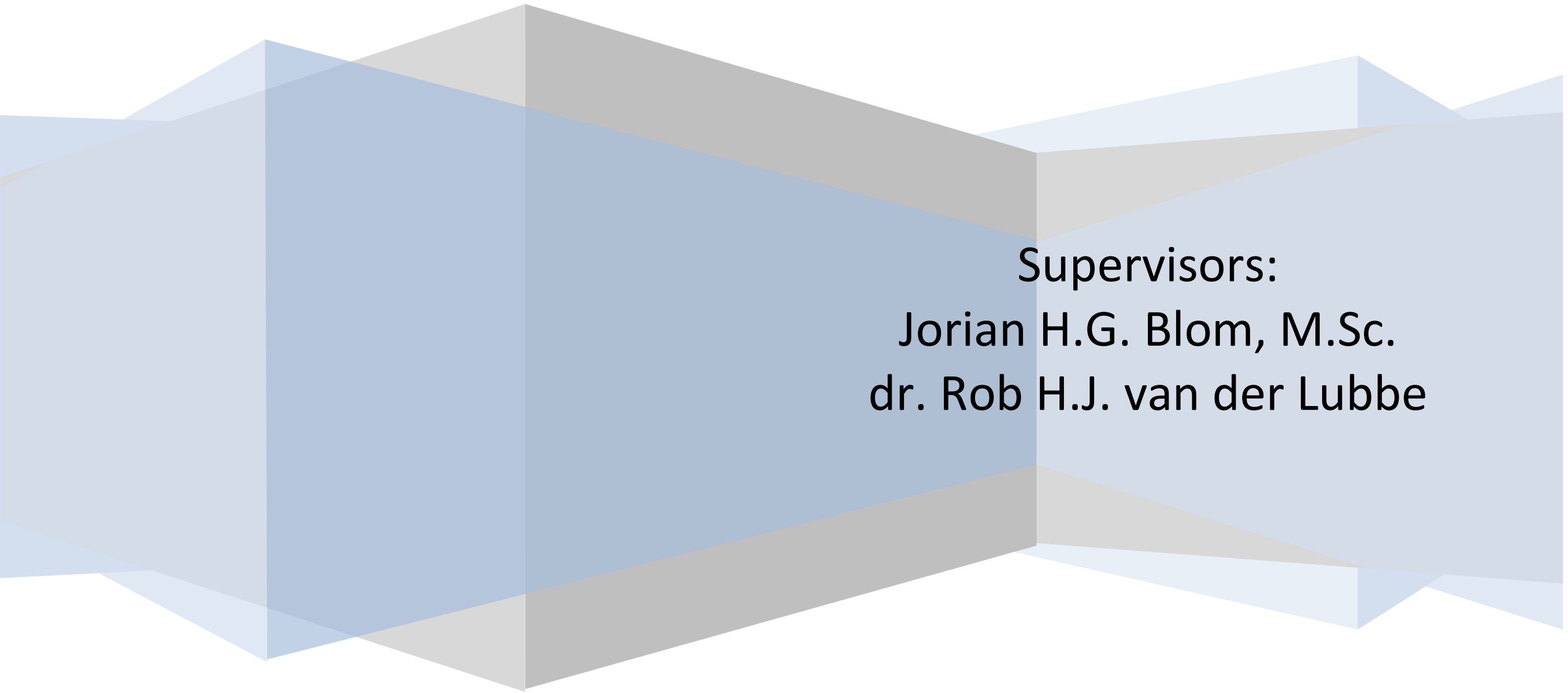
Universiteit Twente

The influence of pain on attention: Electrocutaneous distractors modulate the Attentional Blink

Isabel Sippel
s0196371



Supervisors:
Jorian H.G. Blom, M.Sc.
dr. Rob H.J. van der Lubbe

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1. English summary

The attentional blink effect is known as the inability of participants to report a second target in a stream of rapidly shown non – targets if it occurs about 500 ms after a first target. Studies suggest that this phenomenon is a long-lasting, unavoidable attentional deficit, because it can be observed under a wide variety of task conditions, for example visual, auditory or sensory targets, and cannot be eliminated even with training. Several explanations are suggested, including the Threaded Cognition Model or the Boost and Bounce Theory.

Research is done on the effect of distractors on the attentional blink, suggesting that there are two sides to it. On the one hand, studies have found that the mere presence of distractors can lead to a shorter blink period, while on the other hand some distractors, for example unpleasant ones, can lead to longer blink lengths.

In this experiment, the influence of pain on the attentional blink was studied. It was expected that low intensity pain stimuli have a beneficial effect, while high intensities lead to longer blink periods.

To study this, participants carried out an RSVP task, during which they were presented with an irrelevant electrocutaneous stimulus at the same time as T1 in 33 % of the trials. Participants were asked to report T2 and were tested for their accuracy on this.

The analysis showed that high intensity pain stimuli indeed led to lower accuracy in reporting T2, while low intensity stimuli did not seem to have a significant effect. This can be due to the experimental design, which was the first to use acute pain in contrast to continuous distractors, or the dissimilarity of the distractor stimuli to the targets. In conclusion, the hypothesis that high intensity pain stimuli have a detrimental effect for the attentional blink was confirmed, while the second half of the hypothesis, that low intensity stimuli have a beneficial effect, was not.

