Flow in the Workspace

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Abstract

Documenting is a job that people typically do not find entertaining which causes people to postpone or neglect documentation. Flowtyper is a tool that incorporates the design for flow to make writing more enjoyable and hopefully solve this problem. Csikszentmihalyi first coined the term flow in 1975 which he describes as an autotelic experience. Auditory feedback is used to make a flow inducing writing tool which was tested on 20 participants. Participants were asked to write for 15 minutes behind their own computer twice. Once with Flowtyper enabled and once without. Afterwards they were asked to participate in a survey about their experience using the software. They were also asked to send in their written material to check for spelling errors and participated in a small semi-structured interview about their experience. Afterwards, their experience was measured by use of the flow state scale (FSS) and Self-Assessment Manikin (SAM), Their writing fluency was measured as a metric of productivity.

The participants were split on their writing content (creative or non-creative), their change in valence between the silence and Flowtyper conditions and their change in writing fluency between the same conditions

Participants who chose to write creatively were more fluent than those who wrote non-creatively. The effects of Flowtyper were more noticeable with non-creative writers.

The flow metrics influenced by Flowytper were action & awareness merging, concentration, feeling of total control, transformation of time and the autotelic experience.

These metrics increased for people with high valence towards Flowtyper (Group VF) and decreased in participants with low valence towards Flowtyper (Group VNF). Writing fluency decreased for Group VNF and did not change for Group VF.

The group with increased fluency in the Flowtyper condition (group PF) had lower flow-scores overall than the group with increased fluency in the silent condition (group PNF), indicating that group PF might be understimulated in the silent condition. This group noticed that they found it easier to concentrate on the task at hand because they noticed less external distractions.

Flowtyper increases concentration in people who are more easily distracted by the environment and gives them the necessary stimulus to block out said environment. Those who already can focus on their own accord find it more difficult to concentrate as it introduces another distractor besides standard environmental noise, overwhelming them.

Notable is that group PF is a subset of group VF. Enjoying working with Flowtyper does therfore not warrant an increase in writing fluency. The opposite is more likely true: If someone does not like working with Flowtyper, they will most probably will not benefit in terms of fluency as well.

Contents

Chapter 1

Acknowledgements

During the writing of this thesis, I was never truly alone. Many have helped me to make this thesis to what you read before you now. For that, I would like to thank the following people:
First of all, I want to thank my supervisors Dirk, Jan and Geke. Each feedback session resulted in many re-hauls of this thesis, which eventually sculpted and refined the ideas presented here.
But mostly, I want to thank my parents. My dad, for technical reviewing of each version and his insight to what the reader would like to know. Thanks to him, this thesis is also readable for lay-men. My mother's support was of a different level. Helping setting deadlines and meeting those deadlines. Together, they formed quality control in a timely fashion.
At the start of this thesis, I had a brainstorm session to find a solution to make typing a better experience. This brainstorm was the foundation of everything written here. The participation of Laura, Manouk and Margot is not forgotten. The link from Tetris to typing was made here for the first time. Without their help, Flowtyper would have gotten a completely different form.
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Chapter 2

Introduction

Writing is an important aspect in most lines of work as it can give other people insight in what one has done and why. Important as it is, most people find it a boring or tedious task. Usually the actual task is found to be more entertaining than documenting it. As such, documents do not always contain all the necessary information or are missing altogether.

If we could make the process of typing more engaging, it could make the task of documenting more enjoyable. Hopefully, this could improve everyday working conditions by making work more intrinsically rewarding.

In 1975, Csikszentmihalyi developed a model called the flow model. One of the goals of this model was to make it easier to build intrinsic reward systems in everyday life such as making work more rewarding without taking a paycheck of any kind into account. He therefore examined what makes an activity enjoyable. The work he published in 1975 became the start of flow theory.

Since then, the flow state has often been associated with productivity. Teams that enter flow regularly are more productive than teams that do not. Does a single flow experience cause higher productivity however or are multiple flow experiences beneficial to overall happiness and thus productivity?

In this thesis, flow theory is examined to create a better working environment for documentation in a short term session. By inducing a flow state in single occasions more regularly, one might start to write by their own accord instead of forcing themselves to do it.

As a means to that end, the following research question with subsequent subquestions are proposed:

Main Research Question: *Can an induced flow state improve the enjoyment of typing?*

- Subquestion 1:
  Can the flow-state be induced through auditory feedback in the context of typing?
- Subquestion 2:
  How does the flow-state affect short term productivity in the context of typing?
- Subquestion 3:
  How does the flow-state affect user's experience of typing?

The structure of this thesis is as follows: First, The context is examined from which we will answer subquestion 1. Eventually, the resulting application will be evaluated by subquestions 2 and 3. Lastly, the main research question can be answered via the answers from all subquestions.

For a schematic overview of this thesis, please refer to figure 2.1 below.

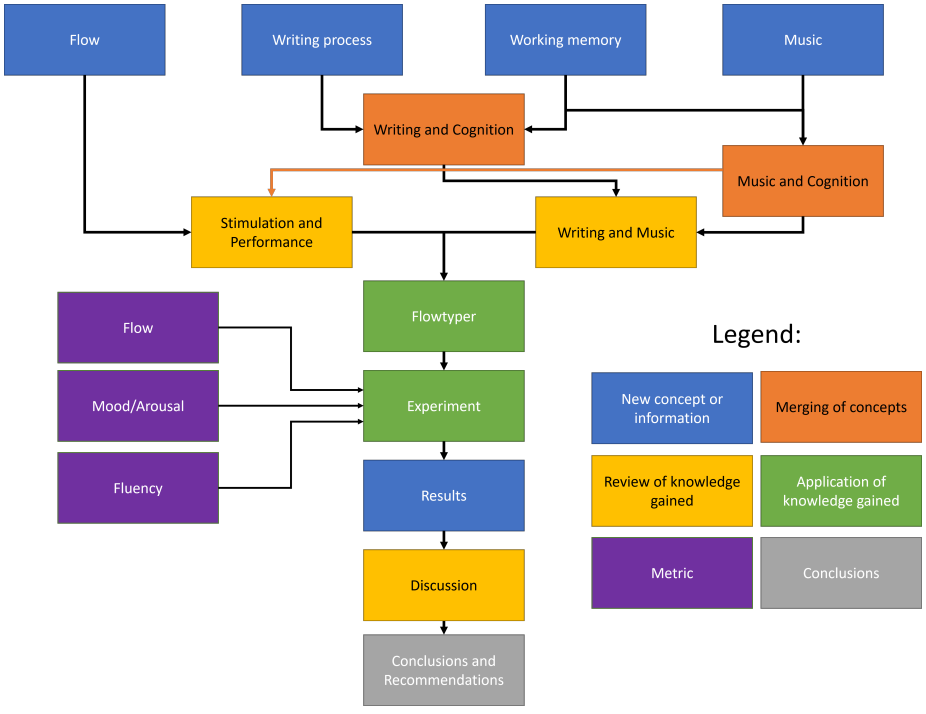


Figure 2.1: Overview of this thesis and how topics interlink.

Chapter 3

Context

In this chapter, the starting principles will be explained by which the rest of the thesis should be read. First, flow will be explained along with its current state in research. Then, the process of writing will be outlined as it is important for the reader to understand the writing process for which we will design Flowtyper.

3.1 Flow

Flow is a state in which an individual is completely immersed in an activity without reflective self-consciousness but with a deep sense of control (Engeser, 2012). In the flow state, the individual works deeply motivated on a specific task and is not easily distracted. As such, flow is often associated with a sense of high productivity. Flow is characterized by the following components according to Csikszentmihalyi (1975):

- Merging of action and awareness: A person is aware of what they are doing but not of the awareness itself.
- Centering of attention on a limited stimulus field: They experience a high degree of concentration
- Loss of self-consciousness: considerations about oneself become irrelevant.
- Feeling of control over one's action and the feeling of control over the demands of the environment.
- Coherent, noncontradictory demands: goals and means of achieving them are logically ordered and actions and reactions are automatic.
- Autotelic nature: no need for external goals of rewards.
- The sense of duration of time is altered.[1]

[1] this last point was later added in 1990 (Csikszentmihalyi, 1990)

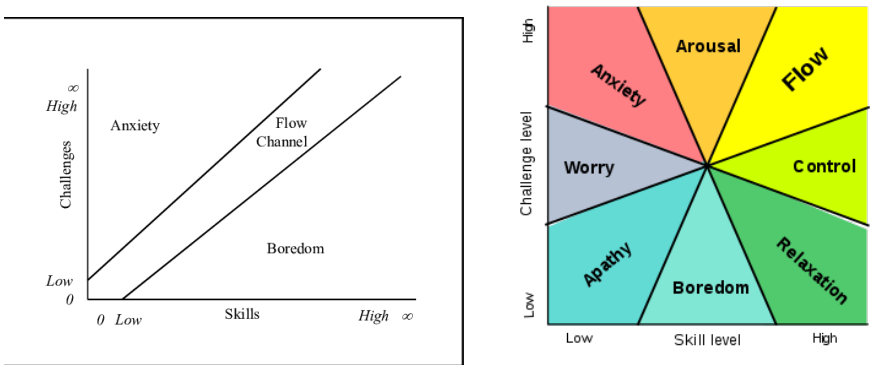
Flow is mostly described by its autotelic nature, because the activity is rewarding in itself and they feel a strong sense of control. The person doing an activity will find themselves highly engaged in said activity (e.g., a hockey player will find that when in flow, they have a strong sense of puck control and controlling the puck will have an autotelic nature). Flow is therefore an experience that can only be experienced by doing an activity.

It is important to note that flow is a multifacetted experience. For example, 'Centering of attention on a limited stimulus field' can also be described as an characteristic for anxiety (Eysenck, Derakshan, Santos, & Calvo, 2007), which is usually described as a negative experience where flow is mainly considered a positive experience.

Moreover, the autotelic nature does not mean that there cannot be an external goal or reward. Someone could still be assigned an assignment but reach a sensation of flow during the execution of said assignment. In sports, the external reward of winning also does not mean that a competitive sporter cannot reach flow.

3.1.1 The flowchannel

Flow is highly dependent on the perceived skill of the individual and the perceived challenge of the exercise. This balance between skill and challenge is called the flowchannel and was visualized by Csikszentmihalyi (1975) in figure 3.1a. It is important to note that the perceived skill and challenge is in balance to reach flow. If someone could easily do a certain task but believes they are unskilled, they will not reach flow. Similarly, someone who perceives a challenge to be at their skill level (while they are not skilled enough) will either notice this during execution (shifting their perceived skill) or reach flow without noticing their mistakes.



