Mental Time Travel: The Accessibility of Events, influenced by Temporal Direction, Temporal Distance and Emotional Valence

Abstract

The unique possibility of the human race to engage in 'mental time travel' (MTT), in other words reliving the past and imagining or preliving the future, has always been a fascinating phenomenon. It is the ability to mentally project oneself backward in time to re-live past personal experiences or forward in time to pre-live possible events in the future. In a within-subjects design, this study examined whether temporal direction (past versus future), temporal distance (near versus distant), and emotional valence (positive versus negative) affect the accessibility of retrieving and generating events. Accessibility is defined as the ease whereby memories and possible future events are retrieved from the brain. Students at the Utrecht University (*N*=75) were asked to mentally re-experience or pre-experience twelve events that differed in temporal direction, temporal distance and valence. Reaction times were measured and used as an indicator for accessibility. The reaction times were submitted to a factorial 2x2x2 repeated measures ANOVA. It was found that future events are more accessible than past events, near events are more accessible than distant events and positive events are more accessible than negative events. However, the latter effect of valence was only found in recent events, in both past and future. These results can be used for further research into the accessibility of MTT.

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Introduction

The unique possibility of the human race to engage in 'mental time travel' (MTT), in other words reliving the past and imagining or preliving the future, has always been a fascinating phenomenon (Van Boven & Ashworth, 2007). It is the ability to mentally project oneself backward in time to re-live past personal experiences or forward in time to pre-live possible events in the future (Berntsen & Jacobson, 2008). Past and future MTT share many similarities and there is evidence that both kinds of MTT rely on the same neural networks and similar cognitive structures (Botzung, Denkova & Manning, 2008). Although past MTT has received attention for quite some time, future MTT is a relatively new studied aspect of mental time travelling. To explain how people create future images, Schachter and Addis (2007) developed the constructive episodic simulation hypothesis, which states that thoughts of past and future events draw on similar information that is stored in episodic memory, and rely on similar underlying processes. Episodic memory is proposed to facilitate the construction of future events through extracting and recombining stored information into a simulation of a novel event. Both past and future thinking can involve positive as well as negative experiences (e.g., imagining one's wedding vs. imagining the death of a loved one), but also ordinary versus rather important experiences (e.g., imagining tomorrow's grocery shopping vs. imagining having your first child).

The accessibility, or ease whereby memories and possible future events are retrieved from the brain, might be influenced by several factors. It is mostly measured using the actual time participants need to retrieve or generate an event, by using reaction times (D'Argembeau & van der Linden, 2004; Newby-Clark & Ross, 2003). A first factor than can influence the accessibility is the *temporal 'direction'* (e.g., past or future) of events. Experimental studies on subjective qualities of the two forms of mental time travel have generally shown that future events involve less sensory imagery than past events (Addis et al, 2007). This might suggest that future MTT entails more complex constructive processes than past MTT. As a result, it may be harder to retrieve possible future events than events that already happened in the past. Furthermore, the *temporal distance* seems to be an important factor, in that it might be more difficult to recollect or construct events from the *distant* past or future, than events from the *recent/near* past or future. Unless memories are frequently reactivated, the phenomenal characteristics of memories tend to be forgotten over time (Suengas & Johnson, 1988). Although future events obviously cannot be forgotten because they have not yet occurred, temporal distance might however affect the subjective experience associated with

