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Towards productive breaking suggestion in Human-Robot Interaction activities

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1 Abstract

The present study investigated the effect of two different types of breaks taking place in a Human-Robot Interaction on short-term memory performance. The stretching break consist of making the subjects do six stretches and some deep breathing, guided by a robot. This break is supposed to be relaxing and previous studies showed that relaxation training can help improve memory. During the free-time break, the subjects are asked to do whatever they want. The subjects (22) were divided in two groups of 11 people, each performing three times a sequence of three memory games and having the two different breaks at a different time of the experiment. The three memory games each test a different aspect of short-term memory : number, word, and visual memory. Stress level was self-reported using a short version of the STAI-Y form before and after each break. The main result suggests that people obtained a significantly greater improvement of their score after the stretch break than after the free-time break in two of the three memory games. This validates the assumption that selecting a break adapted to the task and guided by a robot can help increase performance at this task. The stress score of the subjects significantly decreased during breaks and increased during the memory games. Significant difference between the decrease of stress level due to the two breaks was not found. Also, results are conflicting when trying to assess if a smaller stress score is correlated with a better score at the memory games. A feedback form filled by the participants after the experiment indicates that they considered that the games were challenging, the robot was useful, and the stretch break was more relaxing than the free-time break.

2 Introduction

Robots are more and more used to provide language, science or technology education. Educational robots are used to facilitate learning and improve educational performance of students. Studies on Human-Robot Interaction have been made to improve their ability to be either a tutor, a peer, or a tool during a learning activity. Using a robot as a tutor or a peer requires to give it a good sense of pedagogy. The robot should be able to cheer up the student when he is doing bad, change activity when he is not engaged or reward him after he has done what was asked.
The iReCheck project proposes a method for detection and remediation of handwriting difficulties. It uses a robot to monitor the learning status of the students and keep them engaged in the different writing-related activities. For now, posture correction and breaks between two sessions of activities have been done by a human.
As part of this project, we want to evaluate the effect of a break guided by the robot on the performance of the students. This break may include a posture correction phase : the robot may say to the student how to correct his posture before continuing the exercises, and also, some little stretching exercises. In this pilot study, we do an experiment with adults. Since adults already know how to write, we focus on how a break activity including relaxation exercises as stretching and guided by the robot-tutor can affect the memory performance of the subject. Getting the student in good conditions to learn can be of great importance for example when teaching some new vocabulary when learning a language. We test two different kinds of breaks. The first one consists in doing six stretches with the robot, and a little deep breathing. This type of break is supposed to be relaxing. The second break is free time: the person does whatever she wants to do for a few minutes. We will then analyze the differences in performance after the two types of breaks.

3 Literature review

3.1 Breaks

When doing activities, especially if they are mentally or physically challenging, we sometimes are in need of breaks in order to be able to regain focus. Children are known to have shorter attention spans than adults, thus it is important to provide them efficient breaks in order to facilitate their learning and keep it pleasant. When designing a break, we should care about multiple parameters. We identified those important attributes that we need to keep in mind when designing our break.

First of all, the timing of the break is really important. Ramachandran et al.(2019) established a few heuristics to decide on the timing of a break. We don't want to set the break when the person is focused on the task and doing well, except if we consider that the person needs rest. We can think of different strategies for timing the break. Breaks can be planned to happen after a fixed time of study, be planned to reward people when they do good, or on the contrary when they show poor performance in order to help them refocus. Personalized timing strategies can increase effectiveness of breaks.

To personalize breaks, we should attach a special care to the mindset of the person by taking into account the perseverance of the person, which is the driving force to continue learning according to Silvervarg et al.(2018). We also can decide that our program needs some form of sentimental intelligence, detecting mental states. D'Mello et al.(2012) have defined the key cognitive-affective states to be : engagement/flow , confusion/disequilibrium, frustration, disengagement/boredom. These mental states have been proved to have an impact on learning gains by Nye et al.(2018). Rowe and al.(2011) have shown that engagement is associated with better learning. Interestingly, according to D'Mello et al.(2014) confusion is also seen as an indicator of learning. Disengagement has a negative effect on learning. There is no consensus on whether frustration is good or bad for learning, based on the paper of Baker et al.(2010). Frustration is depending on the person, it should be combined with performance assessment to see if it benefits the activity. For example, frustration and performance decreasing is a good indicator that the child need a break. Many hardware/software systems exist for detecting emotions and we could consider using one with a camera pointing at the face of the child. The results given by this program could then be combined with the performance of the child to have more info for judging if the student needs a break or not. Indeed it has been shown by Grafsgaard et al.(2014), that using multi modal features (sound, image, results at activities) to detect the mindset of a person is more effective than using only one way.

