COMENIUS UNIVERSITY IN BRATISLAVA
FACULTY OF MATHEMATICS, PHYSICS, AND INFORMATICS

The City as a Playground:
Influence of Practicing Parkour on Divergent Thinking

Diploma Thesis

Bratislava, 2020 Johanna Köllner, BSc.

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Study program:	Cognitive Science
Field of study:	2503, Cognitive Science
Supervising department:	Department of Applied Informatics
Supervisor:	RNDr. Barbora Cimrová, PhD.
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Title: The City as a Playground: Influence of Practicing Parkour on Divergent Thinking

Annotation: According to the enactivist approach, cognition does not only emerge from the brain, but rather arises from a cooperation between brain, body, and environment. Hence, possible ways of interaction between humans and their environment, so-called affordances, play a crucial role in a number of cognitive processes. Most spaces designed for a single purpose offer only a few affordances. Such "tight spaces" are perceived as less vivid in comparison to so-called "loose spaces", offering their users a large variety of affordances. The attitude towards the environment is often challenged in a sportive activity called parkour: Its practitioners exercise the ability to "loosen up" spaces by finding additional affordances in initially mono-functional surroundings, as they use urban structures creatively.

Aim: The thesis' aim is to approach an interdisciplinary understanding of the importance of human-environment interactions by investigating the influence of parkour training on divergent thinking as one aspect of cognition.

Literature:
Ameel, L., & Tani, S. (2012). Parkour: Creating loose spaces? Geografiska Annaler, Series B: Human Geography, 94(1), 17–30. https://doi.org/10.1111/j.1468-0467.2012.00393.x
Newen, A., De Bruin, L., & Gallagher, S. (2018). The Oxford handbook of 4E cognition. Oxford: Oxford University Press.

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Názov: The City as a Playground: Influence of Practicing Parkour on Divergent Thinking
Mesto ako ihrisko: vplyv praktizovania parkouru na divergentné myslenie

Anotácia: Podľa enaktivistického prístupu, základom kognície nie je iba mozog, ale vzniká skôr z kooperácie mozgu, tela a prostredia. Možné spôsoby interakcie ľudí s prostredím, tzv. afordancie, preto zohrávajú kľúčovú rolu v množstve kognitívnych procesov. Väčšina priestorov navrhnutých iba na jeden účel ponúka len málo afordancií. Takéto „tesné priestory" pôsobia menej živo v porovnaní s tzv. „voľnými priestormi", ktoré ponúkajú ich užívateľom širokú škálu afordancií. Pôvodný postoj k prostrediu je často spochybňovaný pri športovej činnosti zvanej parkour: ľudia praktizujúci parkour trénujú schopnosť „rozvoľniť" priestor objavovaním nových afordancií aj v pôvodne mono-funkčnom prostredí kreatívnym využívaním štruktúr urbánneho priestoru.

Cieľ: Cieľom tejto práce je pokus o interdisciplinárne porozumenie dôležitosti interakcie človeka s prostredím, skúmaním vplyvu tréningu parkouru na divergentné myslenie, ako jeden z aspektov kognície.

Literatúra: Ameel, L., & Tani, S. (2012). Parkour: Creating loose spaces? Geografiska Annaler, Series B: Human Geography, 94(1), 17–30. https://doi.org/10.1111/j.1468-0467.2012.00393.x
Newen, A., De Bruin, L., & Gallagher, S. (2018). The Oxford handbook of 4E cognition. Oxford: Oxford University Press.

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študent

.....
vedúci práce

I hereby declare that the presented master's thesis is original and the result of my own investigations. Formulations and ideas taken from any other sources are cited as such.

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Johanna Köllner, BSc.

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English Abstract

According to the 4E approach to cognition, cognition does not only emerge from the brain, but rather arises from a cooperation between brain, body, and the environment. Hence, possible ways of interaction between humans and their environment, so-called affordances, play a crucial role in a number of cognitive processes. Most spaces designed for a single purpose offer only a few affordances. Such *tight spaces* are perceived as less vivid in comparison to so-called *loose spaces*, offering their users a large variety of affordances. The attitude towards the environment is often challenged in a sporting activity, which is called parkour: its practitioners, so-called traceurs, exercise the ability to *loosen up* spaces by finding additional affordances in initially mono-functional surroundings, as they use urban structures creatively. The aim of my thesis is to approach an interdisciplinary understanding of the importance of human-environment interactions. Therefore, I hypothesized that parkour training had a beneficial effect on divergent thinking (DT), as an aspect of cognition. DT, being a type of creative thinking, describes the ability to generate a range of diverse ideas as possible solutions to a single problem. Traceurs might apply a similar type of thinking when *loosening up* urban environments.

In my experiment, a group of traceurs solved two DT tasks before and after a parkour training session in an unfamiliar environment. As a control group, I chose gymnasts who trained on gymnastics equipment instead. The DT tasks of both groups were evaluated using a new computational scoring method based on semantic distance.

The participants' DT performance differed depending on the type of task: whereas one task indicated an increased number of ideas after training, the other showed decreased originality across all participants. Furthermore, traceurs had a higher number of ideas that were more original than the gymnasts'. Over all participants, DT performance before and after the training session correlated positively, indicating that my scoring method showed acceptable feasibility.

Although the results are inconsistent, I succeeded in providing a preliminary explorative approach towards the connection between 4E cognition, creativity, the concept of affordances, and urban design. This thesis introduces a new paradigm to investigate how physical activity and interaction with the environment might affect cognitive abilities.

Keywords: 4E cognition, affordances, urban design, creativity, divergent thinking, parkour

Slovak Abstract

Podľa enaktivistického prístupu, kogníciu nevytvára iba mozog, ale vzniká skôr z kooperácie mozgu, tela a prostredia. Možné spôsoby interakcie ľudí s prostredím, tzv. afordancie, preto zohrávajú kľúčovú rolu v množstve kognitívnych procesov. Väčšina priestorov navrhnutých iba pre jeden účel poskytuje len málo afordancií. Takéto „tesné priestory" pôsobia menej živo, v porovnaní s tzv. „voľnými priestormi", ktoré ponúkajú ich užívateľom širokú škálu afordancií. Športová činnosť zvaná parkour často spochybňuje zaužívaný postoj k prostrediu: ľudia praktizujúci parkour (tzv. *traceur-i*) trénujú schopnosť „rozvoľniť" priestor objavovaním nových afordancií, aj v pôvodne mono-funkčnom prostredí, tým, že štruktúry urbánneho priestoru využívajú kreatívnym spôsobom. Cieľom tejto práce je pokus o interdisciplinárne porozumenie významu interakcie človeka s prostredím a to overením hypotézy, že tréning parkouru má priaznivý vplyv na divergentné myslenie (DT, z angl. „divergent thinking", ktoré je jedným z aspektov kognície. DT, ako typ kreatívneho myslenia, opisuje schopnosť generovať celý rad rôznych nápadov ako možných riešení jedného problému. *Traceur-i* by mohli využívať podobný podobný typ myslenia pri „rozvoľňovaní" mestského priestoru.

V mojom experimente skupina *traceur-ov* riešila dve úlohy na DT, pred a po tréningu parkouru v neznámom prostredí. Ako kontrolnú skupinu som si vybrala gymnastov, ktorí namiesto parkour-u trénovali na gymnastickom náčiní. Úlohy na DT boli u oboch skupín vyhodnotené pomocou novej výpočtovej metódy bodovania založenej na sémantickej vzdialenosti.

Výkon v DT účastníkov sa líšil v závislosti od typu úlohy: zatiaľ čo jedna úloha naznačovala zvýšený počet nápadov po tréningu, druhá ukázala zníženú originalitu u všetkých účastníkov. Navyše, *traceur-i* mali v porovnaní s gymnastami vyšší počet nápadov, ktoré boli originálnejšie. U všetkých účastníkov výkon v DT meraný pred a po tréningu pozitívne koreloval, čo naznačuje, že moja metóda bodovania je prijateľne použiteľná.

Hoci moje výsledky nie sú konzistentné, podarilo sa mi navrhnúť a uskutočniť prvotný exploratívny krok k prepojeniu enaktivistického prístupu, s kreativitou, konceptom afordancií a urbanistickým dizajnom. Táto práca poskytuje novú paradigmu na skúmanie toho, ako môže fyzická aktivita a interakcia s prostredím ovplyvniť kognitívne schopnosti.

Kľúčové slová: enaktivizmus, afordancie, urbánny dizajn, kreativita, divergentné myslenie, parkour

Table of Content

1 Introduction

1.1 4E cognition: embodied, embedded, extended, enactive

In the early beginnings of cognitive science, researchers focused on cognition as a phenomenon which took place "in the head", as Clark and Chalmers (1998) described it later. Everything surrounding the head was thought to enter cognition only as an input which was then converted into a mental representation. Cognitive processes were thought to be fully explainable by studying only the brain (Newen, De Bruin, & Gallagher, 2018). Decades later, with additional contributions from neuroscience, philosophy, and anthropology, newer theories which challenged the traditional understanding of cognition, began to become more popular (Thagard, 2005). Since the brain stands in close connection to the body, which is again in permanent interaction with the environment, cognition was found to be something that cannot be fully understood by observing the brain in isolation (Newen et al., 2018). The 1990s brought a spate of publications emphasizing the necessity of studying the brain, the body, and the environment as one inseparable system (e.g. Clark & Chalmers, 1998; Hutchins, 1995; Varela, Thompson, & Rosch, 1991). Later, their theories were brought together under the umbrella term of 4E cognition, referring to cognition as embodied, embedded, extended, or enactive, terms which will now be explained in further detail.

Embodied describes the possible involvement of extracranial processes in cognition (Newen et al., 2018). These processes can either occur bodily or even extrabodily, which also includes the agent's environment. *Extended* and *embedded* theories all take an extrabodily perspective, but they disagree on whether cognitive processes are partially constituted by extracranial processes (extended), or whether they only partially depend on them (embedded; Kiverstein, 2018). Thus, the debate shifted from what is involved in cognition towards where it can be located. The *enactive* approach does not only promote an involvement of extrabodily processes in cognition, but even goes one step further by claiming that cognition is at least partially dependent or even constituted by the ability or disposition to act. Its defenders, therefore, consider active engagement in and with the

environment as an important part of the emergence of cognitive processes (Newen et al., 2018).

1.2 Cognition in a physical environment

As stated above, the environment's role acquired greater importance in cognitive science(s) with the rise of 4E cognition and more specifically enactivism. Cognition appears to not only emerge from the brain or an organism itself, but rather from an active interaction with the environment (Newen et al., 2018). Hence, also the concept of affordances deserves a vast amount of attention. Affordances or action potentials, as Glăveanu (2016) calls them, describe possible interactions the environment offers an animal (Gibson, 1979). What made this term in some way revolutionary was its bidirectionality: on the one hand, an affordance is provided by the object, and, on the other hand, it also has to be perceived by the observer. It unites the physical (i.e. the environment) with the psychological (i.e. the observer), the objective with the subjective. Our surroundings can, therefore, strongly influence or even constitute our cognition and conceptions of the world. To give an example, pre-school children passing a more natural environment on a daily basis were shown to have developed a lower emotional and cognitive appreciation of the connection between humans and nature (Matteo Giusti, Stephan Barthel, & Lars Marcus, 2014). The broad perspective on perception in everyday life as an interactive process also impacts other domains, such as urban design or research on creativity. In the following sections, I will explain their relationship with a focus on the concept of affordances and investigate the roles of the body and the environment for creative performance and human wellbeing.

1.2.1 Affordances in urban design

Affordances play a fundamental role in urban design, as they could be considered as what design is actually about (Norman, 2013). But the crucial point is that affordances cannot merely be designed in a top-down approach and imposed on the users, as they have to emerge mutually from both sides, i.e. the users and the environment. However, the traditional approach in post-industrial urban design is, in fact, that designers create demands on how humans should behave, and physically force them into doing so, instead

of engaging and motivating them (Marcus, Giusti, & Barthel, 2016). This is reflected in the fact that most structures in urban space are designed for a specific use, providing only few affordances. A typical example would be an escalator in a metro station: people have no choice but to use it if they want to leave the station and its only affordance (perceivable by the general population) is to go up or down. Franck and Stevens (2007) introduced the term *tight spaces* to refer to monofunctional spaces such as these, which are often visible in cities nowadays. They contrast them with *loose spaces* such as parks or squares, which are characterized by offering their users a large variety of affordances. Loose spaces are generally perceived as more vivid and lively and allow their users to come up with new affordances themselves. Keeping and increasing the number of loose spaces in cities should be considered a requirement to ensure a high quality of life in spite of a growing population.