the imagination of future happenings. Trope and Liberman (2003) proposed that "the greater the temporal distance from a future event, the more likely the event is to be represented abstractly in terms of a few general features about the essence of the events rather than in terms of concrete and more incidental details of the event". People may therefore find it easier to project themselves into future events that are nearer in time. Besides temporal direction and temporal distance, *valence* (i.e. positive or negative events) seems to play an important role in the accessibility of past and future events (D'Argembeau and van der Linden, 2004; Newby-Clark and Ross, 2003; Szpunar and McDermott, 2008). People tend to hold an optimistic view on the future (Wang et al, 2015; Finnbogadottir & Berntsen, 2013) while they generate positive future events more easily than negative future events. Newby-Clark and Ross (2003) wanted to find out whether valence was of influence on past and future MTT. They used reaction time as an indicator for accessibility, as it shows the actual time participants need to generate or retrieve events. It was expected that individuals would need more time to generate negative future events than positive future events and that there would be a smaller or absent systematic difference in the time participants would take to recall positive and negative past events. Thirty college students had to list a maximum of 10 events from their pasts and 10 events from their futures. Regarding future events, participants took significantly longer to generate negative events (approximately 2,5 minutes) than positive events (1,5 minute). For past events, there was a similar but nonsignificant pattern. Hence, participants were slower in imagining negative future events than positive ones, but there was no difference in reaction time when it came to past events. The authors argued that negative future scenarios come to mind relatively slowly (i.e., are harder to access) because people tend to be highly optimistic about their future and typically devote less thought to negative than to positive future events. However, conclusions about the speed by which positive and negative events came to mind have to be taken with caution, since the sample was relatively small, due to many non-responses. The participants had to write down the reaction times themselves, which led to a large number of missing values, for example when a participant forgot to write a reaction time down. Furthermore, self-report of reaction times is not very reliable.

D'Argembeau and van der Linden (2004) studied the influence of all three factors simultaneously, i.e., valence, temporal direction, and temporal distance, using reaction time as an indicator for accessibility. The study was conducted amongst 40 students, who were asked to recall or imagine events and to describe them in detail. A cue word would be displayed on a screen and the participant's task was to remember or imagine an event, as quickly as possible, in response to that cue. Participants were asked to press the space bar as soon as they had a

specific event in mind and this response time was recorded. Overall, their findings were consistent with the Newby-Clark and Ross (2003) study, but a distinction was found in temporal distance, hence distant or recent events. Regarding the past, it was found that memories of negative experiences were constructed more slowly than memories of positive experiences, but this only applied for memories in the recent past.

Literature shows that the results of studies regarding the accessibility are mostly consistent. Valence, temporal direction and distance are influential factors on accessibility and to be more specific, events with a positive valence and events that happen in the recent past or future are most accessible for people. However, there is still a lack of studies that examine the accessibility of MTT, especially the ones using reaction times as an indicator. More research needs to be done to draw firm conclusions about this accessibility. The studies that have been done have certain limitations. For example, the reaction times are measured by the participants themselves, which causes missing values and therefore, possible distorted results. The present study will try to improve this by measuring the reaction times afterwards and by the researchers themselves. All of the abovementioned factors, hence temporal direction (past vs. future), temporal distance (near vs. distant) and emotional valence (positive vs. negative) will simultaneously be measured as possible influential factors. Therefore, the following questions will be answered: Is there a difference in accessibility in recalled past versus imagined future events? Is there a difference in accessibility in near versus distant events? Is there a difference in positive versus negative events? Do these factors also influence each other in any way? Based on previous literature, it is hypothesized that past events are more accessible than future events. Near events are expected to be more accessible than distant events. Furthermore, it is hypothesized that positive events are more accessible than negative events. An interaction-effect of valence and temporal direction is also expected, in that future positive events will be generated more quickly than future negative events.

Methods

Participants

A total of 75 students at Utrecht University participated in this study. Data from one participant was excluded, because the computer crashed in the middle of the interview and deleted most of the events, leaving a sample of 74 participants. There were 16 men (22%) and 58 women (78%), with an average age of 21.9 years (*SD*=2.7), of whom 8 (11%) participants were currently receiving mental treatment or did so in the past. The participants were also tested on depression and anxiety, using the BDI-II and the STAI respectively. This information was used to describe the sample as thorough as possible. The average score on the BDI-II was 7.5 (*SD*=6.88), which can be interpreted as 'minimal depressive symptoms'. For the STAI, the average score on the 'state anxiety' scale was 33.06 (*SD*=7.44) and the average score on the 'trait anxiety' scale was 34.99 (*SD*=9.39). Both average scores can be interpreted as 'low'.

Design

This experiment used a 2 (past vs. future) x 2 (near vs. distant) x 2 (positive vs. negative) within-subjects design.

Materials

Adapted Autobiographical Interview (A.I.)