After choosing when the break happens, we also need to define how long the break is going to last. This depends on how much time we have in total for the activity and on how much we want the child to work during this time. We also have to define if we should prefer a few long breaks or many short breaks.

The break can also target different goals. It can be organized to boost self-esteem, to help the kid to focus, to get rid of some extra energy the kid has, to create a want to do better, to get more engagement... A break can also be a right time to offer a feedback on the performance and give advice to progress during the next activities. We need to choose the goal that we think will provide the best results and find the best design of break to satisfy this goal.

The nature of activity can also have a significant impact. It can be a manual activity, sport, stretching, advice, and so on. In this study, we will test for two different types of breaks on STM. We will keep a fixed timing, to be able to compare their effects correctly.

3.2 Principles of short-term memory

Memory is a biological and psychic activity that allows to store, preserve and recall information. Historically, psychologists have distinguished two main types of memory : short-term memory (STM), supposed to have a duration of only 15 to 30 seconds, and long-term memory (LTM) for which the duration vary from years to decades (Atkinson et al., 1971). It is important for us to have a good understanding of STM since we want to design activities to test it.

Jonides et al.(2008) reviewed the different studies on short-term memory to find the principles of STM that seem to be the best supported by behavioral and neural evidences. They concluded that representations in memory vary in activation, with a non activated state corresponding to long-term memories, and varying states of activation due to recent perception or retrievals of those representations. Only a limited quantity of information is immediately available for cognitive action. If the information is directly accessible for cognitive action, we say that it is in the focus of attention. This quantity may be limited to a single chunk of information at a time, where a chunk is a set of items that are bound by a common functional context. Chunking allows to remember more items. Items are either entering the focus of attention via perceptual encoding, or via retrieval from long-term memory. The authors thus stated that STM and LTM are probably not independent. Items are maintained in the focus of attention via a process of maintenance, with rehearsal being a case of controlled sequential allocation of focus. Forgetting occurs when items leave the focus of attention and must compete with other items to regain the focus (interference) or when time alter the fidelity of the representation (decay).

Being familiar with the task is also important. Chase and Simon(1973) compared how chess masters and beginners remember the positions of the pawns of a chessboard. They showed that when the pawns were placed randomly, the performance of both were the same. But when the pawns are on actual game positions, the master do a lot better. Item representations are stored where they are processed.

Den Heyer and Barret (1971) showed a double dissociation : verbal tasks interfered with verbal STM but not with visual STM, and visual tasks only interfered on visual STM, but not with verbal STM. This research led to the idea that the two different types of memory can be dissociated. They also do not have the same brain area of activation. Verbal STM shows a marked left hemisphere preference, whereas spatial and object STM can be distinguished mainly by a dorsal versus ventral separation in posterior cortices.

Baddeley (2000) introduced a new model with four components. The first one is a central executive used for chunking, update of the information, selective attention. Then, a visiospatial sketchpad and a phonological loop help maintain and process language and visual semantics respectfully. The last component is the episodic buffer which is used to remember multi-modal concepts (semantics, concepts, visual, spatial, verbal).

Phillips (1974), highlighted the fact that a distinction must be made between sensory storage and short-term visual memory. Short term visual memory involves a schematic representation of strictly limited capacity. Sensory storage has a higher capacity and has a storage time of about 100ms.

3.3 Effect of relaxation on memory

Previous studies have shown that memory performance can be increased by doing relaxation training. Indeed, Kargar et al.(2014) did some research on this subject, and concluded that anxiety has a bad effect on the working memory. They taught relaxation techniques to a group of students during three 1 hour sessions per week. The results show that students obtained better GPA thanks to these sessions, and they also go better results at a working memory capacity test. Schwabe and Wolf(2010) confirmed that learning under stress impairs memory formation, in a study where the participants had recall tests 24 hours later. Nava et al.(2004) also found out that relaxation can improve long-term incidental visual memory. In their study, they showed that subject which been relaxing right after seeing 280 slides had better memory of those slides a few weeks after than the ones which did not relax. In the article "Relaxation and memory training in 39 elderly patients" (The American Journal of Psychiatry, 1984), the authors explain that elders which have done relaxation training before learning a mnemonic technique to improve face and name recall improved more than elders from the control group. They showed that this improvement was significantly correlated with decreased state anxiety scores.

On those studies, we based our assumptions that a relaxing Human-Robot Interaction break could increase short-term memory performance.

3.4 Selection of relaxing activities

Effective relaxation training mainly include three techniques : deep breathing, progressive muscle relaxation (PMR) and stretching.

