Preparation is not Everything

On the Effects of Preparation Time in the Flexion-Extension Task

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Abstract

In a recent study Adam et al. (2008) have found that a longer neutral precue increases reaction times in the reaching task. This is due to the demanding process of maintaining visual attention. We were interested if the effect found in their study could be replicated in the Flexion-Extension task, a perceptual motor skill task, which is comparable to the reaching task in several aspects. Furthermore we investigated the influence of practice and the interaction of practice and precue condition on reaction time in the Flexion-Extension task. In the present research, participants had to move a lever with their right forearm to react to visual stimuli that were preceded by a precue of either 100 ms or 1000 ms. The results showed significantly shorter reaction times in the shorter precue condition. Although reaction times generally decreased with practice, the differences in reaction time between the two precue conditions increased with the duration of the experiment. Differences in average reaction times were three times bigger at the end of the experiment compared to the beginning. We concluded that the Flexion-Extension task involves processes similar to those involved in the reaching task and that the effect of these processes increases with fatigue.

1. Introduction

The present study focused on improving the understanding of the processes involved in the Flexion-Extension (FE) task. The primary objective of this study is to investigate the effect of the duration of a neutral precue on reaction time in the FE task. The FE task is a perceptual-motor skill task in which the participant moves a lever with their arm to a series of target locations (Panzer, Wilde, & Shea, 2010). Panzer et al. (2011) have used this task earlier with fixed movement sequences, focusing on learning procedures. In the present study, a randomized sequence of targeted movements was used to investigate the influences of several factors on reaction times in the FE task.

The findings of this study will ultimately provide a basis for the re-LOAD project. In three stages this project is going to first, characterize the age effects in motor skill learning, second, investigate individual differences and finally develop training protocols for older people to improve in certain perceptual-motor skills. In the project these differences will be assessed by using variations of the Flexion-Extension (FE) task, which has been used earlier by Panzer et al. (2011), and the Discrete Sequence Production (DSP) task developed by Verwey (1999).

1.1 The effects of preparation time in earlier research

In their research on key press and reaching responses and how these are affected by various precues and preparation intervals, Adam, Taminiau, van Veen, Ament, Rijcken and Meijer (2008) found that preparation time played a crucial role in the performance of their participants. With both tasks, participants reacted to the presentation of a stimulus which was preceded by either a neutral, partial or full precue. Each of the precues was presented for 100 ms, 500 ms or 1000 ms. The stimulus and the precue were either presented on-target or off-target. That means the participant either had to press a key/button at the same location as the stimulus or one that was associated with a stimulus on a screen in front of them. In the key press task participants were to press one out of four keys on a keyboard. In the reaching task the participants reached towards one out of 4 buttons in front of them, returning their hand to a starting position after every reaching movement. While respondents generally benefited from a longer preparation time in the key pressing task, a longer preparation time had a negative effect on performance in the reaching task. Adam & Pratt (2004) argued that this is due to the different processes involved in making either a key press or a reaching movement. In the key press condition participants selected a finger with which they would press the key, requiring effector selection. In the reaching condition, however, participants did not have to choose an effector but instead focused their visual attention. According to Adam et al. (2008) the explanation for this finding is that effector selection is a slow, time-consuming process that benefits from longer preparation time whereas visual attention is a fast process that is difficult to maintain across longer preparation intervals.

In the key press task respondents reacted fastest when they had a precue that showed either two possible target locations (partial precue) for the next stimulus or the guaranteed next stimulus position (full precue) for 1000 ms. At the same time there were only small costs in reaction time in the longer precue condition when a neutral precue was presented. Across all three precue conditions combined, benefits were higher in longer precue conditions. In the reaching task, on the other hand, there were big costs in reaction time in the neutral precue condition, in which all possible target positions were filled with the precue. In this way there was no information on where, but only that, the target would appear. Full or partial precues produced only small reaction time benefits in the reaching task and averaging the three precue conditions reaction time costs were highest for the longest precue. Especially in the neutral precue reaching task condition these findings align very well with the explanation of Adam and Pratt (2004) that prolonged attention might be responsible for the costs in reaction time.