1.2.2 Parkour as a case of extended affordances

However, small groups of people have recently started to actively increase the amount of loose spaces around the world: the sport of parkour holds a huge potential to change attitudes towards space. It is often performed on monofunctional concrete structures such as stairs or walls in urban environments. Its practitioners, so-called traceurs, have the ability to *loosen up* spaces by finding additional affordances and actively using urban structures in unconventional ways (Ameel & Tani, 2012b). They thereby transform tight spaces into looser spaces. Their extraordinary approach towards their environment makes them an ideal group to study how a different attitude towards a person's surroundings might affect their cognition. Some traceurs even stated that doing parkour made them change their sense of aesthetics in their everyday environment and allowed them to develop emotional and embodied bonds to their surroundings (Ameel & Tani, 2012a; Saville, 2008). Parkour can be described as a creative and playful reinterpretation of the environments' meanings (Bavinton, 2007).

Traceurs newly assess their surroundings in terms of how people should, would, and could use them, which matches Glăveanu's model of creativity (2012, 2016). He offers a new perspective on what is considered to be creative with regard to the theory of affordances. His model consists of three aspects: normativity (what we *should* do), intentionality (what

we *would* do), and materiality (what we *can* do). According to Glăveanu, creative ideas lie outside the intersection of these three. As most uses of the environment in parkour are rather unconventional with respect to the general norms, it can be considered a highly creative practice. Furthermore, parkour is often related to a sense of freedom (Ameel & Tani, 2012a), which is normally considered as a core feature for creativity (Dul, 2019).

1.3 Creativity

1.3.1 What is creativity?

The question of what the phenomenon of creativity actually describes turns out to be rather complicated. However, there is a widely accepted core definition: creativity is something new and task-appropriate (Kaufman & Glăveanu, 2019). Referencing William James' famous quote, "Everyone knows what attention is" (James, 1890), it also appears that everyone knows what creativity is. After (by-)passing the question of a definition, we are faced with a multitude of theories, all focusing on different aspects, such as how it is operationalized, what is needed to be creative, or how creativity can be enhanced. Overall, none of them seems to have appropriated a dominant role. But since creativity is such a complex domain, it remains doubtful that any understandable theory would ever be able to cover all its aspects. Therefore, Kaufman and Glăveanu (2019) argue in favor of a coexistence and acceptance of various theories tackling different questions.

One of the main current directions in creativity research is to move away from personal attributes towards support systems and other resources needed to be creative (Kaufman & Glăveanu, 2019). However, to date the focus has mainly been on the socio-cultural domain of this aspect (Dul, 2019). Not only in cognitive science(s) in general but also in creativity research, the wide neglect of the role of the physical environment is apparent. Recent estimates suggest that approximately 40% of the context's effect on creativity can be explained by the physical environment (Dul, 2019; Dul, Ceylan, & Jaspers, 2011; Horng, Tsai, Yang, Liu, & Hu, 2016), indicating a great necessity for its closer investigation. Creativity is a cognitive process, and since cognition can be treated as not just happening 'in the head' (see chapter 1.1 4E cognition: embodied, embedded, extended), the investigation of creative processes cannot be reduced to the brain either. Instead, creativity

should be considered a phenomenon emerging from both, humans and their surroundings, in close interaction (Glăveanu, 2012).

Dul (2019) recently created a theoretical framework on how the physical environment could be linked to creativity based on a combination of previously published findings and ideas. This framework consists of three paths possibly modulating creativity: functionality, meaning and mood. *Functionality* is assumed to be a prerequisite, as the environment needs to allow a person to behave in a certain way by technically providing additional affordances. *Meaning* refers to qualities, people attach to their environment. Freedom, inspiration, interaction, privacy, and relaxation were shown to be creativity enhancing meanings (Dul, 2019). *Mood* can also affect creative performance: activating states like happiness, anger, or sometimes even fear, were found to foster creativity (Baas, 2019).

However, there seem to be two different underlying mechanisms: whereas activating negative moods might enhance creativity by enabling the individual to follow ideational paths in great depth (see Baas, 2019), positive activating moods appear to promote creative performance, as they might facilitate a less goal oriented approach, and therefore improve flexibility (Dreisbach & Goschke, 2004). As suggested by Hommel (2015), this increased flexibility, which might be caused by an impaired top-down control, could possibly account for a better creative performance. In fact, Radel, Davranche, Fournier, and Dietrich (2015) found higher scores in divergent thinking performance (see section 1.3.2.1 Originality scoring methods) after they exposed their participants to a task that required strong inhibitory control for an elongated time period. Oppezzo and Schwartz (2014) could show that walking increased creative performance as compared to sitting or being pushed in a wheelchair. Their experiment was replicated and refined by Zhou, Zhang, Hommel, and Zhang (2017), who observed a higher divergent thinking performance when people could walk around freely wherever they wished, as compared to constrained walking, where a path to walk on was given. Additionally, they found that standing was more beneficial for creative performance than sitting or lying. The findings by Oppezzo and Schwartz (2014) and Zhou and colleagues (2017) could possibly be explained by control-depletion: physical activity, such as standing or walking (especially when it is unconstrained) requires more control than sitting. This might exhaust cognitive control to

some extent, which would explain an improved ability of flexible thinking, and therefore creative performance (Zhou et al., 2017).

1.3.2 Creativity assessment

Plucker, Makel, and Qian (2019) divide the ways in which creativity is approached psychometrically into four different groups: the creative process, personality and behavioral correlates, characteristics of creative products, and attributes of creativity fostering environments. The most prominent is the assessment of the creative process in the form of divergent thinking (DT) tasks. As opposed to convergent thinking, which refers to the ability to derive one answer from combining various facts, DT describes the generation of a wide variety of different ideas as possible solutions to a problem (Figure 1; Guilford, 1967). There is a multitude of tasks which were developed within the last century, focusing on its different aspects, such as verbal or figural DT (e.g. Guilford, 1967; Torrance, 1974, 2008; Wallach & Kogan, 1965). One of the most commonly used tests is the Alternate Uses Task (AUT; Guilford, 1967). In this task, the participants are asked to generate as many alternative ideas as possible about how a given object (e.g. a paperclip) could be used.

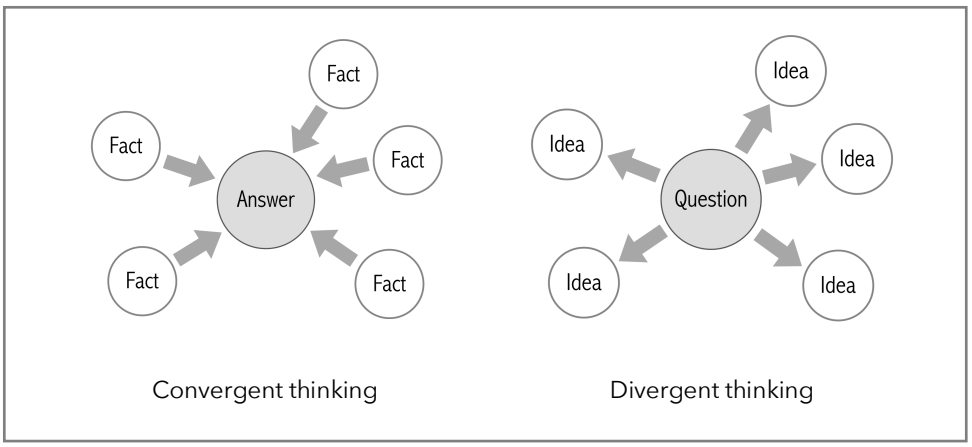

Figure 1. Difference between convergent and divergent thinking.

Although the tests differ in their exact content and administration, they are usually scored on some of the same four dimensions, which are fluency, flexibility, elaboration, and originality. Fluency is simply the number of ideas a participant came up with during a task, making it objective and fast to determine. Therefore, fluency is one of the most frequently used dimensions. However, quantity is, of course, not the only component of DT or

creativity. Flexibility describes the variety of ideas a person develops. Someone who has many ideas that are conceptually different scores high on flexibility. A dimension which is generally used less often is elaboration. It describes how much people go into detail when describing any ideas. Usually, it is simply administered as the number of words per idea. The last and probably most important dimension I would like to explain is originality. It is a measurement of an idea's uncommonness, as compared to general values and norms, or to the experiment's sample, depending on the scoring method. (Guilford, 1967; Plucker et al., 2019)

As I consider originality a crucial dimension for creativity, I will now proceed to explain the several ways in which it is scored in greater detail.

1.3.2.1 Originality scoring methods

Basically, there are two types of scoring methods: on the one hand, there are the traditional methods, relying on subjective ratings while, on the other hand, there are some more objective methods that have been developed within the last decades (Acar & Runco, 2014; Beketayev & Runco, 2016; Dumas & Dunbar, 2014; Forster & Dunbar, 2009; for a review see Acar & Runco, 2019). The most used traditional scoring system – the so-called *average scoring* – relies on a group of judges who rate each idea's originality (e.g. Sternberg, 2006). These scores are then averaged across all ideas of a participant. Despite the training on how to rate the ideas (which is usually administered), this method still remains subjective and the judgements could be biased by preceding ideas. A less time-consuming subtype of the traditional scoring method is called *top-two scoring* (e.g. Silvia, 2011). In this case, each participant is asked to choose their top two original ideas, which are rated and averaged later on, while all the other ideas are discarded. Unsurprisingly, average scoring is generally more reliable than top-two scoring, as it gives a broader picture of an individual's skills (Silvia, 2011).

As a response to the traditional subjective assessment methods, the more objective sample-based infrequency count was introduced: from the pool of all ideas the participants came up with during an experiment, originality is evaluated as a function of frequency, so that the least frequent ideas are classified as being the most original (Acar, Abdulla Alabbasi, Runco, & Beketayev, 2019; Beketayev & Runco, 2016). However, this method greatly

depends on the sample, which means that it could lead to biased results, especially if the sample size is small (Reiter-Palmon, Forthmann, & Barbot, 2019). On the contrary, DT performance appears to be very sensitive towards various testing conditions (Acar et al., 2019), and, therefore, it could also be advantageous to be able to assess originality from the viewpoint of a specific sample.

Further objective methods that might be a better choice, especially when investigating smaller samples, are based on the semantic distance between a given prompt (i.e. the given object in the AUT) and any idea (i.e. any given object's alternative use). The assumption behind the use of semantic distances to measure originality (or, in the broader sense, creativity) is that creativity could be defined as something that departs from what is usual (Guilford, 1967). On the supposition that the usual is semantically closely associated, original ideas would have a high semantic distance from the prompt. To give an example, I assume that a brick is *closely* associated to building a house by most people, but rather *remotely* associated to using it as a nutcracker. Therefore, using a brick as a nutcracker is regarded as a more original idea. Nevertheless, the idea of putting semantic distance on a level with originality has to be treated with caution as they are not identical (Hass, 2017).

Some of the first to propose an attempt towards scoring literal DT tasks like the AUT by the use of semantic networks were Acar and Runco (2014). They used three different networks to create lists of words and concepts that are closely related to the given objects. These related terms included hyponymies (subordinate terms), sister terms, hypernymies (superordinate terms), meronymies (describing a part of a whole), and holonyms (describing a whole with different parts). According to the scoring lists, the participants' ideas were then classified as *close* or *remote*: if the idea's words were included in the list, it was classified as *close*, otherwise as *remote*. This relatively easy operation of screening and matching ideas was executed by means of a computer program, making the process less time-consuming than traditional approaches. Nevertheless, it resulted in discrete ratings, meaning there was no possibility for any fine-grained distinctions between close and remote associations.

Another method that allows for more detailed investigations of semantic distance is the use of latent semantic analysis (LSA; Evangelopoulos, 2013). LSA is a technique to capture semantic relations of words (Deerwester, Dumais, Furnas, Landauer, & Harshman, 1990),

as their meanings are inferred from a statistical analysis of large amounts of texts: words that co-occur often are assumed to be more closely related (Forster & Dunbar, 2009). Each word is then represented by a vector in a multidimensional space (Dumas & Dunbar, 2014). By calculating the cosine similarity, which is the cosine of the angle between two word vectors, the semantic similarity of the words can be determined (Figure 2). The cosine similarity is related to the distance between two vectors that are representations of words in this case (Landauer & Dumais, 1997). The lower the similarity, the greater the angle. Therefore, large angles account for high originality measures.

Using LSA for originality scoring is, in contrast to the sample-based infrequency count, relatively robust in terms of measurement errors or small sample sizes, as long as the text corpus, which is used to train the vectors, is large enough (Dumas & Dunbar, 2014). Forster and Dunbar (2009) correlated originality scores that were created by the use of LSA, with rated creativity by untrained judges and found that they better predicted the subjective creativity ratings than fluency or elaboration counts.

