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Event segmentation causes a release of proactive interference

an attempt to integrate two classical paradigms

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Abstract

Past research on proactive interference has yielded many ways to cause a release of proactive interference. At the same time, the event segmentation paradigm attempts to explain why memory is sometimes enhanced and sometimes diminished and how we understand the world through perception. In a memory experiment carried out in Minecraft, a release of proactive interference is attempted not through a semantic shift as in the classic paradigm but by crossing an event boundary, here defined as a sudden shift of environment. 36 undergraduates at Nils Fredriksson gymnasium were recruited for the experiment.

The results were inconclusive for the average of the two counterbalanced groups and conflicting when the two groups' results were analyzed separately, providing both support for the hypothesis and discrediting it. The causes of these conflicted results are discussed along with improvements for future studies.

Keywords: Event segmentation, Event boundary, Proactive interference, Short-term memory

Introduction

The importance of memory

The ability to remember is probably one of the most important cognitive functions that exist. In order to complete certain goals in our lives, from something as important as writing an essay, to something as trivial as winning a game of poker, memory is key. We constantly use stored knowledge when engaging in any given activity (Reimer, Radvansky, Lorsbach & Armendarez, 2015). We activate distant memories when trying to recall a childhood friend. Where do memories come from? Memory comes from experience and experience facilitates learning, constantly adding on to our quite remarkable knowledge. Memory and learning are quite treacherous tools on the other hand. Far too often we know with a 100% certainty something that we assume to be true but which is actually false, or remember something that is completely inaccurate. While we feel that this might be more common for distant memories residing in our long-term memory, much of the current information that has just recently entered short-term memory is also subject for error. A waiter working at a restaurant who has to take multiple orders at a time would have a hard time keeping these orders separate, which is why they sometimes use a notepad. Statisticians need to be meticulous when copying data from one sheet to another, since all the numbers have a tendency to mix up in our limited short-term memory. So what are the boundaries of our short-term memory? Why is it so superb at manipulating information, yet at the same time so weak? Under what circumstances does the information really stick and why is it that sometimes the wrong or nontarget information comes to mind instead of target information? How come we sometimes walk into a room with purpose, to fetch an item, yet once we're in the room we completely forget why we went there in the first place? Although there are a myriad of variables that affect our memory and learning, this paper will mainly tackle some questions that has arisen from the Event segmentation paradigm and the Proactive interference paradigm related to short-term memory, which will be discussed in the theory section. Although this research in itself is rather exploratory and highly theoretical, it might open up new research venues which have the potential to strongly benefit learning.

Theory and past research

Memory systems. It wouldn't be a surprise if researchers felt a reluctance to use the terms short-term memory and working memory. There are huge discrepancies in the research regarding the two theoretical models and there has been for quite some time. Unsworth &

Engle (2007) conducted a meta-analysis and found that the two tasks traditionally used to measure the two constructs working memory and short-term memory, namely simple span tasks and complex span tasks, both seem to measure the same underlying processes. The theoretical distinction between the two constructs is that short-term memory is seen as a storage unit while working memory holds the same function and the ability to manipulate information (Unsworth & Engle, 2007). To make it easier for the reader and to not add on to the corrosion of the two terms, short-term memory will be the theoretical construct used in this essay. It is the more suitable construct for the present research endeavor since Wickens' proactive interference paradigm will be tested, where the construct short-term memory was used (Wickens & Clark, 1968).

Event segmentation. Event segmentation is the process by which our brain chunks the continuous flow of stimuli into distinct events, by creating event boundaries at the end and beginning of such events (Kurby & Zacks, 2008). Therefore, any given event must always have a beginning and an end. Even though there are no naturally occurring boundaries in our lives, we do tend to describe our daily lives as series of events instead of one ongoing never ending event (Reimer, Radvansky, Lorsbach & Armendarez, 2015). It does usually look something like the following example. This morning, I woke up and got out of bed. I went to the bathroom and had a shower. Then I had breakfast and brushed my teeth before I started getting dressed. It's quite obvious that this morning ritual becomes more meaningful by simply parsing it into discrete units. To see the process of event segmentation, one can simply watch a movie, listen to a conversation or perhaps ask someone to describe the way to the closest food store. It is a very natural mechanism that is needed for perceiving and understanding the world around us (Zacks, Tversky & Iyer, 2001). Therefore, the human language is littered with words and phrases that cause event boundaries (Malaia, Ranaweera, Wilbur & Talavage, 2012; Malaia, 2014). Since there's always an ongoing activity inside an event, we wouldn't be surprised to see that segmentation of events revolves around verbs in human language (Malaia et al, 2012; Malaia, 2014). The earlier example of a typical morning ritual contains 7 verbs in only 3 sentences, signaling where one event ends and where another one begins (Malaia, 2014). Event segmentation is a sensitive mechanism and reacts to acceleration and deceleration of objects or limbs and is very apparent in research done on American sign language (Zacks, Kumar, Abrams & Mehta, 2009; Malaia et al, 2012). The brain finds meaning in parsing the continuous flow of stimuli into discrete events and one byproduct of this is an increase of cognitive control (Reimer et al, 2015). Cognitive control is an important function that people use in their everyday lives when engaging in various tasks.