The Autobiographical Interview (Levine et al, 2002) is an instrument for quantifying episodic and semantic details and is used as a method to assess autobiographical memory. Participants completed an adapted version of the A.I. that probed events from both the past and the future. Participants generated twelve events in response to randomly presented positive or negative cue words that were linked to one of four temporal conditions. The order of presentation was counterbalanced. Participants saw a cue word in combination with a task (temporal condition) on the screen of a computer. There were four different temporal conditions: 1) Describe an event in the distant past (more than 5 years ago), 2) Describe an event in the near past (last month), 3) Describe an event that could happen in the distant future (more than 5 years later), and 4) Describe an event that could happen in the near future (next month). The cue words were combined with a high-pitched tone, to facilitate the measuring of reaction times afterwards. In total, the participant had to describe twelve events, one event for every cue word. During each event, one of the researchers gave specific instructions to facilitate the

process of describing an event in as much detail as possible. For example, the participant had to be personally involved in the remembered or upcoming event, and the event had to be specific in time and place. After each given combination (i.e. twelve times), three steps were followed according to the A.I.:

1) Recall – The participant needed to collect as much information about the event as possible to test whether the event was suitable for scoring. The interviewer could only replay to the subject with "yes" or "go on".

2) General Probe – The interviewer started asking questions about the chosen event. For example, "Tell me more details" or "What can you recall from the event?"

3) Specific Probe – The interviewer investigated the remembered or imagined event as much as possible according to the Specific Probe List. An example of a question of the interviewer is: "What happened next?"

In the present study, information from the first phase (i.e. Recall) was used, as only reaction time was relevant. To examine the accessibility of the generated events, the responses were recorded on a voice recorder, and the reaction time was measured afterwards. The time participants needed to generate an event was measured from the moment they actually started to tell their story, so phrases like "Hmm, let's see.." or "Let me think.." were not included. Levine et al (2002), concluded that the A.I. has an interrater reliability that is high across four scorers. Coefficients for internal and external detail composites were 0.88 and 0.96, respectively, for recall, and 0.89 and 0.94 for specific probe. These results support the construct validity of the Autobiographical Interview to be an established measure.

Cue words

The twelve cue words were obtained from a word-frequency list that was based on the frequency of words in subtitles of Dutch movies and television (Keulers & Brysbaert, 2010). There were six negative cue words (e.g. guilt, pain, fair), and six positive cue words (e.g. luck, love, joy), with approximately equal length and number of syllables. The cue words cycled through one of four temporal conditions (as described in the previous paragraph) in a fully counterbalanced design. The cue words and tasks were shown in bold white characters (font 20, Mono) in the middle of a black screen. The temporal condition was placed underneath the task in italic white characters (font 18, Mono). Participants sat at a viewing distance of approximately 60 cm from a computer screen. The researcher tapped on the spacebar to go to the next screen, to avoid double-clicking. The task was shown on the screen until the participant said he or she was ready to see the cue word and subsequently, the cue

words stayed on the screen until he or she was finished with one event after which a new event started.

Beck Depression Inventory-II (BDI-II)

The Dutch version of the BDI-II (Van der Does, 2002) was used as indicator of depression severity. The average outcome was used to describe the sample, but also to explain possible outliers or biased events. For example, someone who scores high on the BDI-II possibly answers predominantly with negative events, even when a positive cue word is given.
The BDI-II is a self-report inventory consisting of 21 items that each represent a specific behavioural symptom (e.g., fatigue, hopelessness and irritability). Every item contains four statements indicating different levels of severity of a particular symptom experienced over the past week. The Dutch translation of the BDI-II proved to show high internal consistency: Cronbach's α of .92 for a patient population and .88 for a control group. Also, the validity index satisfies general psychometric criteria (van der Does, 2002).

State-Trait Anxiety Inventory (STAI)

The adapted Dutch version of the State-Trait Anxiety Inventory (van der Ploeg et al, 1980) was used to measure the level of general anxiety and anxiety at the moment and was used for the same reasons as the BDI-II. The STAI is a self-report instrument with two questionnaires (state vs. trait) of twenty items each (e.g. 'I am tense'), which either indicate how respondents feel at a given moment in time (state) or in general (trait). The items are rated on a four-point Likert scale, ranging from either 'not at all' to 'a lot'(state) or 'almost never' to 'almost always' (trait). The possible range of sum scores is 20 to 80.
Test-retest reliability scores are between .65 and .75 and research demonstrates a high internal consistency (Cronbach's α reliability scores are between .87 and .92). The validity index proves to be sufficient (Van der Ploeg et al., 2000).