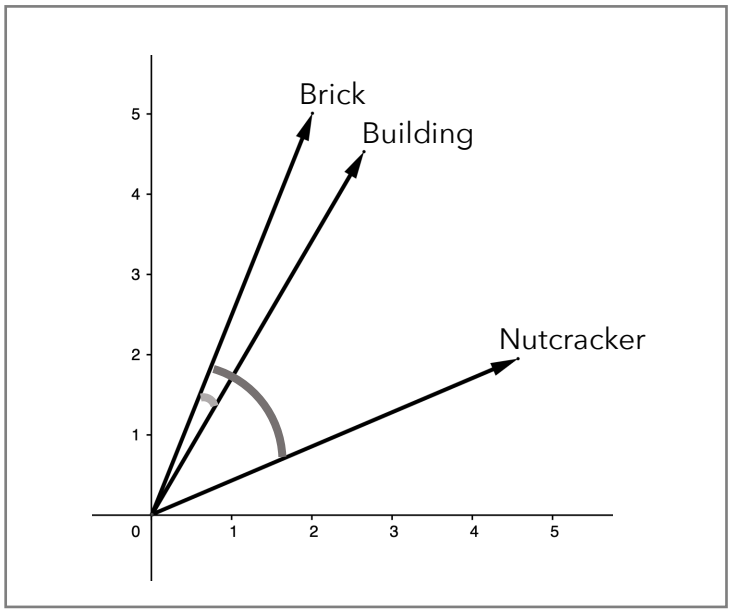

Figure 2. Schematic representation of semantic similarities in a two-dimensional space (for simplification). The angle between "brick" and "nutcracker" (dark gray) is larger than the angle between "brick" and "building" (light gray), depicting less semantic similarity (i.e. larger semantic distance) between "brick" and "nutcracker". Therefore, "nutcracker" is assumed to be a more original use for a brick than "building".

While LSA relies on external criteria (text corpora) only, there is another originality scoring method also incorporating internal criteria (responses to DT tasks): Semantics-

based algorithms are similar to LSA, as they also make use of semantic similarities. However, these are weighted according to other participants' responses to the same task (Acar et al., 2019), which might be useful under the considerations mentioned above in relation to sample-based infrequency counts.

To summarize, there is no general agreement on any scoring procedure yet. Although the more recent computerized methods such as LSA and semantics-based algorithms are objective and cost-efficient, they are still far from being the standard scoring method of choice (Kenett, 2019).

1.4 My experiment

To date, the empirical account on investigating the influence of the physical environment on creativity is only sparse (Dul, 2019). The aim of this thesis is, therefore, to approach an interdisciplinary understanding of the importance of human-environment interactions by exploring their impact on DT in an empirical field study. The main focus is to investigate whether traceurs' DT performance improves after a parkour training session as compared to before. The reason why I assumed that this could be the case was their extraordinary attitude towards space (see 1.2.2 Parkour as a case of extended affordances). Traceurs may be subject to a process similar to DT, as they develop various new affordances for the environmental structures they encounter (Ameel & Tani, 2012b; Bavinton, 2007). Thereby, they might practice a kind of DT, which could possibly reflect on their performance in other DT tasks. As a control group, I selected people who do gymnastics, as these two sports are similar in terms of movement but their rules are almost opposite: in gymnastics all exercises are clearly defined, and there is absolutely no freedom for developing new affordances of how to use gymnastics equipment creatively (International Gymnastics Federation, 2018). Parkour, in contrast, does not have fixed rules at all. Although both, parkour as well as gymnastics, consist of highly complex movements, one could argue that parkour is slightly more demanding in terms of cognitive control. Similar to walking freely as compared to constrained walking (see 1.3.1 What is creativity?; Zhou et al., 2017), doing parkour could be slightly more cognitively demanding because the traceurs have to constantly decide among the almost unlimited amount of affordances the city offers. According to the abovementioned control-depletion approach (see 1.3.1 What is

creativity?), which claims that an exhaust of top-down control could benefit flexibility, traceurs would therefore perform better on DT tasks. Additionally, Oppezzo and Schwartz (2014) found that a creativity boost induced by walking persisted even after sitting down. Therefore, a possible increase in DT performance after doing parkour can be expected to endure when testing the traceurs shortly after instead of during the training session.

I also assumed that the DT performance of the gymnasts would increase, although not as much as that of the traceurs. The relationship between sporting activity and DT is still ambiguous: whereas, light bodily activity, such as walking, seemed to affect DT positively (Oppezzo & Schwartz, 2014; Zhou et al., 2017), more strenuous physical exercising, like cycling, appeared to be rather disadvantageous with regards to flexibility scores (Colzato, Szapora, Pannekoek, & Hommel, 2013). However, their experiment did not reveal any significant changes in terms of originality, fluency, and evaluation.

Not only did I compare the participants' performance in a within-subject design between before and after training, I also contrasted the traceurs' differences from before to after training with those of the gymnasts to assess whether the possible change in DT performance was greater when doing parkour. This would be the case if not only the sporting activity itself, but also the extraordinary interaction with the environment influenced DT. Since there were no differences between traceurs' and gymnasts' changes in DT performance from before to after training, I also tested for changes across all participants, which would indicate that gymnastics, as well as parkour affected DT.

One could argue that creative people per se show more interest in unconventional sports like parkour, where they can express themselves. In this case, a ceiling effect could be encountered, which would make the traceurs' possible improvement after training appear smaller. To account for that, I compared the baseline DT performance between groups. Furthermore, practicing parkour could also have beneficial long-term effects on creative thinking. Therefore, I also decided to test whether traceurs with more training experience performed better in DT.

Furthermore, I created a simple computerized semantics-based scoring method for literal DT tasks in German, following a semantics-based approach. This allows an objective and quick evaluation of participants' ideas on literal DT. In this experiment, I offer some first

insights into this method's feasibility for assessing originality. Therefore, I checked for within-subject correlations between before and after training, which would be expected if my method created meaningful scores, because the participants' performance after training should obviously depend on their performance from before. Nevertheless, I would like to emphasize that this does not support the view that my method could in fact be used to assess originality. Regardless of my results, it still requires proper testing for reliability and validity in the future.

To summarize, my experiment is to some extent groundbreaking in a twofold manner: on the one hand, I offer an empirical approach to 4E cognition and its implications on urban design with an emphasis on active interaction with the physical environment. On the other hand, I offer a first attempt towards an objective scoring method for assessing originality based on literal DT tasks in German.

1.4.1 Hypotheses

The present study investigates if and how unconventionally using the environment could influence DT. I hypothesized the following: (H1) The difference in fluency and originality between before and after a training session is higher when doing parkour than doing gymnastics; (H2) Fluency and originality in DT tasks are improved directly after a training session, as compared to before; (H3) Traceurs' fluency and originality are higher than those of gymnasts; (H4) Baseline fluency and originality are higher the more training experience a traceur has; (H5) Originality before and after a training session correlate across all participants.

2 Material & Methods

2.1 Participants

A group of traceurs (n = 27, 10 women, 17 men, M_{age} = 24.04 years, SD = 7.29 years, age range: 15-53 years) was compared to a control group of gymnasts (n = 18, 13 women, 5 men, M_{age} = 28.06 years, SD = 14.32 years, age range: 15-59 years). All participants were healthy, based in the area of Vienna (Austria), and spoke German, which was the language the experiment was conducted in, on a native speaker level. They were required to practice parkour or gymnastics regularly but people with different levels of expertise from beginners to experts were included (Table 1). One gymnast had to be excluded from all analyses because of a foot injury making him unable to participate in a proper training session, as well as one traceur because he did not fulfill the language requirements. Their data is also not included in any statistics mentioned above. Gymnasts and traceurs showed a similar distribution regarding their level of education (Table 2) and their current mood, which was represented by five smiley faces ranging from very sad to very happy (Table 3).

Table 1

Level of expertise in comparison between traceurs and gymnasts

	n		%	
	Traceurs	Gymnasts	Traceurs	Gymnasts
Beginner	5	1	18.52	5.56
Intermediate	20	12	74.07	66.67
Expert	2	5	7.41	27.78

Table 2

Level of education in comparison between traceurs and gymnasts

	n		%	
	Traceurs	Gymnasts	Traceurs	Gymnasts
University	9	5	33.33	27.78
High School	15	6	55.56	33.33
Vocational school	0	3	0	16.67
Compulsory school	2	4	7.41	22.22

Table 3

Traceurs' and gymnasts' current mood as evaluated via smiley faces

	n		%	
	Traceurs	Gymnasts	Traceurs	Gymnasts
Very sad	0	0	0	0
Sad	0	0	0	0
Neutral	2	2	7.41	11.11
Happy	16	8	59.26	44.44
Very happy	9	8	33.33	44.44

I recruited the traceurs via the community of *Parkour Vienna*, whereas I gathered the gymnasts from the sports institute of the *University of Vienna* (*USI*), and two gymnastics associations based in Vienna (*WAT Rudolfsheim, TV Alsergrund*).

2.2 Experimental procedure

The traceurs participated, one at a time, at a chosen spot in Vienna (Figure 3), which was new to them to provide the possibility of coming up with affordances themselves when doing parkour, rather than recalling them from memories of previous training sessions. I wanted the spot to have a wide variety of environmental features so that everyone, from beginner to expert, would find something to do there. It offered numerous different affordances, as it had railings of various heights and distances between each other. The stairs, as well as the walls and the ramp for wheelchair access, also provided interesting

opportunities. Behind the bushes at the back, there was a low fence, and some participants even used the traffic signs.

Figure 3. Location of the traceurs' experiment at a public space in Vienna.

Figure 4. One of three gyms where the gymnasts were tested.

The gymnasts were tested in gyms to obtain the possibility of using their gymnastics equipment (Figure 4). Because of financial constraints and practical reasons, I conducted their sessions in small groups from two to eight people. Just one gymnast was alone because the other participants who should have joined that day did not show up. Each session took place in one of three gyms: five subjects were invited to a rented gym that was

new to them, whereas the others were tested in their association's gym during one of their regular training sessions. In these cases, the experimental procedure was adapted slightly to fit their requirements, as explained below.

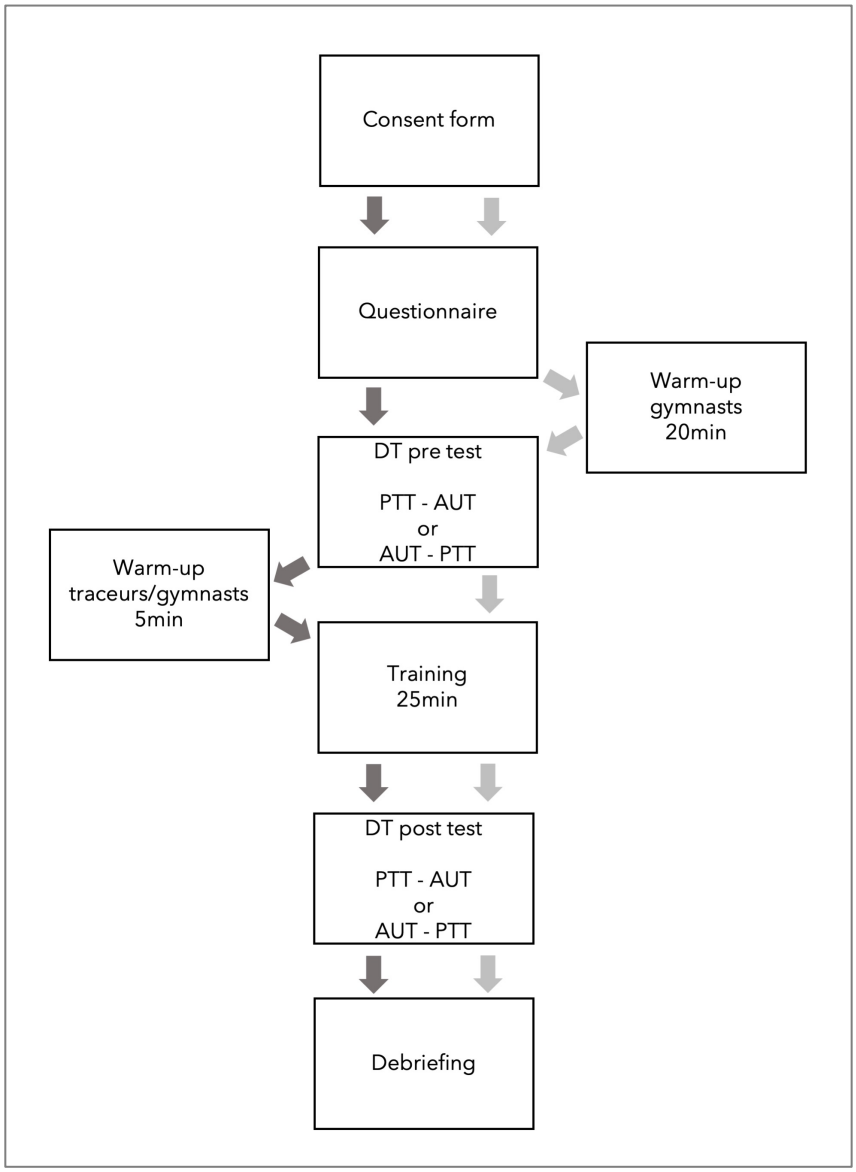

Figure 5. Experimental procedure. DT (divergent thinking) was tested before and after the training session. The order of the tests (AUT = alternate uses task, PTT = plot titles task) was randomized between participants but kept the same in the pre and post condition for each subject. All traceurs and the five gymnasts tested in a rented gym (represented by dark gray arrows) had a short warm-up session of 5min right before the training. The other gymnasts who were tested during their regular training session (light gray arrows) had a longer warm-up session which was shifted to before the DT pre-test to keep the time frame between pre and post test as similar as possible for all groups.