Since the neutral precue does not hold any information on the position at which the stimulus is presented, decreasing attention most likely is the influencing factor.

1.2 The present study

The relevance of these findings for the re-LOAD project becomes apparent when the keying and reaching tasks are compared with the tasks involved in the project. The off target key press condition resembles the Discrete Sequence Production task to a great extent. In both tasks participants respond to stimuli presented on a screen by pressing the corresponding key on the keyboard. The difference is that in the DSP task participants learn fixed sequences of key presses by repeating them instead of being provided with random sequences. The question here is whether preparation time and different precues also have an effect on the learning of fixed sequences. The main question in the present study is whether the negative effect of preparation intervals in the reaching task can be reproduced in the flexion-extension task. There are several aspects that make this a logical assumption. First of all there is no effector selection process involved in the FE task which would benefit from a longer preparation time. Secondly in the FE task the participant has to move their arm to a target location. In the FE task this happens by moving the forearm horizontally in an angle while the elbow stays in a fixed location. Although this is not exactly the same as the movement in the reaching task, it is similar in certain ways and therefore might also involve the same or at least similar processes. In both tasks the participants move their hand to a target location where the stimulus appears. Thus it appears likely that a prolonged period of attention may make it more difficult for the participants to maintain their attention on a high level as described by Adam et al. (2008). It is of course possible that there are more factors contributing to the effects Adam et al found in their experiments that are not the same in the FE task. Assuming that the explanation of Adam et al. (2008) is complete, however, the most important factors should be the same. That means that like with the reaching task, there should be a negative effect of preparation time on the reaction time in the FE task. Since Adam et al. (2008) found a positive relationship between the duration of the preparation interval and reaction time in the neutral stimulus condition that optically appeared to be linear, the present study assessed the effects of only two different preparation intervals. To make sure that the effects are really a result of the preparation time, in which participants have to maintain a high level of directed attention, and not a result of a different length of pauses between single movements, there were fixed pauses of 1 second between each single movement. The neutral precue is either presented for the full 1000 ms of the pause or only during the last 100 ms. While the 1000 ms cue should

show the deficits of prolonged attention, the 100 ms seconds cue should be just long enough to make the participant aware of the oncoming stimulus. We hypothesized that, as in the reaching task, reaction time would be significantly increased in the 1000 ms condition compared to the 100 ms condition.

Additionally we were interested in the possible effects of practice in the Flexion-Extension task. Adam et al. (2008) mentioned the influence of practice on differences between precue benefits in effector selection tasks. The keying tasks involved in the re-LOAD project are effector selection tasks. Adam et al. (2008) discussed an interaction effect of precue and practice on reaction time, namely that those differences in precue benefits decreased with increasing practice. While their statement was based on effector selection, a process that is important in the key press task and not in the reaching task, it still raised the question whether a similar effect could be found for the Flexion-Extension task in the present experiment. Presuming that the effect in the present experiment would be similar to the effect described by Adam et al. (2008), we expected that the difference in reaction time between the 100 ms and the 1000 ms precue condition would decrease with increasing duration of the experiment.

2. Method

2.1 Participants

Seventeen people participated in this study. All participants were aged 18-30 and right- handed. Most of the participants were students of the University of Twente. The sample consisted of 5 males and 12 females. The participants were contacted personally, by flyers or via the university's test-person-panel. The Ethical committee of the University of Twente approved this study.

