Could direct and generative retrieval be two flips of the same coin? A dual-task paradigm study

Abstract

Autobiographical memories are thought to be retrieved using two possible ways: a generative one, which is effortful and follows a general-to-specific pathway, and a direct one, which is automatic and relatively effortless. These two retrieve processes are known to differ on the quantitative side (especially considering retrieval times), from a qualitative point of view, however, evidence is missing. Here, we aimed to disentangle this question by taking advantage of a dual-task paradigm in which the different tasks tax different executive functions. Participants were asked to perform an autobiographical memory task under three different conditions: no cognitive load, non-visual cognitive load and visual cognitive load. On the quantitative side, results replicated previous findings with generative processes being slower compared with direct ones. Conversely, on the qualitative side, results indicated that the retrieval times of both direct and generative retrieval processes varied similarly according to the dual-task condition, thus supporting the idea that the same memory process could underlie both retrievals.

Keywords: direct retrieval; generative retrieval; autobiographical memory; divided attention; visual search task.

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Introduction

How do we remember specific episodes from our own lives? According to a major model in autobiographical memory research (Conway & Pleydell-Pearce, 2000), episodes can be retrieved directly or generatively, with the former process being a minor part of humans' mnestic life, as compared with the latter. Indeed, direct retrieval is relatively effortless when specific cues automatically trigger a specific autobiographic memory, while generative retrieval is effortful, and reconstructive. Additionally, it should be noted that the process itself (i.e., direct vs. generative) is generally independent from the intentionality of the memory (voluntary vs. involuntary) as it is for example possible to observe involuntary generative memories as well as voluntary direct memories (Barzykowski & Staugaard, 2015, 2018; Barzykowski et al., 2019; 2021).

Specifically, the generative retrieval of autobiographical memories follows a general-to-specific pathway (Haque & Conway, 2001), starting from general life themes (e.g., when I was in high school) moving down to general events within those life themes (e.g., a vacation when I was in high school), and then to specific episodes (e.g., that dinner at that restaurant when on vacation when I was in high school). Several approaches claimed that retrieval from autobiographical memory is primarily a reconstructive process requiring cognitive resources, as additional cues need to be created in response to the cue word provided (Haque & Conway, 2001; Harris et al., 2015). This is in line with the idea that generative retrieval relies more than direct retrieval on executive control, memory search, memory elaboration, and retrieval of semantic information (Addis et al., 2012).

Direct retrieval is considered as an alternative retrieval route, albeit a rather rare one, in the Conway and Pledell-Pearce (2000) model as retrieval occurring when specific memories are accessed directly in response to a cue. In this case, the generative process is bypassed, and the specific memory is accessed directly within a few seconds, and presumably without effort. Direct retrieval is assumed also to be responsible for involuntary memories in healthy, non-traumatized, individuals. Involuntary memories are rather common mental events (Berntsen, 1996; Rasmussen & Berntsen, 2011; Vannucci et al., 2014), which seemingly pop into one's mind without effort or conscious retrieval attempts (Schlagman & Kvavilashvili, 2008) and are attributed to the close match between cues and memory representations (Berntsen & Rubin, 2012).

From a quantitative point of view, direct and generative retrieval differ in terms of the cognitive effort required to process the memory (i.e., a slowing down of response time for generative processes was observed using dual-task paradigms; e.g., Anderson, Dewhurst & Dean, 2012; Eade et al., 2006). For example, Anderson and colleagues (2012) measured the retrieval time of the first episodic memory in single task and dual task conditions, using a verbal random number generation task as concomitant task. Results showed that the retrieval times did not differ between the single and dual-task conditions when memories were cued by high imageability words (e.g., cat, house; which are thought to prompt direct retrieval; Williams et al., 1999; Anderson et al., 2012, but cf. also: Uzer et al., 2012). Conversely, retrieval was slower in the dual-task condition when cues were low imageability words (e.g., moral, wisdom; which are thought to prompt generative retrieval; Williams et al., 1999; Anderson et al., 2012, but cf. also: Uzer et al., 2012).