An overview of the experimental procedure, which I will now explain in further detail, is depicted in Figure 5. After welcoming the participants and a short explanation of the procedure, they signed the consent form (Appendix A, Appendix B). Additionally, I asked if they consented to having photos or video recordings of them published in scientific publications and gave them another form to sign if they agreed. Everyone who did not approve could still participate but was not video recorded or photographed. Afterwards, they filled in a short questionnaire to assess their sex, age, educational status, current mood, time of experience in gymnastics/parkour, average frequency of training, and self-rated level of expertise in gymnastics/parkour (Appendix C, Appendix D). The participants were unaware of the other group of athletes they were compared to, and oblivious of my hypotheses until the debriefing at the very end.

The experiment's main part involved a DT test before and after a training session. The DT tests consisted of two tasks each: the AUT (Guilford, 1967) and the Plot Titles Task (PTT; Guilford, 1967), which were presented in randomized order. As mentioned in the introduction, in the AUT, the participants are asked to generate as many alternative ideas as possible about how a given object could be used. In our experiment, a paperclip and a brick (Guilford, 1968) were provided as written words in randomized order, one in the pre- and the other in the post-test (Appendix E, Appendix F). In the PTT, subjects are asked to read a short story and generate as many titles as possible that fit the given story (Appendix G, Appendix H, Appendix I, Appendix J). The two stories I used both had an original content. I took them from Strasbaugh (2019) and translated them to German because I did not find any published stories for the PTT in German which were free to use.

After a short verbal explanation by the experimenter(s), emphasizing that there were no wrong answers, I gave the participants additional written instructions (Appendix K, Appendix L, Appendix M, Appendix N) and the possibility to ask questions to make sure they fully understood the tasks. The instructions focused on fluency ("so viele […] wie möglich", meaning "as many as possible") as well as creativity and quality ("kreative, interessante, ungewöhnliche oder witzige", meaning "creative, interesting, unusual, or funny"), as the combination of quantity and quality instructions seems to boost performance in DT tasks (Acar, Runco, & Park, 2020). Each participant had three minutes to solve each task.

After taking the pre-test, the traceurs trained autonomously for 25 minutes, including approximately five minutes of warm-up and a gradual transition to actually doing parkour. The only instruction given was to use the available environmental structures in many different ways, instead of focusing on perfecting one specific movement. To provide some insight for any readers who might not be familiar with the sport of parkour, Figure 6 shows some examples of exercises the traceurs carried out. During the training, I filmed the participant to be able to assess the number of different usages of each environmental structure later on. The recordings were taken from the opposite side of the street to give the participants more freedom. By the time of submission, this data had not been analyzed yet.

Figure 6. Examples of exercises the traceurs carried out during the experiment.

The gymnasts' procedure differed, according to whether the experiment was conducted in a rented gym, which applied for five participants, or in their association's gym. The formers' procedure was very similar to that for the traceurs: they warmed-up for five minutes immediately before the training session. However, the warm-up exercises were pre-specified and demonstrated by an experimenter to reduce any possibilities of thinking creatively from the beginning. Afterwards, the main training session started during which the gymnasts absolved a circuit training consisting of 15 stations with given tasks to do on

several different types of gymnastics equipment or mats for a fixed amount of time (Figure 7). The time was given by a beeping sound. Each participant started on a different station with a large enough distance between them, so they would not cluster at the stations where they were asked to spend more time.

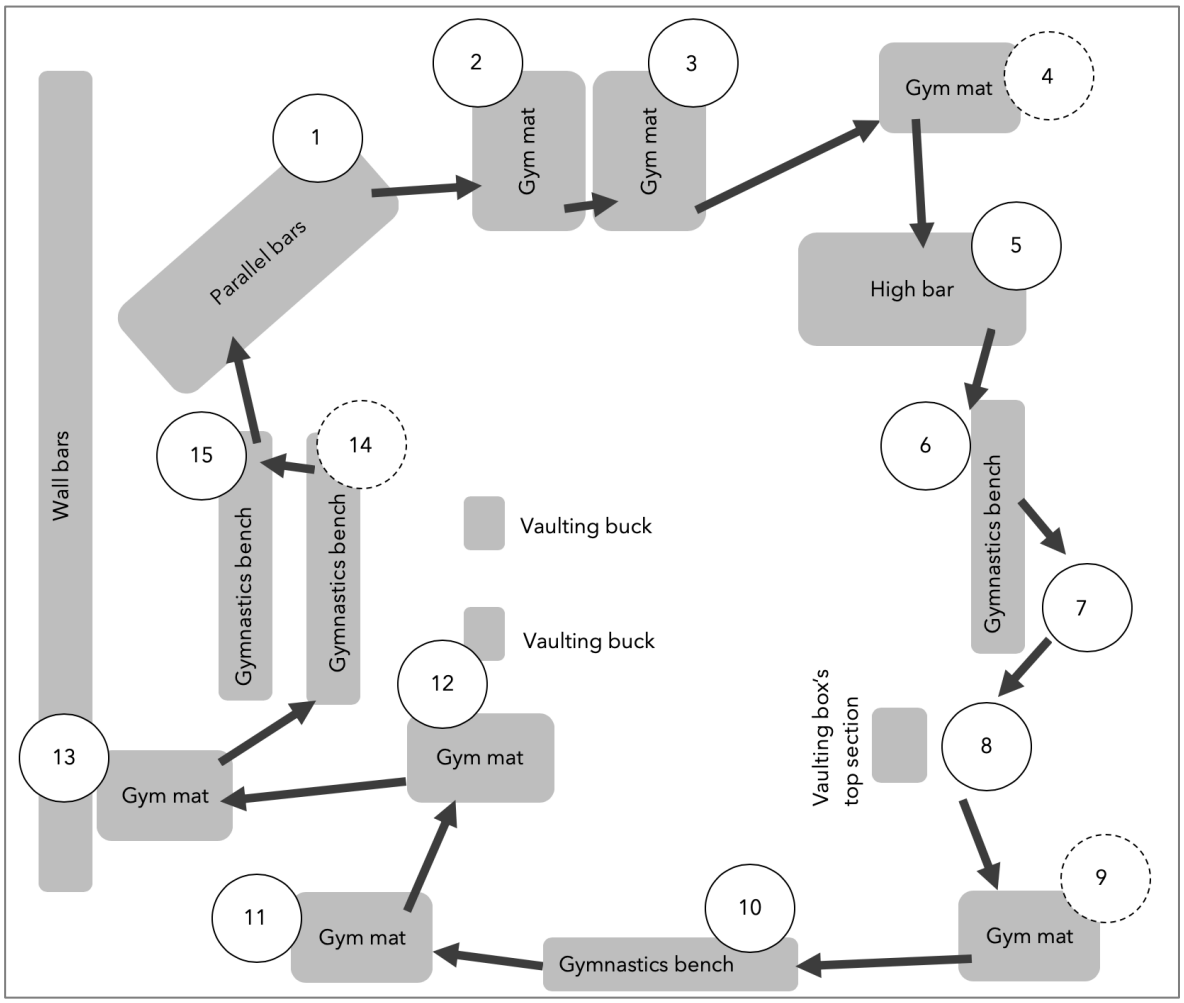

Figure 7. Course of the gymnasts who were training in a rented gym. Each number represents a different exercise. Those with solid circles had to be done 2 x 20s with a break of 25s in between. The exercises represented by dashed circles had to be done continuously for 135s.

The other gymnasts, who I tested during their regular training session, asked for a longer warm-up time for safety reasons, as their exercises were more advanced. To keep the time window between the DT pre- and post-test as similar as possible, I shifted their warm-up session to before the DT pre-test. The participants who were tested in their associations' gyms also had a different style of training because I wanted it to be similar to their usual sessions. Instead of doing circuit training, they could individually move between different gymnastics equipment. However, they all trained to do very specific movements or

exercises on each of them and had no intention of using any of the equipment in a creative or unusual way. Members of the circuit training group had no possibility to talk to each other during the training, whereas the others had to help and secure each other for some exercises and therefore did communicate with each other.

After the training session, I asked the participants to do the two DT tasks again in the same order as before but with the other object and story, respectively. I reminded them verbally of the instructions to make sure they focused on producing many highly original answers again. In the end, I debriefed them and gave them some candy as a thank-you gift for their participation.

2.3 Analyses

2.3.1 Scoring DT tasks

The DT tasks were evaluated on the two most-common dimensions: fluency and originality. To assess the fluency, I simply counted the number of ideas a person came up with for each task (Guilford, 1967). To create originality scores, distributed word representations were used, which were treated similarly to semantic information obtained from LSA (Beketayev & Runco, 2016; Dumas & Dunbar, 2014; Dumas & Runco, 2018). They enabled a time-efficient objective evaluation of each response without the need for experienced raters. The program[1] I created for this purpose accesses the German word vectors by Grave, Bojanowski, Gupta, Joulin, and Mikolov (2018), which were trained on Wikipedia and Common Crawl (Common Crawl Foundation, n.d.) using an extension of the CBOW model with position-dependent weights (Mikolov, Sutskever, Chen, Corrado, & Dean, 2013). The initial objects (paper clip and brick) and stories, as well as each idea created by a participant, was converted into a vector. If the participants' responses contained words that the model could not recognize, I used synonyms instead. I separated compound words in case they were not recognized. There were a couple of occurrences of newly invented words that were an assemblage of existing words. In this case, I split them to enable the program to find their vector representation (e.g. "algebracadabra" was

[1] https://github.com/JohannaKoellner/dt-scoring

converted to “algebra abracadabra”). In the AUT some participants tended to describe their ideas more elaborately, whereas others simply used some keywords to describe their ideas only roughly. To reduce noise, I removed stop words (e.g. conjunctions and other words which were not related to the actual idea), as suggested by Forthmann, Oyebade, Ojo, Günther, and Holling (2019) and Foster and Dunbar (2009) before feeding the data into my program. The PTT’s stories were handled in the same way.

To get only one vector for each story or idea even if they consisted of several words, the operation shown in Equation 1 was performed. It resembles the fastText (Facebook Inc., n.d.) *get_sentence_vector* function (Joulin, Grave, Bojanowski, & Mikolov, 2017). Its purpose is to average all word vectors of a text to create one vector representing the text’s overall semantics. Since the semantic information lies in the vectors’ direction instead of their magnitude (see Landauer & Dumais, 1997), the unit vectors are used. As stated in the numerator, they are calculated by dividing any word vector by its L2 norm, which is its length. All the unit vectors are then summed up, and divided by the number or word vectors, resulting in a vector pointing in the average direction of all word vectors that were fed into the formula.

$$\frac{\Sigma\left(\frac{\text{word vector}}{\text{word vector's L2 norm}}\right)}{\text{number of word vectors}}$$

Equation 1. Formula I used for averaging word vectors.

The cosine between each given vector (brick’s, paperclip’s, or story’s vector) and each idea’s vector was calculated to represent their semantic similarity. It was then subtracted from 1 to convert it into a semantic distance score ranging from 0 (very similar) to 2 (very distant; Acar & Runco, 2019; Dumas & Dunbar, 2014). For each participant I created one score per task by averaging the semantic distances between their ideas and the given object/story, resulting in four originality scores per person (AUT brick, AUT paperclip, PTT story 1, and PTT story 2). Eventually, originality as well as fluency scores were transformed into relative numbers by dividing each through the highest achieved score per task. These relative scores were used for all further analyses.

2.3.2 Statistical analyses

All statistical analyses were performed in IBM SPSS Statistics 23. One parkour practitioner was left out wherever the PTT pre-test scores were needed because they refused to solve this task. In order to test whether the type of training or the physical activity during the training influence DT performance (H1-H3), I ran a 2 × 2 mixed analysis of variance (ANOVA). I used Time (before vs. after the training session) as a repeated measures variable and type of Sporting activity (parkour vs. gymnastics) as an independent measures variable. To test if the required assumptions for a mixed ANOVA were met, I conducted a couple of tests and transformations I will now explain in further detail. First, I applied Shapiro-Wilk tests to see if all subgroups were approximately normally distributed. This was the case for all originality scores, but the fluency scores of both tasks (AUT and PTT) showed some skewness. Therefore, I applied logarithmic transformations for all fluency scores to normalize them, which was successful according to further Shapiro-Wilk tests. The Levene's test for homogeneity of variances and the Box's test of homogeneity of covariances showed that variances and covariances could be assumed to be homogeneous. Even though my data contained some outliers, I decided to keep them as they were because most of them appeared in the gymnasts' groups that had a very small sample size. The application of any common method for dealing with outliers, such as trimming or winsorization would have required to change or even remove about a third of the gymnasts' data which I tried to avoid. However, the mixed ANOVA can be sensitive to outliers, so my results must be taken with a grain of salt.

I will now present further details in the order of the hypotheses (see section 1.4.1 Hypotheses). For simplicity, I refer to fluency and originality, as assessed by the AUT and the PTT on the DT dimensions of fluency and originality, as "DT performance". The analyses for H1-H3 were covered by the ANOVA. Any other analyses are described in the respective section below.