To remain focused on the task at hand, a person must activate relevant memories and knowledge related to the present task while shutting out irrelevant information, while they are keeping in mind what goal they are out to achieve and any updates in such goals (Reimer et al, 2015). This is an explanation to why we tend to parse events the way we do and is in accordance with event segmentation.

A huge body of research indicates that memory is enhanced at event boundaries (Kurby & Zacks, 2008; Tauzin, 2015) Event boundaries are exactly what they sound like, the boundary between two distinct events, and these are located with two different methods, one overt and one covert. The overt method is very straightforward. You simply make a person parse an event by asking them to indicate whenever some meaningful shift occurs. Some research on event segmentation has tried this overt method on mundane chores, such as making a sandwich while others have taken a more abstract route by manipulating geometric forms (Zacks, Tversky & Iyer, 2001; Tauzin, 2015). The latter was an attempt to criticize event segmentation theory, which states that unpredictability is a key component in determining where event boundaries occur. However, what the both approaches found is that there is a high interjudge reliability among the participants who indicate where event boundaries take place. Of course, this parsing procedure can be done at different spectrums. Zacks, Tversky & Iyer (2001) conducted experiments where the participants were asked to parse different recordings of everyday chores into coarse units and fine units over separate viewings. What was found is that the fine units and coarse units overlapped significantly, giving support to the hierarchical bias hypothesis, stating that people understand events as goal-directed hierarchies (Zacks, Tversky & Iyer, 2001). This method in itself is perhaps a bit meager evidence, seeing as we're trying to use an explicit method to implicate an implicit brain function. This is where the covert method comes in. As stated at the top of this paragraph, event boundaries are associated with enhanced memory. By repeating the previous trials with a new group of participants you can then indicate where the event boundaries are not by asking them where they are but by administering a surprise recall test. If everything is done correctly, the covert group's memory will be enhanced where the overt group reported meaningful shifts (Kurby & Zacks, 2008; Tauzin, 2015). This converging evidence gives a strong support for this underlying mechanism. Event segmentation theory that was briefly mentioned earlier explains this enhanced memory at event boundaries through a dump in working memory, freeing up processes and space to encode the information more strongly (Swallow, Zacks & Abrams, 2009). It was also mentioned that the theory is related to prediction which needs elaboration. People are masters at prediction without even realizing it.

If someone is watching a person bending towards an untied shoe lace, you quickly predict that the person is about to tie the lace. All of these different steps, noticing the lace, bending forward and redoing the knot are typical meaningful shifts that can be parsed and predicted. We have so called event models that are accessed in our short-term memory for a myriad of different situations, and they stay in place as long as they can successfully predict what is going on. If error in prediction start to build up because of the event model is being outdated by an introduction to a new environment or the start of a completely different event, an update is necessary and it is at this point that memory is enhanced (Swallow, Zacks & Abrams, 2009; Kurby & Zacks, 2008). In this way, Event segmentation theory stands in close relation to the concept of cognitive control and it helps explain one of its key functions, to update our current goals as the environment changes (Swallow, Zacks & Abrams, 2009; Reimer et al, 2015).

Memory is enhanced at event boundaries, yet when such a boundary is crossed, something very different happens. A rather annoying yet completely normal phenomenon is the memory impairment for the previous segment, when an event boundary is crossed (Radvansky, Krawietz & Tamplin, 2011; Radvansky, Pettijohn & Kim, 2015). Sometimes, a person is sitting in the living room and decides to go to the kitchen to retrieve a specific item, say a pair of scissors. Once that person enters the kitchen they sometimes find themselves oblivious to why they entered the kitchen at all. This is something very common and cleverly designed experiments have shown us how a simple thing as walking through a doorway causes forgetting (Radvansky, Pettijohn & Kim, 2015; Radvansky, Krawietz & Tamplin, 2011). It is important to note however, that this form of amnesia is restricted to short-term memory and not our long-term memory (Radvansky, Krawietz & Tamplin, 2011). It’s probably quite rare that people enter a new room finding themselves oblivious to who they are, what their name is or how old they are.

Why does this forgetfulness occur? According to Event cognition theory, people construct representations of the world they encounter called event models (Radvansky, Pettijohn & Kim, 2015; Thompson & Radvansky, 2015; Radvansky, Krawietz & Tamplin, 2011). These models enable us to understand situations that we are in. If we go back to the kitchen example, an event model for the kitchen could be related to food, preparation of food, eating food and washing the dishes. This model is created because these are the kind of activities that are common within this environment, based on our memories and past experiences inside the kitchen along with our current observations (Radvansky, Krawietz & Tamplin, 2011). It gives us an understanding to what the room and all its furniture, apparatuses and items are for. What happens then, when we walk from one room to another, is that the event model updates. People don't need a mental representation of the bathroom in mind when we engage in kitchen activities, the information becomes irrelevant. The event shifts are quite effortful according to event cognition theory, taking a toll on our working memory and thus making previous information less available (Radvansky, Krawietz & Tamplin, 2011). In other words, updating an event model or walking through a doorway causes forgetting.

Proactive interference. Have you ever attempted to learn a bunch of phone numbers? Naturally it can be rather hard to keep these different sets of numbers apart. This becomes more evident if you need to learn them consecutively in a short period of time, relying only on your limited short-term memory. Proactive interference is when previously learned information interferes with the attempt to learn new material. In a classic paradigm developed by Delos Wickens, proactive interference is established by creating a number of trials with three words in each of the same semantic category, such as fruits or animals. This result in consecutively worse performance after each list is learned and tested (Wickens & Clark, 1968).

