Leveraging Video Games to Improve IT-Solutions for Remote Work

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***Abstract*—The world is experiencing remote interaction in unprecedented frequency, as people stay in touch and work together remotely in pandemic times. IT solutions for remote work such as videoconferencing systems have received a lot of critical attention as they seem to induce fatigue. By contrast, in online video games, people collaborate passionately and energetically for hours at a time. In this paper, we introduce methodological frameworks for studying the impact of online video games on individual thinking capacities and team collaboration, with the goal of inspiring IT solutions for remote work. The research is grounded in neurodesign, an approach that uses neuroscientific research to underpin the analysis of how digital technology impacts humans. A major focus of this paper is body motion and virtual environments, tracing how they impact processes of team formation and creative thinking capacities, both during play and shortly thereafter. The paper reports on three pilot studies and methodological developments. The findings indicate that remote interaction leads to increased team cohesion and creative team performance, in particular when the interaction involves synchronous motion with a team partner, such as driving next to each other in Mario Kart on Nintendo Switch.**

***Index Terms*—Alternative Uses Task, Body Motion, Collaboration, CollabUse, Creativity, C-Tracer, Games for Work, Movement, Neurodesign, Nintendo Switch, Online Game, Remote Collaboration, Remote Work, Team Performance, Videoconferencing Fatigue, Video Game, Warm-Up, Zoom Fatigue**

I. Introduction

Remote work is a widespread phenomenon across the globe. Even before the covid-19 pandemic, remote work was on the rise in numerous companies [1]. Due to the health crises and calls for social distancing, the approach of working from home has become yet more common [2]. Novel online work solutions have been developed and are likely to stay even after the health crisis, not least because they reduce mobility efforts, help lower CO2 levels and are widely accessible [3].

At the same time, tools for online work and online collaboration have received a lot of critical attention [4]. Especially videoconferencing tools have been a major pathway of collaborative online work, while headlines such as "Zoom fatigue" have figured prominently in the press. Already before the onset of the global pandemic and the ensuing transition to online work, neuroscientist Dr Caroline Szymanski summarised an array of neuroscientific research concluding "Your neurons don't like remote work" [5]. Since then, further studies have looked into the causes of "Zoom fatigue", identifying a number of design elements in common videoconferencing systems that elicit exhaustion during online collaboration, such as nonverbal overload due to faces shown close-up, and transmission delays disrupt the conversational flow [6]–[9].

However, does online collaboration have to be exhausting? Is it less gratifying than face-to-face collaboration by the nature of remote encounters? We propose that online games can be a great source of inspiration in helping to refine designs for remote work interactions, to create more gratifying, healthy and productive remote work experiences. In discussions of videoconferencing fatigue, a typical recommendation is that people simply spend less time using these tools [4], [10]. Some authors put it bluntly: "To prevent Zoom fatigue, the most important tip is to limit use of videoconferencing technology" [11]. By contrast, the vast number of online games that people choose to play in their spare time over multiple hours in a row is a strong testimony of how online interaction can be exciting instead of fatiguing, how remote experiences can foster positive sentiments of team cohesion, concentration, on-task focus, engagement and energy over long periods of time. If our neurons can enjoy remote interaction after all, a key question is precisely how to design systems that allow for healthy, gratifying and productive online experiences.

In this paper, we share a proof of concept that games can serve as a useful research and development paradigm to identify and iterate improved IT designs for remote work. The paper covers three pilot studies, introducing novel theoretical frameworks and assessment methodologies for the given research purposes.

In the first study, we introduce a methodology for the

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study of online collaboration, which generates objective scores of team formation with a high temporal resolution across the whole process of online interaction, obtained in a non-obtrusive way during natural online interaction.

In a second pilot study, we review how different levels of navigation expertise can be a severe obstacle for online collaboration. When one team member is a novice in playing a game on a particular platform, while other team members have great expertise in it, balanced team collaboration is disrupted. This helps to phrase expectations as to what can and cannot be expected in terms of team formation when people meet in a captivating online environment.