2.2 Apparatus

The device used in this study was a mechanical lever that the participants had to move with their right forearm. An adjustable handle was mounted on the lever to allow for better control. The mechanical arm could only be turned right- or leftwards and the angle of movement was measured by a potentiometer attached to the axle. The display, showing 9 circles as target locations and the pointer, was projected onto the wall in front of the participant at a distance of 3 m. All circles had dark red as basic color and were simultaneously changed into bright red for either 100 ms or 1000 ms before one of the circles

was colored yellow to mark the target. A small green circle was used as cursor to give participants a visual feedback to the position of their arm. All participants received the same randomized sequence of targets with the same combination of targets and precue conditions (either 100 ms or 1000 ms). The 6-element sequence used in this experiment started at the middle target. After that the new target position was always 2 or 4 circles away from the previous target to either side. The reaction time measured in this experiment was the time it took participants to move the pointer 1/100 of the width of the screen after the stimulus was presented. This translated into an angle of 1° of the lever and minimized the amount of movement time included in the reaction time. To confirm the correct hit of a target, the pointer had to remain in the target circle for 500 ms without touching its edge. Figure 1 shows the phases included in one element of a 6-element sequence. The program used in this study was written in MATLAB, and all data was recorded in MATLAB.

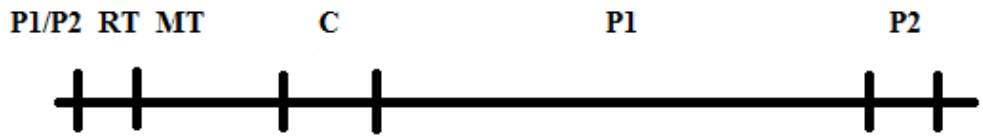

Figure 1. One element of a sequence: Precue of 1000 ms or 100ms (P1/P2), Reaction Time (RT), Movement Time (MT), Confirmation of the target (C) resulting in a new precue (P1 or P2)

2.3 Task

Participants were instructed to move the lever with their right arm in a randomized sequence consisting of 10 blocks of 20 six-element sequences. These six-element sequences were independent from each other, and, with the exception of two cases, no two out of three consecutive sequences were the same. In those two cases the sequence of targets was the same but precue conditions varied. It is therefore very unlikely that the complete sequence appeared to be anything but randomized to the participants. After every six-element sequence they were to reposition their arm to the middle target. Their lower right arm lay on the lever and they gripped the handle with their right hand. Furthermore they were instructed to move the green pointer on the display to the yellow target circle as soon as that circle was displayed. Participants were asked to react and move as fast as possible while at the same time moving as precisely as possible. They were informed that a trial was only valid if the pointer did not leave or hit the edge of the target once it had entered the target completely. Additionally they were instructed not to move away from the previous position before the new yellow target circle appeared.

2.4 Procedure

Firstly participants received instructions on the procedure of the experiment, described in the section below. After receiving the instructions they were asked to take place on the chair next to the lever and adjust the handle on the lever to their personal arm length. Neither the height of the chair nor the chair's distance to the projection on the wall was changeable. Participants then practiced with 10 6-element sequences.

The actual experiment consisted of 10 blocks of 20 six-element sequences. The practice sequence as well as the experimental sequence contained both precue conditions, with the conditions being precues of 100 ms and 1000 ms. After every 6 movements, participants positioned the pointer back at the center of the screen so that each sequence started from the centre position (target 5). After each of the ten blocks participants got a 1 minute break in which the average reaction time for that block and the change in average reaction time compared to the previous block were displayed on the screen. Additionally the program encouraged participants to become faster if their average time was not higher than in the previous block or say "goed zo!" (well done) if they were faster compared to their previous time. Participants were allowed to use the break at their will. It was made clear that the participants could stop the experiment at any moment if they were experiencing physical or psychological distress.

3. Results

3.1 Removal of invalid trials

To make sure that only valid data would be part of the data analysis, all six-element sequences that were not performed according to the instructions were removed from the data. Invalid six-element sequences were sequences of 6 containing at least one of two possible errors. If participants left their current target position before a new target was presented and/or if participants passed the new target (overshoot) and needed more than one second to reenter the target and stay in the target after overshooting, this was considered an error. The first type of error would not have represented actual reaction time since the participant moved before they could react. The second type could have been the result of a random movement that was not a reaction to the stimulus presented. One participant was excluded from further analysis because there was not enough data left to conduct an analysis of variance (ANOVA) on his/her data after removing his/her invalid trials. For the other participants the percentage of invalid six-element sequences was below 5%.