Progressive muscle relaxation is a technique where one first tenses muscles for a few seconds, before releasing that tension and paying attention to how the muscles feel when relaxed. The effectiveness of this method to reduce anxiety has been shown, but how it exactly works is not well understood according to Conrad et al.(2006). It is a bit hard to monitor with a robot since a lot of it cannot be seen with a camera and explaining how to do it quickly is tedious.

Perciavalle et al.(2016), found out that deep breathing can induce an effective improvement in mood and stress both in terms of self-reported evaluations and of biological parameters such as heart rate and salivary cortisol level. Cho et al.(2016), made 32 undergraduate students do daily mindful breathing on their own. Results showed that it reduced test anxiety. To do slow deep breathing, one inhales through the nose for five seconds and exhales through the mouth for the same amount of time. Emotions and respiration have been shown to be closely linked : emotions can affect respiration and vice-versa. Slow deep breathing can induce a shift of the autonomous nervous system from sympathetic to parasympathetic. Based on the study of Jerath et al.(2015), slow deep breathing and cardio-respiratory synchronization may lead to homeostatic increases in cellular membrane potentials and a generalized decrease in intrinsic excitability of pacemakers such as the heart and amygdala, causing physiologic inhibition of negative emotions. Soni et al.(2015) showed that deep breathing sessions of 10 minutes could increase cognitive processes.

Carlson et al.(1990) explored the use of muscle stretching procedures in a relaxation training with clinical population. They found that muscle stretching is a viable clinical approach among persons who report generalized anxiety and muscle tension. According to Logan and Kim(2017) stretching has a positive effect on anxiety of physically inactive people. Stretching can also be good for physical health, which makes it even more interesting. A lot of people end up sitting at a desk all day. It has been shown that it increases strain injuries of the wrists, hands and arms. Human body is not supposed to stay in a sitting position all day. According to Anderson(2002), stretching is a wonderful solution to counteract negative effects of fixed positions. Common desk problems are back pain, stiff muscles, tight joints, poor blood circulation or repetitive strain injuries like wrist pain due to hand tasks. Jeong and Chae(2012) showed that self stretching reduces the intensity and frequency of shoulder pain and increase both shoulder flexibility. Coulson et al.(2008) argue that it helps preventing injuries, can be done everywhere, takes a small amount of time and could even lead to more productivity. Giving people good habits when working is important because it could improve their health and quality of life in the future.

3.5 Assessment of anxiety level

Anxiety level can be measured in different ways. Lupien (2007) summarized the different ways to measure stress in humans. He distinguished two types of methods. The first one is using physiological measures as blood pressure, vagal tone or salivary cortisol for example. The second method is to use psychological questionnaires.

The Spielberger State-Trait Anxiety Inventory (STAI) is a 40-item self-completed questionnaire that aims to assess separately state anxiety (a temporary state influenced by the current situation where the respondent notes how he/she feels right now at this moment) and trait anxiety (a general propensity to be anxious where the respondent notes how he/she feels "generally") with 20 items each. Higher scores are positively correlated with more anxiety. In some cases, the use of the full form is not possible. A six item form using the most correlated anxiety present/absent items has been developed by Marteau et al.(1992) has shown great results, similar to the ones for the full form. In their study, they selected the best representative items of the Spielberger form. These items are : calm, relaxed, content, tense, upset and worried. There are multiple advantages of using a shorter form : it can be answered quicker, and it is likely to minimize the number of response errors.

4 Methods

4.1 Design of the memory games

To test short-term memory, we use multiple games each targeting a specific type of short-term memory. The three games designed target respectively number memory, words memory, and visual memory. Numbers and words memory can be grouped in verbal memory, while the other game is more abstract and target visio-spatial aspect of memory. There is only one attempt for each game, but we explained to the subjects how each game works before the experiment to be sure that they will not loose because they don't understand the rules. Playing all three memory games take a mean time of around 5 minutes.

Numbers memory game
The first game is about remembering numbers. First, the game displays a number for a limited time. Then, after it disappeared, the user is asked to type it. The number starts by having four digit then the number of digits is incremented at each round. According to Miller's law (Miller, 1956), the average person can remember 7 plus or minus 2 digits reliably in short term memory, but this score can increase dramatically when using mnemonic techniques.

Words memory game
The second game is about remembering words. Words are displayed to the user and he must decide if these words have already been displayed or if they are completely new. We test the player on how many words he can keep in STM at once. The number of words the player need to remember grows continually until it becomes too difficult for him to handle. The more words the player has seen before losing, the highest is his score.