Procedure

The experiment was conducted at computers with Windows 7, property of Utrecht University. The programme that was used to run the experiment was OpenSesame 3.0.5. The interview was recorded on a Sony voice recorder, also property of Utrecht University.
The participants were recruited by posters and flyers and could sign themselves in by sending an email to mtt.onderzoek@gmail.com to be scheduled for an appointment. After that, the participants were registered at the desk of the laboratory of the Faculty of Social Sciences,

Utrecht University. Subsequently, they were taken to the cubicle, where they read information about the study and gave informed consent. All participants were tested individually in a soundproof room. In order to avoid influence from results of the questionnaires on the results of the computer task or vice versa, the participants could either start with completing the two questionnaires (STAI and BDI-II), or with the computer task using the A.I. The participants were randomly assigned to one of both orders, as well as to one of the task sequences. The interviews were recorded on a voice recorder and linked to a participant number. At the end, participants had to fill in a debriefing form, after which they received 12 euros for compensation or 1.5 points course credit.

Results

Inspection of the data and check of assumptions

Inspection of the boxplots of reaction times in the various conditions, revealed that there were 7 extreme scores or outliers, equally spread among the different conditions. These outliers were replaced by the total mean of the respective condition. After replacing the outliers, new boxplots and histograms were produced and checked for the assumption of normality, that was now accounted for. Furthermore, since the factors in this study only had two levels each, the assumption of sphericity could not be violated and was automatically accounted for (Field, 2009).

A high degree of interrater reliability using the Intraclass Correlation Coefficient was found between the measurements of two independent raters. They both measured the reaction time of 12 events for 23 randomly chosen participants, so 276 values were compared. The single measures ICC was .933 (the average measures ICC was .965) with a 95% confidence interval from .916 to .947, F (275)= 28,83, p = .000.

Testing of hypotheses

The mean reaction times (in seconds) for the generation of a specific event are presented in Table 1, ordered by temporal direction (past vs. future), temporal distance (near vs. distant), and event valence (positive vs. negative).

TABLE 1

Means and SD of the Generated Past and Future Events

	Past events		Future events	
	Near	Distant	Near	Distant
Positive	15.35 (9.03)	22.57 (15.16)	14.25 (10.81)	17.70 (13.07)
Negative	22.07 (13.99)	21.68 (16.78)	18.84 (14.07)	18.22 (12.52)

Note. N=74. Standard deviations are given in parentheses.

The reaction times were submitted to a factorial 2 x 2 x 2 repeated measures ANOVA. All effects are reported as significant at $p < .05$.

It was expected that events in the past were more accessible than events in the future. The ANOVA indeed indicated a main effect of temporal direction, $F(1, 73) = 10.52$, $p = .002$. However, the effect was opposite to what was expected, since more time was needed to come up with an event in the past than in the future.

It was further expected that near events were more accessible than distant events. The ANOVA showed indeed a main effect of distance, $F(1,73) = 5.95$, $p = .017$, suggesting that participants generated events faster if located in the near past or future.

In addition, it was hypothesized that positive events were more accessible than negative events. The ANOVA showed indeed a main effect of valence, $F(1,73) = 10.91$, $p = .001$, suggesting that participants generated positive events faster than negative events.

Next to the main effects, there was also an interaction effect of distance and valence, $F(1, 73) = 1.32$, $p = .011$, suggesting that positive events were more accessible, but only for the recent past or future. No other interaction-effects were found.