3.2 Effect of precue-condition on reaction times

To test the hypothesis that reaction time is influenced by the duration of the preparation interval, either a 100 ms or a 1000 ms precue (all participants were given the same sequence which included both precue conditions), the mean reaction times for each precue-condition were compared. It appeared that reaction times were higher in the 1000 ms condition. A repeated measures analysis of variance (ANOVA) with a 10 (Block) x 2 (Precue) x 2 (Movement Direction) x 2 (Movement Distance) design was performed on the reaction times. The analysis showed a significant main effect for Precue. Respondents reacted on average 24 ms (387 ms compared to 411 ms) faster in the 100 ms precue-condition than in the 1000 ms precue-condition ($F(1,15) = 45.8$, $p < 0.001$). This is in line with the effects found by Adam et al. (2008) although the difference in total reaction time appears to be smaller in the Flexion-Extension (FE) task.

3.3 Interaction effect between Precue and practice on reaction times

The second hypothesis was that practice would reduce the reaction time difference between the two precue conditions. That means that in later blocks, the difference in mean reaction times between the two precue conditions should be lower than in earlier blocks. The ANOVA results showed a main effect for Block ($F(9,135) = 14.6$, $p < 0.001$). The average reaction time was highest during the first three blocks (427 ms on average) and lowest during the last three blocks (381 ms on average). The analysis of variance results also suggest that