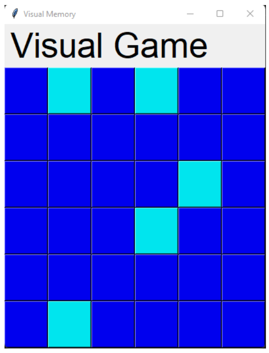

Figure 1: Visual memory game

Visual memory game
The third game is about visio-spatial memory. A square matrix of tiles is displayed on the screen. The player must remember an increasing number of tiles which light up for a

limited time as shown on Figure 1. Then, when all the tiles come back to being the same color, the user must click on all the right tiles. The size of the square matrix is also increasing at each round. The score is the round reached by the player.

4.2 Design of the stretching/deep-breathing break

The relaxing break includes two of the three techniques discussed in paragraph 3.4. We decided to use stretching and deep breathing. Progressive muscle relaxation seemed promising, but was too complex to implement. In total, the stretch break last for approximately 3 minutes, depending on how fast the person does the asked stretches.

4.2.1 Design of the stretching session

We selected six stretches that have benefits for health, and that are doable by the QT robot. In Figure 2 we show two stretches that are considered as being useful when working at a desk for a long time (Anderson, 2002).

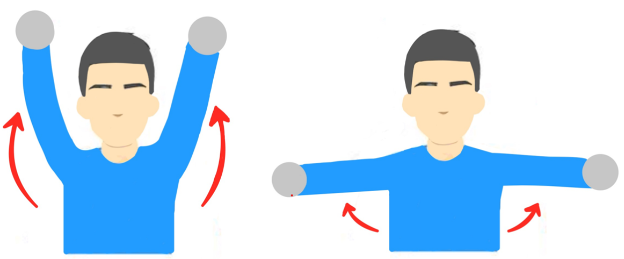

Figure 2: Two arm stretches asked during the stretch break

We also implement some of the head/neck stretches recommended by Gasibat et al.(2020). For one of them, head is tilted from front to back. The other one is turning the head to one side, then to the other side. They are supposed to have good effects on work-related Musculoskeletal Disorders.

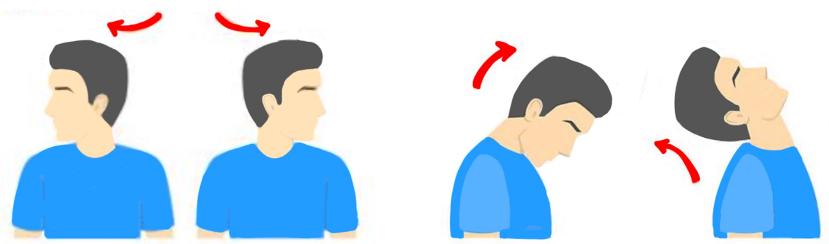

Figure 3: Four neck stretches asked during the stretch break

The subjects were asked to do each stretch for five seconds.

4.2.2 Autonomous detection of the stretches

We need to make the robot able to autonomously detect if the subject is doing the stretch or not. To check if the person did the right movement, we based our approach on coordinates of body joints. We recorded ourselves doing the six stretches shown in Figures 2 and 3 and also no stretch at all. We used mediapipe to extract the skeleton joints coordinates and store them in a csv file. Then we used sklearn to do a train/test split of this data. Finally, we trained a machine learning classification model on this data. The random forest classifier algorithm gave us good results. It is a supervised learning algorithm, highly flexible and easy to implement. It is and ensemble learning technique meaning it uses multiple predictors and aggregate their results. Image classifier is one of its domain of application. It is also widely used for recommendations systems. Every created decision tree votes and the most popular class is the result. It is a robust algorithm because it uses multiple decision trees to get its result but this makes it slower than other algorithms. However for our real-time application, this has not led to any issues and the result is quite fast. The robot counts to five to let the participant know that his stretch is detected. If the robot did not detect the stretch during 25 seconds, the robot simply continues the activities and moves on to the next stretch, so that the interaction could continue even if the participant failed to do a stretch.

4.2.3 Design of the breathing exercise

During the breathing session, the subjects are asked to do maximal sustained inhalation lasting for 5 seconds followed by maximal sustained exhalation also lasting for 5 seconds, and repeat that process during one minute. The robot is telling when to breathe in and breathe out, but does not check whether deep breathing is done or not.

4.3 Design of the Human-Robot Interaction

4.3.1 Sequences of activities

Two groups were performing the memory activities. They were both composed of 11 students/researchers. We will refer to them as group 1 and group 2. Group 1 has done the experiment with condition A (see Figure 4) while group 2 has done the experiment with condition B. The only thing that changed between conditions A and B was the order of the two different breaks. Free-time break was lasting for 3 minutes, which was approximately the duration of the stretch break.