The third pilot study explores the impact of body motion induced by video games on processes of team formation and team performance. For this, further methodological developments have been made. In particular, we adapted the *Alternative Uses Task* – a traditional measurement approach for creative thinking capacities of individuals – to assess both individual and collaborative creative performance. This occurs via the new test paradigm *CollabUse*, realised as a small online game itself. Moreover, the software *C-Tracer* has been developed to analyse any kind of digital behaviour traces relating to people's creative performance. Thus, the impact of interventions delivered via video games on the player's subsequent cognitive performance and team collaboration can be analysed objectively and automatically.

II. Theoretical Basis via Neurodesign: The Importance of Body Motion and Synchrony

Methodologically, the studies reported here are rooted in neurodesign — an approach that uses neuroscientific research to underpin the analysis of how digital technology impacts humans, and to gain inspiration for worthwhile IT innovation [12], [13]. In the study of team collaboration, neuroscientific research highlights the importance of physiological synchrony among team members – dynamics that get stimulated when people move in unison. Moreover, apart from topics of team collaboration, body motion also impacts individual thinking capacities.

Notably, many video games are more motion-intensive than the typical interaction in a videoconference. Indeed, current videoconferencing systems tend to immobilise users [14]: People often sit glancing at the speaker's video, which appears always at the same position on the screen, while the torso of conference attendees is barely transmitted so that hand gestures or body postures do not contribute to the communication and therefore diminish. The contrast to video games varies across cases, but certainly there are motion-intensive games, for example on the Nintendo Switch. In terms of research and development, a key question is how much motion various IT systems allow or encourage. However, neuropsychological research is even more fine-grained. To predict the impact of remote interaction on people's individual and collaborative performance, the kind of body motion people perform matters, and the degree to which movements are synchronised among team members.

Neuroscientific studies on mechanisms of collaboration show that people work particularly well together and team cohesion builds up when the bodies of team members synchronise on a physiological level. One example of this is increased synchrony in the brainwaves of team members, as measured via electroencephalography (EEG) [15]. Other common examples include synchronisation of skin conductance, heart rate and facial emotion expression [16], [17]. One major causal mechanism underlying and fostering physiological synchrony among team members is body motion [18]. When people move together, e.g. following the same rhythm, their body physiology synchronises, and this, in turn, increases team performance.

Beyond the impact on teams, movement patterns also have pinpointed effects on the cognitive abilities of individuals. Notably, fluid movements involving the left and right side of the body have an enhancing effect on creative thinking. This can be observed, for instance, when study participants walk instead of sitting [19], when they move both arms in alternation rather than just one arm [20] when they walk around fluidly-free in a room rather than following the rigid lines of a rectangle [20], or when they trace fluid lines as opposed to angular lines [19]. Such research findings are consistent with studies into brain activation [21]; people who perform well in creative thinking tasks exhibit increased activation in the cerebellum, an evolutionarily old brain structure that helps mammals pursue bilateral, fluid movements in space.

Generally, studies in this research tradition show how important it is that people, as individuals, move. In this sense, creative thinking is most enhanced when people walk by themselves; there is a slight enhancement when people are driven around in a wheelchair and therefore experience motion without moving their own body; there is no enhancement when people sit stationary [22]. However, research on avatars and virtual environments indicates that experiences in video games can be so engaging as to have a significant impact on people's creative thinking performance and team collaboration during and after the play [23]–[25]. For instance, study participants who obtain a creative-looking inventor avatar in the video-game-like virtual environment Second Life behave more creatively in real life afterwards. Moreover, different virtual environments as created in Second Life affect people's creative thinking and collaboration in significant ways.

All in all, video games can be a yielding source of inspiration in the design of IT systems for online work. This is not only the case due to the potentials of gamification including elements of competition, continuous challenge and eventual reward. It is also the case due to more subtle elements in video games, such as the patterns of body motion that get stimulated, due to psychological processes caused by avatars, game environments and more.

III. Pilot Study 1: Video Games as a Source of Inspiration for Remote Work Solutions

The first pilot study is directed towards three major ends. One is to identify beneficial conditions for immediately successful remote collaboration. This means looking out for scenarios where successful team formation can readily be observed online, people work productively on their task together and they are not exhausted quickly (cf. sec. III-A). A second purpose is to achieve objective, quantitative measures of team formation in remote versus face-to-face scenarios with a high temporal resolution (cf. sec. III-B). A third purpose is to explore whether we can present a proof-of-concept: Will favourable dynamics of team formation be found in the context of video games so that inspiration can be gained for remote work solutions?