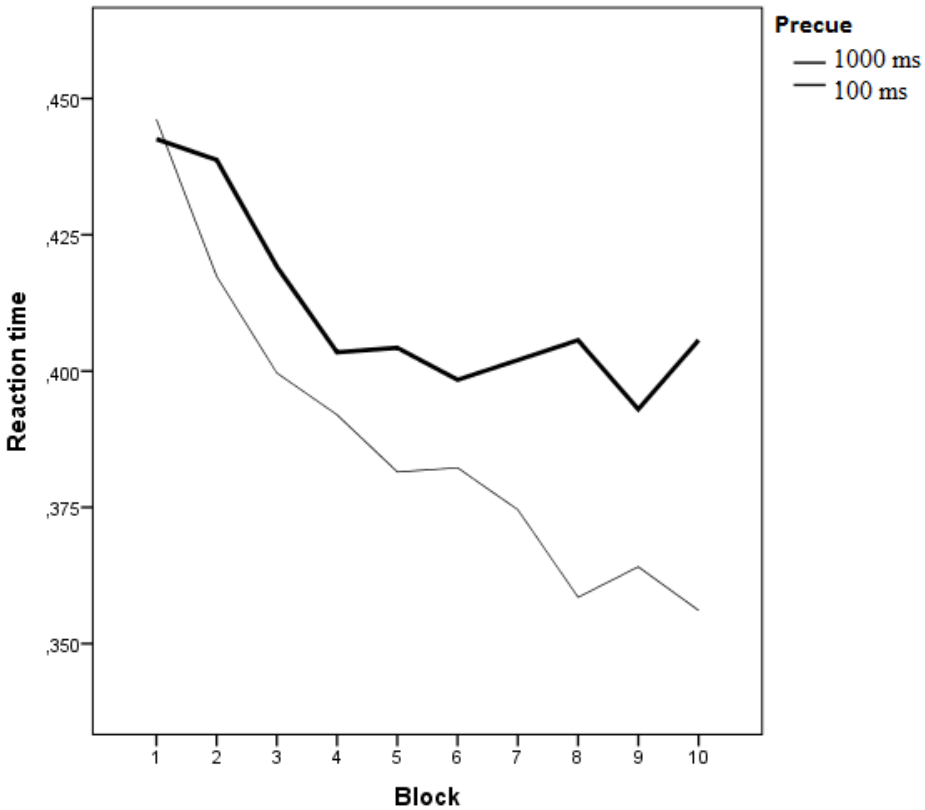

Figure 2. Reaction times for Block and Precue

there is indeed a Block x Precue interaction ($F(9,135) = 17.003$, $p < 0.001$). Figure 2 shows this Interaction. While the average reaction time in the 100 ms condition starts off slightly above the average reaction time for the 1000 ms condition, it drops below the longer precue condition in block 2 and remains lower for the rest of the experiment. The differences are most obvious for the last three blocks. On average the difference between the two conditions is 13 ms (421 ms in the 100 ms precue condition, 434 ms in the 1000 ms condition) in the first 3 blocks and 41 ms (360 ms, 401 ms) in the last three blocks. This appears to contradict the hypothesis that practice weakens the benefit of the shorter precue if the targets appear in a random sequence.

3.4 Other significant effects of possible interest

The analysis of variance further showed that the other two factors in the experiment, Direction (left or right) and Distance (2 or 4 targets distance), also had significant main effects ($F(1,15) = 4.533$, $p = 0.05$; $F(1,15) = 97.754$, $p < 0.001$). The difference in average reaction time between the two movement directions was 7 ms (396 ms compared to 403 ms), favoring movements to the left and therefore towards the body (flexion). The average reaction time for the shorter movement distances (2 targets distance) was 11 ms higher than the average reaction time on the longer movement distances (405 ms for the two targets distance compared to 394 ms for the four targets distance).

4. Discussion

4.1 The effect of preparation on reaction time

The first hypothesis of this research was that a longer precue would result in higher reaction times in the Flexion-Extension task. The analysis showed that this, indeed, was the case in the present study. Participants reacted significantly slower in the longer precue condition. From these results we conclude that prolonged attention slows down reaction times in the FE task. This is probably due to the same reasons that Adam and Pratt (2004) found in their reaching task experiment, namely that focusing visual attention is a fast process and that maintaining this attention is demanding.

4.2 Interaction effect of preparation and practice on reaction time

The second hypothesis was that with practice, differences in reaction times between the two precue conditions would decline. Contrary to our expectations this was not the case in

the present experiment. On average over all conditions, reaction times decreased with the duration of the experiment, suggesting a positive effect of practice on reaction time. But the effect of practice differed between the two precue conditions. While the differences were small in the first three blocks, they became bigger in the later blocks resulting in a difference in average reaction times during the last 3 blocks that was more than 3 times bigger than the average reaction time in the first three blocks. From this we conclude that in the Flexion-Extension task differs from effector selection tasks in terms of underlying processes. This should be of interest to the re-LOAD project since the project involves the Flexion-Extension task, as well as the Discrete Sequence Production task in which effector selection does play an important role. A Possible explanation for the Interaction found in the present experiment could be that the negative effect of prolonged attention increases with the duration of the experiment and therefore equalizes the benefits of practice to a certain degree. If maintaining attention is already demanding early on in the experiment, it is likely to have an even greater impact on a person that is already tired from performing a repetitive task for 45 minutes. The shorter precue on the other hand might work as a kind of wake up call, refocusing the participant's attention. Further research will have to investigate this effect and its possible causes.

4.3 Individual factors

During the pilot study, one participant reported counting in his head to be able to react faster since new targets always appeared after the same interval. Since this behavior does not reflect reaction anymore, but simply rhythm, it was considered invalid. To make sure that none of the participants of the actual experiment was applying the same strategy, all participants were asked after the experiment whether they had applied any techniques to become faster. None of the respondents reported using counting or any form of rhythm to shorten their reaction time. Several respondents however did report anticipating the direction in which they would have to move next. If their current target was on position 7 they would e.g. expect the next target to be rather on position 5 or 3 than on position 9. Unfortunately there was not enough data to run an ANOVA that could take into account the effect of the starting position for each movement.

5. Recommendations

For future research with the Flexion-extension task we recommend to further investigate the interaction between different durations of preparation time and practice on reaction times. The effect found in this study may have interesting implications for interactive technologies such as driving assistance in which attention and reaction times play an important role. Generally this might be an interesting effect for human factors psychologists to explore further.