(a) the orignal flowchannel

(b) The experience fluctuation model (EFM)

Figure 3.1: model of the flow state as described by Csikszentmihalyi in 1975, when a person believes his action opportunities to be too demanding for their capabilities, the resulting stress is experienced as anxiety. When skills are greater than than the challenges, the resulting experience state is boredom. Between these states is a so called flow-channel, where the challenge and skill level is balance. In this channel, the flow state can emerge.

Later, The flowchannel was expanded by including other states in this balance of challenge and skill (Csikszentmihalyi, 1997). This is called the experience fluctuation model and is more informative than the flowchannel as it describes the broader spectrum in which flow occurs. In essence, it is an zoomed-out mapping of the flowchannel (see figure 3.1b).

One type of media that excels at creating flow is games. A game as simple as Tetris can already become addictive because the balance between perceived challenge and skill is slowly increased. The skill-level needed constantly increases over time to accommodate for the learning curve. Most games are designed with flow in mind (Sweetser & Wyeth, 2005)(Chen, 2007)(Cruz & Uresti, 2017) as it makes playing the game more enjoyable. As such, there is much research within the field of flow in games. In games, flow is often described along with presence and interchangeably described with immersion. The main difference however, is the autotelic nature of flow and its relation to the action itself, whereas immersion has a more phenomenological connection to the emotional level of the experience (Lammers, 2021).

3.1.2 Limitations of flow

There are some limitations of flow. As stated earlier, flow is an experience of perception, rather than perfomance. As such, flow does not necessarily increase the efficiency of the task at hand (Schüler & Brunner, 2009). In a marathon race flow was less effective than pushing oneself to run faster. It was however more associated with higher training motivation rather than performance.

Flow is sometimes associated with studying or productivity in general. However, this assumption might be false (Schüler, 2007). While one can find examples online that flow increases productivity by 5 times as much. Most of these online articles point to the same source such as (Cranston & Keller, 2013), these are often self-report studies which are subjective at best. Robust research towards flow and productivity has either not been conducted or is difficult to find. However, reaching flow regularly has been correlated with increased happiness (Csikszentmihalyi & Wong, 2014) and happiness is correlated to productivity (Bellet, Neve, & Ward, 2019). This suggests a link to flow and productivity in the long term. It is not expected that productivity is increased during the flow-experience.

While flow does provide incentives for developing skills and personal growth, there already needs to be a certain level of skill within the individual. Flow cannot arise within a task that is new to the individual or in which the individual is completely unskilled. This might also apply for people who dislike writing as they may have avoided the activity, making them unskilled in the process.

3.2 Writing, Thinking and Typing

What actually constitutes writing? The writing process is defined by 3 steps:

- Plan
- Generate/Translate
- Review

These three steps are made recursively throughout the writing process. First, the writer plans a certain structure of what they need to say and how they will write it down. Then, there is a phase where thoughts are translated into written text. Some literature calls this process translation (Flower & Hayes, 1981) whereas others call it text generation (McCutchen, 1996). In this thesis, they are used interchangeably. The third step in the writing process is the review stage. In this stage, the currently written text is reviewed. This reviewing phase is where the main difference lies between poor writers and expert ones. Most poor writers often seem to get stuck on reviewing a sentence level instead of on a holistic level(Hayes & Flower, 1986). Where expert writers focus more on the story that they want to tell (macro level), poor writers seem to get stuck on individual sentences and segments (micro level). Expert writers master the micro level sufficiently, making it a second nature to them. In the meantime, poor writers seem to get stuck on sentences. As such, they can't see the forest for its trees. There seems to be some kind of hurdle to be overcome. On the one hand, the environment demands of writers that they can make a coherent story, but at the same time, poor writer are only skilled enough to perfect individual sentences. Writing a full report or other document seems to be too high of a challenge for poor writers. Knocking them out of their flow channel, if they ever get in said channel. The result is that they increase their challenge level very

slowly, if at all. There are no shortcuts for getting better at something without putting in time and effort. Writing is no exception in this. That being said, focusing on other parts of the task can help in gaining new perspectives. If poor writers could zoom out of the micro level of their text. They might be able to be trained in the macro levels of writing, which could improve their writing skills in the long run.

Writing Fluency

Writing fluency is defined as writing accuracy and speed (Johnson & Street, 2004). However, there is no current standard to find writing fluency. Some use the total words written (TWW), others take the amount of sentences over a specific amount of time (Nguyen, 2015). It is also possible to incorporate the amount of deletions into the fluency calculation (Waes & Leijten, 2015) or look at the amount of pauses during the writing process (Lindgren, Miller, & Sullivan, 2008). As there is no real consensus on how to calculate writing fluency, we will try to use these methods to create our own metric which uses the data available and gives us the most useful information in a single number. We will have the following metrics available to us.

- The total words written (TWW)
- The amount of words spelled correctly (WSC)
- The amount of time used to write (15 minutes).
- The average TWW of all participants over both tests (TWWa)

As our speed can be measured by dividing the TWW over 15 minutes. The accuracy is the WSC divided over the TWW. Because of the nature of the speed and accuracy metrics, both division and multiplication result in a metric that either rewards low accuracy or speed (division), or does not take the total amount of words written into account (multiplication).

Instead, we will use the relative speed of an individual weighted to their accuracy as our calculation of fluency. While this method gives no insight in the writing fluency of an individual, it does show whether they are more fluent than the rest of the sample. A fluency of 1 means writing the exact number of words correctly as the average participant writes in terms of TWW.

$$Speed\,(words\ per\ minute) = \frac{TWW}{15} \tag{3.1}$$

$$Accuracy = \frac{WSC}{TWW} \tag{3.2}$$

$$Relative\ speed = \frac{\frac{TWW}{15}}{\frac{TWWa}{15}} = \frac{TWW}{TWWa} \tag{3.3}$$

$$Relative fluency = Relative\ Speed \bullet Accuracy = \frac{TWW}{TWWa} \bullet \frac{WSC}{TWW} = \frac{WSC}{TWWa} \tag{3.4}$$

This metric is then used to analyse how Flowtyper will influence the writers fluency. It is expected that the speed will increase but that accuracy will decrease. Which might mean that the writing fluency stays roughly the same.

3.3 Working memory

Working memory (WM) is a term to describe the ability to store and process information briefly in the brain. Baddeley and Hitch (1974) developed the multicomponent model of working memory. In this model, WM consists of several parts. See figure 3.2

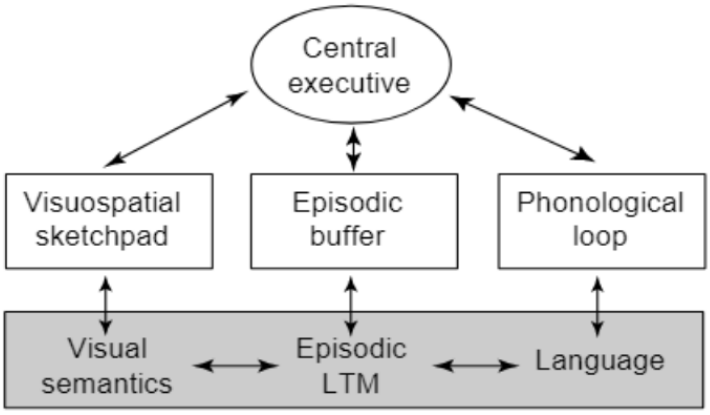


Figure 3.2: Overview of working memory according to Baddeley's revised model.

Central executive

This part of WM divides attention and filters out irrelevant information. The central executive also divides tasks to the other parts of the system

Phonological loop

This part of working memory processes sound and language. Sound processing is done by the phonological store (inner ear) and linguistic patterns are processed by the articulatory control system (inner voice). When writing is concerned, the articulatory control system is used to form sentences from thoughts. Whereas the phonological store is more sound related and has more relation to listening (e.g. sounds, sentences, words, syllables). Music containing voices requires more working memory capacity because of the phonological decoding necessary.

Visuo-spatial sketchpad

This can be described as the inner eye and manages visual and spatial information. The visuo-spatial sketchpad is used during the planning of larger texts.

Episodic buffer

This part was later added into the model and processes memories to be stored in long-term memory.

Working memory is used in the following parts of the writing process:

	Working Memory Resource		
Basic process	Visuo-spatial sketchpad	Central executive	Phonological loop
Planning	X	X	
Translating		X	X
Programming		X	
Executing			
Reading		X	X
Editing		X	

Table 3.1: Table overview of working memory resources using during each phase of the writing process as described by Kellogg (2013). The reviewing phase is split into two subparts here: reading and editing. In order to physically make the text appear (the movements needed for the hands), programming and execution of motor functions are also included in this table.

3.4 Stimulation

When designing for flow, one has to take stimulus into account as a means of providing feedback. The amount of stimulus required is person dependent however. Some might be overwhelmed by relatively few stimuli, whereas others are understimulated under normal conditions and become more easily distracted as the current task appears unengaging to them. As such, a closer review is needed. Specifically, we need to understand the relation between writing and working memory, the effects music has on working memory, and why there are individual differences in these effects. Furthermore, we need to understand whether Flowtyper actually helps people to start writing in the future.

The stimulus threshold for each person to function properly is variable (Helps, Bamford, Sonuga-Barke, & Söderlund, 2014). This makes designing a one-size-fits-all solution problematic. However, people whom are normally stimulated well enough to work properly will probably not benefit as much from added feedback. See figure 3.3.

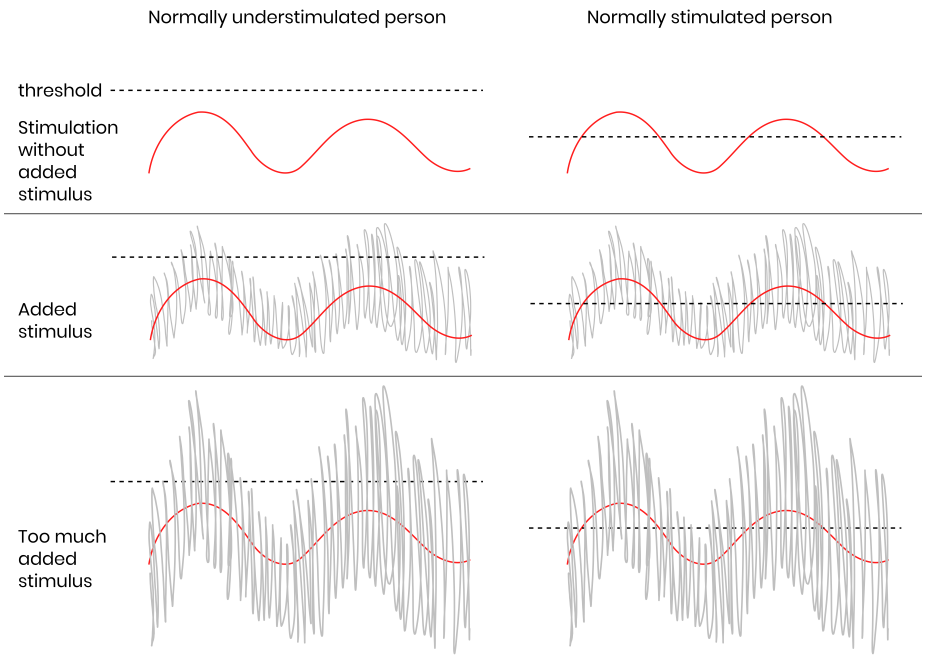


Figure 3.3: Differences in stimulation from person to person. Some people may be understimulated under normal conditions (never reaching the threshold) and may require additional stimuli to function normally (visualized here as noise), whereas others may be overstimulated in the same conditions, which put them under stress.