2. Dutch summary

Het attentional blink effect staat bekent als een onvermogen van proefpersonen om een tweede target in een reeks van snel achter elkaar volgende non – targets te rapporteren als deze ongeveer 500 ms na een eerste target verschijnt. Studies laten zien dat dit fenomeen een lang voortdurende, onvermijdbare deficit in aandacht is. Het wordt onder veel verschillende condities, bijvoorbeeld met visuele, auditieve of sensorische targets, gevonden, en kan ook met training niet geëlimineerd worden. Verschillende verklaringen worden gesteld, bijvoorbeeld het Threaded Cognition Model of de Boost and Bounce Theory.

Er is veel onderzoek gedaan naar het effect van distractors op de attentional blink, waarin gesteld wordt dat er twee zijden zijn. Aan de ene kant is aangetoond dat de aanwezigheid van distractors tot een kortere blink periode kan leiden, maar aan de andere kant zijn er distractors, bijvoorbeeld onaangename, die tot langere blink lengtes leiden.

In ons experiment werd de invloed van pijn op de attentional blink onderzoekt en er werd verwacht dat pijn stimuli met een lage intensiteit een voordelig effect hebben, en dat hoge intensiteiten tot een langere blink periode leiden.

Om dit de onderzoeken voerden proefpersonen een RSVP taak uit, waarbij ze in 33 % van de trials een irrelevante electrocutaneous stimulus op het zelfde moment als T1 toegediend kregen. Proefpersonen werden gevraagd om T2 te rapporteren en werden op hun accuratesse hierop getoetst.

De analyse laat zien dat pijn stimuli met een hoge intensiteit inderdaad tot minder accuratesse leden, maar lage intensiteiten hadden geen significant effect. Dit kan verklaard worden door het experimentele opzet, omdat het de eerste studie was, die acute pijn in tegenstelling tot continu distractor stimuli gebruikte, of het verschil tussen de distractors en de targets. Concluderend is te zeggen dat de hypothese dat hoge intensiteiten een negatief effect op de attentional blink hebben bevestigd werd, maar de hypothese dat lage intensiteiten een positief effect hebben werd niet bevestigd.

3. Introduction

In our daily life, we receive a great deal of information at the same time. While processing these stimuli, many of them interact when they are in close temporal or special proximity.

The effect of these proximities on processing multiple stimuli can be studied experimentally, for example by using a rapid serial visual presentation (RSVP) task (Van der Burg, Brederoo, Nieuwenstein, Theeuwes & Olivers, 2001). In this task, participants have to detect targets in a stream of rapidly shown non-targets, which appear about 50 ms after one another. A common finding is that an impairment occurs in detecting a second target when it appears within half a second after detecting the first target. This inability of participants to report the second target is labeled the ‘attentional blink effect’ (Martens & Wyble, 2010).

Studies suggest that the attentional blink is a long-lasting, unavoidable attentional deficit, because it can be observed under a wide variety of task conditions, for example with visual, auditory or sensory targets, and cannot be eliminated even with training (Braun, 1998). It should also be mentioned that there are great individual differences in blink length between people, ranging from large magnitudes to showing no attentional blink at all. These differences can be accounted for by non-target suppression, where non-blinkers are able to inhibit and ignore the non – targets better than individuals who show large blink lengths. (Dux & Marois, 2008).

There are several different theories on how to explain the occurrence of the attentional blink. Firstly, Taatgen, Juniva, Schipper, Borst and Martens (2009) developed the Threaded Cognition model. They state that there are attentional control mechanisms, which protect the encoding of a target by directing all attention to the task at hand. While these mechanisms are at work, the detection of a second target is shut off because all cognitive resources are used to process the first target. According to this model, the attentional blink is a cause of cognitive processes which make sure that target encoding is not disrupted. The authors claim that this mechanism may be useful in real life circumstances, but that it is harmful in an RSPV task.

Secondly, the Boost and Bounce model, proposed by Olivers and Meeter (2008), describes the attentional blink as a way of keeping unwanted information out of working memory. They claim that detection of a target leads to an attentional “boost” to enhance processing. To prevent this “boost” from carrying over to following non-targets, a “bounce” is triggered, which blocks further processing. If the second target happens to be within this “bounce” period, it is also suppressed, thereby leading to the attentional blink.

Finally, the episodic simultaneous type, serial token (eSTST) model was developed by Wyble, Bowman and Nieuwenstein (2009). They state that the attentional blink is a means to divide the continuous stream of stimuli, which people receive, into attentional episodes. Separately presented targets are stored in different working memory representations and the attentional blink is claimed to reflect the suppression of attention which provides this separation.

Recent studies suggest, that not one model, but an interplay of the Threaded Cognition and the eSTST model best explains the occurrence of the attentional blink (Martens & Wyble, 2010). Limited resources for processing and less attentional control mechanisms clearly play a role. In addition, the Threaded Cognition model offers an explanation on why some individuals show no attentional blink at all. Taatgen et al. (2009) conducted an ERP study, in which they effectively showed that memory consolidation sets on earlier in non-blinkers and therefore does not interfere with detection of the second target. Furthermore, the eSTST model is favored by some because studies suggest that episodic forms of information processing are involved in the occurrence of the attentional blink (Martens & Wyble, 2010).

To study the attentional blink further, a lot of research is done on the effect of distractors on the attentional blink. In this case, only task-irrelevant distractor stimuli, not non-targets of the task, are labeled as “distractors”. Studies suggest that there are two different sides to their effect.