A. Four Heuristics for Immediately Successful Online Team Collaboration

In order to identify game design elements that foster individual cognitive capacities as well as collaboration, it is very helpful to know about scenarios where such favourable developments can be observed at all. Prior research has found a lot of negative impacts of remote interaction (cf. sect. I). Simply playing any kind of video game with arbitrary team constellations will not magically bring about excellent online experiences. To avoid a lot of resource-ineffective research across numerous games and team constellations in undirected ways, we have first formulated heuristics for research scenarios where favourable dynamics can be expected online. These heuristics are informed by neuro-psychological studies into team collaboration (cf. [26]).

1. Personal Familiarity. The collaborating team members know each other well prior to the study. This corresponds to employees who have already worked together face-to-face before they deploy tools for online collaboration.

2. Joint Vision. The team members work towards a joint goal, which they experience as personally meaningful and motivating. In the context of games, this can be a joint vision of wanting to win a game together, which the participants like to play, and play with serious effort.

3. Task Experience. The team members are experienced and skilled in the task they tackle jointly. In the context of games, this means team members know the game and are familiar with the controls.

4. Captivating Online Environment. The team members meet in an online game environment, which they experience as captivating. This online environment can serve as a substitute for joint encounters in the real world as it may increase the feeling of "being in the same situation, together".

B. Procedure — Emotion Synchrony as an Objective Measure of Team Formation with High Temporal Resolution

A pair of participants plays Counter-Strike in Wingman mode. The participants are male, both 23 years old. They play 20 matches altogether. First, participants play 10 matches in a remote collaboration scenario, where verbal communication occurs via voice chat through Discord. On another day, 10 matches are played with participants co-located in the same room, allowing for face-to-face communication. All matches are played on the same map ("Inferno"). During play, the faces of participants are filmed with cameras positioned at a fixed location in front of each player.

Subsequently, the video data is analysed via the software OpenFace, which extracts "action units" related to different parts of the face, such as eyebrows or corners of the mouth. Facial gestures get identified that are indicative of emotions, such as smiles or expressions of anger. In addition, objective game data is captured of matches won versus matches lost. Altogether, this study covers about 230 min of gameplay, 500 min of video material (47GB), and 208 MB of OpenFace data on facial action units.

In the analysis, emotional synchrony is used as an indicator of successful team formation. For each emotional peak of one player on an analysed emotional dimension, such as happiness, the time frame of one second is screened in the other player, to assess whether this person also produces an emotional peak on the same emotional dimension. Thus, dichotomous results are obtained: Regarding each emotional peak of one player, emotional synchrony is either found or not found in the other player, depending on whether or not this person produces a corresponding emotional peak in the one-second-frame of analysis. Overall, the assessment covers emotional dimensions labelled as "happiness" (OpenFace action units 6+12), "sadness" (action units 1+4+15) and "anger" (action units 4+5+7+23).

C. Results

More emotional synchrony is found in the remote collaboration condition, as assessed via a t-test for dependent samples ($p= 0.023$). In the remote situation, 68 rounds are won and 68 lost. In the face-to-face condition, 62 rounds are won and 71 lost. Moreover, in the face-to-face encounter more emotions get expressed, i.e. the peak detection algorithm finds a greater number of emotional peaks ($p=0.006$). No decline of emotional synchrony or game performance is found over time, despite players spending hours in a row on their task.

D. Conclusion and Discussion

Based on objective gameplay and emotional synchrony data, it has been demonstrated how team formation and collaboration can develop favourably in online scenarios. Indeed, the task-related emotional synchrony was even higher when the team collaborated online, compared to working face-to-face. Thus, the four guiding heuristics for scenarios that aid online collaboration – prior personal familiarity, joint vision, task experience and a captivating online environment – can be maintained and further explored in subsequent pilot studies. Overall, games provide a context where favourable dynamics of team formation and online collaboration can readily be observed.

Regarding the data analysis, processing emotion peaks was a viable means to achieve objective data of team synchronisation with a high temporal resolution. However, the analysis was resource-intensive. It involved multiple hours of video recording, large files of OpenFace data and a lot of manual data handling. Our subsequent studies, therefore, aim at an automation of the analysis procedure and time-effective tests of team collaboration (cf. sect. V).