Not only is the amount of feedback important, the type of feedback also requires some thought. To select the correct type of feedback, we need to examine the context in which someone is likely to write.

Usually writing happens at a desk (either at home or at an office) where external noise (either auditory or visual) is likely to be present. Using haptic feedback requires additional hardware that a company is unlikely to provide. Visual feedback is difficult to animate and requires special software for the user to write in (Lammers, 2021). In contrast, auditory feedback can run in the background and does not require additional hardware that is not already standard equipment. A practical approach was chosen to include auditory feedback.

3.5 Music theory

To make a system that provides auditory feedback smoothly. It is useful to know how music generally behaves if we want to make adaptive music as stimulus.

3.5.1 Beats, bars and phrases

Most western music is divided into beats bars and phrases.

- A beat is a basic unit of time within a song (Berry, 1976). It is usually the guiding rhythm of a song and is the unit that musicians use to count.
- A bar is usually a group of 4 beats and is used for cue points in music.
- A phrase is a unique segment of music and is usually a group of 8 bars or a multiple of that. Phrases are usually marked as the moment instruments are added or removed from the composition.

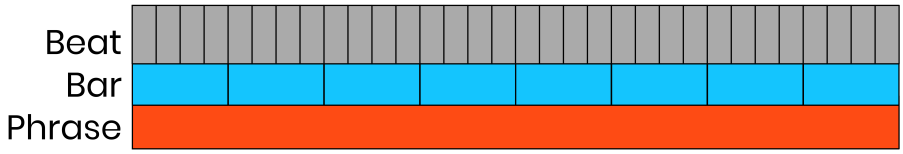


Figure 3.4: 32 Beats in 8 bars in 1 phrase.

In mixing music, bars and phrases are important as they are points that make mixing of music easier. Mixing music at the start or end of a phrase makes it easier to have a seamless transition whereas bars can often be put in a loop (as long as there are no overarching elements in the phrase). When the bar has finished looping the number of bars a phrase has, a new phrase can be introduced. If a song is subdivided into phrases, one can seamlessly mix phrases into one another and could make responsive music.

3.5.2 Music, stimulation and working memory

Is music effective in stimulating a person or does music distract? Current research is split on the matter.

Husain, Thompson, and Schellenberg (2002) let participants perform folding puzzles after listening to music at a different tempo and mode (major/minor). They found that music does not impact cognitive abilities directly. Instead, music impacts one's mood and arousal, which in turn impacts studying ability.

Lehmann and Seufert (2017) suggests that music has a negative impact on study for people with low-working memory as it impairs learning ability. They performed reading recall tests with background music, the higher ones working memory, the lower the negative impact music had on a subject. While this confirms the seductive detail effect[2], it contradicts the mood-arousal theory when looking beyond the scope of neurotypical behavior. For example, people

[2]Seductive details are interesting, but irrelevant information to reach a certain goal. It is assumed that this effect happens during overloading of working memory. People with low-working memory are therefore more prone to the seductive detail effect.

with ADHD are often understimulated and should benefit from stimulus during study (Helps et al., 2014). However, as ADHD is sometimes described as a working memory deficit disorder, the seductive detail effect would apply as well.

Kämpfe, Sedlmeier, and Renkewitz (2011) did a meta-analysis and could not find a pattern in music and cognitive performance. On one hand, they mention that background music could distract from the main task, decreasing performance. On the other hand, they mention the beneficial effects of increased arousal that Husain et al. (2002) describes.

Overall, it seems that current theories are incomplete to accurately make predictions as to how auditory stimulation impacts a person. While working memory plays a role, it is unclear whether a high working memory capacity makes someone less prone to distraction or low working memory capacity makes a person understimulated under normal conditions and stimulation helps them in maintaining focus.

3.6 General conclusions and Functional Specifications

From the context, we have found that there are 5 concepts worth noting. First, it is important to have a certain balance between perceived challenge and skill and can be measured by looking for its characteristics such as an autotelic experience. Second, writing is a complex task consisting of planning, translating and reviewing phases. Third, these phases all require working memory. While all phases require the central executive, planning also uses the visual-spatial sketchpad, whereas translating and reviewing both require the phonological loop. Fourth, for people who find writing understimulating, it is expected that providing additional feedback can help them focus on the writing task, although this same stimulus can also distract normally stimulated individuals. Fifth, using music as a method of providing feedback requires the use of musical phrases for the song to seamlessly blend into itself.

It is important to note that Flowtyper should not only use direct feedback when typing as this does not stimulate the planning and reviewing phase. However, it is difficult to assess in which writing phase someone is based on keyboard input alone.

From the context, specifications for the Flowtyper can be distilled.

- Immediate feedback is needed to provide stimulus, it should however not overstimulate.
- Constant feedback is required to stimulate the brain outside of the translation phase. Only giving feedback while typing is not enough.
- As flow is a balance between challenge and skill, certain feedback must be harder to achieve when writing speed is high, and easier when typing speed is low.

Most types of feedback can assist in inducing flow state. In the context of typing, auditory feedback shows most promise as it can be implemented without the use of a device that is normally not included in computing systems.

From these functional specifications. We will discuss the design of the application, Flowtyper, in the next chapter.

Chapter 4

Designing Flowtyper

This chapter will outline how Flowtyper was made and why design choices were made. Gathering the conclusions from the theory, this chapter will focus on Flowtyper's design. We will outline different inspiration sources, music theory and revisit the flow model to find a balance between thinking and typing in the writing process. From here, Flowtyper will be explained and expectations about the effects of Flowtyper will be set.

The song that is used for Flowtyper is Lunar Discourse by Hydelic. The reason for this specific song is that it is made for the game Tetris Effect. This game (not to be confused with its similarly named phenomenon or its predecessor Tetris) adds animations and soundscapes to the base game of Tetris in order to get people in the flow. Because Lunar Discourse is already made for a game that induces flow, it is easier to make responsive and has already shown that it can produce flow in certain contexts. The reason that this song is chosen over other songs in the album is that Lunar Discourse has less energy and that would be more fitting in the context of writing. It also is unvoiced which is an upside in the case of writing. As voiced songs can make people lose concentration when reading and writing as it also uses the phonological loop of working memory (Kellogg, Whiteford, Turner, Cahill, & Mertens, 2013).

4.1 Balancing writing and thinking

Flowtyper operates on the microlevel of writing and has room for the planning phase in terms of lower energetic music at points where no writing occurs. It is assumed that at these points, the current text is being reviewed and the next segment of text is being planned. However, the music should not stop as it keeps the writer engaged in the writing process. During text generation, higher typing speeds are a measuring device for the speed of the translation of thought. These are rewarded by more energetic music which should give the writer a sense of achievement.

Often, writers go back through their text to reexamine the top-level goal

and review the currently written text (Flower & Hayes, 1981). From there new inferences can be drawn and its concepts consolidated. Expert writers tend to return to that top-level goal more often. First, there needs to be text to be re-examined. When poor writers examine the micro-level, they often inadvertently introduce errors because of misconceptions about grammar (Ferrari, Bouffard, & Rainville, 1998). A side effect of Flowtyper might therefore be that poor writers will review longer pieces of text and focus less on the micro level as they will try to maximize their reviewing output.

Flow model

The flow model states that there should be a balance between experiencing boredom and stress to achieve flow. It also states that the balance between perceived challenge and skill should be maintained. Flowtyper should therefore try to nudge the user to improve their current typing ability in order for flow to occur. In order to maintain the medium activation, the user should continuously try to improve their average typing speed. However, if the speed needed proves to be unattainable, Flowtyper should respond to this by making it easier to reach more energetic phrases. The exact rules can be found in section 4.2.

4.2 Flowtyper

When the user is typing, Flowtyper records the number of keystrokes of the last four seconds and calculates the typing speed per second, it then divides that speed over the average of the last four cycles. If the speed is 30% higher than the average speed, Flowtyper will randomly select one of the most energetic phrases (humanly curated). If the current typing speed is the average speed or lower, Flowtyper will randomly select one of the least energetic phrases. If the typing speed is zero, Flowtyper will not include this cycle into the average speed. In any other case, a random phrase of medium activity will be selected.