On the one hand, it is stated that the mere presence of distractors has a beneficial effect and leads to a shorter attentional blink (Kawahara, 2009). Even task - irrelevant distractors or distractors of categories, which are different from the targets, reduce the length of the attentional blink (Choo & Kim, 2006). Martens and Wyble (2010) offer an explanation for this reduction effect by suggesting that irrelevant mental activity leads to distributed attentional states. These help to make resources, which would normally be allocated to the first target, available for the detection of the second target. Olivers and Nieuwenhuis (2005) support this view based on findings observed in their study. There, participants had to listen to music or make holiday plans while carrying out an attentional blink task. This resulted in significantly shorter blink lengths, which were attributed to freed resources that could be used for processing of the second target.

However, Kawahara (2009) found out that distractors must be neither too similar nor too dissimilar to the target to have this effect, hereby suggesting that there might be an “optimal level of distraction”.

On the other hand, there are a variety of studies showing that in contrast to this beneficial effect of distraction, it can have the opposite effect, thus increasing the length of the attentional blink.

MacLean, Arnell and Busseri (2010) proposed that distractors which induce negative affect, for example disturbing pictures, words like "rape" or even sad music, would lead to a lengthened attentional blink. This happens because negative affect focuses attention, thereby interfering with the processing of the second target (Olivers & Nieuwenhuis, 2005). This means that even though the negative affect is induced by the distractor, all attention will be focused on the first target, therefore leaving no resources to process the second. This effect could also be found when the distractor was totally task-irrelevant, suggesting that a negative stimulus grabs attention and is more difficult to ignore than a neutral one (Gotoh, Kikuchi & Olofsson, 2010).

Furthermore, Lipp, Neumann, Pretorius and McHugh (2003) found a positive correlation between blink length and rated stimulus unpleasantness, regardless of the modality of the stimuli, meaning that the more unpleasant a participant perceived the stimulus to be, the longer their attentional blink was.

In addition to this, Asplund, Todd, Snyder, Gilbert and Marois (2010) found evidence that surprise stimuli lead to increased attentional blink. They observed that even emotionally neutral and task-irrelevant stimuli capture attention as long as they are unexpected, arguing that participants in attentional blink tasks depend on a "top-down" manner of processing which can be disrupted involuntarily by surprise stimuli in a "bottom-up" manner. This form of attention is referred to as stimulus-driven, suggesting that unexpected events will always capture attention (Egeth & Yantis, 1997).

As can be seen, there are different effects of distractors observable, and in this study, the goal is to find out more about the effects of pain, which acts as an irrelevant distractor stimulus, on the attentional blink.

Pain is an unpleasant sensory experience often associated with possible tissue damage. It is a biological safety mechanism, which warns individuals when something is physically wrong and helps to take appropriate action (Marks, Murray, Ewans, Willig, Woodall & Sykes, 2005). The experience of pain evoked by a harmful stimulus directs attention to possible danger and holds attention at the thread (Kalat, 2007). By this, it disrupts ongoing behavior by motivating individuals to orient towards the pain and make attempts to stop it (Melzack & Wall, 1988).

Furthermore, pain is also an emotional stimulus, because of its unpleasantness and the willingness of individuals to avoid it (International Association for the Study of Pain [IASP], 1994). It should also be noted that pain is always a subjective experience, because one can never know what someone else is feeling and therefore pain is whatever the person experiencing it says it is, and it is existing whenever they say it does (McCaffery & Thorpe, 1988). People's thoughts and cognitions also influence the experience of pain, because increased attention has been associated with increased pain perception (Marks et al., 2005).

Up to now, no studies on the effect of pain on the attentional blink have been conducted, and only a few in the tactile domain, which resembles pain in the way that it is also a sensory experience induced from the outside.

Research suggests that the tactile attentional blink exist, in purely tactile as well as in cross-modal settings. Hereby, the tactile stimulus was used as a target and was "blinked" when both targets where tactile as well as when only one of them was tactile and the other either visual or auditory (Dell'Acqua, Turatto & Jolicoeur, 2001).

Furthermore, Dell'Acqua, Jolicoeur, Sessa and Turatto (2006) showed that it was impossible for participants to ignore tactile stimuli that work as distractors, even if they knew beforehand that they would occur, suggesting automatic capture of tactile attention even if this was unwanted or irrelevant to the task.

Even though pain resembles tactile stimuli in some ways, there are also differences. Firstly, pain is always an emotional stimulus and induces negative affect, while tactile stimuli can very well be neutral.

Secondly, pain doesn't always have to be a sensory experience, as studies of phantom pain suggest (Kalat, 2007). Therefore, it is clear that pain is a highly subjective experience while tactile stimuli are somewhat objective (IASP, 1994).

In the planned experiment, an RSVP task will be presented, during which participants will have to detect number targets in a stream of distraction letters. In some of the trials, participants will receive irrelevant electrocutaneous stimuli at the same time at which they view the first target. As mentioned above, no research on the effect of pain on the attentional blink is conducted up to now. As a result, it is hard to anticipate what might happen, because as described above pain stimuli will be different to earlier studied distractors in significant ways. Regarding the mentioned findings, one can say that pain strongly captures attention and can therefore hardly be ignored. Furthermore, it is expected that pain stimuli will be negatively valued, which is why they focus attention. It is also the case that tactile stimuli, which as mentioned above resemble pain stimuli in some significant ways, can hardly be ignored and would therefore increase the attentional blink.