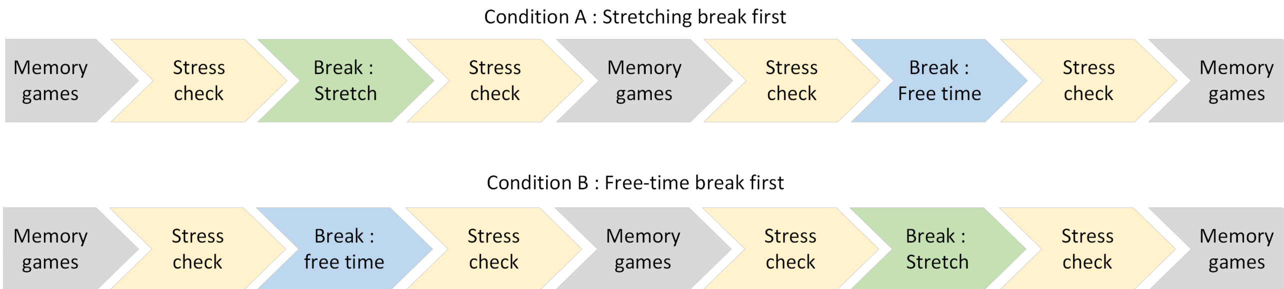

Figure 4: Different conditions of the experiment

The whole experiment took about 25 minutes. We would have wanted to have participants staying for a longer time, because the effect of a break is more important after a great period of cognitive activity. However, we could not keep the participants for too much time. Both of the groups played the memory game sequence three times, while answering questions on their stress state and having a break between each attempts at the games.

4.3.2 State machine

To implement the two conditions, we used a state machine where the different sequences of states for the two groups are shown on Figure 4. The stretch break state was divided into seven sub-states: one for each of the six stretches and one for the breathing session. The participants were given a group number before starting the experiment and the two groups had different transitions between states according to this group number. At the end of each memory game and stress check, the results were stored in a csv file. Transition to the next state occurred when the the task of the present state had been accomplished: either playing all three games, filling the forms, doing the stretches, or just waiting during the free-time break. Scores were also passed from one state to another so that the robot could give a quick feedback on the task. This feedback was telling the user if he did good or not and if he had improved his results since the last attempts. The robot then told the participant what to do. Participants played the games and filled the stress forms on a laptop. The robot was standing one meter behind the laptop, guiding the experiment. No human intervention was required during the experiment.

4.4 Assessment of anxiety level

We want to have a measure of anxiety during the experiment. Physiological measures are good because we can extract from them continuous data concerning the stress level, whereas forms are only measuring the stress at a given time. Since we have no equipment to take physiological measures, we still decided to use forms to assess anxiety level, at the most important time for us. We developed four different forms, inspired from the six items STAI form, which can be found on Table 1. The form was changed so that the participants don't answer in the same way each time but really think about how they feel. We used synonyms and kept 3 correlated anxiety present items and 3 anxiety correlated absent items in each form, as suggested in Marteau et al.(1992). The participants to the experiment are asked to answer items of forms 1 and 2 respectively before and after the first break, and items of forms 3 and 4 respectively before and after the second break.

Form 1	Form 2	Form 3	Form 4
I feel confuse	I feel strained	I feel pleased	I feel untroubled
I feel satisfied	I feel peaceful	I feel concerned	I feel perturbed
I feel worried	I feel nervous	I feel relaxed	I feel happy
I feel at ease	I feel comfortable	I feel tensed	I feel anxious
I feel calm	I feel indecisive	I feel tranquil	I feel pleasantly good
I feel stressed out	I feel content	I feel not confident	I feel self-doubting

Table 1: Short forms developed to measure anxiety

For each item, the participants are asked to check boxes going from 1 to 4. Their meaning is :

1- Not at all
2- Somewhat
3- Moderately so
4- Very much so

The items with anxiety present correlation gives the points corresponding to the number. The items with anxiety absent correlation are graded in the opposite way : 4 is one point, 3 is two points, 2 is three points, and 1 is four points. The maximum number of points one can get is therefore 24 points for a maximal stress and the minimum is 6.

5 Participants

22 participants took part in the experiment. All of them are in their twenties. 7 of them are women (32%) and 15 of them are men (68%). The majority of the participants are students (16/22). The others are either project coordinators (3/22), researchers (2/22) or teachers (1/22).

19/22 participants had never interacted with a social robot before the experiment. Among the three people who had already interacted with a social robot before, one had only one interaction before, another one had two interactions and the last one had five.

On the 22 participants, 6 perform physical activities occasionally. 5 do it two times a week, 6 do it three times, 5 do it four times, 2 five times and 1 six times a week. The majority of the participants (13/22) say their activities are of medium intensity, while 4 of them describe them as being of low intensity and 4 as being intense.