Wickens showed us how a switch to another semantic category causes a release of the proactive interference, causing performance on the recall test to go back to the level of the first trial (Wickens & Clark, 1968). Proactive interference is a well-researched subject and additional strategies to cause release from proactive interference have been demonstrated. A switch in language causes a release from proactive interference, with greater effect when the participant is fluent in both languages tested (Goggin & Wickens, 1971). Testing newly acquired information before proceeding to new material also causes a release of proactive interference, due to the segregating effects the testing produces on the previously studied material (Walheim, 2015).

Another important thing to keep in mind is the temporal aspect when inducing proactive interference. Wickens did indeed check for a myriad of aspects that affect the encoding of words and found that time is of the essence. In one experiment it is demonstrated how a 120-seconds time delay is enough to reduce proactive interference with 74% and the greater portion of that release occurred already after a 45-sec delay (Kincaid & Wickens, 1970). With this in mind, it is imperative that there is a very short or preferably no delay between trials while establishing proactive interference.

Why do we experience these difficulties? One view is to see the information kept in short-term memory as noisy codes that retains a high degree of activation even after being probed for (Craig, Berman, Jonides & Lustig, 2013). Target information that is currently needed which arises either from an activation of a long-term memory or simply by observation, can easily be drowned in the noise of recent nontarget information (Craig, Berman, Jonides & Lustig, 2013). This seems plausible not only in a theoretical setting but also a practical one. At social gatherings with a lot of new faces it can be extremely difficult to put a name to every face in the room despite the fact that every person introduced themselves. It wouldn't be surprising if you get a name wrong. A smart strategy would be to test oneself. Repeat the names and engage in conversations with everyone to segregate the information (Walheim, 2015). Testing has proven to be effective in social settings as well (Weinstein, McDermott & Szpunar, 2011).

Kliegl, Pastötter and Bäuml (2015) offer an explanation where both encoding and retrieval adds to the effect of proactive interference by utilizing EEG during encoding and recall of target and nontarget words. They also measured participants working memory capacity and found that participants with larger capacity experienced less difficulty with proactive interference. Some people seem to be more resistant to proactive interference based on working memory capacity and age also seems to factor in (Loosli, Unterrainer, Rahm, Weiller & Kaller, 2014). Using two working memory tasks related to proactive interference, an inverted U shape curve could be seen in performance on participants ranging from ages of 8 to 74, with young adults (age 19-27) outperforming other age groups (Loosli et al, 2014). Are there any more relevant ways to shield oneself from proactive interference? The answer is yes. Wahlheim & Jacoby (2011) indicated in a series of experiments that experience of proactive interference can diminish its effects, enabling participants to use different processes or strategies to deal with the interference. This requires the participants to actually understand the emerging difficulties they experience during the trials in order to counter it. Of course, people usually notice what's going on and decides to deal with the difficulty with a spontaneous strategy. However, if a powerful mnemonic technique such as the method of loci is employed, a significant resistance to proactive interference can be observed compared to control group who relies only on spontaneous strategies (Bass & Oswald, 2014). The method of loci is particularly helpful to resist proactive interference since it uses mental imagery and sequences to make clear distinctions between target and nontarget information (Bass & Oswald, 2014). This is another reason to impose no delay between trials when proactive interference is established. It would give the participants the time needed to develop less spontaneous and more useful mental strategies, which would diminish the effects of proactive interference.

Research question

Proactive interference and event segmentation are two different aspects relating to memory. How do they relate to each other? Past research indicated that a release of proactive interference can be established through semantic shifts or a shift in language. On the other hand, event segmentation is the process by which we segment a continuous flow of stimuli to create meaning. However, a shift in content or in language is definitely a meaningful event. Couldn't one argue that a semantic shift or a shift in language could qualify as an event boundary in itself? There is a possibility that event segmentation has partially explained the release of proactive interference back in Wickens' days. As we've seen in the introduction, passing an event boundary causes forgetting of the previous segment. This could cause a release of proactive interference according to event cognition theory. Short-term memory may be strained. This results in a dump of short-term memory and thus alleviates the negative effects of proactive interference (Radvansky, Krawietz & Tamplin, 2011). If short-term memory activation is indeed stored as noisy codes as Craig et al (2013) suggested, it becomes apparent how such a wipe of short-term memory is very useful.

It is hard to know if a semantic shift would pass as an event boundary. Finding out would be rather simple though. Just apply the overt method of detecting event boundaries during an experiment following Wickens' paradigm. Another way to approach this problem, which is more decisive and has the potential to generate more knowledge, would be to establish proactive interference and see if an event boundary could cause a release from proactive interference without actually switching semantic categories. This mirrors the endeavor of the current research effort.

The experiment will be carried out in Minecraft. Minecraft was chosen because it is a virtual world of which one can control the entire environment completely. Minecraft is also a first-person game. In previous experiments where event segmentation theory was tested people usually had to watch other people engaging in activities (Kurby & Zacks, 2008; Magliano, Radvansky, Forsythe & Copeland, 2014). This could be misleading, since people are actually used to a first-person perspective in real life. The event boundaries, or independent variables, used to check for release of proactive interference is simple environment shifts. Participants will explore a world following a path, with sudden drops down to entirely new and contrasting environments. During the gameplay, proactive interference will be established through lists of words generated from semantic categories and event boundaries effects on proactive interference will be tested.