On the other hand, it is said that some distraction is beneficial for the attentional blink task.

As indicated above, irrelevant mental activity helps to free additional resources, which can then be used to detect the second target. Pain stimuli could thus possibly have the right amount of dissimilarity to the target to cause this effect.

In light of these contradictory findings on distractors, it is hard to predict what the effect of pain on the attentional blink will be. The stimuli used in the experiment will thus be of low, middle or high intensity to find out if the strength of the pain stimuli will make a difference for task performance. Because of that the hypothesis will be two-sided to find out if there is a difference in influencing reporting accuracy between high and low pain stimuli.

Therefore, the experiment will be conducted in light of the following predictions:

The implementation of low electrocutaneous pain stimuli will be beneficial to the length of the attentional blink, thus leading to a shorter blink period, while high electrocutaneous pain stimuli will have the opposite effect, thus leading to a longer blink period.

4. Methods

4.1. Participants

In total, 21 healthy participants completed the experiment, which lasted one hour. The data of two of the participants could not be used for further analysis due to technical errors.

Of the 19 participants, four were male and 15 were female. The age was ranging from 19 to 28 years, with a mean age of 21.1 years.

Furthermore, all the participants were right-handed, except one who showed ambidexterity.

It should also be noted that three of the participants had dyslexia, but this made no difference for task performance.

Before starting the experiment, participants were asked to read an information brochure with information on the task. All participants also signed an informed consent form, wherein was noted that they had received understandable information on the task, could always ask further questions and could stop the experiment at any time without any consequences for them, which is all in line with the Helsinki declaration (cp. World Medical Association [WMA], 1964).

4.2. Stimuli and Procedure

Before the experiment, participants completed a form with general information about themselves, a handedness inventory and the “Thayer mood scales” (cp. Attachment 1). In this questionnaire, they placed a stripe on an 11 cm scale ranging from “absolutely not” to “very much”, to indicate how strongly they felt certain emotions as “excited” or “fearful” at the given moment. The mood scales were filled in again after completing the experiment.

To account for individual differences in pain experience, three thresholds were identified before the beginning of the experiment: the sensation threshold, the pain detection threshold and the pain tolerance. Every threshold was measured three times. 3-pulse stimuli current amplitudes were increased by steps of 0.1 mA starting at zero. Participants were instructed to press the space bar when their personal threshold was reached. The sensation threshold had a mean of 0.45 mA with a standard deviation of 0.10. The pain detection threshold had a mean of 0.73 mA with a standard deviation of 0.53 and the pain toleration had a mean of 1.17 mA with a standard deviation of 1.08.

Before block one and after each block a measurement of the pain experience was conducted. Two 1-pulse, two 3-pulse and two 5-pulse stimuli were presented in random order. Participants were asked to rate the intensity of the stimuli by using a visual analogue scale (VAS-scale). This scale is used to measure subjective attitudes by asking participants to indicate their level of agreement by marking a position on a continuous line. The scale used in our experiment ranged from zero to ten. Hereby, “zero” meant “no sensation”, “five” was the “pain threshold” and “ten” stood for “extreme pain”. These measurements were used to follow possible changes in the pain perception of the participants as the experiment continued.

4.3. Task

Every participant completed four blocks with 108 trials per block. Between the blocks were pauses of approximately two minutes.

At the beginning of every trial, participants were shown a fixation cross which stayed on screen for 1780 ms. Then a stream of 20 randomly chosen letters followed, whereby the letters B, I, O, Q and S were excluded from the set to prevent confusion with targets. Further, every letter was presented in every trial just once. They were presented for 60 ms. In every trial, one or two letters were replaced by a number randomly chosen from the numbers two to nine. These numbers acted as first (T1) and second target (T2). There were also trials were T2 was absent. Furthermore, no number was presented in a trial more than once.

The number of letters between T1 and T2 could vary, with zero distractors (short), two distractors (medium) or four distractors (long). After 36 and 72 trials, there was a short pause of 35 seconds. Participants knew beforehand that there could be one or two numbers in the stream of letters. They were asked to type in the numbers in order of their appearance 1000 ms after the end of the stream of letters. If they were unsure about T2 they were instructed to guess if they thought it was there but did not know for sure which number it was. If they thought that T2 was absent, they were asked to type in a 0. 200 ms after giving the last response, a new trial started.

Participants were presented with an irrelevant electrocutaneous stimulus at the same time as T1 in 33 % of the trials. The stimuli were evoked by a DS5 constant current stimulator (Digitimer, Welwyn Garden City, UK) and a stainless steel concentric bipolar needle electrode developed by Inui, Tran, Hoshiyama and Kagiki (2002; Inui, Tsuji & Kagiki, 2006), consisting of a needle cathode surrounded by a cylindrical anode, was placed on the left arm of the participants. The stimuli could be of low (1-pulse), middle (3-pulse) or high (5-pulse) intensity. Pulse trials consisted of 1 ms rectangular pulses with 5 ms interpulse intervals.