Discussion

The aim of this study was to examine the influence of temporal direction (past vs. future), temporal distance (near vs. distant) and valence (positive vs. negative) on the accessibility of generated or retrieved events. The research concerning MTT is scarce and especially research into the accessibility of events during MTT is still in its infancy. In the present study, reaction time was used as an indicator for accessibility, based on previous studies (D'Argembeau & van der Linden, 2004; Newby-Clark & Ross, 2003), as it shows the actual time people need to generate or remember certain events. The lower the reaction time is, the more accessible an event is. Four hypotheses regarding temporal direction, temporal distance, and valence were tested. First, it was expected that past events are more accessible than future events. Second, it was expected that near events are more accessible than distant events. Third, it was hypothesized that positive events are more accessible than negative events. Fourth, an interaction effect was expected of temporal direction and valence, in that positive future events are more accessible than positive past events.

When looking at the accessibility of past and future events, the data showed that participants needed more time to come up with events in their past than in their future. This result was contrary to what was hypothesized, namely that participants would be faster in generating past events. When looking at the data and the conducted interviews of the present study, an explanation for this unexpected finding could be that during the interviews, the participants admitted quite often that they were forgetful about the past. They sometimes had to 'dig deep' to come up with something they experienced in their near or distant past, especially the latter one. The choice of using students as participants could have caused this, as students are quite busy with a lot of different things these days, especially with what will happen in their futures (i.e. exams, graduating, parties, finding jobs). This could hinder retrieving events from the past. Meanwhile, as predicted, participants generated events in the near past or future faster than events in the distant past or future. This result is consistent with the study of d'Argembeau and van der Linden (2004). They argued that people have clearer representations of the kinds of events that will probably happen in the near future. Furthermore, they argued that people may find it more difficult to project themselves into temporally distant events (both past and future) because the self-concepts that are involved in creating these events could differ from the present self-concept. Temporally close events typically involve self-concepts that are perceived as being similar to the present self-concept, whereas temporally distant events involve self-concepts that may seem different because

people may feel they have changed. In addition, it was found that the valence of the events affected the time participants took to generate events. Participants, as hypothesized, took more time to generate negative events than positive events, in both past and future. This finding is consistent with the Newby-Clark and Ross study (2003), that argued that negative future scenarios come to mind relatively slowly because people tend to be highly optimistic about their future and typically devote less thought to negative than to positive future events. People may attach more importance to positive aspects of their self-concepts, making them more motivated to think of positive rather than negative events. D'Argembeau and van der Linden (2004), who also examined the influence of valence on the accessibility of events during MTT, found that most events were positive, for both past and future. Finally, it was hypothesized that there would be an interaction effect of valence and temporal direction, in that positive future events would be faster generated than negative future events. This interaction-effect was not found. Meanwhile, an unexpected interaction effect of distance and valence was found, in that positive events are more accessible in the recent past or future than in the distant past or future.

Several limitations and strengths of the present study should be mentioned and suggestions will be made for future research. During the experiment of the present study, we noticed that twelve events per participant was quite exhausting. Several participants suggested that we should use less events, as they got tired at the end of the interview. This could have influenced the reaction times, as participants needed more time to come up with an event due to fatigue, not being able to think clearly anymore. Longer reaction times thus might have represented fatigue instead of lesser accessibility. Future research should reduce the number of events or at least take the attention span of their participants into account. We will conclude with several strengths of this study. As mentioned before, the research about the accessibility of MTT is scarce, let alone as it is defined as the actual time participants need to come up with events. Even though studies have shown this to be a good indicator, this study improved its reliability by measuring the recorded reaction times afterwards and by the researchers themselves, instead of self-reported by the participants. In addition, this study took several influential factors simultaneously into account and also looked at possible interaction effects. By our knowledge, next to the D'Argembeau and van der Linden study (2004), the present study is the only study that includes multiple factors in one experiment. It is therefore a comprehensive and a complete addition to the research field.

In summary, this study attempted to further explore the accessibility of events, taking

into account the temporal direction, the temporal distance and the valence of these events. Accessibility was measured by recording the time participants needed to come up with an event. It was found that participants needed more time to come up with events in the past than in the future and needed more time to generate events in the distant past or future than nearby. They also needed more time to come up with negative events than positive ones. An interaction effect of temporal distance and valence was also found. It can therefore be concluded that future, near and positive events are more accessible than past, distant and negative events. Although these findings reveal more about MTT and give grounds to further research into human brain and exploring the field of MTT, more research must be done to form an innovative and broader understanding of this fascinating phenomenon.

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