From a qualitative point of view – i.e., whether direct and generative retrieval could be based on different memory processes, rather than being a short and a long version of the same process –, some recent papers have provided important information (e.g., Barzykowski & Staugaard, 2015, 2018; Barzykowski et al., 2019; 2021). This study aims at providing additional data, using a different methodology, in establishing if direct and generative retrieval are two different processes or the same process. Regarding possible differences/commonalities, seminal perspectives proposed that directive retrieval processes bypass reconstructive components, while generative retrieval processes should be top-down and reconstructive (Haque & Conway, 2001), while other researchers proposed that these could differ in the time needed to complete the retrieval (Uzer et al., 2012) or in the subjective effort required (Harris & Berntsen, 2019, see also e.g., Barzykowski et al., 2019; 2021). In the present study we thus aimed to disentangle this question by taking advantage of a dual-task paradigm in which the different tasks tax different executive functions. Participants were asked to perform an autobiographical memory task under three different conditions: no cognitive load, non-visual cognitive load and visual cognitive load. The two cognitive load tasks consisted of (i) a non-visual, verbal random number generation (RNG) task (Miyake et al., 2000; similar to those previously used: Anderson et al., 2012; Eade et al., 2006), and (ii) a visual search task (Woodman et al., 2001). Verbal random number generation relies on executive functions and should thus use cognitive resources, while the visual dual task not only taxes cognitive resources, but it also takes up, and thus divides, visual processes (Woodman et al., 2001). We decided to include both visual and non-visual tasks since visual processes represent an important component of autobiographical memory retrieval (Holland et al., 2011; Rubin & Greenberg, 1998). It has also been proposed that visual processes contribute more to the retrieval of specific episodic memories than to the retrieval of general-level memories (Addis et al., 2004). We believe that by comparing the effect on retrieval times by the two concomitant task conditions it is possible to obtain some qualitative indications of the retrieval processes involved. Specifically, for example, in case of selective visual (or verbal) involvement in one of the two memory processes, the concomitant task tapping on that relevant function would interfere with the ongoing retrieval and reconstruction of the memory. That is, in case of more pronounced visual or verbal involvement in one of the two memory processes, we should observe a selective slowing down in one of (or both) the two dual-task conditions in one of the two retrieval types, thus indicating different characteristics of the memory processes involved. Conversely, comparable effects of the dual-tasks conditions across the two retrieval types would indicate that direct and generative retrieval could be two flips of the same coin, thus differing only in terms of the time required to retrieve the memory.

Method

Participants

Thirty-six participants (3 males, 33 females; mean age = 24.4, *SD* = 3.7) from the [redacted] in the UK (6 participants) and the [redacted], Hungary (30 participants) were tested individually. They participated in return for 8£ payment. All participants were informed that their responses were anonymous, and that they should not report anything that was uncomfortable for them to disclose. Prior to the experiment they signed an informed consent form. The study was approved by the ethics committees of the [redacted] and [redacted].

Materials and apparatus

Sixty-six cue words were used to elicit memories. They were selected from words that had been used successfully in prior autobiographical memory studies (e.g., Conway & Bekerian, 1987; Haque & Conway, 2001), which in turn had been selected from Hampton and Gardiner (1983). In addition, prototypical exemplars were selected from the categories clothing, fruits, vegetables, furniture, sports, and vehicles (Hampton & Gardiner, 1983). The cue words were divided into six lists of 11 words each (1 practice cue word and 10 experimental cue words, see Appendix A; for Hungarian participants the words were translated). Three lists were used for each participant, counterbalanced across conditions and participants. The practice words were always presented first and the cue words in each list were randomized across participants.

Procedure

Three within-subjects conditions: (i) autobiographical memory task without concomitant task (from now on called no-task condition), (ii) autobiographical memory task with concomitant visual search task (from now on called visual-task condition), and (iii) autobiographical memory task with concomitant random number generation task (from now on called RNG-task condition), were presented in blocks, and counterbalanced across participants. In each condition 10 different cue words were presented. The complete session took about 40 minutes to complete.