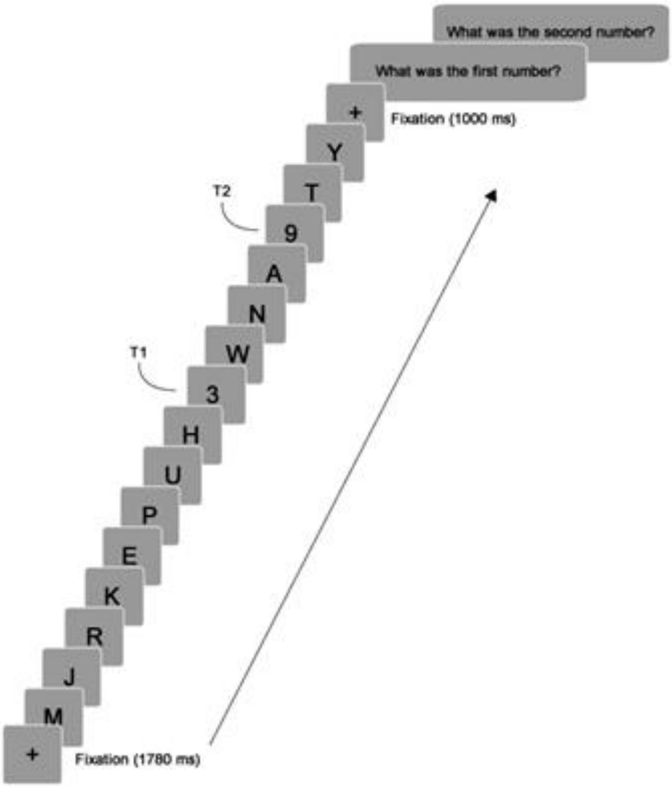

Figure 1 *Example of RSVP task*

4.4. Analysis procedure

All analyses were done using SPSS, Statistical Package for Social Sciences, version 18.0 (SPSS, 2008).

Scores of one participant could not be used in the analysis because the scores on the VAS-scales indicated that the electrode did not transmit the stimuli correctly, which was displayed by very low VAS-scores in block 2, 3 and 4.

In order to seek an answer to the research questions, cross tabulations of the accuracy scores on the first number and on the second number were made, to see how the overall accuracy on T1 and T2 was in percentages. These were then also differentiated by the different pain stimuli strengths and the number of distractors between the two numbers. This was to see if these differences had an influence on the accuracy of performance.

Furthermore, the Pearson Chi-Square was conducted to see if the performance on reporting the first number was correlated to performance on reporting the second.

To see if pain stimuli strengths and the number of distractors made any difference, repeated measures ANOVA with two within – subject factors was used. These within - subject factors were the pain stimuli intensities, which had four levels (absent, low, medium and high), and the distractor interval lengths, which had four levels as well (absent T2, short, medium and long). Contrast analysis and Bonferroni confidence intervals were conducted to further analyze where the differences lay.

To see if there were differences in pain experience as the experiment went on, the VAS-scales were used. The means of the measurements of pain perception before the experiment and after every block were conducted and then compared using repeated measures ANOVA. Hereby, the stimulus intensities with three levels (1-pulse, 3-pulse and 5-pulse) and the blocks with five levels (before the experiment and after each block) acted as within-subject factors. Contrast analysis was used to find out where the differences lay.

Lastly, difference scores for the mood scales were computed to asses if participants felt significantly different before and after the experiments.

5. Results

5.1 VAS - scales

Firstly, the analysis of the VAS-scales showed that the pain perception of the participants diminished slightly as the experiment went on.

In the 1-pulse trials the mean of the measurement before the experiment was 2.8 and after the last block it was 1.2. In the 3-pulse trials, the mean was 5.2 at the beginning and 4.8 after the last block. Lastly, in the 5-pulse trials the mean was 6.3 before the experiment and 5.9 after the last block. The repeated measures ANOVA also confirmed a main effect of the block ($F(4,13) = 4.320$, $p = 0.019$). It also showed a significant effect of the stimulus intensity ($F(2,15) = 58.469$, $p < 0.001$). Interaction effects of block and intensity were also observable ($F(8,9) = 4.309$, $p = 0.021$). The contrast analysis revealed that the differences between all blocks were not significant, except between the measurements before the experiment and after block 1 ($p = 0.092$), which was significant if one – sided testing with a significance level of 0.1 was used. It also showed that significant differences between all stimulus intensities were observable. These results can be seen in figure 2.

