NTNU / BENJAMIN SCHÖNE / EXPERIMENTAL VR PSYCHOLOGY

HOW TO WRITE A SCIENTIFIC PAPER.

(and train a pet velociraptor)

Slides, exercises, demos



A ROARING START

Meet your new writing partner: Veloci the Raptor.

Veloci has read your draft. Veloci has opinions. Veloci eats vague sentences and, occasionally, reference lists.

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WHAT IS COMING

FOUR PARTS, ONE PAPER

1
THE BASICS

What a thesis is for. Sentences velociraptors hate. The essentials of paper writing.

2
THE ABSTRACT

What is in a paper, and how the abstract mirrors it. Two published examples.

3
SECTION BY SECTION

Introduction, paragraphs, methods, results, discussion, references.

4
BEFORE YOU SUBMIT

The Raptor Test, and six exercises to practise at home.

WHAT IS THE PURPOSE OF YOUR THESIS?

- You learn how to communicate concepts and data, i.e. statistical results, in a scientific way: you write a paper.
- “If you can’t explain it simply, you don’t understand it well enough.” Usually attributed to Einstein. No source exists. Check your quotes.
- Show that you have read the papers, that you have understood them and that you can tell what is relevant: show that you can think critically.
- A thesis or paper identifies a relevant(!) knowledge gap in the scientific literature and addresses it. An experiment fills this gap, or a part of it.



SENTENCES VELOCIRAPTORS HATE. VERY MUCH.

No storytelling. You write a scientific paper, not a book, not a diary entry, not a love letter, not a guide on how to train a velociraptor. A paper has no protagonist who thinks, believes or feels. Data imply, research suggests, but nobody is thinking. Do not write “I think”, “We believe” or “Interestingly”.

No empty sentences. If you write “This is important”, think twice.

WRONG

fNIRS is an important tool to measure brain activity. (No shit, Sherlock.)

RIGHT

In our study, fNIRS allows us to assess the cognitive control resources allocated to maintain action control.



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BE. SPECIFIC.

If there is a difference in behaviour, do not say that there is a difference. Say which one.

WRONG

There is a difference in reaction time.

RIGHT

People in condition A react faster.

WRONG

There is a difference in working memory between the two conditions.

RIGHT

Participants in condition A had a higher working memory load.

WRONG

Participants report different emotional states between conditions.

RIGHT

Participants in condition A were more anxious.

If you write “different”, think twice.



TO DO

- **Know the background.** Conduct a thorough literature review to see what is already out there and where your work fits in.
- **Ask a clear question.** Know exactly what you are investigating. No one wants a muddy hypothesis.
- **Analyse rigorously.** Use appropriate statistical tests and be transparent about how you crunched the numbers.
- **Discuss honestly.** Tie the results back to the hypothesis, acknowledge limitations, suggest future directions.
- **Follow the formatting rules.** Use the required style (e.g. APA) and cite sources correctly.
- **Stay organised.** Keep track of references, drafts and feedback. Your sanity (and your paper) will thank you.



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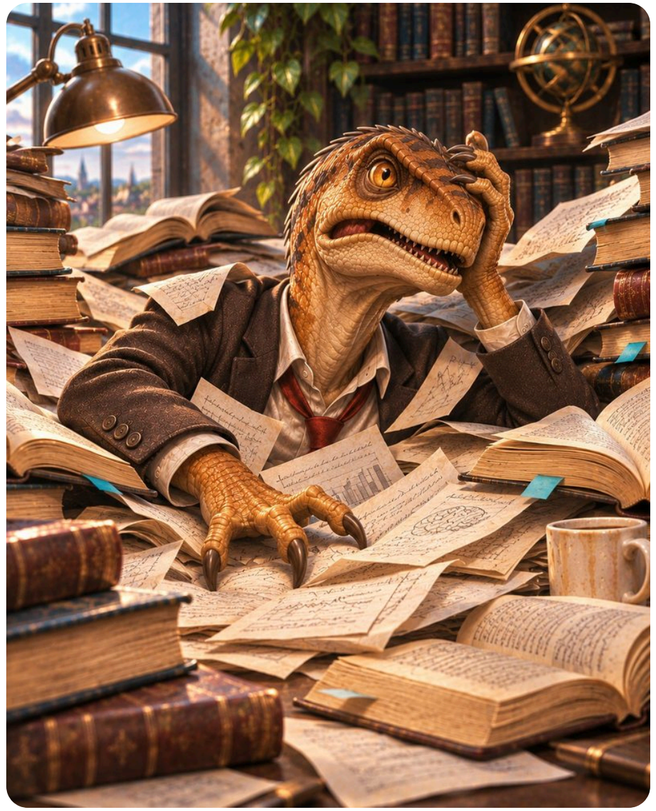
THE ESSENTIALS OF PAPER WRITING · 2/2