(H1) To assess whether the change in DT performance from before to after the training session was higher for traceurs than for gymnasts, I looked at possible interactions between Time and Sporting activity, as tested by the use of the ANOVA.

(H2) I compared DT performance from before to after the training session over all participants based on the main effects of Time (pre-test vs. post-test).

(H3) When comparing gymnasts to traceurs regarding their DT performance, I tested for main effects of the Sporting activity (parkour vs. gymnastics).

(H4) By combining the time of experience with the average frequency of training, I created an absolute number of the frequency of training, representing overall experience. Therefore, I multiplied the time of experience in months by one of the following factors depending on the frequency of training: 28 (daily), 20 (four to six times per week), 8 (one to three times per week), 2 (one to three times per month). One participant had to be excluded because they did not state their frequency of training. To test for correlations of baseline DT performance with the traceurs' overall experience, mostly Pearson correlations were applied since the data was likely to be normally distributed, as assessed by using one-sample Kolmogorov-Smirnov tests. Only the pre-test's fluency of the PTT did not show a normal distribution. Therefore, a Spearman correlation was calculated between these values and experience. The significances regarding the correlations are one-tailed, as I had clear predictions in which direction the effect could go.

(H5) To test for correlations of originality between before and after the training session, I used a Pearson correlation for the AUT, as these values were normally distributed, and a Spearman correlation for the PTT.

3 Results

3.1 Immediate effects on DT

3.1.1 Traceurs' vs. gymnasts' change in DT (H1)

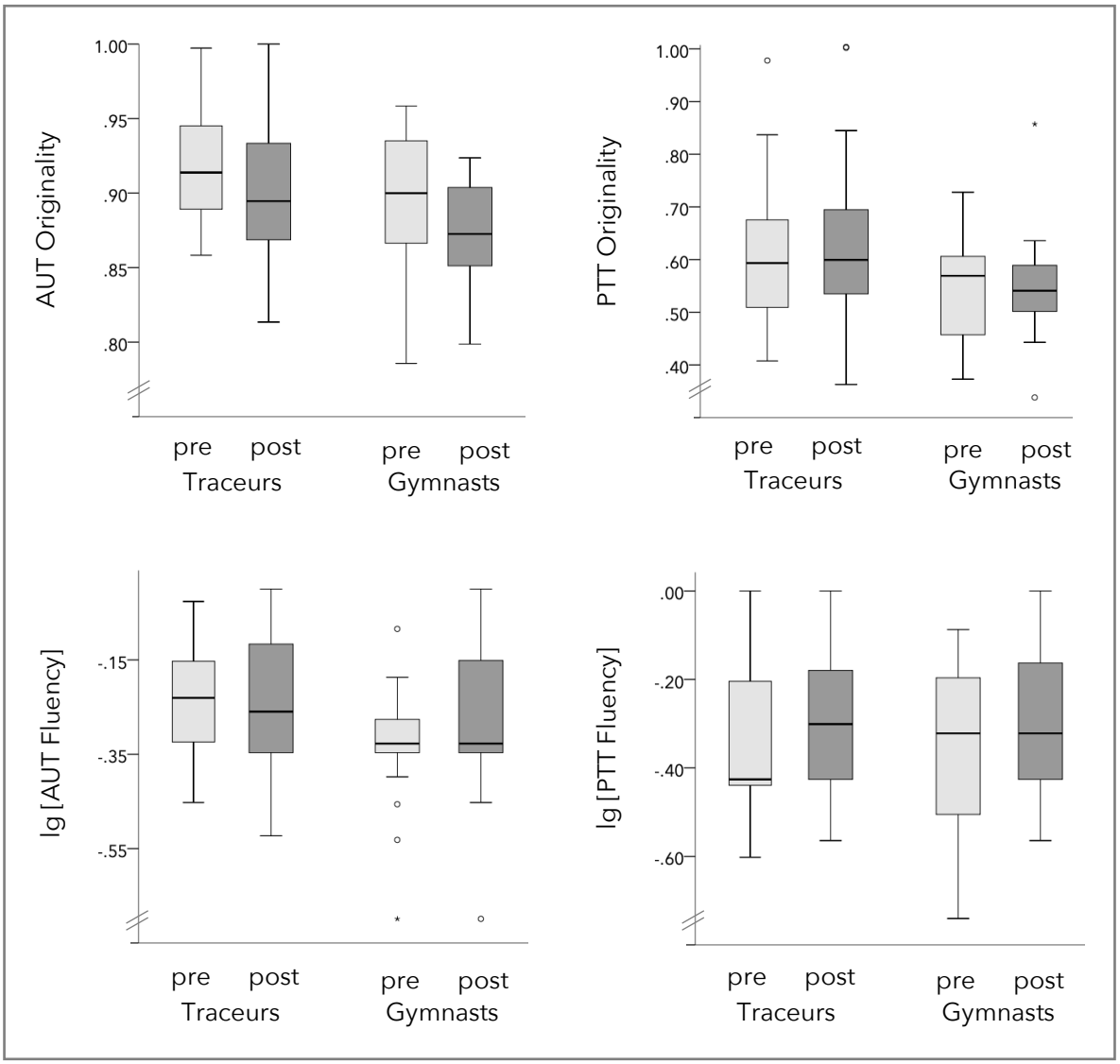

Figure 8. General overview of all DT data separated by Time (before vs. after the training session) and Sporting activity (parkour vs. gymnastics). Traceurs' baseline DT performance and experience in parkour (H4)

There were no significant interactions between Time (before vs. after training) and Sporting activity (parkour vs. gymnastics) regarding the DT performance, as assessed by ANOVA (Table 4). Figure 9 gives a detailed overview of the DT scores separated by Time

and Sporting activity. The change in DT performance from before to after the training session in comparison between the traceurs and the gymnasts is depicted in *Figure 10*.

Table 4

Results of the ANOVA regarding the interaction between Time (before vs. after the training session) and Sporting activity (parkour vs. gymnastics)

	$df_{numerator}$	$df_{denominator}$	*F*	*p*	partial η^2
Originality AUT	1	43	.000	.983	< .001
Fluency AUT	1	43	.911	.345	.021
lg [Originality PTT]	1	42	.193	.663	.005
lg [Fluency PTT]	1	42	.006	.937	< .001

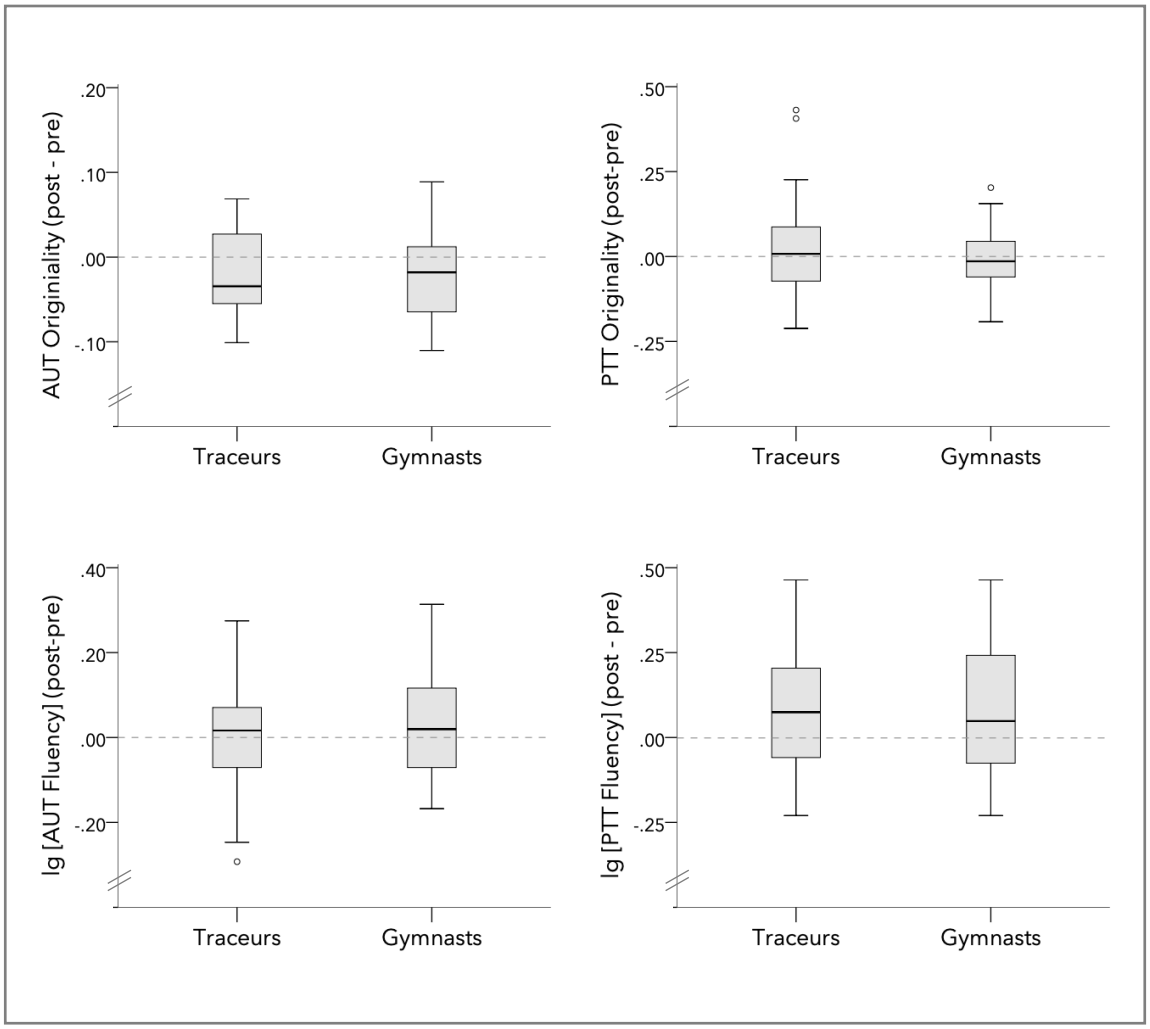

Figure 9. Change in DT performance from before to after the training session compared between traceurs and gymnasts. The y-axes represent the differences between post- and pre-scores. Positive values suggest an improvement in DT after training, whereas negative values indicate a decline.

3.1.2 DT before vs. after training (H2)

Next, I tested for main effects of Time to observe any differences in DT performance between before and after the training session. Concerning the AUT, the participants' originality score was significantly lower after the training session as compared to before, but the logarithmic transformation of fluency remained unchanged. Regarding the PTT, on the other hand, originality scores remained approximately the same, whereas the fluency's logarithmic transformation was significantly higher after the training session (Table 5). An overview of the comparison between pre- and post-test over all participants is provided in Figure 10.

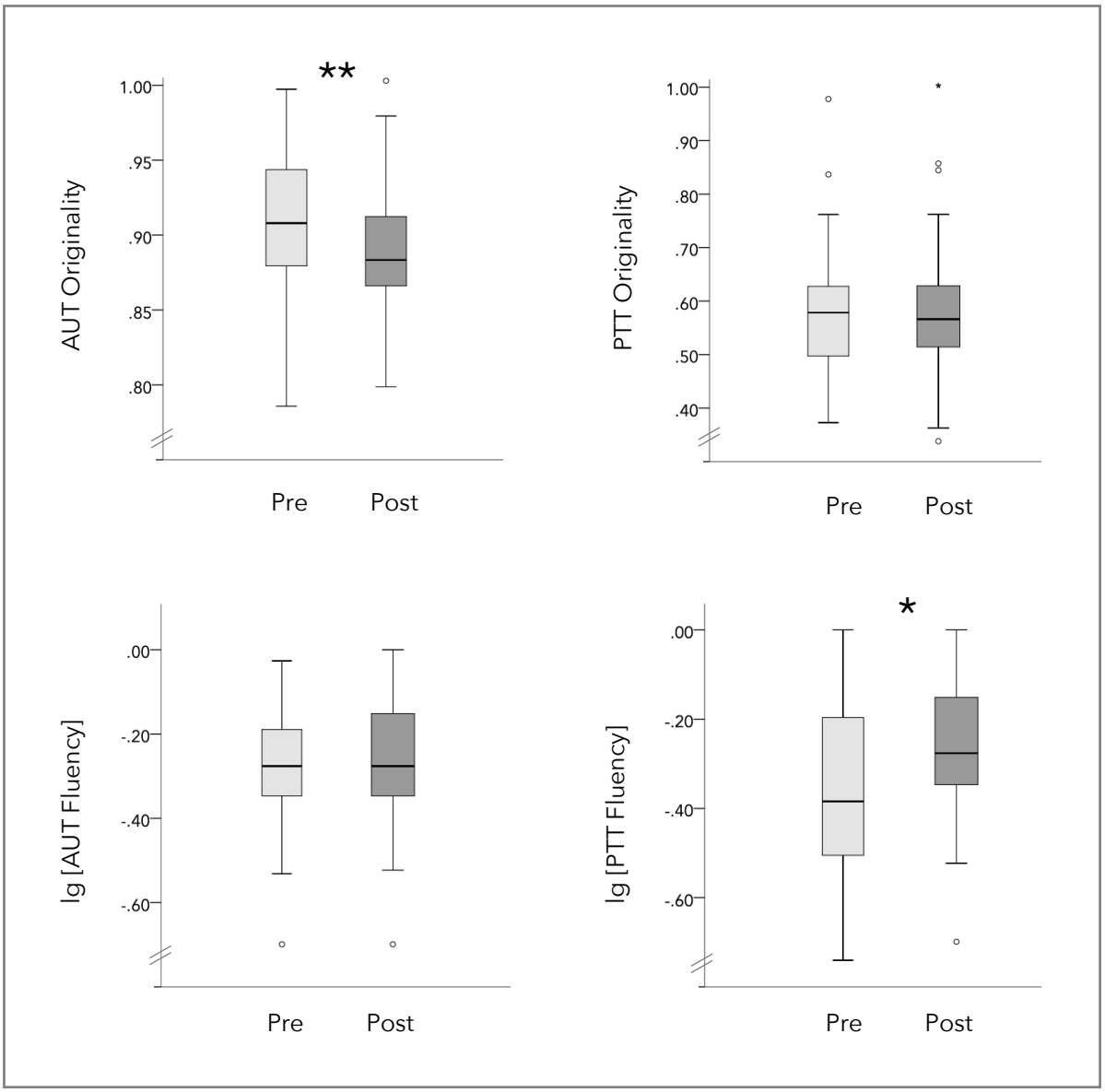

Figure 10. DT performance before and after the training session in comparison over all participants. Significant results are marked with asterisks (* $p \leq .05$, ** $p \leq .01$).