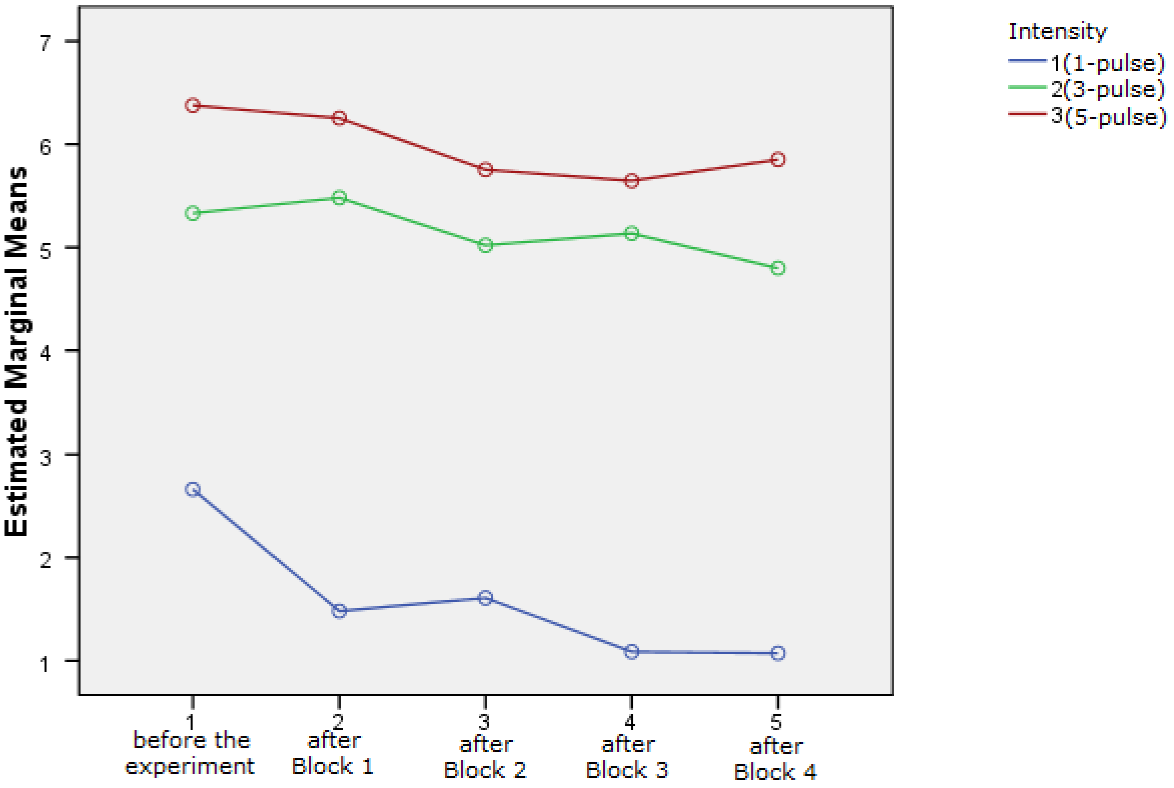

Figure 2 *Means of the VAS-scales*

5.2 Attentional blink effect

Firstly, the cross tabulation of the accuracy scores on T1 and T2 showed that T1 was reported correctly 65.5 % of all trials. In trials without stimuli, T1 was reported correctly in 63.4 % of the trials and 69.0 % in trials with pain stimuli. Furthermore, one can see that T2 was reported correctly 50.2 %. But if one looks at the scores differentiated by the correct and incorrect report of T1, one can see that T2 was reported correctly in 85.5 % of the cases when T1 was reported correctly as well. In contrast to that, T2 was reported correctly only in 14.5 % of the trials when T1 was incorrect. This suggests that T1 performance is correlated to T2 performance, this was also confirmed by the Chi – Square test with Pearson $X^2 = 1.353$ ($p < 0.001$). In further analysis, only trials where T1 was reported correctly will be taken into account.

Firstly, it is important to note that an attentional blink effect was observable in the trials without pain stimuli. The difference in accuracy of T2 reporting between the numbers of distractors was significant (F(3,15) = 13.148, p < 0.001). In trials with pain stimuli, the attentional blink effect was found as well. Here, the difference between the number of distractors was also significant (F(3,15) = 13.619, p < 0.001). The repeated measures ANOVA showed that the stimulus intensity did not have any significant effect (F(3,15) = 2.200, p = 0.130). But contrast analysis for the difference between the absence of pain stimuli and only one of the intensities revealed a significant effect of high intensities (F(1,17)= 7.418, p = 0.014). The Bonferroni confidence interval showed that participants scored significantly higher in trials without pain stimuli (p = 0.014). Differences between the absence of pain stimuli and low intensities were not significant (F(1,17) = 0.540, p = 0.487). Also, medium intensities did not have any effect in comparison to the absence of pain stimuli (F(1,17) = 1.764, p = 0.202). Further details can be found in table 1.

Table 1 *repeated measures ANOVA for different intensities*

Difference	F value	Significance
Absent and High	7.418	0.014
Absent and Low	0.540	0.487
Absent and Medium	1.764	0.202
High and Low	1.731	0.206
High and Medium	0.827	0.376
Low and Medium	0.169	0.686

In addition to these results, the repeated measures ANOVA showed a significant main effect of the interval length (F(3,15) = 15.032, p < 0.001). The Bonferroni confidence intervals further showed that participants scored significantly higher in trials with absent T2 than in trials with long or medium interval length (p = 0.033 and p = 0.003 respectively). Also, scores were significantly higher in trials with short intervals than in trials with long intervals (p < 0.001), as well as in trials with medium intervals (p < 0.001). Scores of trials with absent T2 and short interval length did not differ significantly (p = 1.000). Further, differences between long and medium intervals were not significant (p = 0.126).

All these results can be seen in figure 3.