WRITE A SCIENTIFIC PAPER. NOTHING ELSE.

- **Use precise terms,** and use the same term for the same thing throughout. Technical terms: yes. Complicated sentences: hell no.
- **Know your audience:** people probably smarter than you. You do not need to explain the basics or repeat textbook knowledge. Maybe a little bit, sometimes. You write for your fellow scientists.
- **Communicate with purpose.** Communicate ideas and the rationale of your experiment. Identify a problem, then say how your study provides a solution. Keep it relevant.



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THE ANATOMY OF A PAPER

WHAT IS IN A PAPER?

Section	The question it answers	The rule
Abstract	What is the whole paper, in one paragraph?	Not a teaser. It gives everything away.
Introduction	Why did you do this study?	Starts wide, ends at the hypothesis.
Methods	What exactly did you do?	Complete and boring.
Results	What did you find?	No interpretation.
Discussion	What does it mean?	Starts with your finding, ends with what the reader knows now.
References	Whose work did you build on?	Every source in the text, and only those.

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THE ABSTRACT: EVERYTHING AT ONE GLANCE.

- The abstract tells the reader everything they need to know. It is not a teaser.
- It follows the structure of the paper: introduction, methods, results, discussion.
- The claims in the abstract match exactly what is in the paper. No secret revelations in the full text that the abstract does not mention, and vice versa.



THE ABSTRACT · EXAMPLE 1

ONE ABSTRACT, FOUR SECTIONS

Abstract VR-based paradigms could substantially increase the ecological validity of various psychological research topics as VR allows for submerging into real-life experiences under controlled laboratory conditions. In particular, in the field of mnemonic research, concerns have been raised that "laboratory memory" differs significantly from "real-life" autobiographical memory. Our study aimed to assess the immersive qualities of VR not only upon application but -more importantly- during the retrieval of the virtual experiences subsequent to a VR session. We presented participants with either a 360° VR or a 2D video of a motorcycle ride followed by an unannounced recognition memory task 48 h later. Increased retrieval success and delayed reaction times in the VR group indicate that immersive VR experiences become part of an extensive autobiographical associative network, whereas the conventional video experience remains an isolated episodic event.

- **Introduction (yellow, top):** VR is a good method for research. This provides relevance.
- **Introduction (blue):** The research question concerns the difference between two memory systems.
- **Introduction (pink):** A cognitive mechanism is being researched: retrieval.
- **Methods (purple):** A memory task following a VR or a 2D experience.
- **Results (dark red):** Better memory performance, slower reaction times.
- **Discussion (yellow, bottom):** Both results are interpreted by comparing the groups. Conclusion about the underlying memory structure.

Schöne, B., Wessels, M., & Gruber, T. (2019). Experiences in Virtual Reality: a Window to Autobiographical Memory. Current Psychology, 38(3), 715–719.