Table 5

Main effects of Time (before vs. after the training session) on DT performance, as assessed by the ANOVA. Significant results are marked with asterisks (p ≤ .05, ** p ≤ .01).*

	$df_{numerator}$	$df_{denominator}$	F	p	partial η^2	M_{pre}	M_{post}
Originality AUT	1	43	7.217	.010**	.144	0.91	0.89
Fluency AUT	1	43	1.019	.318	.023	-.27	-.26
lg [Originality PTT]	1	42	.382	.540	.009	.58	.60
lg [Fluency PTT]	1	42	6.247	.016*	.129	-.36	-.28

3.2 Long-term effects on DT

3.2.1 Traceurs' vs. gymnasts' overall DT performance (H3)

Furthermore, the ANOVA revealed that the traceurs performed significantly better than the gymnasts in originality and fluency in the AUT, and in originality in the PTT (Table 6). Only the logarithmic transformation of fluency in the PTT did not differ significantly between the two groups of athletes. The overall differences in DT performance between traceurs and gymnasts are depicted in Figure 11.

Table 6

Main effects of Sporting activity (parkour vs. gymnastics) on DT performance as assessed by the ANOVA. Significant results are marked with asterisks (p ≤ .05).*

	$df_{numerator}$	$df_{denominator}$	F	p	partial η^2	$M_{traceurs}$	$M_{gymnasts}$
Originality AUT	1	43	4.111	.049*	.087	.907	.885
Fluency AUT	1	43	4.339	.043*	.092	-.235	-.311
lg [Originality PTT]	1	42	4.458	.041*	.096	.619	.549
lg [Fluency PTT]	1	42	.162	.689	.004	-.312	-.330

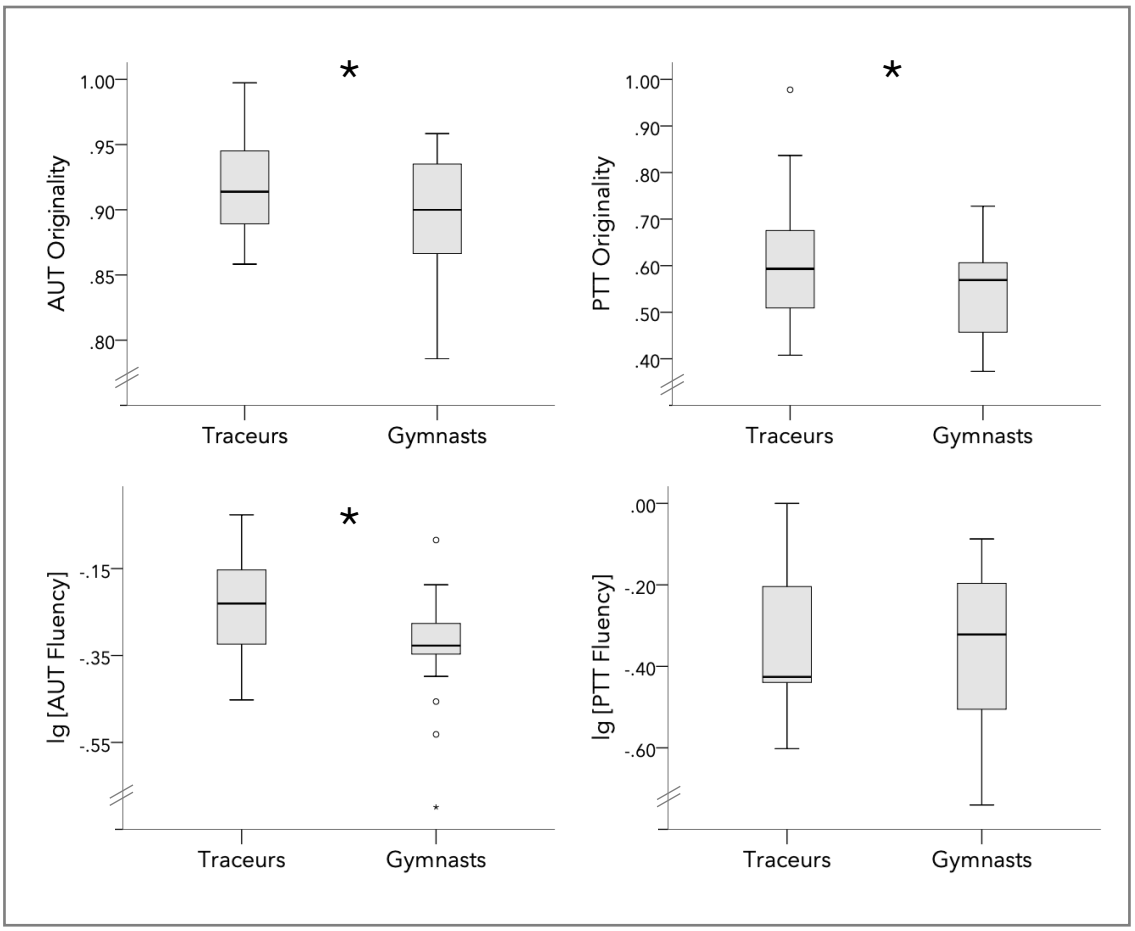

Figure 11. Overall differences between traceurs and gymnasts on DT performance. Significant main effects of Sporting activity are marked with asterisks (* $p \leq .05$).

3.2.2 Traceurs' baseline DT performance and experience in parkour (H4)

There were no significant correlations between DT baseline performance, measured as fluency and originality, and estimated total frequency of parkour training sessions (Figure 12). However, a trend towards a positive correlation of frequency of training and originality is observable in both DT tasks, but especially in the AUT (AUT originality: r(26) = .299, p = .069; PTT originality: r(25) = .145, p = .244). In terms of fluency, the distribution against frequency of training appeared to be relatively random (AUT fluency: r(26) = -.166, p = .208; PTT fluency: r_S (25) = -.009, p = .483).

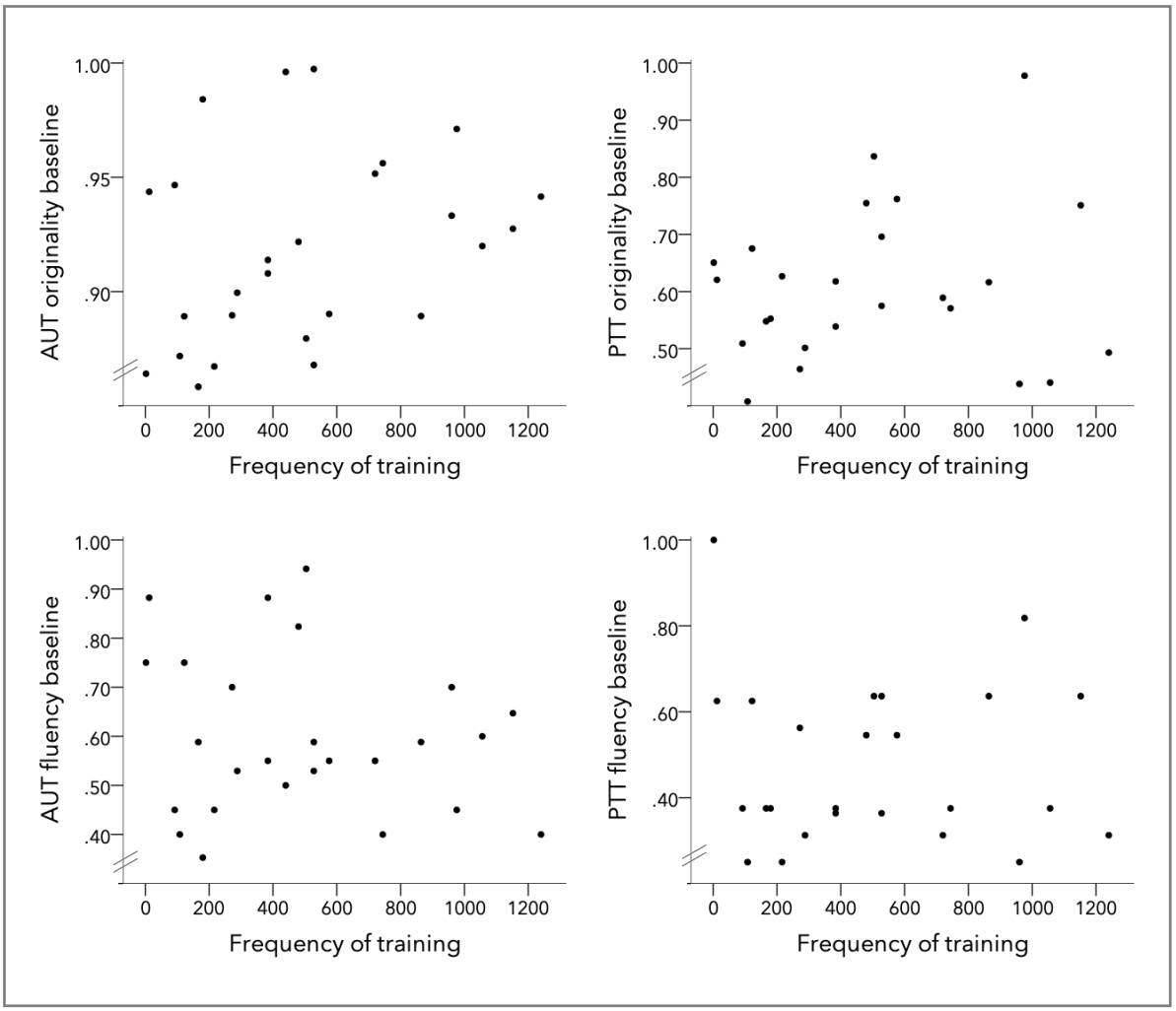

Figure 12. Correlations between DT performance and absolute frequency of training (estimated number of total training sessions). No significant results were found.

3.3 New originality scoring method (H5)

Across all participants, there was a significant positive correlation between originality scores from before and after the training session (Figure 13; AUT originality: $r(45) = .341$, $p = .022$; PTT originality: $r_S\,(44) = .473, p = .001$).

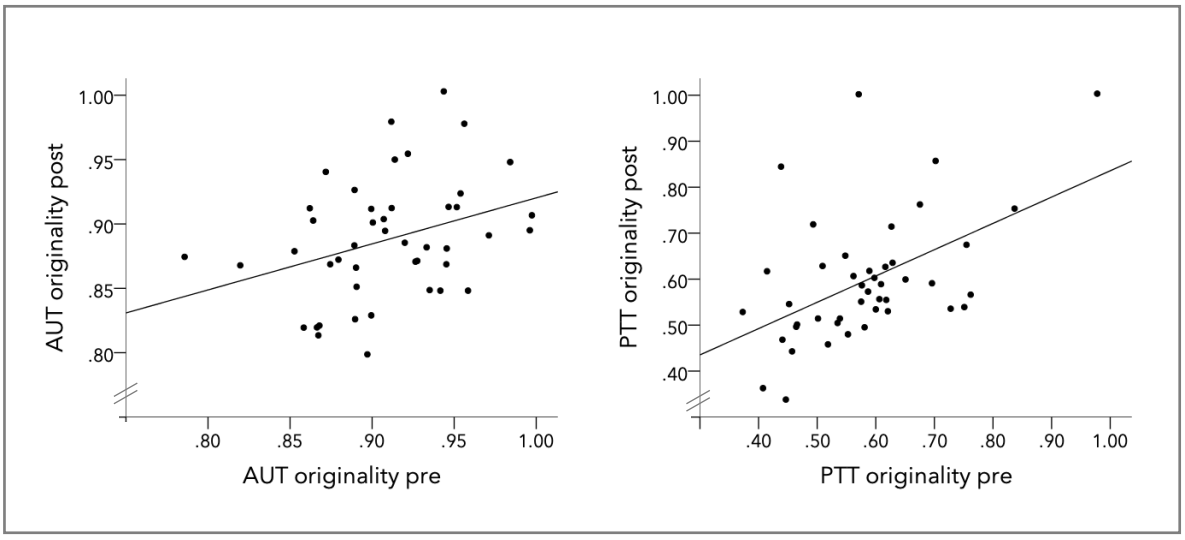

Figure 13. The originality scorings of before (pre) and after (post) training correlated positively for both DT tests.