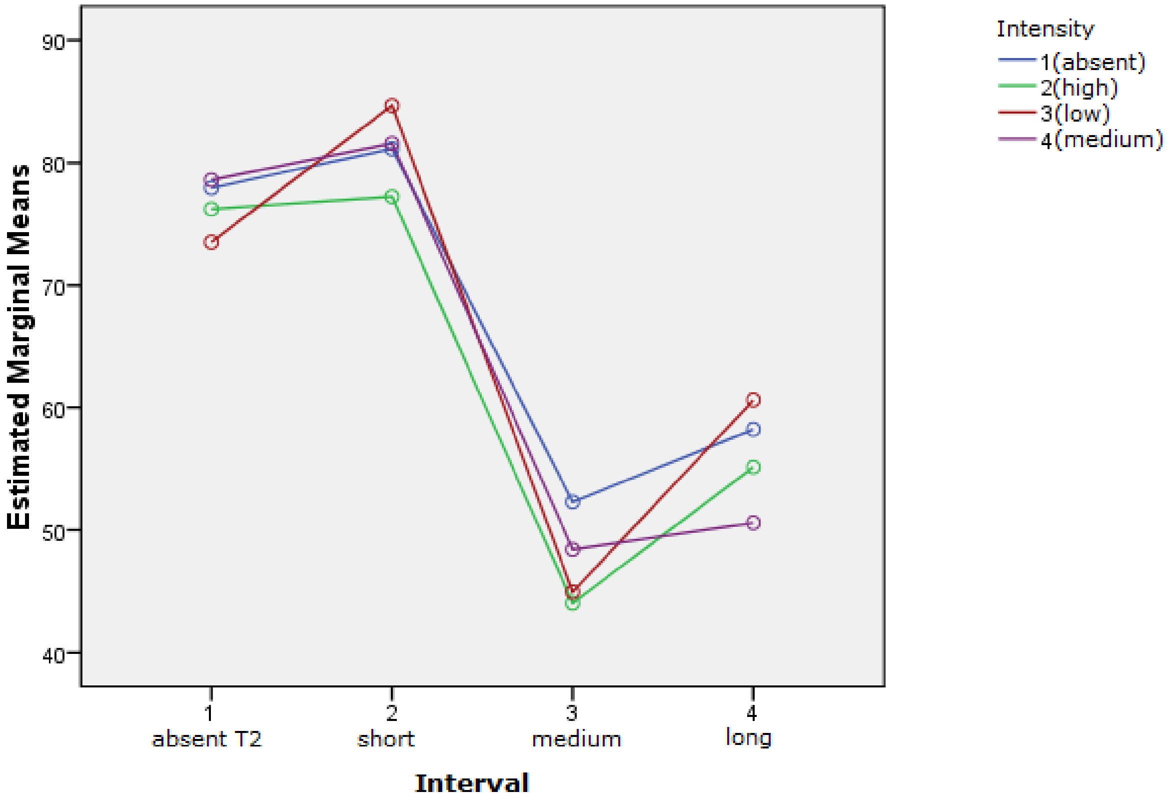

Figure 3 *Mean percentages*

The cross tabulation of the interval lengths and the pain stimuli strengths further showed the following results. When T2 was absent altogether, this was reported accurately in approximately 80 % of the trials, regardless of the strength of the pain stimuli.

When the interval between T1 and T2 was long, T2 accuracy had the best results when the pain stimulus was low (62.5 %) and the worst when it was of medium strength (52.3 %). It could further be observed that when the interval between T1 and T2 was of medium length, accuracy had the best result when the pain stimulus was absent (52.6 %) and the worst when it was of high intensity (42.2 %). When the interval between T1 and T2 was short, it could be observed that T2 accuracy was better with 80.8 % correctly reported trials when the pain stimulus was of medium intensity, and 85.3 % when it was low.

In support of these findings, the repeated measures ANOVA revealed no significant interaction effects ($F(9,9) = 1.069$, $p = 0.461$).

5.3 Mood scales

The analysis of the mood scales showed that participants were more fearful before the experiment ($p = 0.007$). They were also more tired afterwards, but this was no significant differences ($p = 0.074$). The other difference scores also showed no significant changes.

6. Conclusions and Discussion

In light of the two – sided hypothesis that the implementation of low electrocutaneous pain stimuli will be beneficial to the length of the attentional blink, thus leading to a shorter blink period, while high electrocutaneous pain stimuli will have the opposite effect, thus leading to a longer blink period, it can be concluded that only one half was confirmed. While high intensity stimuli indeed led to increased blink length, low intensities did not have any effect. Nonetheless, the results match discussed attentional blink models. The attentional blink was observable in the trials with and without pain stimuli. The difference in accuracy of reporting T2 between the numbers of distractors was significant, showing that, as discussed above, limited processing resources and attentional control mechanisms play a role (Martens & Wyble, 2010). It was also observable that participants were better in reporting T2 in trials with short intervals, thus without any non-targets between T1 and T2. Potter, Staub and O'Connor (2002) suggest that this is a "normal" attentional blink pattern, which is most likely to occur when T1 and T2 have the same perceptual criterion. This effect is explained by the observation that attention is not immediately cut off after T1 detection, so that any item following it will be processed as well. In short interval trials, this happened to be T2, so that accuracy of reporting is facilitated.

Furthermore, there was no difference in accuracy of reporting T2 between medium and long intervals observable in the results. This can be explained by the fact that both lie within the 200 ms to 500 ms period which is normally suggested as the interval in which the attentional blink is most likely to occur (Martens & Wyble, 2009).

Interestingly, participants were better in reporting that T2 was absent than reporting T2 in trials with medium or long intervals, but there was no significant difference between short intervals and the absence of T2. These observations can be explained with the finding that T2 is often perceived, but does not reach a stage of higher processing (Potter et al., 2002). Participants thus knew that T2 was there, but could not report it, which led to lower accuracy in medium and long intervals. When T2 was absent, participants could report this accurately, because they did not perceive any stimulus.

When having a closer look at the effect of the pain stimuli on reporting T2, there were no significant effects observable if all trials are taken together. But if one looks at only one of the intensities in comparison to the others, the following results were observed:

Firstly, it could be seen that participants scored significantly better in trials with absent pain stimuli than in trials with high intensities. The hypothesis that high pain stimuli intensities have a detrimental effect on the accuracy of reporting T2 in attentional blink settings was thus confirmed. MacLean et al. (2010) suggest that this is happening because the greater negative affect a stimulus induces the greater the attentional blink magnitude is. In our study, high intensities were clearly valued more negatively, because they were more painful, and thus led to longer blink periods. Furthermore, studies confirm that negatively valued stimuli grab attention more fiercely, thereby leading to longer blink lengths (Gotoh et al., 2010).