6 Results

6.1 Experiment results

The mean games scores and stresses for each group along with their standard errors are represented on Figure 5. We used an alpha level of 0.05 for all statistical student t-tests. To compare the progression of one group to the one of the other, we subtract for each participant of the groups the result at their first attempt and their result at their second attempt. We present here our conclusions based on the results :

- **Impact of the breaks on number memory game results**

  At the visual game, group 1 obtained better mean results at their second attempt, after the stretch break, than at their first one (p=0.022*). Their mean performance then decreased during the third attempt(p=0.071ns), which took place after the free-time break. Group 2 performance also decreased after the after the free-time break(p=0.27ns) and increased after the stretch break (p=0.13ns). From these results, we can assume that the stretch break helps participants to increase their short-term number memory performance while the free-time break may have the opposite result. However these results could be due to other parameters than the break, people may improve their result with time or be less focused on the games at their last attempts.

  Thus, to confirm these assumptions, we also compare progress at each attempt between the two groups. Our data shows that, after the two breaks, performance at the number game of the group doing the stretch break improved more than performance of the group doing the free-time break(respectively p=0.014* and p=0.003** for break 1 and break 2). These results confirm our hypothesis that the stretch session break is more beneficial to participants short-term number memory compared to the free-time break.

- **Impact of the breaks on word memory game results**

  We now evaluate the impact of the breaks on word game results. Groups 1 and 2 mean score improved after the stretching break (respectively p=0.10ns and p=0.25ns) and decreased after the free-time break (respectively p=0.029* and p=0.063ns). As for the number game results, we can thus assume that stretching break helped improve performance of the participants of each group while free-time break had a bad effect.

  The participants having the stretch session as first break did improve their score on the word game more than the participants having the free time break (p = 0.013*). After the second break, we also note a better change of performance with the stretch session break ($p = 0.043$*). From these results, we conclude that the stretch session break helped improve performance much more than the free-time break.

- **Impact of the breaks on visual memory game results**

  For the visual memory game, the two groups mean score doesn't change much between the first and the second attempt. Between the second and the third attempt, mean score of group 2 improves (p= 0.14ns) while the mean score of group 1 stays the same. These results makes us reject the assumption that either of the breaks influence significantly visual memory. We can assume that since the visual game was the third one to be played, the effect of the break on the results is less strong, or just that the type of break just do not have influence on visual short term memory.

- **Impact of memory games and breaks on stress measures**

  The stress measure indicates that the mean stress of the participants increases during the second memory games ($p = 0.0006$***). Breaks 1 and 2 make the mean stress of the participants decrease (respectively $p = 0.0066$** and $p = 0.0034$**). We did not find evidence that the stretch session break decreases more the anxiety than the free time break, based on the forms (respectively $p =$ 1ns and $p = 0.71$ns for the two breaks).

  Group 1 is always more stressed than group 2 for all four stress checks (respectively $p = 0.17$ns, $p = 0.20$ns, $p = 0.11$ns, $p = 0.048$*).

- **Correlation between stress and short-term memory performance**

  With our data, we cannot tell if being less anxious gives better short-term memory performance, because the results are not statistically significant at every time. We observe that, after the last stress check, where the stress of group 1 is significantly greater than the stress of group 2 ($p =$ 0.048*), the less stressed group obtains better performance at both the number, word, and visual memory games (respectively p=0.18ns, p=0.13ns,p=0.28ns). But after the second stress check, where the stress of group 2 is a bit lower than the one of group 1 ($p = 0.20$ns), the mean score of group 1 is greater than the mean score of group 2 at every game (respectively $p = 0.048$*,$p =$ 0.073ns,$p = 0.334$ns). These two results are in conflict.