THE ABSTRACT · EXAMPLE 2

SAME STRUCTURE, DIFFERENT PAPER

Mindful breath awareness meditation facilitates efficiency gains in brain networks: A steady-state visually evoked potentials study

Benjamin Schöne[1], Thomas Gruber[1], Sebastian Graetz[1], Martin Bernhof[1] & Peter Malinowski[2]

The beneficial effects of mindfulness-based therapeutic interventions have stimulated a rapidly growing body of scientific research into underlying psychological processes. Resulting evidence indicates that engaging with mindfulness meditation is associated with increased performance on a range of cognitive tasks. However, the mechanisms promoting these improvements require further investigation. We studied changes in behavioural performance of 34 participants during a multiple object tracking (MOT) task that taps core cognitive processes, namely sustained selective visual attention and spatial working memory. Concurrently, we recorded the steady-state visually evoked potential (SSVEP), an EEG signal elicited by the continuously flickering moving objects, and indicator of attentional engagement. Participants were tested before and after practicing eight weeks of mindful breath awareness meditation or progressive muscle relaxation as active control condition. The meditation group improved their MOT-performance and exhibited a reduction of SSVEP amplitudes, whereas no such changes were observed in the relaxation group. Neither group changed in self-reported positive affect and mindfulness, while a marginal increase in negative affect was observed in the mindfulness group. This novel way of combining MOT and SSVEP provides the important insight that mindful breath awareness meditation may lead to refinements of attention networks, enabling more efficient use of attentional resources.

- **Introduction (yellow, top):** Meditation is used therapeutically and improves cognitive performance.
- **Introduction (blue):** The question is open: nothing precise is known about the mechanism. What leads to the improvement?
- **Methods (pink):** Two groups, MOT task, EEG-SSVEP. The mechanisms are visual attention and working memory, and the SSVEP measures them.
- **Results (dark red):** The meditation group was better in the MOT task and had a lower SSVEP amplitude.
- **Discussion (yellow, bottom):** Higher performance (MOT) with lower amplitude (SSVEP) is interpreted as more efficient attention networks.

Schöne, B., Gruber, T., Graetz, S., Bernhof, M., & Malinowski, P. (2018). Mindful breath awareness meditation facilitates efficiency gains in brain networks: A steady-state visually evoked potentials study. Scientific Reports, 8, 13687.

INTRODUCTION

- Start with the phenomenon, not with the history of mankind. Or dinosaurs.
- Only cite what the reader needs to understand your question. You read 80 papers. Nobody cares.
- Name the gap. Precisely. “Little is known about X” is not a gap, it is a shrug.
- Research question = the underlying mechanism (cognitive, emotional or neural). Hypothesis = what you measure to get at it.
- Test: cover the last paragraph. Can a colleague guess your hypothesis? If not, rewrite.

The introduction starts wide and becomes narrow. It leads to the hypothesis. Example: “Velociraptors that sleep after training remember the target better than velociraptors that are kept awake.”



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THE COMMON THREAD

Every paragraph hangs on one thread: your research question.

Germans and Norwegians call it the red thread (roter Faden, rød tråd). If a paragraph does not hang on it, cut it.