Autobiographical memory task

Directly prior to the experiment participants were given the following instructions verbally, which stressed the specific nature of the memories to be retrieved:

“Each new trial will begin with a new word presented on the screen for 1 second. Your task is to remember a specific event that is related to that word. As soon as the specific event comes to mind press the space bar; you have up to 60 seconds to remember an event. Importantly, the remembered event should: (i) have taken place at a specific time and location, (ii) not have lasted for more than 1 day, (iii) be a singular, non-repetitive, activity (e.g., going to volleyball practice every week is not good), (iv) should be from your own life. For example, if you think back and remember your math teacher, this is not good, because these are several memories connected to one person. It is also not good if you have a longer period in mind, for example going on vacation to France. It is an event that was longer than one day. In that case you should try to find a specific memory from that event. For example, you can think about drinking coffee next to the Eiffel Tower, this is a specific event. It can also happen that you have something in mind that kept happening to you. For example, attending dance classes. That is also not good, because it is a memory of a whole period. But if you can remember specific examples from these events, that is good. For example, you can remember the class when you first danced with John. The memories do not have to be strictly about the cue word. Anything that the cue word reminds you of is fine. They neither have to be important, funny or interesting. Anything that comes to mind and fits this type of memory is good. Please press the spacebar as soon as you have a specific memory in mind." In the practice trial participants were required to give an example of a memory cued by the word "A-level" to check if they understood the instructions correctly.

Each trial started with a fixation cross, presented in the middle of the computer screen for 500 ms. This was followed by the cue word presented at the same location, which remained on the screen for 1000 ms. The reaction times (RTs) timer started at the onset of the cue word. Participants pressed the spacebar as soon as they had retrieved a memory, which stopped the RTs timer. After the participant reported the memory verbally, a report was written down by the experimenter. In order to classify the memory as either direct or generative, participants were asked a question about retrieval mode, which has been used in prior studies of autobiographical memory retrieval (Uzer et al., 2012): "Was it only the cue word that triggered the memory or did you use any additional information from your life to find the memory".

Concomitant tasks

In the two dual-task conditions, each trial started with the concomitant task. After 10 seconds of solely the concomitant task, the autobiographical memory task started. The concomitant task continued until the spacebar was pressed to indicate that a memory was found. Please, note that the concomitant task was present with the same procedure for each cue word presented in the conditions with a concomitant task. The decision to interrupt the concomitant task as soon as the participant indicated to have found a memory was driven by the fact that our dependent variable of interest was participants' response time, which then was already collected.

Concomitant task 1: Visual search. The task was to search for the letter T among many letters L (18-22) randomly placed on the screen in a static display. The task was adapted from Duncan and Humphreys (1989). Participants had to press the T key on the keyboard as soon as they spotted the T, or the L key in case they decided there was no letter T in the display. In 20% of the trials there was no T. After three runs of the visual search task (which took about 10s) the cue word appeared for 1 second, immediately followed by a continuation of the visual search task. When the cue word was on the screen no visual search letters were shown simultaneously. The participants had to complete the visual search task while retrieving a memory triggered by the cue word. As soon as the memory was retrieved they said 'now', and pressed the spacebar, which immediately cleared the screen and the participant reported the memory verbally (written down by the experimenter).

Concomitant task 2: Random number generation. In the verbal random number generation (RNG) task (Towse & Neil, 1998) participants were instructed to say randomly the numbers 1 to 9 out loud, one number per second. A metronome-like ticking noise helped participants to keep pace. During presentation of the cue word on the screen (1s) the participants did not generate numbers. The RNG task was continued immediately after the word had disappeared while retrieving a memory triggered by the cue word. When a memory was retrieved, participants had to press the space bar. The RNG task stopped as soon as they pressed the spacebar to indicate they retrieved a memory.

