Visible-experiment, showing no significant difference. Right: Mean reaction times per emotion (x-axis) for cue and target.



Figures 8&9. Left: Mean reaction times of the different categories for the Cue Invisible-experiment, showing no significant difference. Right: Mean reaction times per emotion (x-axis) for cue and target.

4. Discussion

Our results show that we have to reject our first hypothesis, which was that we would find difference in reaction time between neutral and emotional stimuli. We could not find significant differences to support this hypothesis, and therefore we reject our first hypothesis. Our second hypothesis cannot be rejected just yet, since it was that the phenomenon *freezing* could be taken into account. The hypothesis about this was that the possibility of freezing by the presentation of emotional stimuli could lead to similar or even worse reaction times compared to neutral stimuli. The latter obviously is not the case, but the first could still be the case. How likely this hypothesis is must be subject to further research since there are too many other possible influences which could have caused these results.

An initial thought of changing or improving our experiment is changing the size of the stimuli, for instance to life-size proportions. This could influence reaction speeds positively since the subjects might have been unmoved by the small stimuli, and therefore not responding (enough) to the emotions presented by the stimuli.

One might also give the subjects a questionnaire after they completed the experiments, asking whether and how much they sensed the emotions displayed, for in our experiment several subjects noticed during the experiments that the emotions of the faces might have something to do with what we were researching.

Also it might be important to know in what extend the subjects felt moved by the emotions displayed, since our experiments focused on emotional reaction speeds, which means we hoped to see emotional reactions on the stimuli.

Another thought is improving the CFS, since it didn't work for the full 100% in our experiment. Whether it is possible to improve occlusion to 100% or not must also be proven by further research. Possible also is taking different stimuli instead of facial expressions, like words, animals or scary things. These might have more impact to the subjects.

Besides all that one can vary various other variables like luminance, contrast and environment.

In summary, following our experiments there has been no reason to conclude that there is any significant difference in processing speeds according emotional and neutral stimuli. Changing or improving parts of the experiments might lead to better insight according the freezing phenomenon, but as for now we conclude there is no difference in processing speeds.

[1]The actual date and paper he first mentioned this phenomenon remains unsure as several sources claim different dates, e.g. as early as 1914.

[2]The experiment performed showing this result used trials with a maximum of 180 seconds per trial, thereby possibly giving wrong conclusions.

[3]The maximum of 3 seconds should not ever be exceeded given a normal trial. Therefore when a trial should exceed the 3 seconds-threshold the result will be determined as a false trial and will be excluded from the data being examined.

[4]If the SOA would be similar each trial, the subjects might anticipate to the SOA, pressing a key before actually (consciously) seeing the target, resulting in false data.

[5]Sphericity assumed.

5. References

Bocanegra, B. R. & Zeelenberg, R. (2008). Emotion improves and impairs early vision. *Psychological Science, 20, 6,* 707-713. doi: 10.1111/j.1467-9280.2009.02354.x

Bracha, H. S., Ralston, T. C., Matsukawa, J. M., et al. (2004). Does "Fight or Flight" Need Updating? *Psychosomatics, 45,* 448-449.

De Gelder, B., van Honk, J. & Tamietto, M. (2011). Emotion in the brain: of low roads, high roads and roads less travelled. *Nature Reviews Neuroscience 11,* 773-783. doi:10.1038/nrn2920

Johnson, S. (2003). Emotions and the brain: Fear. *Discover Magazine.*

LeDoux, J. (1996). The Emotional Brain: The Mysterious Underpinnings of Emotional Life. *Simon & Schuster: New York,* 372 pp.

Tsuchiya, N. & Koch, C. (2005). Continuous Flash Suppression Reduces Negative Afterimages. *Nature Neuroscience 8,* 1096-1101. doi:10.1038/nn1500

Vazdarjanova, A. & McGaugh, J. L. (1998). Basolateral amygdala is not critical for cognitive memory of contextual fear conditioning. *Proc. Natl. Acad. Sci. USA, 95,* 15003-15007

Walker, L. (2004). *Changing with NLP: a casebook of neuro-linguistic programming in medical practice.* Radcliffe Medical Press