For the usage of the FE task in the re-LOAD project we have another recommendation. Before using a fixed movement sequence with repeating stimulus sequences, the effects of starting positions should be investigated to ensure that the effects discovered in the present experiment can be transferred to a fixed, repeating sequence design.

6. References

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7. Appendix

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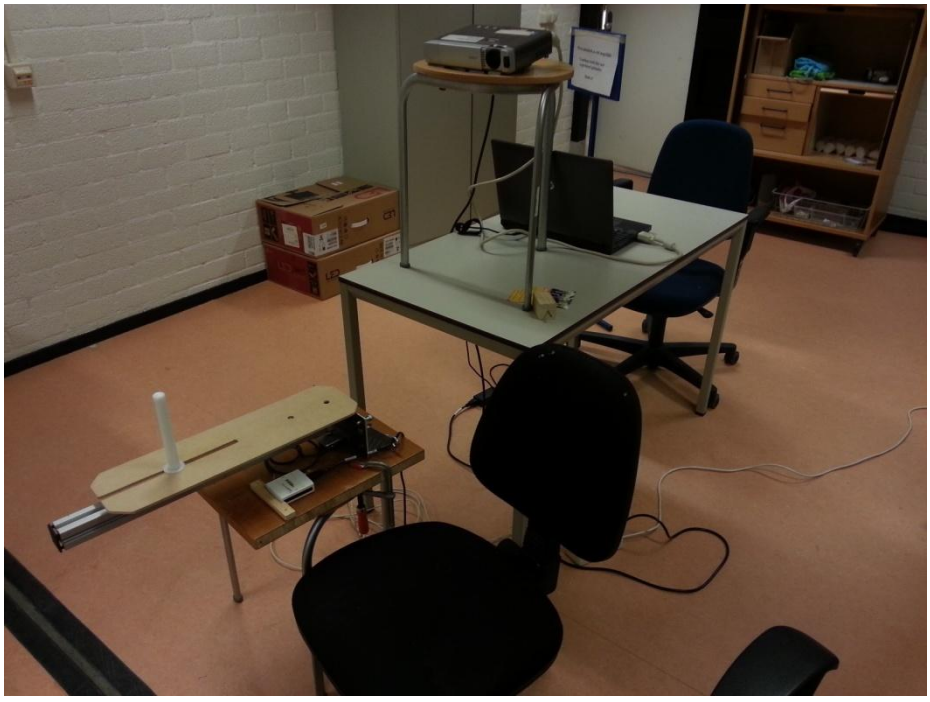
Appendix 1



Appendix 2

Toestemmingsverklaringformulier (informed consent)

Titel onderzoek: Preparation is not everything

Verantwoordelijke onderzoeker: Ole Selg

In te vullen door de deelnemer

Ik verklaar op een voor mij duidelijke wijze te zijn ingelicht over de aard, methode, doel en [indien aanwezig] de risico's en belasting van het onderzoek. Ik weet dat de gegevens en resultaten van het onderzoek alleen anoniem en vertrouwelijk aan derden bekend gemaakt zullen worden.
Mijn vragen zijn naar tevredenheid beantwoord.

Ik stem geheel vrijwillig in met deelname aan dit onderzoek. Ik behoud me daarbij het recht voor om op elk moment zonder opgaaf van redenen mijn deelname aan dit onderzoek te beëindigen.

Naam deelnemer: .....

Datum: ..... Handtekening deelnemer: .....

In te vullen door de uitvoerende onderzoeker

Ik heb een mondelinge en schriftelijke toelichting gegeven op het onderzoek. Ik zal resterende vragen over het onderzoek naar vermogen beantwoorden. De deelnemer zal van een eventuele voortijdige beëindiging van deelname aan dit onderzoek geen nadelige gevolgen ondervinden.

Naam onderzoeker: .....

Datum: ..... Handtekening onderzoeker: .....