Data analysis and results

Mean participants' RTs of each condition were our dependent variable. In a few cases reported memories were deemed inadequate as they did not match the instruction criteria and were removed from the analysis: no-task condition, 6.8% of the trials; visual-task condition, 6.1%; RGN-task condition, 6.5%. In case of missing direct or generative memories, the missing RTs values were imputed through deterministic regression imputation method (Van Buuren, 2018) using the *mice* R package (Van Buuren & Groothuis-Oudshoorn, 2011; 14% of the data were imputed). In the no-dual task condition, generative memories were the 78%, while the 18% were classified as direct (no memories were reported in the 2.8% of the cases); in the visual task the percentages were respectively the 82% and the 14% (no memories were reported in the 3% of the cases); while in the RNG task they were respectively the 80% and the 18% (no memories were reported in the 1.7% of the cases). Conversely, regarding RTs, generative retrievals required more time to be completed across no-dual task (M = 7.09 s, SD = 3.45 s), visual task (M = 9.21 s, SD = 4.84 s) and RNG task (M = 7.89 s, SD = 4.12 s) compared with direct retrievals (respectively: M = 2.88 s, SD = .97 s; M = 4.43 s, SD = 1.58 s; and M = 3.23 s, SD = 1.32 s).

In order to assess whether the dual-tasks condition modulated participants RTs across the two retrieval processes we performed a frequentist 3x2 ANOVA having type of task (no dual-task vs. visual vs. RNG) and retrieval process (direct vs. generative) and their interaction as within-participants factors. The frequentist ANOVA showed that participants' RTs were modulated by the type of task, $F(2,70) = 11.05$, $p < .001$, $\eta^2_p = .24$, and by the retrieval process, $F(1,35) = 68.70$, $p < .001$, $\eta^2_p = .66$; the interaction type of task by retrieval process was not significant, $F(2,70) = .33$, $p = .71$, $\eta^2_p = .01$. Post-hoc t-tests showed that participants' RTs were slower when they were performing the autobiographical memory task paired with the visual task compared with both no dual-task, $t(35) = 4.60$, $p < .001$, and RNG conditions, $t(35) = 3.16$, $p = .004$; no differences were found between no dual-task and RNG conditions, $t(35) = 1.44$, $p = .30$ (p-values are Bonferroni corrected). In addition, post-hoc t-tests showed that participants' RTs were faster when they reported a memory as direct compared with generative ones, $t(35) = 8.29$, $p < .001$[1,2].

Then, since we were interested in estimating the relative evidence supporting the model including the interaction type of task by retrieval process versus the model including additively the two main factors (i.e., alternative hypothesis vs. null hypothesis; Dienes, 2014), we also performed two Bayesian repeated-measures ANOVAs using JASP in its default settings for the a priori distribution of the parameters (r scale fixed effects = .5, r scale random effects = 1; for more information regarding priors see: Rouder et al., 2012; van den Bergh et al., 2020; JASP Team, 2018; Wagenmakers et al., 2018). Since Bayes Factor (BF) computation is a ratio between the probabilities of two different hypotheses, in the present analysis BFs above 1 indicate evidence for the null hypothesis and BF below 1 indicate evidence for the alternative. We considered BFs above 3 as indicative of moderate evidence in favor of the null hypothesis and 0.33 as indicative of moderate evidence in favor of the alternative hypothesis (Dienes, 2014). The BF was 10.51, indicating that the best model explaining the data was the one without the interaction type of task by retrieval process (i.e., the null hypothesis).

Discussion

In the present study, we explored whether direct and generative retrieval processes could be based on different memory processes, rather than being a short and a long version of the same memory process. We aimed to disentangle this question by taking advantage of a dual-task

[1] Comparable results were obtained also when including only Hungarian participants ($N = 30$), as well as when including the group (English participants vs. Hungarian participants) as between participant factor, with this factor being not significant, $F(1,34) = .70$, $p = .40$, $\eta^2_p = .02$, nor interacting with the other factors (all ps > .17, all η^2_ps < .05). Comparable results were obtained also when excluding the imputed observations, with significant main effects of retrieval process, $p < .001$, and of type of task, $p = .003$, and non-significant interaction, $p = .80$.
[2] The sensitivity analysis performed showed that we were able to observe a *Cohen's d* > .48.