Purpose and hypothesis

The purpose of this experiment is to conclude if an event boundary can cause a release of proactive interference, in accordance with event cognition theory. This offers a deeper understanding in how our short-term memory works and would help to integrate two different research paradigms. The research is exploratory and has the potential of generating many new venues of research related to proactive interference and event segmentation. The hypothesis is as follows:

-Crossing an event boundary causes a release of proactive interference

Method

Participants

36 undergraduates from Nils Fredrikson utbildning with an age ranging from 18 to 19 (M=18.32 SD=.47) were recruited for the experiment. Since the experiment investigated learning and recall, students at a gymnasium can find the research valuable. Interest for Minecraft is also probably higher among students at a gymnasium compared to and older age group. Only one age group was used since previous research has indicated large differences in resistance to proactive interference in the life span and this can be considered a confounding factor (Loosli et al, 2014). The participants' native language was not asserted nor was Swedish as a native language a requirement. It was obvious however that all the participants were well versed in the Swedish language and all who participated had studied or were studying Swedish at the gymnasium. Written informed consent was obtained from all participants.

Material

There were 20 trials in each block, divided into four semantic categories. The categories were fruits, insects, body parts and furniture. Each trial contained four Swedish words that were typical for their category. These different lists were generated using the research Swedish category norms and are designed specifically to establish proactive interference (Hellerstedt, Rasmussen & Johansson, 2012). Hellerstedt, Rasmussen & Johansson (2012) generated lists for 80 categories based on associative strength for the category by simply asking participants for exemplars for the given category. The lists generated for the present experiment can be seen in the appendix. The different trials, distraction task and recall task were recorded and added to a playlist file in VLC mediaplayer.

Minecraft was used to create the two virtual worlds. The first world created was named ABBA. ABBA was generated with a superflat setting and the result was a 4 layered world. Each layer had its own distinctive type of floor tile. After this, each layer was enriched manually by construction and this yielded four separate environments. The world was named ABBA because of the order of the conditions, where the “As” represents baseline conditions and “Bs” represent experimental conditions. A red path was created in each environment, which led to a hole in the ground that would drop the participant down to the next environment. The second world was named BAAB and was created by making a copy of the ABBA world, making the two worlds identical. BAAB was then repurposed to act as a counterbalance, keeping the environments in the same place but changing the order of the baseline conditions and the experimental conditions. This was done simply by varying time spent in each environment by altering the locations of the drops to the next environments. A more detailed account of this can be seen in the design section.

Each distinctive environment will be described shortly below, as it was for the participants in order to strengthen the effect of environmental shifts and immerse the participant in the game. Because of the nature of proactive interference, the negative effects on recall that keeps escalating until a semantic shifts occurs, it was always the fifth and last trial of a specific semantic category that coincided with the environmental shift.

The game was displayed on a 20 inch screen monitor (HP LE2001W). Siberia Steelseries headsets were used for the audio recordings. A Logitech keyboard was used to control the character but since the only command the participant had to issue was “run”, all keys but W were unbound during the experiment.

Minecraft maps

Block town is a rural community inhabited by humans. In this map, the participant had to walk through a seemingly endless grouping of houses, gardens and squares. It is a very green and beautiful environment, since all the heavy industry of Block town is actually carried out somewhere below ground.

Cobweb caverns are the cave system below Block town. Here the inhabitants of Block town erected great spider farms in order to harvest cobweb. The caves are littered with spiders, cobweb and toadstools. Since Block town is built above the caves, it is not uncommon to see some wells that have been dug into the cave in order to gain access to water.

Copacacacti is the vacation paradise of your dreams. It is a beach land with a breath taking sea to the west. It is inhabited by the mighty “Cacti”, the beings that empowered the inhabitants of Block town and gave them the technology to create such a promising community. If you manage to take your eyes off of the sea, do look east. If you do, you can see many of the monuments and altars erected to honor the Cacti. If you are lucky, you might even witness a convening of the Cacti council.

The molten quarry is a breathtaking sight. Situated inside a volcano, this mining operation has created gigantic voids inside the once solid mountain. This is the essence of Block town's heavy industry where many important ores and minerals are gathered. The lava which naturally belongs within the volcano is used to process the ore. Walk along the inspector's track and be amazed of the gigantic halls and all the mining tracks erected in this fiery maze. Are you wondering what other uses the lava has? Well, you can take a shower in it, but I assure you the shower would be very brief. With this in mind, always stay on the Inspector's track!

Design

A within subject design with ABBA and BAAB counterbalancing was used to counter order effects related to proactive interference and release of proactive interference. The A conditions in these groups were baseline conditions where proactive interference was established and maintained, meaning 5 consecutive trials in the same environment. The B conditions were experimental conditions aiming to cause a release of proactive interference through environmental shifts, meaning an environment shift between trials 4 and 5. Since proactive interference is by definition a repeated measure, no other alternative was available and nor would it have been more suitable. See Fig. 1 below for an illustration of the experiment design.