For an overview of the rules that Flowtyper uses for its selection of phrases see equation 4.1 to 4.4

$$\frac{\text{Typing speed}}{\text{average speed}} > 1.3 \rightarrow \text{select most energetic phrase.} \tag{4.1}$$

$$\frac{\text{Typing speed}}{\text{average speed}} \leq 1 \rightarrow \text{select least energetic phrase.} \tag{4.2}$$

$$\text{Typing speed} = 0 \rightarrow \text{select least energetic phrase and do not add this cycle to the average.} \tag{4.3}$$

$$\text{Any other case} \rightarrow \text{select medium energetic phrase.} \tag{4.4}$$

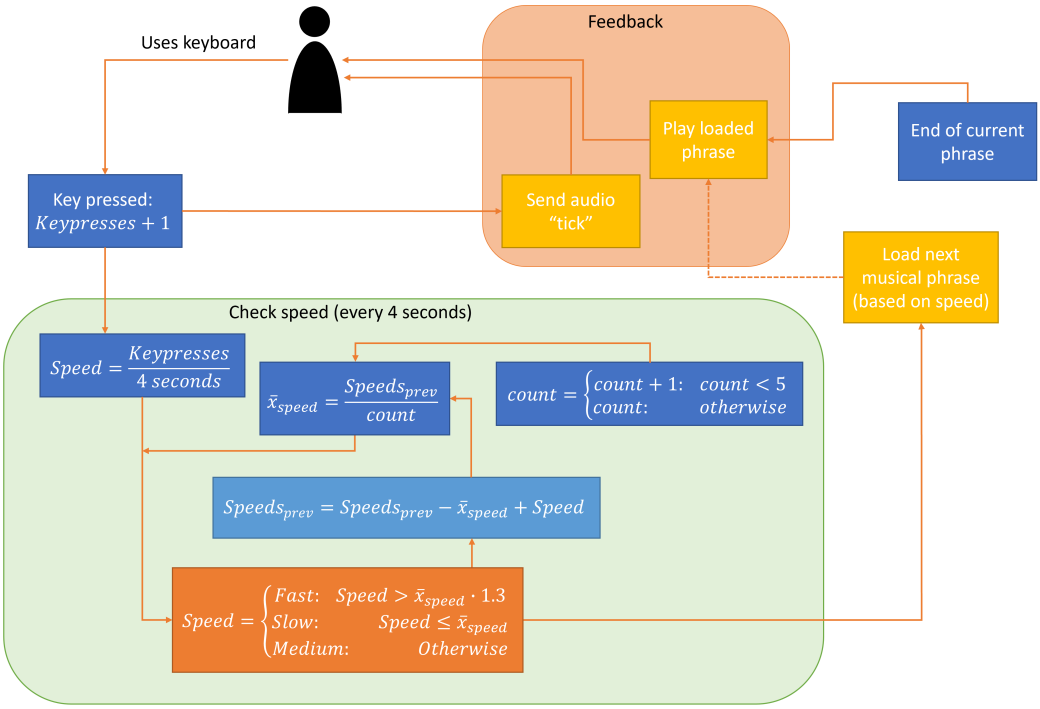


Figure 4.1: systematic overview of Flowtyper. When the user is typing, it both sends direct feedback and adds it to the amount of keypresses in the last 4 seconds. From there, Flowtyper calculates the writer's speed and loads a musical phrase that corresponds to the typing speed. Keep in mind that Flowtyper overwrites the last loaded phrase (due to technical circumstances) and each phrase is approximately 12 seconds. Meaning that only the last there are roughly 3 'cycles' per played phrase.

Chapter 5

Testing Flowtyper

In the previous chapter, we discussed the design of Flowtyper and its general behaviour. In this chapter we will focus on testing whether such a system would indeed improve the writing experience in an experiment setting. For this, a setup was developed as can be read in the following sections. In the next chapters, we will show the results and reflect on what they mean in relation to the test and Flowtyper.

5.1 Setup of the test

For setting up the test. There are a couple of elements to keep in mind:

- Flowtyper has been designed towards the translation part of the writing process.
- The writing process has three phases, which can be entered at any time.
- Both the productivity of participants and their experience need to be measured (as per subquestions 2 and 3).
- Flow is similar, but different than immersion.

First, we need to find a proper metric to be able to determine if someone reaches the flow-state. For that, we use the Flow-State-Scale (FSS). Which is a series of self-report questions that should be filled in directly after the experience and is tailored to assess whether the participant achieved an increase in flow metrics (Jackson & Marsh, 1996). In essence the FSS reviews whether there is an increase in flow.

We also need to determine whether the participants experience positive affect, even if they do not reach the flow state. For establishing the affect, we will use the Self-Assessment Manikin. The SAM is a metric in which the affect is described in terms of happiness, excitement and the sensation of being control (Bradley & Lang, 1994)

As a general setup, participants are asked to write a segment of text (in English) within fifteen minutes for which the subject is up to them. Participants will be randomly assigned a condition by either typing with Flowtyper or normally. After this exercise, the participant will be asked to fill in the FSS and the SAM and will then continue to redo the assignment with the other condition.

The entire questionnaire list and what it measures can be found in appendix B.

5.1.1 Measuring productivity

Productivity will be measured using writing fluency as described in 3.2. Grammatical errors will not be taken into account as there might be grammatical structures which show a difference in linguistic style which might be falsely flagged as incorrect. Spelling errors resulting from poor grammar such as "I have writed" will be taken into account.

5.1.2 Measuring Mood and Arousal

For measuring the effect of Flowtyper on mood and arousal, the Self-Assessment Manikin (SAM) is used.

5.1.3 Hypotheses

From the theory, it is expected that there will be a group that will feel closer to flow due to the use of Flowtyper, whereas others will feel overwhelmed by the amount of stimuli. Whether or not someone is more fluent overall will be unrelated to their affect towards Flowtyper. Applying the mood-arousal theory, it is expected that Flowtyper will increase arousal in most individuals, but that only those with an increase in valence will benefit from Flowtyper in terms of writing fluency. To analyse this, a split based on writing fluency will be made and change in affective state will be measured.

Additionally, it is expected that those who enjoy typing with Flowtyper (Higher valence) will write faster than in the silent condition, but will make more spelling errors as they will want to increase typing speeds and may pay less attention to writing quality.

Chapter 6

Method

This chapter explains the experiment setup. For a visual overview, see fig 6.1

6.1 Demographics and recruitment

For the experiment, participants between the age of 18-28 were recruited via social messaging applications such as WhatsApp, Telegram and Discord. All participants either studied or have studied at the University of Twente and used a Windows operating system. Participants were allowed to keep Flowtyper on their device as compensated for their participation. Prior to the test, the participant was encouraged to already prepare a topic to write about during the test.

6.2 Experiment design

The experiment was performed via videocalling with the participant in Microsoft Teams. After a brief introduction, the participant received the Flowtyper through a download link, from which they could install the application on their own computer. From there, they had to write for 15 minutes on a topic of their own choice in an application of their choice (Flowtyper worked in the background when it was activated). During the writing exercise, the participant could choose to turn off their video and audio. The researcher did the same and unmuted themselves when the 15 minutes where over. After the writing exercise. Participants were asked to send their text and fill in a questionnaire regarding their writing experience (Flow state scale and self-assessment manikin). When the first round was completed, the participant did the same exercise in the other condition (silence or Flowtyper).

Semi-structured interview

When both rounds were completed, a semi-structured interview was conducted were the researcher asked questions about both experiences and whether working with Flowtyper was pleasant. If the participants mentioned anything of note, the researcher asked for more details.

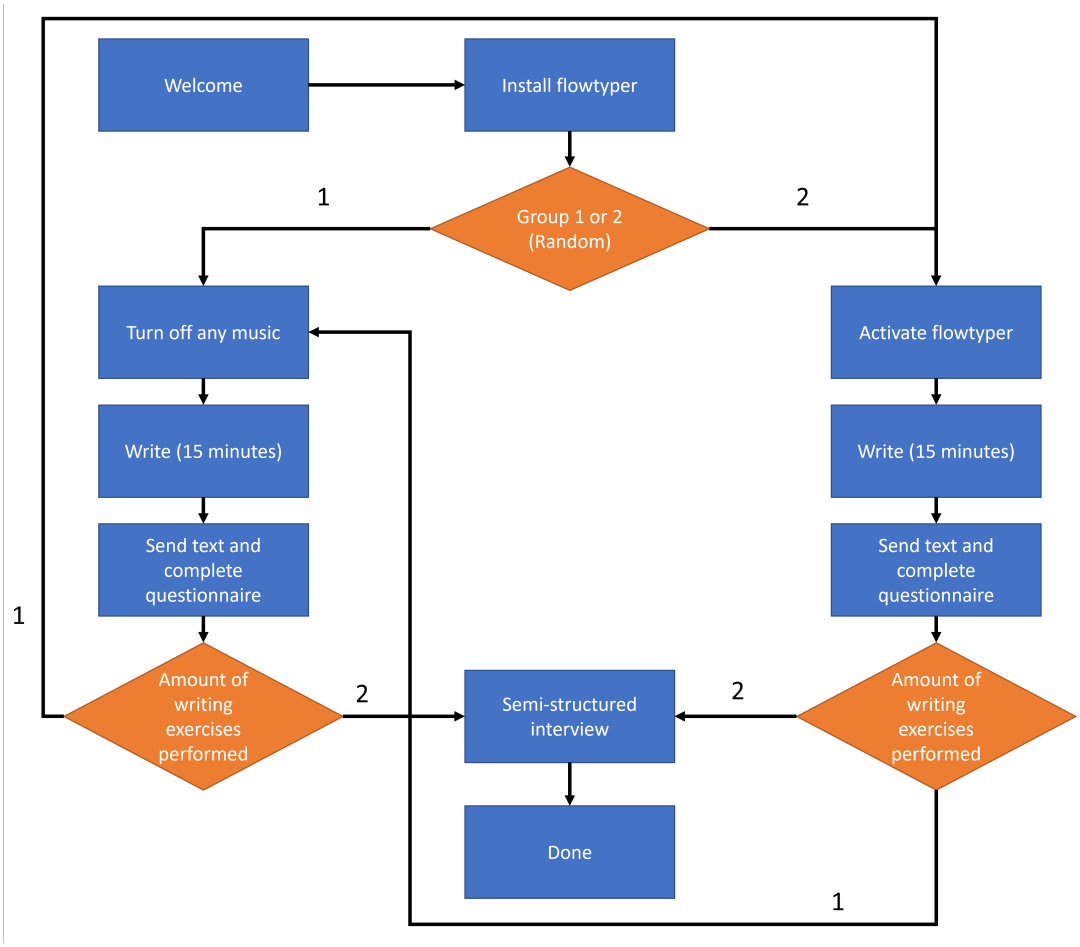


Figure 6.1: Experiment setup

Chapter 7

Results

In this chapter, we will delve into the results of the experiments and give context from the interview where it is warranted. In the next chapter, we will delve into why the results are as they are. From there, we will discuss the effects of Flowtyper in the discussion.

In total 20 people participated in the study. which was about 20 less than planned. Due to corona, the researcher could only ask people digitally. Which made it more difficult to recruit participants. As such, the sample size is very small.

Most notably, participants showed the following changes when using Flowtyper in regard to the exercise without Flowtyper enabled that are significant at confidence level 0.05:

- A 25.62% increase in their perceived transformation of time. There was a light trend towards experiencing time moving in slow motion and time stopping.
- A 23.41% increase in experiencing autotelicness.
- A 11.50% increase in concentration.
- A 30.00% increase in arousal.
- A 3.86% decrease in words spelled correctly.

On the surface, it appears as if Flowtyper is effective in increasing flow metrics with a small decrease in WSC. However, there are some major differences between individual participants which follow two trends, whether they had an increase in valence and control working with Flowtyper and what they were writing. It is therefore not useful to only look at the statistics from the experiment on a superficial level. We need to examine these two factors further.

- How does the type of writing influence the writing experience.

- What are the differences between people who enjoy working with Flowtyper and those who do not?