approach: participants were asked to perform an autobiographical task and a concomitant task. Two different concomitant tasks were employed, each one tapping different executive functions. As already mentioned in previous recent studies (e.g., Barzykoski et al., 2019), both direct and generative retrieval are voluntary in nature. However, differently from generative retrieval (Conway, 2005, Conway & Loveday, 2010, Conway & Pleydell-Pearce, 2000), direct retrieval has the phenomenological characteristic of being perceived as effortless and almost automatic, even if intentional (Uzer et al., 2012, Uzer & Brown, 2017). As shown in previous studies (e.g., Barzykoski & Staugaard, 2016; Barzykowski et al., 2019) processes involved in autobiographical retrieval reflect a) intentionality vs. lack of intentionality; b) monitoring, and c) effort. Direct retrieval is similar to generative retrieval because they both require initial intention to retrieve and monitoring, but differs from it because in the former cognitive effort is apparently absent. This is, however, just a phenomenological perception on the part of the retriever. The aim of this study was to assess whether effort is indeed the discriminating variable between direct and generative retrieval. If effort is absent, a dual-task that taxes cognitive resources should not affect direct retrieval, but influence negatively generative retrieval. In other words, we should have observed increased retrieval times for generative memories in one of the concomitant tasks as compared with the no-dual task condition. Besides replicating previous findings on the quantitative side (i.e., generative processes were slower compared with direct ones), results indicated that the effects of the various conditions (i.e., no dual-task vs. visual vs. non-visual) were comparable across the two retrieval processes, with participants being slower in the visual condition regardless of the retrieval process. Specifically, this conclusion was supported by the inclusion of Bayesian analyses, which allowed to estimate the relative evidence supporting the null model vs. the alternative one.

Seminal theories proposed that generative retrieval processes are essentially top-down and reconstructive, while directive retrieval processes bypass such reconstructive components (Haque & Conway, 2001). Alternatively, other perspectives proposed that both generative and direct retrieval processes access pre-stored event representations, thus differing only in the time needed to complete the retrieval, which is cue dependent (Uzer et al., 2012). Finally, more recent perspectives proposed that both generative and directive retrieval processes are constructive, but that they differ in the degree of subjective effort required (Harris & Berntsen, 2019). This subjective effort, which is thought to be reduced in direct retrieval processes, can be defined across multiple cognitive levels, including: cue elaboration, semantic association, memory construction, control processes, and inhibition of irrelevant information. The latter perspective predicts that tasks tapping on different executive functions should modulate the retrieval time needed to fully recall the memory. Specifically, we should have observed increased reaction times in the generative retrieve processes during the visual or the non-visual condition. Conversely, our findings indicate that the speed of both generative and direct retrieval processes varied similarly according to the dual-task condition, thus supporting the cue-dependent perspective (Uzer et al., 2012). However, the present findings do not fully corroborate the latter perspective, since the concomitant tasks employed here did not involve all the possible sources of subjective effort listed by Harris and Berntsen (2019).

Regarding the specific effects of the concomitant tasks employed here, the non-visual task (random number generation; Towse & Neil, 1998) had no effect on both generative and direct retrieval processes. This result is rather unexpected and, specifically, questions at some level the effortful nature of generative retrieval. There is strong evidence in the literature that random number generation tasks recruit executive functions, as they involve, for example, suppression of habitual counting (e.g., Jahanshahi, Dirnberger, Fuller & Frith, 2000), interfere with concomitant immediate serial recall and likely with task switching (e.g. Baddeley, 1998). Overall retrieval time in generative processes might be longer as a function of the higher number of steps involved in reaching specific memories. Thus, while automatic spreading of activation is usually mentioned in the context of involuntary memories (Berntsen, 2009; Mace, 2007), it could also play a role in voluntary memory retrieval as it can reach every level of the autobiographical knowledge base (Mace, Clevinger, & Bernas, 2012).