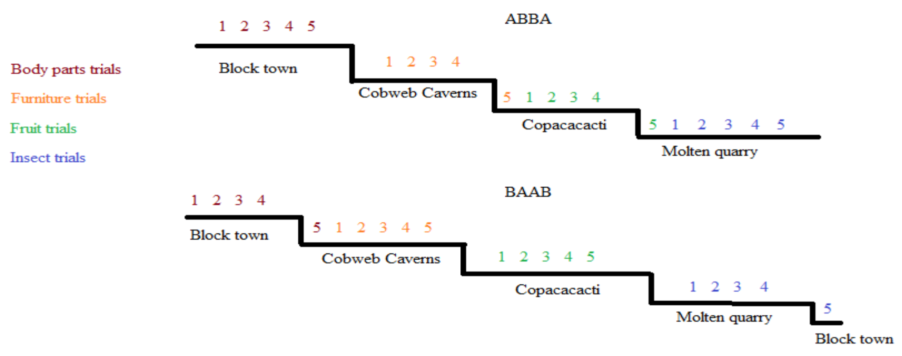

Fig. 1

The figure depicts the order of environments, semantic categories and the different locations of the experimental and baseline conditions.

Procedure

After informed consent was signed, participants were assigned by order of appearance to one of two blocks, ABBA or BAAB. They were asked to sit down in front of the computer. Test trials were administered for each participant until they felt comfortable doing the experimental trials and until the researcher felt that the participant understood the task completely. The participants were also offered a chance to enter a pilot world consisting of nothing but a flat bedrock landscape in order to test what it was like to run in minecraft. Few felt a need to do so. Both the preparation and the experiment itself were carried out individually. The four environments were shortly described so as to strengthen the participant's immersion into the game and create a greater contrast between them. Weather conditions and time of day was kept constant for all participants, by issuing minecraft commands /time set and /weather set. Participants were instructed to never stop running when the experiment started and to keep their eyes on the screen. The researcher instructed the participant to never deviate from the red trail, prompted the participant to start running when they heard the audio cue and activated the recording. The four words in each trial were presented with a two second interval and as soon as the list ended, the participants were asked to count backwards out loud from a four digit number with an interval of three. The distraction task lasted 18 seconds. After that, the participants were prompted to recall as many words as possible and to say them out loud. The next trial began after the recall period of 10 seconds when the recording prompted the participant to stop recalling and indicating the beginning of next trial, making each trial with exposure, distraction and recall 43 seconds long. The entire blocks took about 15 minutes to finish but including test trials and debrief the participant spent about 30-40 minutes of their time. Upon completion, participants were rewarded a chocolate bar, a cookie or a bag of candy.

Ethics

Written informed consent was obtained from everyone participating in the experiment. The form briefly stated the purpose of the experiment, that it was a memory test taking place in minecraft and it informed the participants that participation was not mandatory and their rights to withdraw from the experiment without any negative consequences at any given time. The form stated that the participation would be anonymous and confidential. The ehtical aspects of the participant were also mentioned, that they should try to the best of their abilities to complete the test in the manner requested and not to leak information regarding the test until the research leader approves. Questions were allowed before the experiment begun but most participants decided to ask the questions during the debrief that followed the experiment.

At the end of the debrief the participants were given an email adress if they would like to have a copy of the complete raport. All data that could remotely be considered sensitive, such as results and personal information, has been kept under lock or in a disconnected USB-device at all times. Internet connection has been disabled on the computer while this information has been used to write the report.

Data manipulation

Before analysis begun, the scores were added together and an index mean were created to form a baseline condition and an experimental condition for the total pool of participants, the ABBA group and the BAAB group.

Results

One point was awarded for every correct word recalled, regardless of any order they were recalled in, making 4 points a perfect score. Two participants' results were excluded due to mechanical failure which was graphical bugs in the game. The means of the baseline and experimental condition for all participants are displayed in fig.2.

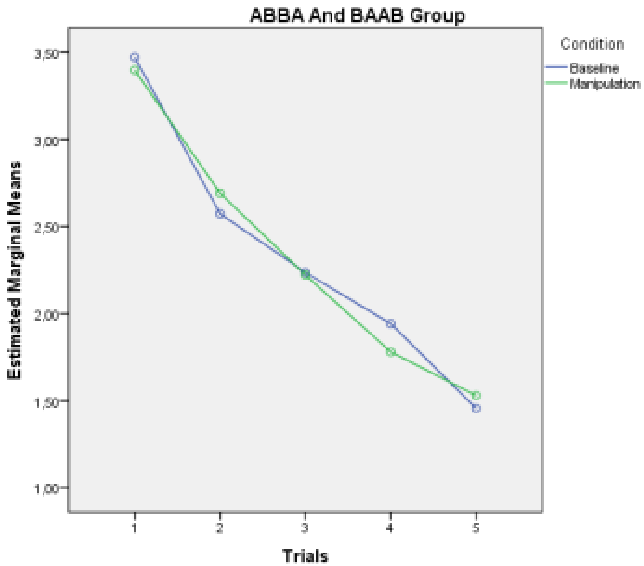

Fig. 2 Mean recall across trials for both groups.