4 Discussion

4.1 Immediate effects on DT (H1 & H2)

The results do not show any consistent line regarding the influence of parkour or gymnastics training on DT performance. There was no significant interaction between Time (before vs. after the training session) and Sporting activity (parkour vs. gymnastics; H1). Whenever the participants' performance improved or declined, the effect seemed to be almost equal for both groups.

The main within-subject effect of Time (before vs. after the training session) on DT performance seems ambiguous (H2): whereas traceurs showed a decline in originality in the AUT from before to after training, they became more fluent in the PTT. At first glance, these results might seem contradictory because originality and fluency are both regularly used as indicators of DT performance, but their relationship is not very clear to date (Forthmann, Szardenings, & Holling, 2020): on the one hand, the chance to come up with original ideas increases with the total number of ideas. Therefore, a positive correlation of fluency and originality could be expected. On the other hand, one very original idea has a smaller effect on the overall originality score if the participant provides many additional replies that might be less original, because the originality score is created by averaging all ideas' originality. This means, that participants who choose a more selective strategy, which goes along with a lower fluency, might end up with a higher originality score than those who write down everything that comes to their mind. Furthermore, Acar and colleagues (2019) found that original ideas take a longer thinking time to develop. Both would account for a negative correlation between fluency and originality, especially in a time-constrained experimental set-up like mine. However, in my experiment, the two effects occurred in different tasks, so they are not directly comparable. Furthermore, there were no visible effects for traceurs on fluency in the AUT or originality in the PTT, which does not allow me to draw any clear conclusions about the direction in which my data leads.

Since the effects of decreased originality in the AUT and increased fluency in the PTT appeared when testing over all participants, they cannot be ascribed to using the

environment unconventionally when doing parkour but could rather be seen as an effect of engaging in a sporting activity that occurred in both groups. The decline in originality resembles the effects found in a study by Colzato and colleagues (2013). Their participants showed a drop in flexibility in an AUT after intense physical exercising. Originality, fluency, and elaboration behaved similarly but did not reach significance. Colzato and colleagues (2013) explain their findings by a possible exhaustion of cognitive control that occurs after physical exercise. In contrast, Zhou and colleagues (2017) attribute a mild exhaust in cognitive control to beneficial effects on flexibility, as they found that unconstrained walking increased creative performance. I argue that these effects might depend on the intensity of physical exercising. Whereas Zhou and colleagues (2017) examined walking, the participants in the experiment by Colzato and colleagues (2013) were cycling normally for 6 minutes, and intensely for another 6 minutes, which is by far more exhausting for obvious reasons. As a reference, in my experiment, the participants trained quite intensely for 25 minutes. Therefore, it might not be surprising that my results are more similar to those of Colzato and colleagues (2013). Furthermore, cycling could possibly require less cognitive resources than gymnastics or even parkour, as there are a higher number of more complex movements involved in the latter. Especially the parkour training might have been very cognitively demanding because of the lack of restrictions. The participants needed to constantly consider which exercises they would like to perform on which environmental feature, and if they were skillful enough to do them. More choices seem to require more cognitive resources (Berlyne, 1957). Therefore, the participants could have exceeded the beneficial level of control-depletion, which was observed by Oppezzo and Schwartz (2014) and Zhou and colleagues (2017), towards a rather impairing stage.

The contrasting increase in fluency could possibly also be explained by lower cognitive control: instructing participants to be creative was shown to lead to more original, but fewer responses (Nusbaum, Silvia, & Beaty, 2014), as they might reject ideas that do not seem creative enough to them. I propose that the evaluation of ideas could require more cognitive control than finding creative ideas. Since the participants were instructed to come up with creative responses in my experiment, they may have tried to evaluate them before writing them down. As their cognitive control could have been worse after training, they

could have faced difficulties in the evaluation process, leading them towards writing down a higher percentage of the ideas that came to their mind. However, these are only hypothetical explanations which would require to be tested in the future.

Overall, I suggest that the immediate effects of an unconventional use of the city (such as when doing parkour) on DT are either small, so they are not visible in a small sample size like in this experiment, or they simply do not exist for settings similar to those in this experiment. Since DT is a very complex cognitive process, there are numerous variables influencing creative performance (Kaufman & Glăveanu, 2019), allowing the possible effect of parkour training to disappear easily. DT performance during parkour training is not only interesting from the perspective of interaction with the environment, but also in terms of embodiment. Getting a clearer picture of the effects of physical activity alone on DT performance would be beneficial before continuing to investigate the enactive component, including the environment. Nevertheless, my findings on the immediate effects of parkour training and gymnastics on DT offer a first exploration of the complex interplay of DT, embodiment, and enactivism.

4.2 Long term effects on DT (H3 & H4)

The ANOVA revealed overall higher DT scores of the traceurs on both dimensions of the AUT and regarding the originality of the PTT, which could have two reasons: since parkour is a very unconventional sport (Ameel & Tani, 2012a), creative people could be more drawn towards practicing it. Additionally, DT can be enhanced by training (Scott, Leritz, & Mumford, 2004). As traceurs develop additional affordances for a given environment (Ameel & Tani, 2012b; Bavinton, 2007), which might be a process similar to DT, their experience in training parkour could also explain the improved performance. However, it is unclear if training in one domain of DT also affects others. An interesting direction for future research would be to assess traceurs' values and their attitude towards creativity (Acar & Runco, 2014), as an addition to DT performance comparisons. However, in the experiment by Acar and Runco, creative values and attitudes correlated well with the DT scores.

The traceurs' baseline DT and training experience did not correlate significantly (H4). Regarding originality, there was still a visible trend but especially originality in the AUT had a few outliers among the beginners who already showed a very high creative performance. I suggest that no correlations were found because a combination of both aforementioned factors (creative people like parkour and parkour makes them creative) was present. A long-term study, where participants are randomly assigned to conditions, could shed light on the exact dependencies.

4.3 New originality scoring method (H5)

The newly developed program seems to be a feasible method for scoring originality, as I obtained meaningful results which match and complement previous studies. The originality in pre- and post-test correlated significantly, making it highly improbable that my program only produced random originality scores. Nevertheless, in order to be able to make use of my scoring method in future studies, proper testing would still have to be undertaken to assess its validity and reliability. Still, I decided to use it to test its practicability. Furthermore, its logic follows that of previous methods based on LSA (Dumas & Dunbar, 2014). Only the word vectors I used were trained differently (Grave et al., 2018).

To the best of my knowledge, the developed method is the first applicable for the German language. Grave and colleagues (2018) provide word vectors in the same format for 156 additional languages, which could simply be imported into my program. Without any additional changes, it could, therefore, also be easily applied to assess originality in a multitude of other languages. My scoring method could not only be used for scoring originality, but also for assessing flexibility if each idea's semantic distance were compared to the participant's previous idea. This was, however, not done in my experiment because my instructions only focused on leading the subjects towards many (i.e. fluency) creative (i.e. original) ideas. As compared to previous approaches, my method offers a more elegant approach towards associative distance, as it offers continuous, rather than discrete results (Acar & Runco, 2014), which allow for a more fine-grained differentiation. Furthermore, I believe that I am the first to apply a semantics-based scoring method on the PTT, as computerized methods seem to have focused mostly on the AUT to date (e.g. Beketayev & Runco, 2016; Dumas & Dunbar, 2014; Forster &

Dunbar, 2009). However, my approach should only be considered a preliminary attempt which can be built upon in the future, as averaging all word vectors of a text can ultimately be a noisy affair, even when removing stop words, as I did.

It is noteworthy that computerized methods do not assess exactly the same phenomena as traditional scoring methods. In fact, Dumas and Dunbar (2014) even suggest that originality scores obtained by LSA differ from traditional evaluations. However, this certainly does not mean that one is right and the other is wrong. More generally speaking, I dare to doubt that one specific phenomenon of DT even exists if we look at it from a neuroscientific perspective. Instead, I propose considering DT as an umbrella term for a multiplicity of processes that merely appear to be similar from the outside. Neuroscientific research also shows that structural and functional correlates of DT depend to a great extent on the type of DT test (Cousijn, Koolschijn, Zanolie, Kleibeuker, & Crone, 2014; Runco & Acar, 2019), matching earlier suggestions from psychology (Guilford, 1968). Differences are, unsurprisingly, especially prominent between verbal and figural tasks. All scores for measuring DT performance are developed by humans and do not directly reflect an actual scale, which occurs naturally. Therefore, I am of the opinion that it is difficult, if not impossible, to assess which of the two scores – the traditional or the computerized – is more valid, but this experiment's results show that my newly developed approach appears to be feasible and promising. Due to its objectivity and time-efficient application, I suggest that it would be advantageous to investigate it further with a view to possibly using it in future assessments of literal DT.

Nevertheless, it should be emphasized that an objective DT scoring method also brings some disadvantages. I propose that an idea's originality cannot be assessed absolutely detached from the creator, as creativity rises and falls with experience. Runco and Acar (2010) found that experiences explained 65% of originality scores. An idea can therefore be objectively very creative, but if it is obtained from memory rather than actual DT on site, it distorts the result, which will no longer reflect the person's actual performance. The traditional scoring method could not account for that, neither does the computerized method I used in this experiment. However, this could be changed: the vectors used in my experiment were trained on Wikipedia and Common Crawl, but a new set of vectors tailored to the participants' knowledge could be created by future researchers (Dumas &

Dunbar, 2014). In theory, the vectors could be trained on all websites the subject has visited, all books they have read, all movies they have watched, and all conversations they have had. Eventually, the vectors' semantic distances would probably be very close to the semantic distances between the person's mental representations. Obviously, this is not possible in the real world, but at least it could be approximated. To some extent, this approach would also tackle another limitation, namely that originality is not the same as semantic distance (Hass, 2017): Hass claims that originality should be considered as a more subjective construct, which might differ depending on the culture and the individuals themselves. By tailoring the semantic network to the sample, it would fit their background better, which could possibly diminish the disparity between originality and semantic distance.

Semantics-based scoring appears to be a promising method for future assessment of DT tasks, with far-reaching implications not only for academia, but also for educational purposes. But still to this day, they seem to be partially neglected in the field of psychology: Reiter-Palmon and colleagues (2019) recently published a review on scoring DT tasks, which did not go into any detail about semantics-based scoring methods. Therefore, I suggest that more research in this field would be highly beneficial. In particular, a comparison between the methods that have been published to date (LSA, semantics-based algorithms, and also my scoring method) would be very useful to get an overview of their respective strengths and weaknesses.

4.4 Limitations

The experiment's explorative design has a couple of limitations I would like to address. First of all, it was tied to two very specific groups of participants who were partially hard to recruit. Eventually, I had to compromise and accept the slightly different experimental procedure of some gymnasts in order to have a sufficient number of participants. However, the COVID-19 crisis intervened and the final experimental session with another group of gymnasts could not be performed, which explains the large difference in sample-size between the gymnasts and the traceurs. Possibly, some results would have been clearer if I had had the possibility to test more gymnasts.

Splitting the gymnasts into groups with slightly different procedures was obviously not the best way to perform an experiment. Some participants visited the experiment's location for the first time, whereas others had been training there for years. Also, the training styles differed to some extent: the participants who were tested in a rented gym had a stricter time schedule as the number of seconds to perform each exercise was given. The size of each subgroup was too small to perform any significant tests to assess possible differences between them.

Moreover, the two groups (gymnasts and traceurs) had to be assessed in very different environments, as the traceurs needed an urban space and the gymnasts required their equipment. Since the traceurs were tested outside in a much busier environment than the gymnasts, they were exposed to more distractions, possibly influencing their creative performance (Dul, 2019). What leaps to the eye in Figure 3 and Figure 4 is that the gym appears considerably more spacious than the winding urban environment with all the cars and edges. According to the findings by Chan and Nokes-Malach (2016), more spacious places can boost performance in the AUT, matching the approach of Dul (2019), who considers freedom as one of the core features for creativity. But since traceurs were shown to have an altered attitude towards space (Ameel & Tani, 2012a), and walls and railings barely represent obstacles for them, they were possibly not as much influenced by this situation as an outsider would expect. Additionally, I would like to stress that this was a field experiment, which carries its main value in the fact that traceurs were actually training in the city and gymnasts in the gym, as they would do in real life conditions.