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HOW TO STRUCTURE YOUR TEXT

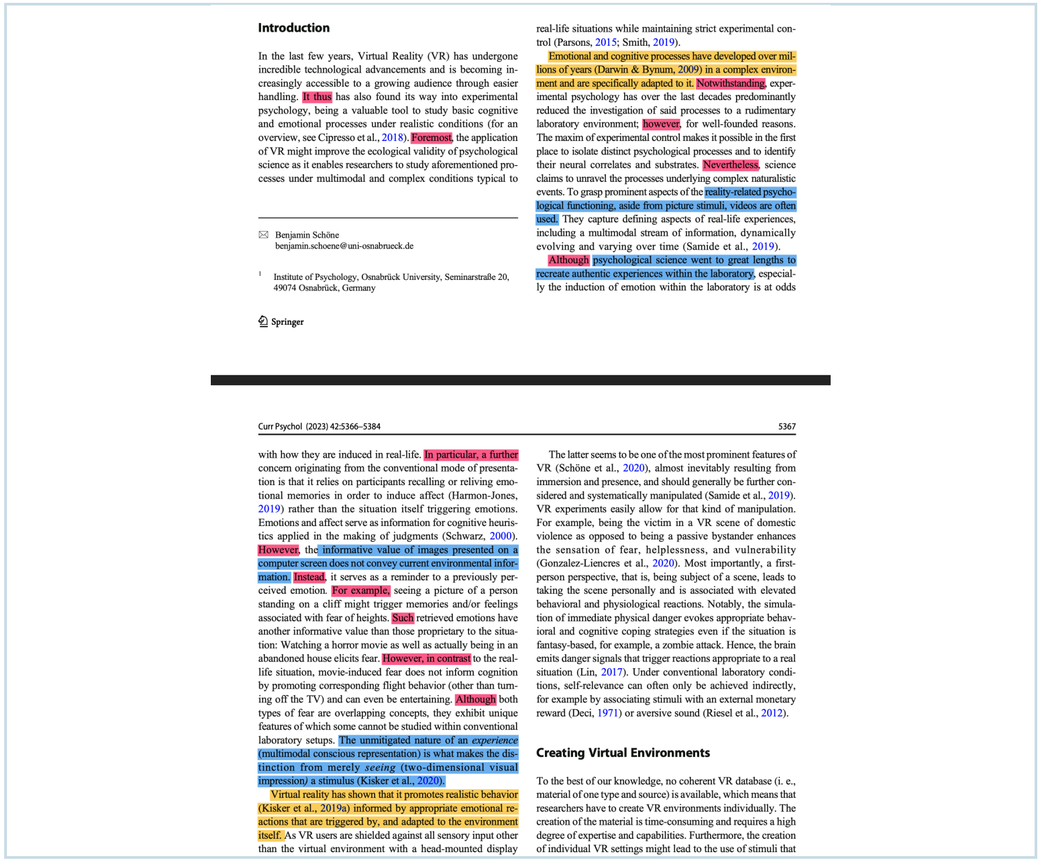
A paragraph starts with a strong and clear statement of what it is about.

- Stick to a single theme in the paragraph.
- Your job, your only job, is to communicate information (studies, data, models) so that it leads to your research question (introduction) or your conclusion (discussion).

A paragraph ends with a conclusion, a take-away or a hint at the next paragraph.

- You create flow, a common thread, by connecting ideas across paragraphs.
- Make it easy for your reader: think for them, don't make them think.

Use transitions to connect your ideas. In the example: orange marks topic sentences, blue marks conclusions, pink marks transitions.



Introduction

In the last few years, Virtual Reality (VR) has undergone incredible technological advancements and is becoming increasingly accessible to a growing audience through easier handling. It thus has also found its way into experimental psychology, being a valuable tool to study basic cognitive and emotional processes under realistic conditions (for an overview, see Cipresso et al., 2018). Foremost, the application of VR might improve the ecological validity of psychological science as it enables researchers to study aforementioned processes under multimodal and complex conditions typical to real-life situations while maintaining strict experimental control (Parsons, 2015; Smith, 2019).

Emotional and cognitive processes have developed over millions of years (Darwin & Bynum, 2009) in a complex environment and are specifically adapted to it. Notwithstanding, experimental psychology has over the last decades predominantly reduced the investigation of said processes to a rudimentary laboratory environment; however, for well-founded reasons. The maxim of experimental control makes it possible in the first place to isolate distinct psychological processes and to identify their neural correlates and substrates. Nevertheless, science claims to unravel the processes underlying complex naturalistic events. To grasp prominent aspects of the reality-related psychological functioning, aside from picture stimuli, videos are often used. They capture defining aspects of real-life experiences, including a multimodal stream of information, dynamically evolving and varying over time (Samide et al., 2019).