Repeated measure analysis of variance was used to compare scores between the different trials and the two conditions, baseline and experimental condition. There was a significant effect of trial, Sphericity assumed, $F(4,132) = 109.27$, $p<.0001$, partial eta squared =.76, indicating a strong buildup of proactive interference. There was no significant interaction of trial and condition, Sphericity assumed, $F(4,132) =.46$, $p=.76$. A paired samples t-test was conducted to evaluate the effect of environment shift in the last trials (*M*=1.52 , *SD*=.90) compared to the baseline condition of the last trials (*M*= 1.45, *SD*=.87. There was no significant release of proactive interference, *t* (33) = -0.35, *p*=.729.

While plotting the results in a group dichotomized manner, differences could be observed on graphs between the ABBA and BAAB worlds. The means of the two different groups can be seen in Fig.3 and Fig.4 respectively.

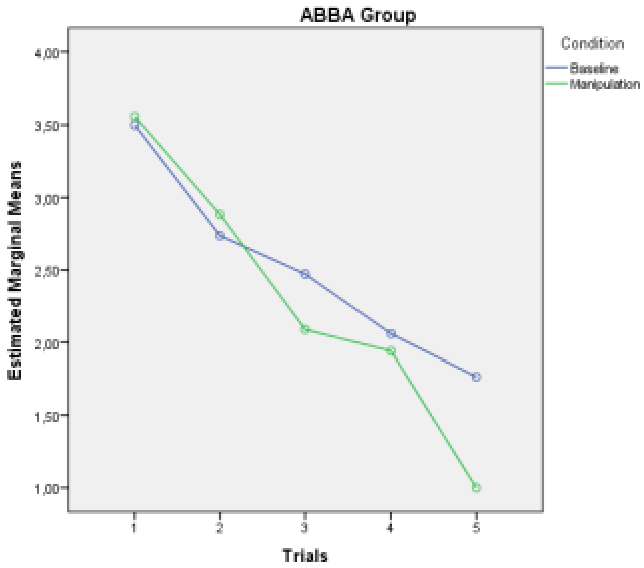

Fig. 3 Mean recall across trials for the ABBA group.

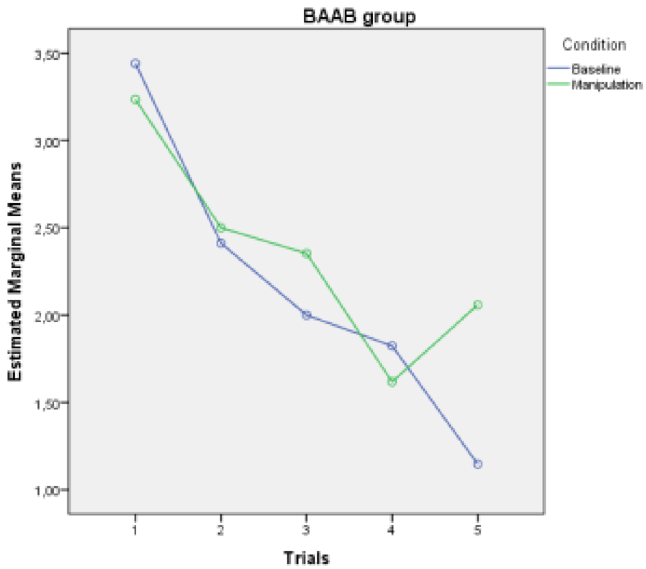

Fig. 4 Mean recall across trials for participants in the BAAB group.

A paired samples T-test was conducted to evaluate the effect of environment shift in the last trials for ABBA and BAAB (*M*=1.0, *SD*=.66, *M*=2.05, *SD*=.80) respectively, compared to the baseline condition (*M*=1.76, *SD*=.70, *M*=1.14, *SD*=.93) respectively. There was a significant and strong negative effect of environment shift on mean recall in the ABBA world, t (16) = 3.97, p=.001, d=.49. A significant and strong positive effect of environment shift on mean recall was found in the BAAB world, t (16) = -3.80, p=.002, d=.47. Since there was a difference between the two groups, descriptive statistics of the original results before collapsing into baseline and experimental condition will also be displayed in Fig. 5 and Fig. 6.

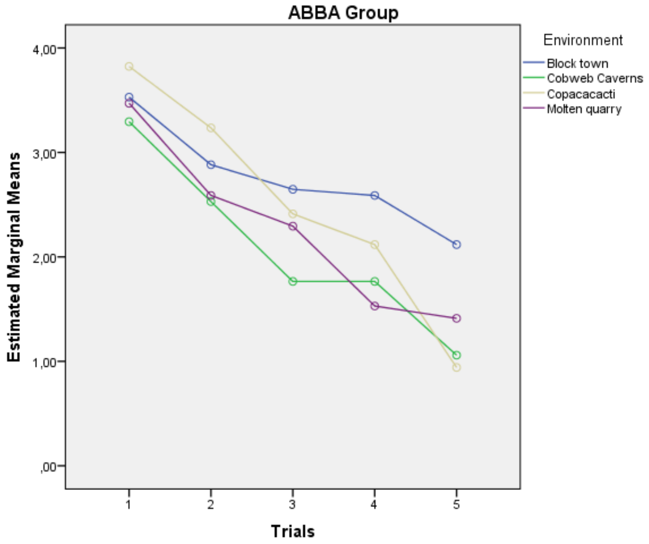

Fig. 5 Mean recall across trials for each environment for participants in the ABBA group.