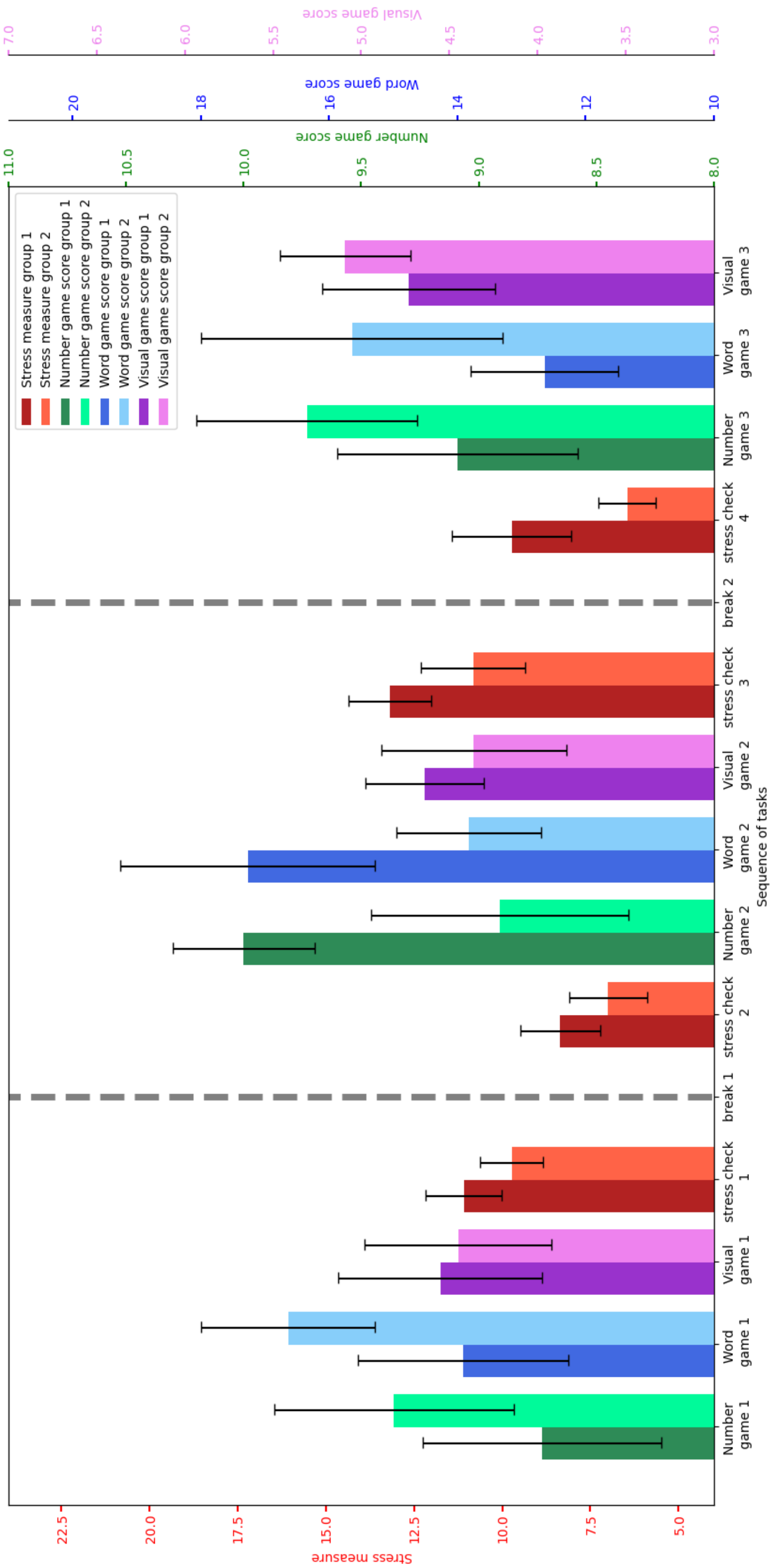

Figure 5: Evolution of the mean scores and mean stress levels of the two groups throughout the experiment. Group 1 has the stretch break as break 1, and the free-time break as break 2. Group 2 has the free-time break as break 1, and the stretch break as break 2. Stress measure is the sum of the stress scores attributed to each answer of the form.

6.2 Additional observations

During the free-time break, 3 people used their cellphone, 4 were waiting patiently, 3 wanted to start a conversation, and 12 were eating chocolates or apples that were offered to the participants. We have a hypothesis that these tasks are more relaxing than the the memory games, based on the results.

We observed a few tactics used by the participants to increase their short-term memory capacity. Verbal rehearsal was used a lot by the participants during the number memory game, but not at all during the word memory game where people were deciding fast if they had seen the word or not, not really trying to remember a growing list of word. For the visual game, it seems that most of the people tried to click on the tiles as fast as possible to not forget their position over time.

6.3 Feedback from the participants

In order to understand better those results, we did obtain feedback from the participants between one and three days after the experiment. 20/22 people answered. The answers are shown on Figure 6. People tend to found the two types of breaks relaxing, although they found the stretch break more relaxing, which was not noticed with the forms the day of the experiment. 16/20 people preferred the stretch session. 18/20 participants think the robot was useful, but the opinions are divided on the fact that they could stretch better or not without the robot. 4/20 people did not really try to stretch but rather tried to be detected by the robot, which can diminish the effectiveness of the stretch session.

All three games were found to be challenging by the participants, the visual game being the more challenging, and the word game the less challenging.