Secondly, no significant differences between the absence of pain stimuli and low or medium intensities were observed. The hypothesis that low intensities have a beneficial effect on the attentional blink length has thus not been confirmed. For these findings, several explanations are possible. On the one hand, studies have found that some types of distractors are not able to produce the reduction effect, because they are too dissimilar from the target and can thus easily be ignored (Visser, Bischof & Di Lollo, 2004). Dell'Acqua et al. (2006) also found that distractors are more likely to capture attention if they share features with the target, especially if these features are on a dimension which is used to select targets among non – targets. It is thus possible that the pain stimuli were too different from the letter targets to have any effect on blink length, because they were so irrelevant for the task that they could be ignored easily. On the other hand, Kawahara (2009) offers a different explanation by suggesting that an "optimal level of distraction" is needed for a distractor to have beneficial effects on blink length. There is no effect if the distractors are too similar to other target conditions. It is thus possible that low intensity stimuli were merely too low to have an effect, because of being too similar to the overall absence of pain.

Lastly, if comparing any of the intensities with each other, no significant differences in their effect on reporting T2 accurately were found. These findings can be explained by the fact that it is difficult for participants to differentiate between tactile stimuli (Dell'Acqua et al., 2001). In a study conducted by Lipp et al. (2003) it was also observed that blink length often does not differ for tactile stimuli, no matter how strong they are.

These findings suggests that the differences between the stimulus intensities might have been too low to be noticed, but the analysis of the VAS – scales confirms that participants were able to distinguish between the intensities. Answers to the question why it made no differences for attentional blink length, if it is clearly observable that participants could differentiate between the stimuli intensities, can be sought in the experimental design. This experiment was the first to use acute pain in combination with the attentional blink, meaning that pain stimuli were not present the whole time, but only shortly and acutely. Other experiments with distractor stimuli often used continuous distractors. For example, participants listened to music during the attentional blink task (Olivers & Nieuwenhuis, 2005). It is possible that the effect of these distractors resembles chronic pain more than the presentation of acute pain stimuli. Lipp et al. (2003) also failed to find an effect of acute tactile stimuli on attentional blink length. In their study, discontinuous vibrating pulses were presented to the participants, while they were carrying out an attentional blink task. These pulses did not have any effect and the authors suggest that continuous stimuli, for example streams of air directed at the skin, will lead to differences in blink length. It is thus possible that acute distractor stimuli are not fit to have effect on the attentional blink. Furthermore, explanations for the fact that no effect was found can be sought in the task implementation. There could have been too few trials with pain stimuli or too many combinations of intensities and interval lengths. Besides, the pain stimuli were always presented at the same time as T1, so alternating onsets or positions of the pain stimuli, for example shortly after T1 presentation, could produce different effects.

The number of participants is also a factor on which improvement is needed. Other studies used between 40 and 200 participants (cp. Brisson, Spalek & Di Lollo, 2010 and Lipp et al., 2003). Because of the low number of participants in our experiment, it could be possible that differences between intensities were not significant or too little to be observable because of the spreading of responses.

It can be suggested that further experiments in this field could be conducted with alternating lengths, positions or onsets of the pain stimuli and more participants.

Further analysis of the VAS – scales also brought forward that the pain perception of participants diminished slightly, mostly between the measurement before the experiment and after the first block, as the experiment went further. This observation could be due to habituation effects (Melzack & Wall, 1988), meaning that participants got used to the feeling of pain and therefore did not perceive it as strongly as in the beginning anymore. Another explanation could be desensitization effects. This means that participants did not perceive the stimuli as strong as in the beginning, because their pain preceptors did not fire as much anymore, because the stimuli had been there before and were not perceived as an acute thread anymore (IASP, 1994).

In addition to these results, the analysis of the mood scales did not show any surprising findings. It was to be expected that participants were more fearful before the experiment, because they knew they were to perceive pain. They were also more tired afterwards, which was also expected because they had to look at a computer screen for quite some time and the attentional blink is a demanding task.

To conclude, it can be said that the hypothesis that high intensity pain stimuli have a detrimental effect for attentional blink length, was confirmed. In contrast to that, low and medium intensities did not have any effect. The second part of the hypothesis was thus not confirmed. It is suggested to replicate the experiment with more participants and variations on the pain stimuli. Although not all results could be found to be significant, the study nonetheless shows promising starting points for further research, suggesting that more experiments with discontinuous distractor stimuli are needed.

7. References

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8. Attachment

8.1. Thayer mood scales

MOOD INVENTORY

Geef bij de volgende emoties door middel van een streepje aan in hoeverre (van helemaal niet tot heel erg) ze voor jou van toepassing zijn.

gespannen

helemaal niet heel erg

positief

helemaal niet heel erg

prikkelbaar

helemaal niet heel erg

opgewonden

helemaal niet heel erg

ontspannen

helemaal niet heel erg

moe

helemaal niet heel erg

onverschillig

helemaal niet heel erg

angstig

helemaal niet heel erg

vrolijk

helemaal niet heel erg

energiek

helemaal niet heel erg