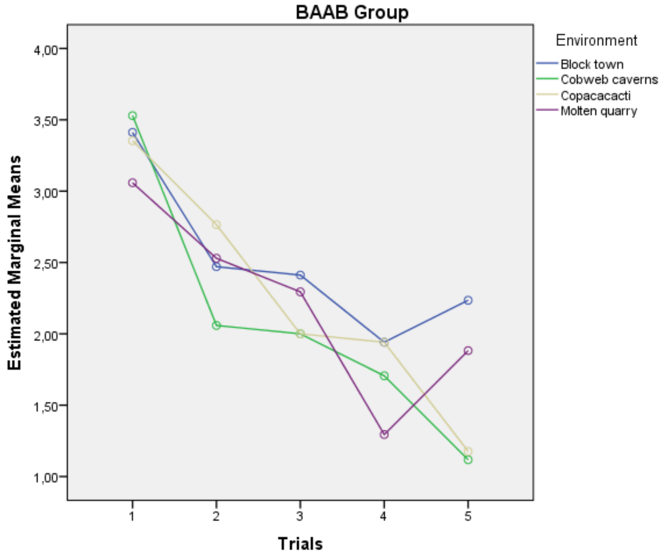

Fig. 6 Mean recall across trials for each environment for participants in the BAAB group.

Discussion

The goal of this experiment is to conclude if the process of event segmentation can cause a release of proactive interference. This was attempted by inserting an event boundary defined as an environmental shift between the fourth and fifth trial of a given semantic category.

The results are very conflicting. We can clearly see a stable buildup of proactive interference in the total baseline and experimental conditions, in accordance with Wickens' paradigm. One could not hope for a more smooth and beautiful curve. Analysis of the both groups performance yields the result that the experiment simply is inconclusive. It's inconclusive in a very decisive manner as well, Fig. 2 displays very well that the average of the two groups make them nearly identical. However, by dichotomizing the two groups into separate units, observation of Fig. 3 shows a great decrease in performance in the ABBA world at the experimental condition, while Fig. 4 shows a release of proactive interference in the BAAB world. The two worlds are as similar as they could possibly be, the BAAB world is a copy of the ABBA world where the experimental conditions has shifted to the first and last environment instead of the second and third environment. The only variance is the time spent in each environment, since the experimental condition always coincides with the fifth and last trial of any given semantic category. This was to make any effect as tangible as possible, seeing as proactive interference is greater in the last trial for the comparison baseline. The lists themselves have been thoroughly tested in a previous experiment and all the data indicate a good buildup of proactive interference (Hellerstedt, Rasmussen & Johansson, 2012). With this in mind, we shouldn't be seeing the results we are seeing despite the fact that different semantic categories contained the experimental manipulation in the two different blocks. In the ABBA block, the last trials of furniture and fruits were tested after an event boundary. In the BAAB block, the last trials of body parts and insects were the experimental condition. This is highly unlikely to have created such contrasting effects. All the lists had high associative strength in the first trials with a diminishing strength across the trials (Hellerstedt, Rasmussen & Johansson, 2012). Additionally, the experimental trials that indicated a release of proactive interference did not indicate a release of proactive interference during the baseline condition. Therefore, what is more likely to be a confound is the maps' environments themselves. In the ABBA block, the experimental conditions are between Cobweb caverns and Copacacacti, and between Copacacacti and Molten quarry while in the BAAB block, the experimental conditions lie between Block town and Cobweb caverns and between Molten quarry and Block town. The return to the original starting environment is unlikely to be the problem and it would only explain the effect of the very last trial in the BAAB block.

Previous research on event segmentation indicates that such a return to a previous location would not have any beneficial effects on memory (Radvansky, Krawietz & Tamplin, 2011). Further diminishing the suspicion of this as a confound, is the fact that a different semantic category was tested in Block town in the first visit. If this reinstatement of a previous environment would have had an effect, people would be remembering body parts instead of insects and no formal or informal reports of this phenomena was reported. It could be that the environments themselves aren't equal. They had to be different in order to create a clear event boundary and all of the environments' templates were generated in Minecraft using a superflat setting. This makes all the environments identical except for the different ground tiles, which were grass, sand, stone and nether rock. After the template generation environments were enriched manually. This manual enrichment which was made to increase the chance the player would discriminate between them might have caused the problem and made the environments unequal. It's important to note however that if there was any inequality, the inequality is not between worlds, but between the environments. The BAAB world copy was made first after the manual enrichment was complete. If we scrutinize the environments, the contrast between Block town and Cobweb caverns could be interpreted as greater, seeing as there's a greater number of structures in Block town. Block town is also a whole lot more spacious, since it's above ground. The sun gives a more natural lighting to the environment, whereas Cobweb caverns, Copacacacti and Molten quarry are below ground. Because of this an artificial light source called "glowstone" was used for Cobweb caverns and flaming torches were used to light up Copacacacti. In Molten quarry, rivers of lava lit up the environment. Although all of the environments were lit up, a distinct feeling of being above ground and below ground might create a much greater contrast than being below ground and going deeper below ground. This could be the explanation for why the hypothesis was only supported in the BAAB world, where the experimental conditions were placed at such environmental shifts, meaning above ground to below ground, and below ground to above ground. There were also differences in the shift between Cobweb caverns and Copacacacti, where many of the buildings and monuments made for the same contrast mentioned earlier, apparently had eluded some of the participants gaze while following the red track. This information was given during the debrief, when the participants were briefly asked about the different maps and what they liked about them.