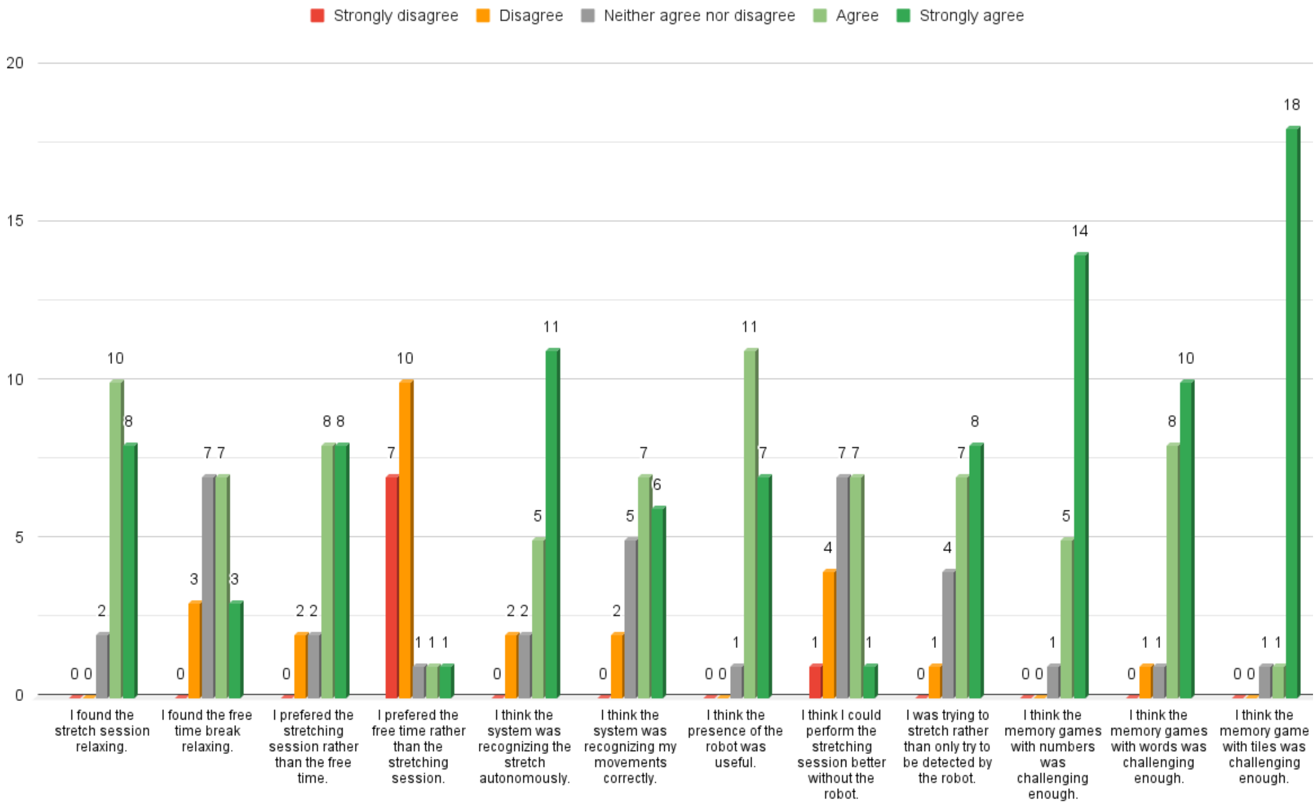

Figure 6: Feedback from participants

7 Discussion

Even though we have found some significant results on the effect of doing a relaxing break guided by the robot on short-term memory performance, the present study has a few shortcomings. First, having only 22 participants lead to some insignificant result. Then, the digits, words, and tiles were generated randomly, which could have led to some plays being easier than others. Indeed, if a digit appears 2 or 3 times in a row in number, it makes the number easier to remember. We do not believe that this implies a strong bias in the results, but for a future study, we think that the task should be exactly the same for each participants. Also, since we could not keep the subjects for too much time, the memory games sequences only last for five to six minutes, which makes the breaks close to each other, and may not reflect their effect when learning for much more time before taking the break. Finally, our method for self-report of stress is derived from a tested questionnaire, but we can't say for sure that the stress do not decrease because of the way the questionnaires are made for break 2 and 4. In next studies, we should considerate using equipment to make physiological assessment of stress.

8 Conclusion

In this study, we tested the effect of two types of breaks on short-term memory performance of 22 subjects. Both breaks were effective to reduce stress of the subjects. Results are conflicting when trying to assess if a smaller stress level is correlated with a better score at the memory games. Participants obtained a significant improvement of their score after the stretch break for two of the three memory games. This improvement was not observed after the free-time break. This validates the assumption that selecting a break adapted to the task and guided by a robot can help increase performance at this task. This result is to further be tested with kids to see if they show better learning after a relaxing break or not. The timing of the break should also be personalized, to see if this allows to get more benefits or not.

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