Although psychological science went to great lengths to recreate authentic experiences within the laboratory, especially the induction of emotion within the laboratory is at odds

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with how they are induced in real-life. In particular, a further concern originating from the conventional mode of presentation is that it relies on participants recalling or reliving emotional memories in order to induce affect (Harmon-Jones, 2019) rather than the situation itself triggering emotions. Emotions and affect serve as information for cognitive heuristics applied in the making of judgments (Schwarz, 2000). However, the informative value of images presented on a computer screen does not convey current environmental information. Instead, it serves as a reminder to a previously perceived emotion. For example, seeing a picture of a person standing on a cliff might trigger memories and/or feelings associated with fear of heights. Such retrieved emotions have another informative value than those proprietary to the situation: Watching a horror movie as well as actually being in an abandoned house elicits fear. However, in contrast to the real-life situation, movie-induced fear does not inform cognition by promoting corresponding flight behavior (other than turning off the TV) and can even be entertaining. Although both types of fear are overlapping concepts, they exhibit unique features of which some cannot be studied within conventional laboratory setups. The unmitigated nature of an *experience* (multimodal conscious representation) is what makes the distinction from merely *seeing* (two-dimensional visual impression) a stimulus (Kisker et al., 2020).

Virtual reality has shown that it promotes realistic behavior (Kisker et al., 2019a) informed by appropriate emotional reactions that are triggered by, and adapted to the environment itself. As VR users are shielded against all sensory input other than the virtual environment with a head-mounted display

The latter seems to be one of the most prominent features of VR (Schöne et al., 2020), almost inevitably resulting from immersion and presence, and should generally be further considered and systematically manipulated (Samide et al., 2019). VR experiments easily allow for that kind of manipulation. For example, being the victim in a VR scene of domestic violence as opposed to being a passive bystander enhances the sensation of fear, helplessness, and vulnerability (Gonzalez-Liencres et al., 2020). Most importantly, a first-person perspective, that is, being subject of a scene, leads to taking the scene personally and is associated with elevated behavioral and physiological reactions. Notably, the simulation of immediate physical danger evokes appropriate behavioral and cognitive coping strategies even if the situation is fantasy-based, for example, a zombie attack. Hence, the brain emits danger signals that trigger reactions appropriate to a real situation (Lin, 2017). Under conventional laboratory conditions, self-relevance can often only be achieved indirectly, for example by associating stimuli with an external monetary reward (Deci, 1971) or aversive sound (Riesel et al., 2012).

Creating Virtual Environments

To the best of our knowledge, no coherent VR database (i. e., material of one type and source) is available, which means that researchers have to create VR environments individually. The creation of the material is time-consuming and requires a high degree of expertise and capabilities. Furthermore, the creation of individual VR settings might lead to the use of stimuli that

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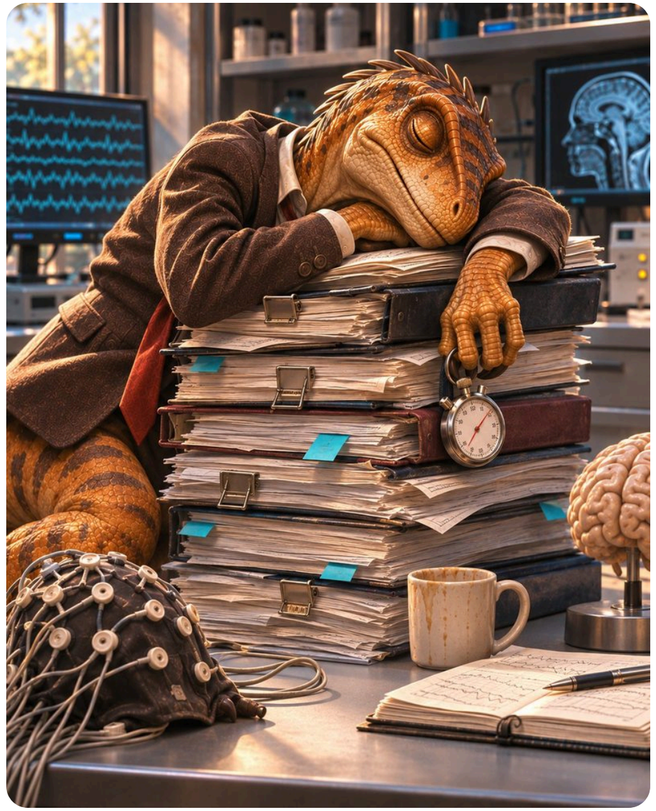
METHODS: BE BORING.