While this offers a possible explanation for why the hypothesis was only supported in the BAAB world, another pressing concern is still unanswered. How come we see the exact opposite effect in the ABBA world? In the BAAB world, the statistical analysis revealed an effect size of .47, which is a rather large effect on release on proactive interference. However, a slightly greater effect was discovered in the ABBA world, where recall actually decreased instead, with an effect size of .49. This sudden drop in recall score is opposed to the hypothesis and can't be explained by the previous arguments. That the two groups would be any different is hard to imagine. They were assigned to the two blocks by order of appearance in an alternating fashion. A greater number of participants might yield more stable results. Unfortunately the experiment itself was rather time consuming since it required practice trials and many of the participants were eligible for the experiment were away on various internships. Game immersion has been tested in similar experiments and no effect of smaller or greater immersion has been found (Radvansky, Krawietz & Tamplin, 2011). A word of warning was raised in the introduction regarding practice effects in relation to proactive interference (Wahlheim & Jacoby, 2011). However, neither immersion nor practice effects should affect the ABBA group alone. The most logical explanation is a hidden variable. Something seems to interact with the experimental condition in a modulating way. What can affect the results to sometimes be better and sometimes worse? The environments are still the most probable culprits. The description of Block town is quite accurate and the environment is indeed beautiful and almost peaceful. Cobweb caverns are littered with cobwebs and poisonous toadstools, two items that easily can yield a negative association. Copacacacti was intended to be a vacation paradise, yet the static cacti inhabitants have a large frown on their faces. Nelson, Fitzgerald, Klumpp, Shankman & Phan (2015) conducted an FMRI study on brain activation as a response to negative and neutral faces and found that different parts of the brain are involved while processing stimuli with emotional valence. Emotional valence is a possible candidate for the hidden variable. The valence can range from negative to positive and there's quite the possibility that negative valence made the ABBA group perform worse seeing as their experimental conditions resides within the environments that are negatively loaded. The BAAB group on the other hand experienced their experimental condition in relation to the more positively loaded environment of Block town. While this offers quite the elegant explanation to the conflicting results, it is a highly hypothetical argument that needs to be tested. If time had allowed it, additional experiments could be performed to analyze the emotional valence of the different environments and the theorized modulating effects of emotional valence could be incorporated and tested. Can the present data give support to this theory? The first instinct was to collapse the group to create baseline conditions and experimental conditions. As the results unfolded, it was evident that collapsing the data might have been premature. In Fig. 5 and Fig. 6 it is clear that both Cobweb Caverns and

Copacacacti, the two environments argued to hold the strongest negative valence, are the two environments with the lowest scores at the fifth trials in both groups. No inferential statistic can vindicate these results seeing as the negative valence can apply either to the proactive interference, to the release of proactive interference, or both. This will have to be a question for future projects were more controlled counter balancing is employed.

Conclusion and future research

These results are confounded and cannot support the hypothesis, thus the experiment is inconclusive. The results are not compatible with event cognition theory regarding the event model updating effect, which should cause a release of proactive interference once an environmental shift occurred. This might be explained by the unequal environments created, with regards to both environmental contrast and emotional valence.

For future research it is recommended to test the maps using the overt and covert methods discussed in the introduction. That would be the best way to make sure that the environments were truly equal in the more critical aspect and it was at first considered but then rejected because of the time table. The experiment can be more controlled by balancing for order effects, which was impossible in this study due to the time limit. Template generation and manual enrichment took approximately 48 hours to complete and a copy was made instead of creating the environments in every possible order to save time.

Although the experiment is inconclusive, very exciting and promising results have been generated. The results may support event cognition theory in the regard of the positive effects on proactive interference. Future experiments can investigate if there is a possible interaction effect between emotional valence, event segmentation and proactive interference.

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Appendix

Body parts
Trial 1A
Arm, Ben, Finger, Fot
Trial 2A
Huvud, Hand, Mage, Tå
Trial 3A
Näsa, Öra, Bröst, Knä
Trial 4A
Öga, Lår, Rumpa, Vad
Trial 5A
Mun, Hals, Rygg, Armbåge

Furniture
Trial 1B
Stol, Bord, Soffa, Fåtölj
Trial 2B
Säng, Bokhylla, Pall, Hylla
Trial 3B
Nattduksbord, Byrå, Skrivbord, Garderob
Trial 4B
Lampa, Soffbord, Tv-bänk, Bänk
Trial 5B
Matbord, Skåp, Divan, Skohylla

Fruit
Trial 1C
Äpple, Apelsin, Banan, Päron
Trial 2C
Kiwi, Ananas, Mango, Klementin
Trial 3C
Vindruva, Plommon, Melon, Citron
Trial 4C
Papaya, Körsbär, Mandarin, Nektarin
Trial 5C
Persika, Aprikos, Grapefrukt, Passionsfrukt

Insects
Trial 1D
Fluga, Mygga, Bi, Getting
Trial 2D
Humla, Myra, Skalbagge, Spindel
Trial 3D
Fjäril, Knott, Gräshoppa, Nyckelpiga

Trial 4D
Fästing, Larv, Gråsugga, Trollslända
Trial 5D
Broms, Kackerlacka, Mask, Slända