Conversely, the visual concomitant task did significantly slow down both direct and generative episodic retrieval by approximately 2s. When considering the negative effect of the visual task on generative retrieval together with the ineffective random number generation task, at least two possible explanations can be proposed. First, the visual task might demand more cognitive resources than the random number generation task. However, we believe that the present findings are driven by a specific visual interference, in which the visual modality of the task interferes with the visual processes involved in retrieval from autobiographical memory. Visual processes are strongly involved in autobiographical memory retrieval (e.g., Rubin, 2007), and personal memories are typically very rich in visual details (Mazzoni, et al., 2014). Consistent with this, several neuroimaging studies also reported greater activation in visual areas as markers of autobiographical retrieval (e.g., left precuneus, left superior parietal lobule, and right cuneus; Addis et al. 2004; Cabeza et al., 2004; Gardini et al., 2006; Greenberg & Rubin, 2003).

In addition, the slowing down of the RTs for direct retrieval due to a concomitant visual task may be surprising given the assumed automatic and effortless nature of direct retrieval (Uzer et al., 2012; Addis et al., 2012; Uzer, 2016). We need to point out that in previous work it was suggested that direct retrieval may be largely based on visual processes, possibly even to a greater extent than generative retrieval (Addis et al., 2012; Anderson et al., 2012). Therefore, the current results of the visual concomitant task confirm the importance of visual processes in direct retrieval.

Finally, a few limitations need to be acknowledged. Firstly, although the sample size is comparable with recent studies on the same topic (Mace et al., 2021) it could be considered not sufficient to detect qualitative differences between generative and direct retrieval processes. Secondly, and related to this, possible differences related to participants' nationality could not be fully accounted for in the present study due to the low numerosity and the higher need for statistical power. Additionally, in order to test the (possible) difference in subjective effort required in directive vs. generative retrieval processes, future studies might employ other concomitant tasks, such as priming tasks or go/no-go tasks. Another relevant future direction could be related to the analysis of the semantic content of the words employed as cue, possibly through the application of distributional semantic models (Gatti, Rinaldi, Marelli, Mazzoni, & Vecchi, 2021; Günther, Rinaldi, & Marelli, 2019). Thirdly, the overall amount of directly retrieved memories is lower as compared with previous studies (e.g., Uzer et al., 2012), which reported higher levels of directly retrieved memories. However, it should be noted that the proportions found in our study fully corroborate the seminal Conway and Pledell-Pearce (2000) model proposing that direct retrieval is an alternative retrieval route, but a rather rare one. Finally, the requirements were to consider only specific memories as. Such requirement could have influenced participants' performance as previous studies on involuntary memories have shown that providing participants the need to select which memories to report could influence their reports (e.g., Barzykowski et al., 2021; Vannucci et al., 2014). In our study, however, we examined voluntary, not involuntary memories, and the decision to include such restrictive requirement was driven by the need of homogeneity of the memories, which had to be specific and not repeated to be eligible for this study. Future studies are required to replicate the present findings possibly testing participants' memory using less restrictive requirements for the retrieval reports.

In conclusion, in the present study, using a dual-task paradigm, we investigated quantitative and qualitative differences between direct and generative retrieval processes. Results indicated that the retrieval times of both direct and generative retrieval processes varied similarly according to the dual-task condition, with the direct processes being faster compared with the generative ones, thus supporting the idea that they differ only on the quantitative side.

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Appendix A

List A: (practice: cat), book, telephone, bag, shy, surprised, beach, apple, car, soccer, skirt

List B: (practice: door), dog, river, bread, bored, happy, cinema, orange, bus, swimming, jeans

List C: (practice: rose), TV, bicycle, desk, daring, frustrated, pub, garlic, plane, running, pyjamas

List D: (practice: tree), pencil, chair, radio, afraid, satisfied, restaurant, carrot, taxi, basketball, suit

List E: (practice: pigeon), window, pill, bed, sad, amused, garden, bean, motorbike, ping-pong, coat

List F: (practice: fly), picture, pizza, coffee, angry, excited, station, banana, train, skating, bikini