- Methods should be boring. Like, really boring.
- It is an information dump that provides everything needed to replicate the experiment to the millisecond.
- It needs to be complete, not beautiful.
- Test: could a stranger rerun your study with nothing but this section?



RESULTS: NO INTERPRETATION.

- Provide complete and adequate statistics, in a logical order and in a readable format.
- Use subheadings if you have several analyses, e.g. “Behavioural results” and “Neural correlates”.

WRONG

The raptors slept well and therefore consolidated the target.

RIGHT

Raptors in the sleep group selected the target more often than raptors in the wake group.

What it means comes later, in the discussion.

Results Study 2

Presence

As expected, the VR condition elicited a stronger sensation of feeling present in the virtual environment as compared to the PC condition, reflected in all IPQ scales (general presence: $U = 240.50$, $z = -3.17$, $p = .001$, $r = 0.41$; spatial presence: $U = 205.00$, $z = -3.63$, $p < .001$, $r = 0.47$; involvement: $U = 213.00$, $z = -3.51$, $p < .001$, $r = 0.45$; realness: $U = 335.00$, $z = -1.71$, $p = .044$, $r = 0.22$). Cronbach’s α indicates acceptable to good reliability for all scales (all $\alpha > 0.73$; *see* Table 4).

Memory Performance

Participants of the VR condition freely recalled 55.6% of the scenes and hence, ca. 6% more as compared to the PC condition, who remembered approximately 49% ($t(58) = 1.98$, $p = .026$, $d = 0.50$, $M_{VR} = 0.556$, $M_{PC} = 0.491$; see Fig. 6). However, the performance of the groups did not

A real results section: statistics in a clear order, no interpretation.



DISCUSSION 1/2

- First sentence: what you wanted to know. Second sentence: what you found. No warm-up.
- One finding, one paragraph. Say what it means for the mechanism, not that it is “interesting”.
- No statistics here. The reader has seen the test values.
- Then the literature: who found the same? Who did not? Why might that be?

WRONG

The effect was significant, which is a robust learning effect.

RIGHT

Recall was higher after sleep than after wakefulness. This suggests that the raptors consolidated the target during sleep.



individual videos. Descriptively, the recall rate was higher in the VR group for 17 of the videos and equal in both groups for seven videos.

Discussion Study 2

The aim of study No. 2 was to replicate the memory superiority effect of VR experiences and shed new light on previously inconsistent results (Kisker et al., 2019b; Krokos et al., 2019; Schöne et al., 2019; Smith, 2019). As expected, the participants in the VR condition reported a higher sense of presence, which presumably is the most important factor underlying the also obtained VR memory superiority effect for the free recall (see Sauzéon et al., 2012). Both effects are important markings towards a broader application of VR tools in experimental psychology. The rapid mode of serial video presentation aligned with conventional paradigms yielded the same effects as previous VR studies investigating mnemonic mechanisms in a single environment. This is remarkable as the mode of presentation in this study might have a diminishing effect on the factors constituting the unique VR experience: The timed changes of place participants underwent is inconsistent with the laws of physics and make the user repeatedly aware that they are just in a VR simulation.

The cued recall did not yield significant results, meaning that no group exhibited a higher recall rate for scenic details. However, an effect could have been expected. Specifically, the feeling of being present in the scene might facilitate the

Table 4 Descriptive statistics and reliability of the IPQ presence scales for both groups

	M_{VR}	SD_{VR}	M_{PC}	SD_{PC}	Cronbach's α
General Presence	0.90	1.47	−0.53	1.70	–
Spatial Presence	3.40	4.77	−2.77	6.47	.747
Involvement	2.80	5.47	−2.53	5.28	.830
Realness	−0.73	3.46	−2.33	4.33	.737

DISCUSSION 2/2

- Not every result is equally important. Decide which one is, and say so.
- Limitations: only those that change the interpretation. “The sample was small” is not a limitation unless you say what it does to your conclusion. One study is no study.
- Future research: one concrete next experiment, not “more research is needed”.
- Last paragraph: what does the reader know now that they did not know before? Do not “pave the way”. Raptors eat people who pave the way.