Regarding the PTT, I had no access to any texts of validated tests in the German language, so I chose to translate the English texts by Strasbaugh (2019). My German texts were translated quite freely, as the original texts used many figurative expressions that could not be directly transferred to German. There was also no further evaluative process, as is usually the case for psychological tests.

As common in most experiments using DT tasks, I did not question where the participants' ideas came from. The chances are high that some were actually obtained from memory, rather than created on site. Silvia, Nusbaum, and Beaty (2017) asked participants to rate their responses as "old" or "new". They showed that old responses appeared earlier and were less creative. This was in line with the findings of Acar and colleagues (2019) that a

higher latency predicted originality. Therefore, answers from memory could make the data unnecessarily noisy, especially when the tasks are time constrained.

4.5 Contributions to the theoretical concepts and future directions

In summary, it can be said that the impact of unconventional human-environment interactions on DT remains unclear. Although there were some findings, as described above, I cannot rule out that they occurred by chance or that there is actually no meaningful connection. Nevertheless, I suggest that creatively interacting with the physical environment can influence cognitive processes, but the exact mechanisms are likely complex, making it hard to find clear effects. As mentioned in the introduction, this experiment was intended to provide a preliminary explorative approach towards 4E cognition, creativity, and the concept of affordances, which might still take us one small step further towards their understanding. Regarding the interaction between brain and body, I found that elongated physical activity of higher intensity affected originality negatively, but enhanced fluency. However, these findings were inconsistent among the two DT tasks I used.

From a broader perspective, my experiment tackled the question of how to make urban environments more human-friendly. Franck & Stevens (2007) reported that environments with many affordances are often perceived more positively, and a good mood seems to have a positive impact on creativity (Dul, 2019). But still, there were no consistent findings that the perception of many affordances, as is the case when practicing parkour, had a positive influence on DT. Adding a phenomenological approach could give some valuable insights into the issue of how the perceived affordances in the physical environment might be experienced during parkour or gymnastics training. It would also be interesting to test how leaving out physical exercising and focusing solely on the environmental aspect would influence the results. In the long-term, further research in this direction could help to gain new insights on how to design urban environments more successfully, supporting long-term wellbeing.

Conclusion

My experiment allowed some insight into what could potentially be done when combining initially philosophical concepts with psychology, behavioral biology, computer science, and a pinch of linguistics. The inconsistent results of my first explorative approach towards human-environment interactions do not allow me to draw any clear conclusions. However, I suggest that physically and cognitively demanding exercising could affect originality in DT tasks negatively, while promoting fluency. The effects of unconventionally using the environment on DT performance appear to be minor, if present, as they were not visible in my data. They could have been covert under the possibly stronger effects of physical exercise. Furthermore, I presented a computerized method for scoring originality, and likely also flexibility, which can easily be adapted for application for various languages. My first tests for its feasibility were promising, however the method would still have to be refined and evaluated properly before it can be used in future research to extend my findings on the interaction between the brain, the body, and the environment. After all, the city is likely more than just a playground our brain acts upon. Perhaps it is, like our body, an active element that constitutes, or at least influences, our cognitive processes and actions.

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Supplemental Material

Appendix A Consent form's original version for traceurs

Appendix B Consent form translated to English

Appendix C Questionnaire's original version for traceurs

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Appendix G PTT sheet showing text 1 in German

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Consent form

Allgemeine Information zur Studienteilnahme

Ziel der Studie: Untersuchung des divergenten Denkens

Ablauf: Fragebogen, zwei kurze Denkaufgaben, 30min selbstständige Ausübung von Parkour (inkl. Aufwärmen), zwei weitere kurze Denkaufgaben

Risiken: Von den Verletzungsrisiken, die die Ausübung von Parkour mit sich bringt, abgesehen, birgt die Teilnahme keine zusätzlichen Risiken.

Falls du noch weitere Fragen hast, kannst du dich jederzeit an die Versuchsleiterinnen wenden.

Einverständniserklärung zur Studienteilnahme

Ich, _____ (Vor- und Nachname), nehme an dieser Studie freiwillig teil und kann jederzeit ohne Angabe von Gründen meine Zustimmung zur Teilnahme widerrufen, ohne dass mir deswegen Nachteile entstehen.

Ich wurde über die Ziele und den Ablauf der Studie informiert und erkläre mich mit den angewandten Methoden einverstanden. Meine Fragen im Zusammenhang mit der Teilnahme an dieser Studie sind mir zufriedenstellend beantwortet worden.

Ich erkläre mich damit einverstanden, dass die von mir aufgezeichneten Daten in anonymisierter Form zu Forschungszwecken verwendet werden und die ausgewerteten Daten veröffentlicht werden dürfen. Ich erhebe keine rechtlichen Ansprüche auf das aufgezeichnete Material.

_____ _____

Ort, Datum Unterschrift

Appendix A. Consent form's original version for traceurs. The gymnasts' version looked the same except that there was written "Geräteturnen" (gymnastics) instead of "Parkour".

General information about the participation

Goal: Investigation of divergent thinking

Procedure: Questionnaire, two short cognitive tasks, 30min independently training parkour (incl. warm-up), two further short cognitive tasks

Risks: Apart from any injury risks associated to doing parkour, there are no additional risks. The participation happens at one's own risk.

In case you have any additional questions, you can always ask the examiners.

Consent form

I, _____ (pre- and surname), am participating voluntarily. I can revoke my consent any time without giving any reason, and I will not face any disadvantage by doing so.

I was informed about this experiment's goals and procedure and I agree to the methods that will be used. My questions about my participation were answered adequately.

I consent, that my collected data will be used for research purposes in an anonymized form und I allow the publication of the processed data. I do not raise any claim for the recorded data.

_____ _____

Place, date Signature

Appendix B. Consent form translated to English for better understanding.

Questionnaire

Datum: _____ Teilnehmer/in #: ___

Fragebogen

Geschlecht

- ❍ weiblich
- ❍ männlich

Alter _____ Jahre

Höchste abgeschlossene Schulbildung

- ❍ Hochschule
- ❍ Matura
- ❍ Berufsschule
- ❍ Pflichtschule
- ❍ Volksschule

Wie fühlst du dich gerade? 

Wie lange betreibst du schon Parkour? _____ Jahre, _____ Monate

Wie oft betreibst du Parkour im Schnitt (seit Beginn)?

- ❍ täglich
- ❍ 4- bis 6-mal pro Woche
- ❍ 1- bis 3-mal pro Woche
- ❍ 1- bis 3-mal pro Monat
- ❍ seltener: _____

Wie schätzt du dein Niveau in Parkour ein?

- ❍ Anfänger/in
- ❍ Fortgeschrittene/r
- ❍ Profi

Appendix C. Questionnaire's original version for traceurs. The gymnasts' version looked the same except that there was written "Geräteturnen" (gymnastics) instead of "Parkour".

Date: _____ Participant #: ___

Questionnaire

Gender

- ❍ female
- ❍ male

Age _____ years

Highest degree of education

- ❍ University
- ❍ School-leaving examination
- ❍ Vocational school
- ❍ Mandatory school
- ❍ Primary school

How do you feel right now? 

How long have you been doing parkour? _____ years, _____ months

How often do you practice parkour in average (since you started)?

- ❍ Daily
- ❍ 4 to 6 times per week
- ❍ 1 to 3 times per week
- ❍ 1 to 3 times per month
- ❍ Less often: _____

How would you rate your level of expertise in parkour?

- ❍ Beginner
- ❍ Intermediate
- ❍ Expert

Appendix D. Questionnaire translated to English for better understanding.

DT Tasks

Pre / Post AUT, PTT // PTT, AUT Teilnehmer/in #: ___

Gegenstand: Ziegelstein

Verwendungsmöglichkeiten:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____
21. _____

Appendix E. Original AUT with "Ziegelstein" as the given object. The sheet for the other object looked the same, except that there was written "Büroklammer" at the top.

Pre / Post AUT, PTT // PTT,AUT Participant #: __

Object: Brick

Possible uses:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____
21. _____

Appendix F. AUT translated to English for better understanding.

Pre / Post AUT, PTT // PTT, AUT Teilnehmer/in #: ___

Viktoria ist eine richtige Businesswoman: erfolgreich, intelligent, in einer glücklichen Beziehung. Wenn sie nur aus dem Gefängnis hinauskommen könnte! Nachdem ihr Chef ihr einen Betrug zuschob, und sie inhaftiert wurde, muss die Prinzessin nun lernen, wie man sich im Gefängnis behauptet. Eingeschüchtert, aber nicht alleine, lernt sie jetzt, wie befreiend das Leben als Gefangene sein kann.

Titel:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____

Appendix G. PTT sheet showing text 1 in German. I translated it from the English version by Strasbaugh (2019)

Pre / Post AUT, PTT // PTT,AUT Participant #: __

Viktoria is your average businesswoman. Successful. Smart. She's got the guy. Now if she could just get out of prison. After her boss shoves a scam into her lap and gets her incarcerated, this Manhattan Princess must learn how to be a Prison Queen before her big trial. Scared but not alone, she learns just how liberating being imprisoned can be.

Titles:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____

Appendix H. My experiment's PTT sheet showing text 1 in English for better understanding. The text is slightly modified (the name was changed) from Strasbaugh (2019).

Pre / Post AUT, PTT // PTT, AUT Teilnehmer/in #: ___

Rebecca hat gerade begonnen, zu studieren, und teilt alles mit ihrer Mitbewohnerin Helene. Nach ein paar Wochen, bemerkt Rebecca, dass Helene nicht nur einfach ein bisschen anders ist… Sie ist eine Hexe! Gefangen in einer fesselnden Freundschaft, entwickelt sich eine starke Verbindung, während die beiden sich ihren Weg durch das Studium zaubern.

Titel:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____

Appendix I. PTT sheet showing text 2 in German. I translated it from the English version by Strasbaugh (2019) and slightly changed the names, so they fit the German language.

Pre / Post AUT, PTT // PTT,AUT Participant #: __

Rebecca is a freshman in college who decided to go potluck with her roommate, Helene. A few weeks in, Rebecca begins to notice that Helene isn't just a little different—she's a witch! Now caught up in a spellbinding friendship, a deep bond is brewing as the two try to charm their way through college.

Titles:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____

Appendix J. My experiment's PTT sheet showing text 2 in English for better understanding. The text is slightly modified (the names were changed) from Strasbaugh (2019).

DT Instructions

AUT

In dieser Aufgabe wird ein Gegenstand aufgelistet sein. Wir würden dich bitten, dir so viele kreative, interessante, ungewöhnliche oder witzige Möglichkeiten wie möglich zu überlegen, wofür man diesen Gegenstand benutzen könnte.

Du hast dafür 3 Minuten Zeit. Wenn du die Instruktionen gelesen hast, gib bitte Bescheid.

Appendix K. AUT instructions' original version.

AUT

In this task an object will be listed. We would like to ask you to think of as many creative, interesting, unusual, or funny ways as possible of how to use this object.

You have 3 minutes. Let us know if you have finished reading the instructions.

Appendix L. AUT instructions translated to English for better understanding.

PTT

Für diese Aufgabe bekommst du eine kurze Geschichte. Wir würden dich bitten, diese zu lesen, und daraufhin so viele kreative, interessante, ungewöhnliche oder witzige Titel wie möglich zu finden, die zu der Geschichte passen.

Beispiel

Julian ist ein CIA-Agent, der kurz vor der größten Beförderung seiner ganzen Karriere steht, wenn er nur seinem Partner Lukas zuvorkommen könnte. In einem Kopf-an-Kopf-Rennen zeigt dieses actionreiche Abenteuer das seltsame Duo in den Straßen von Washington beim Lösen einer Reihe von Verbrechen, die bis zum Präsidenten führen.

Titel:
1. Egoshooter - ein Wettlauf für Amerika und die eigene Karriere
2. Washington Detectives: Ein (un)zertrennliches Team?
3. Kampf der Agenten
4. Zu zweit gegen das Böse
5. (Selbst)gerecht
6. ….

Du hast dafür 3 Minuten Zeit. Wenn du die Instruktionen gelesen hast, gib bitte Bescheid.

Appendix M. PTT instructions' original version.

PTT

In this task you will get a short story to read. We would like to ask you to create as many creative, interesting, unusual, or funny titles as possible that fit the story.

Example

Julio is a CIA agent on the verge of the biggest promotion of his career, if he can just beat his partner Lucas to the punch. Pinned head-to-head, and spy-to-spy, this actionpacked adventure features an unlikely duo taking to the streets of DC to solve a string of crimes reaching all the way up to the Presidency.

Titles:
1. Egoshooter - a Competition for America and Your Own Career
2. Washington Detectives: An (In)separable Team
3. Fight of Agents
4. Two by Two Against the Evil
5. (Self)righteous
6. ….

You have 3 minutes. Let us know if you have finished reading the instructions.

Appendix N. PTT instructions translated to English for better understanding.