65% (N=13) of the participants had an increase in their reported valence of the exercise when using Flowtyper. Whereas 30% (N=6) showed a decrease in valence. A single individual reported no change in valence between both exercises.

As participants were allowed to write on a topic of their choosing, some chose to write on a report or similar documents while others wrote creative stories. Creative writers scored higher on the SAM metrics, as well as fluency. This group had an average fluency of 1.412 over both conditions, as opposed to non-creative writers who had an average fluency of 0.788.

These differences are important to keep in mind, as the group which performed worse when using Flowtyper (in terms of fluency) consists for 4/10 out of this group, as opposed to 2/10 in the group in which fluency increased in the Flowtyper condition.

As we want to find whether Flowtyper assists in reaching flow and whether Flowtyper improves fluency, we will make a division on whether there is an increase in fluency in the Flowtyper (Group PF (Performance Flowtyper)) condition in relation to the Silent condition (Group PNF (Performance Non-Flowtyper)).

Whenever we split the sample, we will use the following abbreviations:

- C: Creative writing, this group did not write productively for study or work.
- NC: Non-Creative writing, this group wrote productively for study or work.
- PF: Performance Flowtyper, this group had higher writing fluency in the Flowtyper condition.
- PNF: Performance Not-Flowtyper, this group had lower writing fluency in the Flowtyper condition.
- VF: Valence Flowtyper, this group had higher valence in the Flowtyper condition.
- NVF: Valence Not-Flowtyper, this group had lower valence in the Flowtyper condition.

There was a single participant who reported no difference in valence during both exercises in the questionnaire. Upon further investigation, they reported a higher sense of control and showed an increase in most flow aspects, they also noted that they enjoyed Flowtyper during the interview. As such, they were included in group VF.

	PF	PNF	C	NC	VF	VNF
PF	9	-	2	7	8	1
PNF	-	11	4	7	6	5
C	2	4	6	-	3	3
NC	7	7	-	14	11	3
VF	8	6	3	11	14	-
VNF	1	5	3	3	-	6

Table 7.1: Matrix of combinations possible. From this overview. It is visible that writing fluency does not seem to be linked to valence towards Flowtyper as group PNF is roughly equally split when looking at valence (VF and VNF). The same is true for the inverse. A higher valence in the Flowtyper condition does not mean that fluency increases (VF, PF and PNF)

7.1 Challenges regarding the results

Making divisions on an already small dataset does raise some challenges. First of all, it makes proper statistical analysis near impossible. As such, I will only disclose confidence intervals whenever the whole set is concerned. However, since there are some large differences between the previously mentioned groups, large differences will be discussed.

However, the semi-structured interview done after the experiment provides more clarity towards the statistics. Therefore, we will first look at the statistics and give context via the answers given during the interview. The average scores per metric can be found in Appendix A

Some of the metrics in the Flow State Scale questionnaire are ambiguous. For example, it is unclear whether the transformation of time metric means that time is experienced as slowed down or speeded up. It is therefore useful to look at the questions themselves in these cases.

7.1.1 Flow state scale

To measure whether Flowtyper induced flow, we will use the flow state scale (FSS).

Challenge and skill

As we can see from appendix A, the balance between challenge and skill diminished for non-creative writers in Group VNF (-19%,-0.75 on a 5 point likert-scale), while the rest of the writers don't seem to notice much change.

Merging of action & awareness

The merging of action and awareness showed only an increase in non-creative writers of Group VF(34%, 0.95 on a 5 point likert-scale). This metric decreased for both Group VNF (-31%, -1.17 (creative) and -0.92 (non-creative) on a 5

point likert-scale) and creative writers of Group VF (-11%, -0.33 on a 5 point likert-scale), albeit to a lesser extent in the last category.

Goal clarity

There were no changes of note in this metric. However, group VNF consistently scored higher in this metric. This might suggest that people in Group VNF have clearer goals set before the writing assignment.

Feedback un-ambiguity

Feedback unambiguity increased for creative writers of both Group VF and B (12 and 13%, 0.33 and 0.42 on a 5 point likert-scale respectively) while it decreased for non-creative writers of Group VNF (-32%, -1.17 on a 5 point likert-scale).

Concentration

Group VNF lost concentration. this effect was higher within creative writers (-56% (creative) and -22%(non-creative), -2.00 and -0.67 on a 5 point likert-scale).

Participants in Group VF found it easier to concentrate. But the nature of their text was important. People in this group who wrote non-creatively expected creative writing to become easier than non-creative writing with Flowtyper. However, the inverse seems to be the case (-5% (creative) 55% (non-creative), -0.17 and 1.36 on a 5 point likert-scale).

While participants (in Group VF) who wrote creatively had a higher fluency, they experienced the effects of Flowtyper to a lesser extent. Both make intuitive sense: Writing creatively is already considered a more 'fun' experience, making it harder to improve an already high score. Moreover, writing reports needs more working memory for structural planning of the text, which slows down the translation process of writing. This decreases the fluency for non-creative writers (more on this in 8).

Some participants remarked that they found it easier to think due to the repetitive nature of the music. However, one participant noticed that the music enforced "thinking" where it was not warranted. This participant was a notably fluent writer (2nd most fluent) and wrote creatively.

Multiple participants remarked that they needed to get used to Flowtyper at first but found themselves more concentrated as the writing session continued. During the session without Flowtyper, 5 participants said they were more distracted by their environment. Flowtyper worked as a filter for them. There was one participant who did not enjoy working with Flowtyper during the experiment because they were distracted by the additional noises at first. When they tried Flowtyper again out on their own accord, they told the researcher that they found working with Flowtyper enjoyable after they got used to it.

Time transformation

Time seems to slow down for both groups VF and VNF. However, each group experiences this slowing of time differently. Group VF mostly experienced time stopping during the while they while working and group VNF experienced the entire exercise as happening in slow motion. This difference in transformation of time can be further explained by the answers of the interview. Participants of group VF thought the assignment with Flowtyper was over quicker than without Flowtyper, while group VNF noted the inverse and experienced the assignment as more "of a chore". These answers suggest that, while the transformation of time exist in both groups, the affective experience towards the time transformation is very different. Group VF experienced the transformation of time as positive, while group VNF believed the time dilation to be a negative experience.

Autotelic experience

Group VF experience a high increase in autotelicness whereas group VNF experienced a decrease. 5 people in Group VF remarked that they lost focus on thinking about what they were writing and were more focused on writing itself. This also helped them to get over the 'empty page'-stage as they just wanted to write. One person mentioned that they were unsure if the quality of the writing was the same as the scenario without Flowtyper because they had more focus on the writing itself and felt as if they paid less attention to structural quality. Another participant found writing with Flowtyper to be a more "magical experience" than 'regular' writing. Which highlights the gamifying effect Flowtyper might have.

7.1.2 Fluency

To measure short-term productivity, we use the relative writing fluency as described in 3.2.

Creative writers were more fluent than non-creative writers. Overall, creative writing results in an average fluency of 1.43 in the silent condition and a fluency of 1.39 with Flowtyper. Non-creative writing had considerably lower fluency scores (0.80 and 0.76 respectively). There were minor differences between groups VF or VNF when considering the writing type. However, group PF was less fluent than group PNF regardless of writing type.

Keep in mind that the total sample of creative writers is 6. As such, we will mostly discuss group NC when considering other changes.

7.1.3 Self-Assessment Manikin

To test whether the flow-state affects the experience of typing, we use the Self-assessment manikin. Specifically, whether group VF sees any changes in their flow-scores in regards to group VNF.

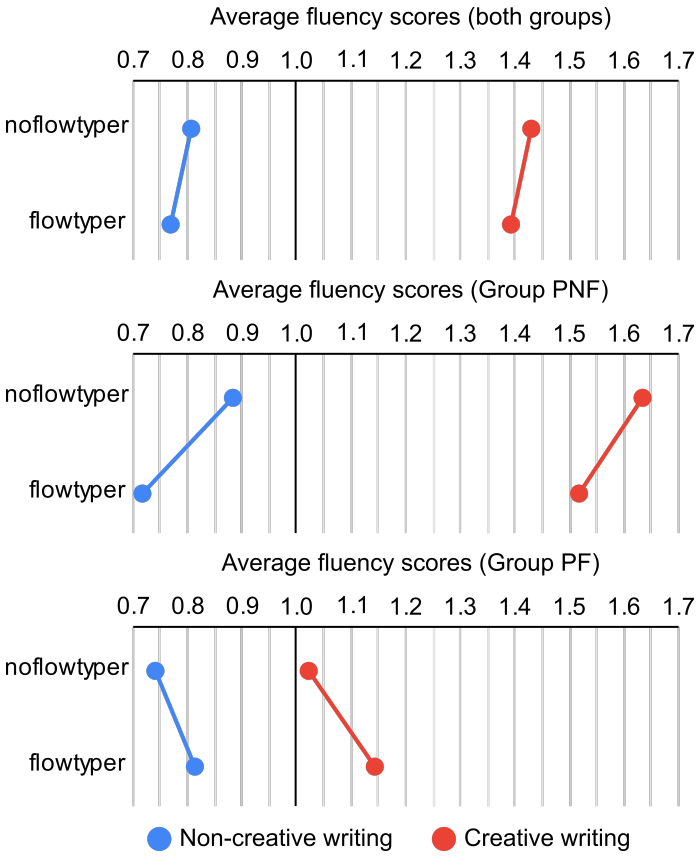


Figure 7.1: Average fluency scores split based on writing style (creative or non-creative) and fluency increase. On average, creative writers are more fluent than non creative writers, and those who benefit from Flowtyper (PF) are less fluent than those who do not.

Overall, there is a valence increase in the Self-Assessment Manikin, while we are filtering groups VF and VNF based on their valence increase when using Flowtyper, there is a more notable contrast in Group VF during non-creative writing than there is in creative writing.

Arousal does not show change in Group VNF. However, the non-creative writers in Group VF showed a high increase in arousal (54%, 1.91 points on a 9 point likert-scale).

The feeling of control increased for Group VF, especially for non-creative writers (29%, 1.45 points on a 9 point likert-scale) and decreased for Group VNF ((-17% (creative) and -43% (non-creative), 0.67 and 1.45 on a 9 point likert-scale, respectively).