Conclusion

Virtual reality could be a valuable extension for the toolbox of experimental psychology. Two experiments have provided evidence that cognitive-affective psychological science might benefit from the use of VR paradigms. Study No. 1 showed that presence and especially three-dimensionality fundamentally alter motivational processing and the perceived valence of stimulus. The driving factors underlying these effects have yet to be determined. However, study No. 1 provides first evidences that when presenting the same material under realistic as opposed to two-dimensional conditions the brain exhibits different functional properties. Study No. 2 replicated the memory superiority of virtual reality over on-screen presentation under the aggravated conditions of a fast-paced, everchanging stimulus set. This rather conventional mode of presentation has proven to be capable to facilitate the formation of autobiographical memories (e. g. Schöne et al., 2019; Kisker et al., 2020). Virtual experiences with material from the luVRe database thus are processed with the same mnemonic mechanisms as real-life experiences making the case for their realness and their feasibility for VR based research and aiming at reproducing real-life scenarios. A field of research, which could benefit from luVRe is research on autobiographical memory. Especially immersive media seem to aid free recall (Ernstsen et al., 2019; Harman et al., 2017; Ventura et al., 2019) as it is the mode of retrieval of autobiographical memory and commonly used for research on unique, lifelike events (Oedekoven et al., 2017).

Concludingly, VR combines the best of two worlds: Firstly, the enhanced realism of immersive simulations facilitates more naturalistic processing. As the brain has evolved under three-dimensional conditions throughout its



REFERENCES: WHERE MANY TEARS ARE SHED.

- Follow the required style (e.g. APA) to the letter.
- Every claim that is not yours needs a source.
- Every source in the text is in the reference list, and the other way round.
- Cite what you have read, not what somebody else says the paper says.
- Pro tip: keep an eye on your reference list. “References eaten by raptor” will not win you any sympathy when you are graded.



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BEFORE YOU SUBMIT

THE RAPTOR TEST

- The abstract gives everything away.
- No “different” and no “important” without content.
- Every paragraph starts with a topic sentence.
- The reader can guess the hypothesis before you state it.
- The methods are boring.
- The results contain no interpretation.
- Every source in the text is in the reference list.



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PRACTISE AT HOME

RAPTOR SCHOOL

Six exercises. A few minutes each. No paper of your own required.

- Fix the sentence
- Sort the abstract
- Result or interpretation?
- Raptor bait
- Which sentence does not belong?
- Build the funnel

syncorelab.github.io/syncorelab-web/teaching/raptor-school.html



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READ THE ORIGINALS

PAPERS USED IN THESE SLIDES

Abstract, example 1. Schöne, B., Wessels, M., & Gruber, T. (2019). Experiences in Virtual Reality: a Window to Autobiographical Memory. Current Psychology, 38(3), 715–719.

doi.org/10.1007/s12144-017-9648-y

Abstract, example 2. Schöne, B., Gruber, T., Graetz, S., Bernhof, M., & Malinowski, P. (2018). Mindful breath awareness meditation facilitates efficiency gains in brain networks: A steady-state visually evoked potentials study. Scientific Reports, 8, 13687.

doi.org/10.1038/s41598-018-32046-5

Structure, results and discussion. Schöne, B., Kisker, J., Sylvester, R. S., Radtke, E. L., & Gruber, T. (2023). Library for universal virtual reality experiments (luVRe): A standardized immersive 3D/360° picture and video database for VR based research. Current Psychology, 42(7), 5366–5384.

doi.org/10.1007/s12144-021-01841-1