Most notably, groups VNF and VF see major differences in their increase in flow scores. Group VNF sees a decrease in most FSS-scores in the Flowtyper

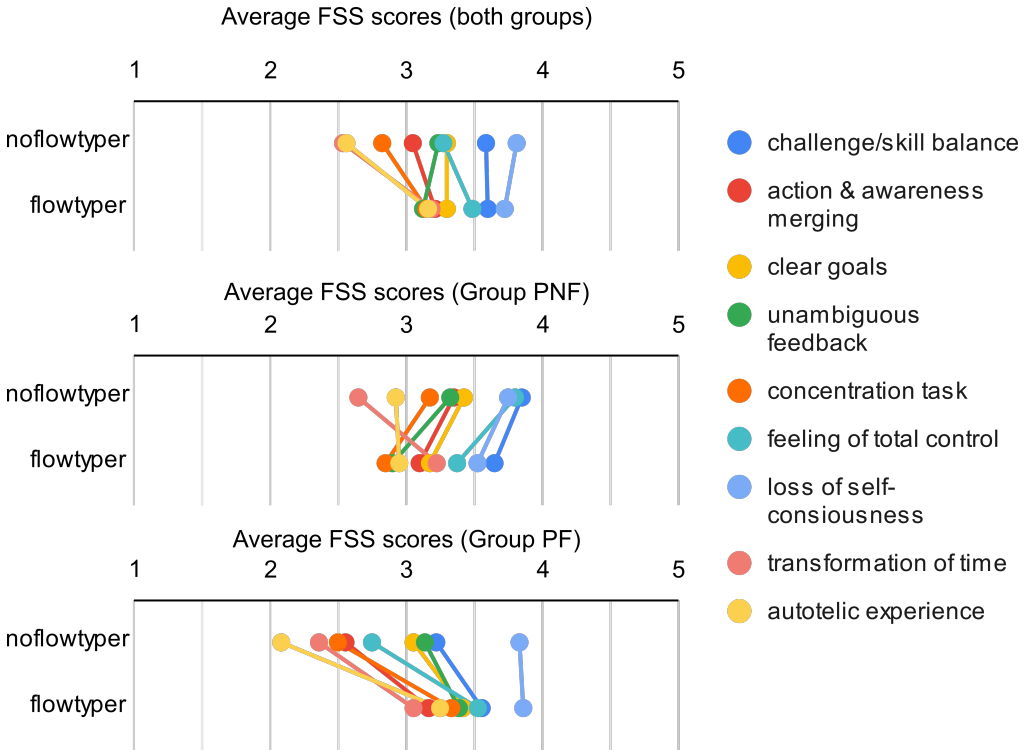


Figure 7.2: Average flow scores split based on writing fluency. On average, the scores of group PF seems to increase while the group PNF decreases. Furthermore, group PF scores lower on all flow metrics in the silent condition, with the exception of loss of self-consciousness.

condition, whereas group VF increases most scores. See figure 7.5.

7.1.4 Overall differences

Group VNF scored higher on most flow metrics than Group VF when not using Flowtyper (this is true for both creative and non-creative writers). This would suggest that they perceive themselves more skilled when writing is considered. Most notably, they report higher merging of action and awareness, goal clarity, concentration and a higher autotelic nature of the exercise. They also report a higher sense of control without Flowtyper.

When Flowtyper is used, group VNF reported a high decrease in concentration, the autotelic experience and a merging of action and awareness. They also reported a lower sense of control. Group VF however showed an increase in these metrics, along with a higher reported arousal and transformation of time. The goals clarity saw no notable change in either group.

Group VF did see a difference in the increase of the above-mentioned metrics

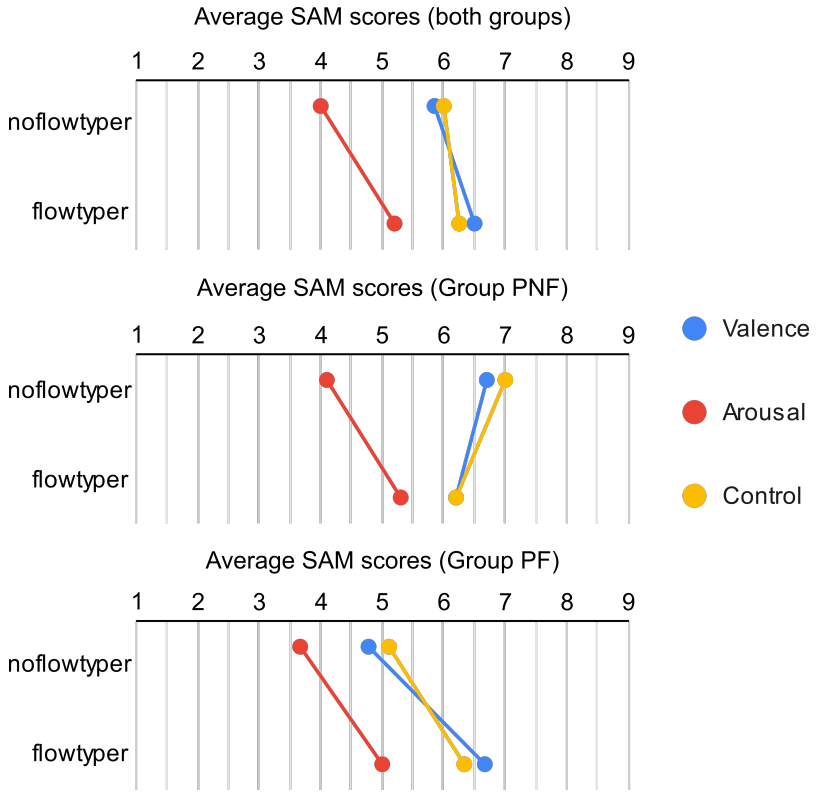


Figure 7.3: SAM scores split based on writing fluency.

when the type of writing was concerned. Group NC saw a higher increase in these metrics than group C (a minimum difference of 0.2 on a 5-point likert-scale, and an average of 0.36). most notable in this is the change in concentration, which decreased slightly for group C (-0.05) but increased for group NC (0.55).

It seems as if Flowtyper alters these metrics (action & awareness merging, concentration, feeling of total control, transformation of time and the autotelic experience) while leaving other metrics almost untouched. Most notably, the goal clarity showed almost no change in both groups, but between groups VF and VNF there is a difference in the average (0.8 point difference on a 5 point likert-scale).

While Flowtyper does seem to assist people that perceive themselves as less skilled to increase their flow-level, it does the opposite for those who already perceive themselves skilled. Group VNF showed a decrease in every flow-metric, except for the clarity of goals (which remained the same). Group VF showed an increase in all flow-metrics.

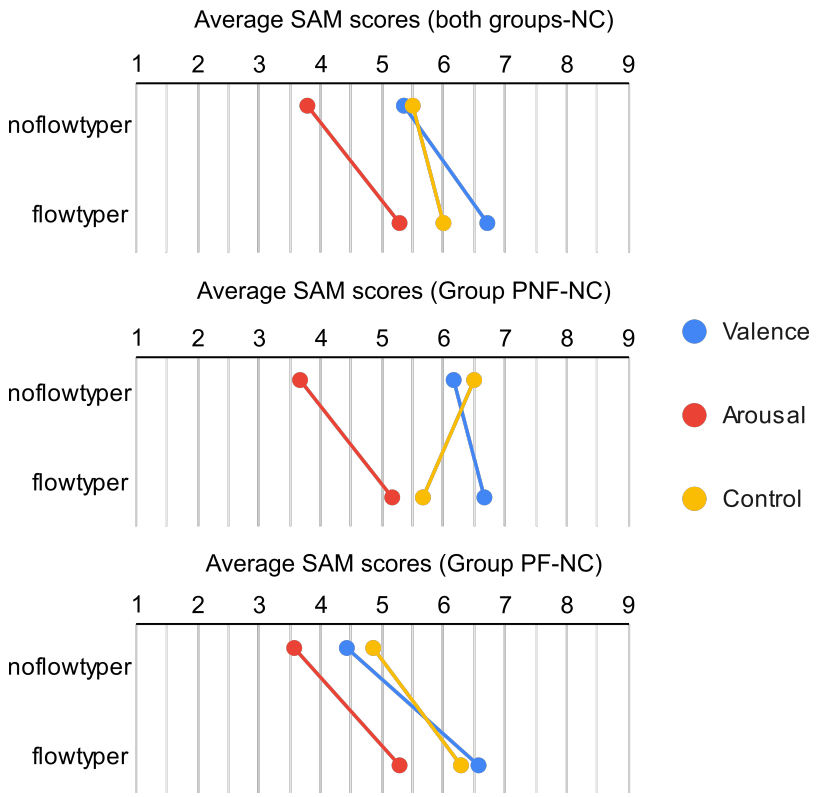


Figure 7.4: SAM scores split based on writing fluency, specified on the NC group. While most differences are minute, the PNF group has an increase in arousal instead of a decrease when compared to the previous figure.

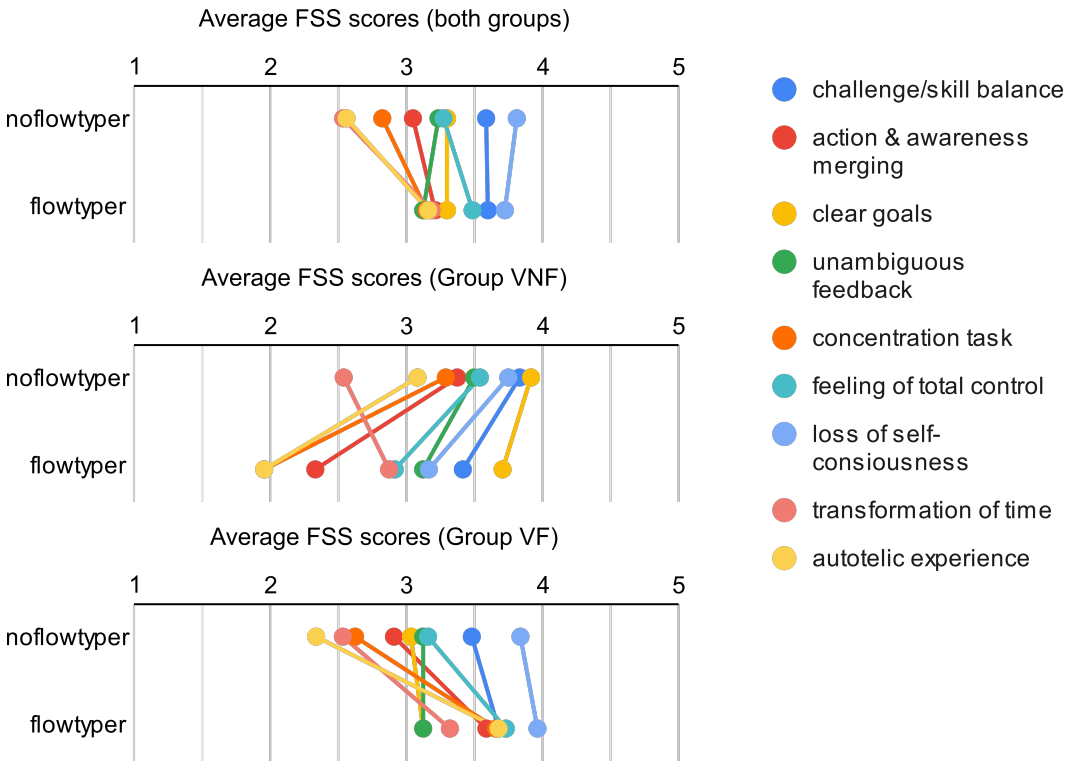


Figure 7.5: Average flow scores split based on valence. On average, the scores of group VF seems to increase while the group VNF decreases.

Chapter 8

Discussion

In this chapter, we will take the results from the previous chapter and reflect on them based on literature. What is different from our expectations in 5.1.3 and can that be explained from the literature that we reviewed so far?

8.1 Stimulation and flow

While we correctly predicted that more spelling errors would be made, I failed to anticipate that Flowtyper had a mostly positive effect on those who were less stimulated. Additionally, it appears that those who benefit in terms of writing fluency from Flowtyper are also less fluent in writing. It might be that these participants need more stimulus to perform well than others do. Zentall (1986) found that individuals with ADHD tend to seek out stimulation in order to function as described in 3.4. While it is a stretch to say that individuals that had higher fluency with Flowtyper than without are individuals with ADHD, it might very well be that these individuals are generally understimulated during writing tasks in silence and that Flowtyper helps in this stimulation.

8.1.1 Writing and working memory

As described in 3.2, the writing process constitutes of the following:

- Plan
- Generate/Translate
- Review

During the experiment, participants were allowed to use the assignment text for their own use. Many participants used this time to write (parts of) a report they needed to write outside the experiment. This introduced planning for a larger text than one can write in 15 minutes in relation to creative writing, thus increasing the working memory needed for planning. There was a similar effect

on the reviewing process. Whenever the participant reviewed the text, the text was reviewed as a text in a larger structure than in creative writing, where the text was self-contained. This change in the amount of working memory could explain the changes in fluency between creative and non-creative writers and some of the changes in Flowtypers' effect on these types of writing.

Non-creative writers experienced most effects of Flowtyper to a higher extent than creative writers regardless whether the effect was positive or negative. As non-creative writers require more working memory than creative writers in this excercise, any changes in available working memory are expected to become more accentuated. Specifically, the planning and reviewing phases are designed to be reduced in Flowtyper and translating is stimulated. In creative writers, theses phases are already small relative to the translating phase.

For group VNF, this effect seems to work counterproductive: Flowtyper inhibits their concentration and makes them focus on Flowtyper as a distractor, instead of the text itself.

Music and writing

There are differences to how people like to concentrate. Some people state that they can only focus with music on, where others never do and get distracted by music. In some open offices, there is a radio present to remove the standard office noise (Mehta, Zhu, & Cheema, 2012).

In order to discuss the nuanced differences between the two groups, it is useful to look at more extreme examples in our society. Let's focus on two neurodevelopmental disorder spectrums. The autistic spectrum and the ADHD spectrum[1]. Both of these neurodevelopmental disorders have trouble with filtering noise in the outside world. Where people with autism get overwhelmed more easily by noise, people with ADHD require a lot of stimulation before something becomes interesting. This means both get distracted easily, but it has different effects on them when tasks are concerned. Music can be a great stimulus for a person with ADHD to even be able start working on a task, but can utterly distract a person with autism and even block them from doing said task.

While these brains work differently than those of neurotypical people, it does show that there is a neurodiversity present in the population. During the experiments, there were three participants who mentioned that they did have ADHD. All of them enjoyed working with Flowtyper, which indicates that Flowtyper may be more enjoyable for those who need more stimulation in their working environment.

The main difference between people that perform better working with Flowtyper and those who don't can best be described as the amount of stimulation they need to work productively. While there is also a group that feels as if they

[1]Please note that these disorders are more complex than is written in this thesis (for example, ADHD patients can become overwhelmed by stimulus just as people with autism can highly concentrate on a single task within a noisy environment). The examples in this thesis are mainly here to provide more clarity on the neurodiversity within the whole population.

are working better, this is not always the case. It is difficult to assess in which group someone belongs beforehand though.

Current research about whether music is detrimental for studying or beneficial is split. Our results seem to match with this non-consensus. For some participants, using Flowtyper increased flow metrics along with valence, arousal and control. It seems that these individuals become more engaged when exposed to stimuli. Participant whose fluency decreased during Flowtyper experienced the opposite changes with the exception of arousal, which increases (see figure 7.3). These findings point to the arousal hypothesis, where the correct amount of stimulation is needed to engage in flow.

8.1.2 Motivational model

From the mood-arousal model, we can take a look at how this impacts motivation. Does a lack of arousal explain why people procrastinate, rush or forego work? Many people can still start an activity without high arousal levels. The question then is, why do people start a task (or why don't they)?

The reason most people are putting off work is due to a lack of motivation. This can either be motivation for something else or lack of motivation for the task at hand. Still, it is important to delve into the question of how motivation even forms so we can get a better understanding of what Flowtyper does for the writer's motivation to write during it's use and after using it.

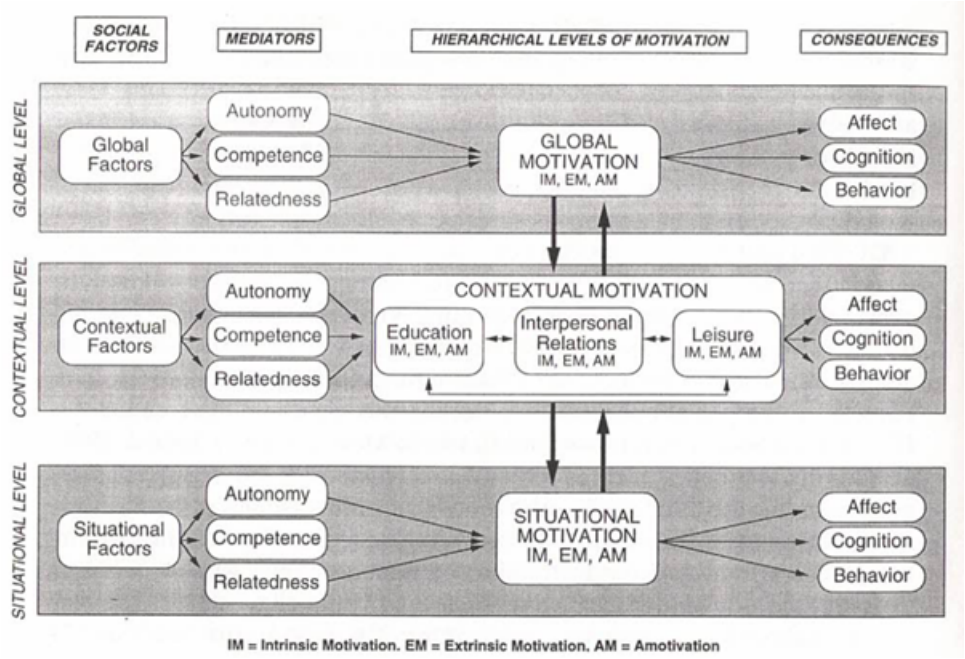


Figure 8.1: The hierarchical motivational model according to Vallerand (1997).

Vallerand proposed a hierarchical model of motivation. He described that there are 3 levels of motivation: Global, contextual, and situational motivation. All of these levels are subjected to feelings of autonomy (feeling free to choose a course of action), competence (how effectively one can interact with the environment) and relatedness (the social connection to others) called mediators.

Global motivation is related to how motivated a person is about a task in general. In our case, this is writing-related motivation (e.g. "I don't like to write") Contextual motivation is narrowed down to the context of the task (e.g. school:"writing reports for school is boring because I am forced to do it"). This level is a bit more complex than the other two, as it deals with contextual dealings such as interpersonal relationships.

Situational motivation is then the motivation in a specific instant (e.g. "This assignment is more engaging to me than others, because I like the topic"). These levels have some interaction with each other, but the global level of motivation will not be able to directly interact with the situation motivational level and vice versa. Each level can only influence the level adjacent to it. For example, A student could be amotivated to do anything because they feel work is 'forced upon them'. When the context changes by having a new teacher with a different approach (such as writing about your interests), the situational mediator changes because the work has more autonomy. Which in turn makes the student write about a subject they are competent in. This can increase the contextual motivation ("I do like to write about subjects that interest me."). Lastly, the contextual motivation affects the global motivation (instead of "I don't like to write", it becomes "I sometimes like to write").

As we have seen, the outcomes of motivation can be affective, cognitive, or behavioural in nature. The motivation of the example we followed not only caused the amotivated student to change their affective stance on writing, it can also make the student write on their own about the subject they like, spurring a behavioural change.

In section 3.5.2, we have seen that music affects the arousal and mood of an individual (Husain et al., 2002). Flowtyper effectively rewards the writer through its music, which could be described as auditory feedback. Verbal feedback has a lasting impact on one's intrinsic motivation (Deci, 1971). By rewarding the writer during the writing process, it is expected that this can have a lasting effect on one's intrinsic motivation.

8.2 Flowtypers effect on motivation

From Vallerand's motivational model, we can make predictions on how Flowtyper will affect long-term motivation. Flowtyper changes the situational factors by introducing more direct feedback during the writing process, indicating the level of competence of the writing fluency. In the previous chapters, we saw that Flowtyper influences the autotelicness of the writing assignment. This can have the effect that writers will see writing as a more enjoyable experience, increasing their contextual competence mediator. This increase can influence the global

motivation of writers, but more research about how tools such as Flowtyper can increase global motivation is required.

8.3 Answering the research questions

At the start of this thesis. the following questions were raised: Main Research Question: *Can an induced flow state improve the enjoyment of typing?*

- Subquestion 1:
  Can the flow-state be induced through auditory feedback in the context of typing?
- Subquestion 2:
  How does the flow-state affect short term productivity in the context of typing?
- Subquestion 3:
  How does the flow-state affect user's experience of typing?

While induced flow definitely assists in the enjoyment of typing, it is difficult to induce flow reliably through a tool such Flowtyper. There is a delicate balance between stimulation and working memory that is dependent on the individual and is difficult to assess. While Flowtyper worked as planned for some, others were overwhelmed by the stimuli Flowtyper presented.

The flow state does not affect productivity performance directly(Schüler & Brunner, 2009). However, enjoyment of an activity makes an individual more intrinsically motivated to return to their work (Vallerand, 1997). The results of this thesis support the current models. Inducing a flow state to increase short term productivity also seems to be a good strategy for normally understimulated individuals, although a larger sample size is necessary to make this conclusion more solid.

Flowtyper induced the following flow metrics in group VF (Valence Flowtyper):

- Action & awareness merging
- Concentration task
- Transformation of time
- Autotelic experience

While the writers in Group VF noticed positive affect towards the typing exercise, not every flow-metric was induced. As such, we cannot state that flow was induced. Most notably, the balance between challenge and skill and unambiguous feedback were not increased. This was unexpected as challenge was regulated though feedback and is the main principle behind Flowtyper. Nonetheless, The increase in flow-characteristics are positively correlated to

positive affect towards the writing exercise. As such, we can state that the flow-state affects the user's experience positively.

In group PF (Performance Flowtyper), Flowtyper induced the following flow metrics:

- Action & awareness merging
- Concentration task
- Feeling of total control
- Autotelic experience

Notable is that group PF is mostly a subset of group VF (with one exception). This means that enjoying working with Flowtyper does not warrant an increase in writing fluency. The opposite is more likely true: If someone does not like working with Flowtyper, they will most probably will not benefit in terms of fluency as well.

8.4 Limitations

In this thesis, writing was found to be a difficult subject to encapsulate. There were more parameters to take into account than initially planned. Specifically, working memory and the effect music has on it. It seems that literature on music and affect, while thoroughly studied, can only make basic predictions on the effects on productivity. There seems to be a missing link when music and cognition is concerned. There seems to be some promise towards the balance between arousal and overstimulation as described in (Kämpfe et al., 2011) but no conclusive study has been found.

The sample size of the study is small. This is mainly due to the COVID-19 pandemic and the inability to search for participants outside of digital promotion. While the differences between the groups are large, the sample size is too small to make reliable statements about the population. The pandemic also resulted in making an application that people could use outside of the experiment (as a reward). This resulted in the application not saving the typing behaviour of participants. While the data used was sufficient to make conclusions, being able to view typing behaviour would have given more insight into Flowtyper's effect.

Personal biases

This design of Flowtyper was based on a tinkering based approach. While tinkering and testing on oneself is an effective tool for discovery and understanding in a time-efficient manner, it can also bring personal biases to the table. This report has mostly been written with Flowtyper enabled. This might have had an influence on my own view of Flowtyper.

8.5 Ethical concerns

Addictivity

Flow is usually seen as a positive experience. However, flow has also shown to have some addictive properties. Some ascribe the addictiveness of games to flow and the are even recordings of people missing the flow of combat in wartimes (Harari, 2008). People who were disgusted by war still missed the flow state that emerged in the act of killing. This is a serious concern while designing for flow. In this thesis, flow is used to increase productivity in a writing setting. While the content of the written material is unaccounted for, writing is not harmful in itself. It is however important to stay vigilant as making activities more enjoyable could have unintended side effects

8.6 Conclusions and recommendations

Flowtyper is a tool that, on average, helps writers to get into the flow state through auditory feedback. Reaching flow through Flowtyper is however not directly related to higher writing fluency. Although normally understimulated individuals (such as people with ADHD) do benefit from Flowtyper as their stimulation is normalized, it seems to only marginally improve fluency.

If one was to run other experiments with Flowtyper. It would be interesting to see whether the stimulation theory holds water when accounting for ADHD and whether there is a difference in those who use stimulant medication and those who do not, and if this differs from neurotypical people. Using measures for arousal and mood would be more practical than the currently used flow state scale as flow is not directly linked to productivity.

Performing a long term study would be useful to assess the promise of productivity commonly associated with Flow.

Flowtyper uses music to try to get people into flow. It is however the question whether simple white noise can be just as effective as a stimulus. Helps et al. (2014) showed that white noise improves performance for sub-attentive children. If we follow the optimal stimulation theory, white noise could be just as effective as Flowtyper in increasing performance of understimulated individuals.

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Appendix A

Average results from the experiment

silence	Overall		Group VF		Group VNF	
	creative	report	creative	report	creative	report
length	540	302.5	508.6666667	300.2727273	571.3333333	310.6666667
mistakes	14.66666667	7.384615385	17.33333333	7.3	12	7.666666667
mistakes/lenght	0.02971664593	0.021145116	0.03228988954	0.01948066086	0.02714340232	0.0266932998
fluency	37.0201817	20.76546558	35.12210909	20.62432233	38.91825432	21.2359431
valence	7	5.357142857	6.333333333	5.090909091	7.666666667	6.333333333
arousal	4.5	3.785714286	4.666666667	3.545454545	4.333333333	4.666666667
control	7.166666667	5.5	6.333333333	5.090909091	8	7
challenge/skill balance	3.458333333	3.642857143	3.25	3.545454545	3.666666667	4
action & awareness merging	3.458333333	2.875	3.166666667	2.840909091	3.75	3
clear goals	3.083333333	3.392857143	2.166666667	3.272727273	4	3.833333333
unambiguous feedback	3.083333333	3.303571429	2.833333333	3.204545455	3.333333333	3.666666667
concentration task	3.375	2.589285714	3.166666667	2.477272727	3.583333333	3
feeling of total control	3.541666667	3.160714286	3.333333333	3.113636364	3.75	3.333333333
loss of self-consiousness	4.125	3.678571429	4.083333333	3.772727273	4.166666667	3.333333333
transformation of time	2.791666667	2.428571429	2.833333333	2.454545455	2.75	2.333333333
autotelic experience	2.833333333	2.446428571	2.416666667	2.318181818	3.25	2.916666667
N	6	14	3	11	3	3
flowtyper						
length	528.8333333	288.9285714	536	290.2727273	521.6666667	284
mistakes	17.16666667	8	20.66666667	7.8	13.66666667	8.666666667
mistakes/lenght	0.03841619568	0.02255647465	0.03553976253	0.019816688	0.04129262883	0.0316890965
fluency	36.47267714	19.92725388	37.18135626	20.04641764	35.76399802	19.53004136
valence	6	6.714285714	7	7.454545455	5	4
arousal	5	5.285714286	5.333333333	5.454545455	4.666666667	4.666666667
control	6.833333333	6	7	6.545454545	6.666666667	4
challenge/skill balance	3.5	3.642857143	3.416666667	3.75	3.583333333	3.25
action & awareness merging	2.708333333	3.428571429	2.833333333	3.795454545	2.583333333	2.083333333
clear goals	3.125	3.375	2.416666667	3.318181818	3.833333333	3.583333333
unambiguous feedback	3.458333333	2.982142857	3.166666667	3.113636364	3.75	2.5
concentration task	2.291666667	3.517857143	3	3.840909091	1.583333333	2.333333333
feeling of total control	3.333333333	3.553571429	3.416666667	3.818181818	3.25	2.583333333
loss of self-consiousness	3.708333333	3.732142857	4.333333333	3.863636364	3.083333333	3.25
transformation of time	2.875	3.321428571	2.916666667	3.431818182	2.833333333	2.916666667
autotelic experience	2.625	3.392857143	3.083333333	3.840909091	2.166666667	1.75
N	6	14	3	11	3	3
increase %						
length	-2.07	-4.49	5.37	-3.33	-8.69	-8.58
mistakes	17.05	8.33	19.23	6.85	13.89	13.04
mistakes/lenght	29.28	6.67	10.06	1.72	52.13	18.72
fluency	-1.48	-4.04	5.86	-2.80	-8.10	-8.03
valence	-14.29	25.33	10.53	46.43	-34.78	-36.84
arousal	11.11	39.62	14.29	53.85	7.69	0.00
control	-4.65	9.09	10.53	28.57	-16.67	-42.86
challenge/skill balance	1.20	0.00	5.13	5.77	-2.27	-18.75
action & awareness merging	-21.69	19.25	-10.53	33.60	-31.11	-30.56
clear goals	1.35	-0.53	11.54	1.39	-4.17	-6.52
unambiguous feedback	12.16	-9.73	11.76	-2.84	12.50	-31.82
concentration task	-32.10	35.86	-5.26	55.05	-55.81	-22.22
feeling of total control	-5.88	12.43	2.50	22.63	-13.33	-22.50
loss of self-consiousness	-10.10	1.46	6.12	2.41	-26.00	-2.50
transformation of time	2.99	36.76	2.94	39.81	3.03	25.00
autotelic experience	-7.35	38.69	27.59	65.69	-33.33	-40.00

Appendix B

Experiment questionnaire

metric	Timestamp
gender	What is your gender
education	What is your highest completed education?
enjoyment	How much do you enjoy writing?
Music training	Do you often listen to music while you are writing?
nativeness	Is English your primary language?
Length & spelling errors	Exercise: please write about anything for 15 minutes. Please refrain from correcting any spelling errors while typing. The researcher will set a timer for you. If you have music running in the background, please turn it off for now.
valence	How pleased were you during the exercise?
arousal	How excited were you during the exercise?
control	How much did you feel in control during the exercise?
Flowtyper affect	Would you use Flowtyper again?
action & awareness merging	I made the correct movements without thinking about trying to do so.
	Things just seemed to be happening automatically.
	I performed automatically.
	I did things spontaneously and automatically without having to think.
transformation of time	I really enjoyed the experience.
	I loved the feeling of that performance and want to capture it again.
	The experience left me feeling great.
	I found the experience extremely rewarding.
clear goals	I knew clearly what I wanted to do.
	I had a strong sense of what I wanted to do.
	I knew what I wanted to achieve.
	My goals were clearly defined
challenge/skill balance	I was challenged, but I believed my skills would allow me to meet the challenge.
	My abilities matched the high challenge of the situation.
	I felt I was competent enough to meet the high demands of the situation.
	The challenge and my skills were at an equally high level.
concentration task	My attention was focused entirely on what I was doing.
	It was no effort to keep my mind on what was happening.
	I had total concentration.
	I was completely focused on the task at hand
feeling of total control	I felt in total control of what I was doing.
	I felt like I could control what I was doing.
	I had a feeling of total control.
	I felt in total control of my body.
	I was not concerned with what others may have been thinking of me.

metric	Timestamp
loss of self-consiousness	I was not worried about my performance during the event.
	I was not concerned with how I was presenting myself.
	I was not worried about what others may have been thinking of me.
transformation of time	Time seemed to alter (either slowed down or speeded up).
	The way time passed seemed to be different from normal.
	It felt like time stopped while I was performing.
	At times, it almost seemed like things were happening in slow motion.
unambiguous feedback	It was really clear to me that I was doing well.
	I was aware of how well I was performing.
	I had a good idea while I was performing about how well I was doing.
	I could tell by the way I was performing how well I was doing.