In terms of empirical observations, a notably higher emotional expressiveness was measured in the face-to-face situation. This indicates a more frequent sharing of personal, individual feelings through facial emotion expressions in the face-to-face condition. These personal expressions affect measures of emotional team synchrony negatively because the percentage of *shared* emotions compared to *individual* emotions declines. This can explain the potentially surprising finding of higher emotional synchrony in the remote-working condition. From neuroscientific research, emotional expressiveness is known as a sign of cooperativeness that people send in social situations [27], usually without conscious awareness. The data suggests that playing face-to-face created more of a "social situation" for study participants than playing together remotely. This is an aspect that calls for further exploration in subsequent studies.

Generally, research needs to be conducted with greater numbers of participants. This pilot was conducted in autumn 2019, immediately before the pandemic [28]. As face-to-face measurements became difficult in the health crisis, we decided to shift the focus towards comparisons across different conditions of remote interaction.

IV. Pilot Study 2: Handling Expertise-Differences that Disrupt Online Team Collaboration

Being mindful of the facilitating impact that joint online environments can have for remote team formation, as well as favourable impacts of motion, a subsequent pilot study explored in further depth the impact of different game environments and hardware systems. For instance, the game Meadow (PC) suggests a natural environment where participants control animal avatars. Thus, such a game environment could be used to simulate a joint walk through the woods. This would be expected to have favourable impacts both due to the walking motion (expected to improve individual creative thinking performance) as well as due to synchronous movements in space (expected to foster team formation and team performance). While surely real body movements would be most favourable, already avatar experiences can be expected to have favourable effects (cf. sect. II). However, pilot study II also serves to test complicating conditions, namely different expertise levels of team members concerning the game and hardware. It is known from team collaboration research that expertise has a strong impact on team performance, and similar levels of expertise often predict best teamwork results [29].

Altogether, this pilot study traces team dynamics across a number of games and systems: Minecraft (PS4, PC), Meadow (PC) and Mario Kart (Nintendo Switch). All of them are chosen because they offer compelling game environments, in which players can navigate with notable aspects of user motion and/or avatar motion. The logic of the study is that expertise differences are likely to disrupt feelings of team cohesion and performance. However, there could be great differences across games and systems in terms of learning times. Game interactions that are easy to learn will be more suited in work contexts to facilitate team formation and performance. Thus, we seek to identify promising games and hardware systems for further studies, where the impact of motion in teams shall be explored more systematically (cf. pilot study 3).

A. Procedure — Tracking the Impact of Online Environments and Navigation Challenges

Out of N=10 study participants, a number of sub-teams are formed, with group sizes of two to four members. Half of the participants are male, half are female, the average age is 40,75 years with a standard deviation of 23,39. In each team, there is at least one team member who knows the game very well, while another team member is a complete novice in the game and its navigation, e.g., the novice has never played any game on the hardware platform before. As in pilot study one, apart from expertise-differences favourable conditions of team collaboration are sought. In particular, it is ensured that all team members know each other well prior to the study.

The tested game gets played for 10 minutes. This is roughly the time span that a warm-up could last in work contexts. After each game test, participants fill out a short questionnaire with five items (we will refer to this as the *Digital Experience Questionnaire [DEQ]* henceforth), see Table I.

Across all items, difference scores are calculated per team. E.g., when in one team person A finds the navigation very easy (2), while for person B navigation is rather difficult (-1), their difference-score on the dimension of navigation is 3.

B. Results

When participants find the navigation easier, they also enjoy the game environment more (Pearson correlation r=.567).

When people enjoy the game environment more, they are also more motivated by the game goal (r=.819).

How much participants enjoy the game environment has no statistically significant impact on how connected people feel in the team (r=.066).

The more people feel connected in the team, the better they find their team performance (r=.546).

When there is a discrepancy in how team members experience the navigation process – navigation is easy for one partner and difficult for another – people find their team performance reduced. In numerical terms, the "difference score on navigation" correlates negatively with "perceived team performance" at a value of r=-.541.

First-time navigation with Nintendo Switch and the PlayStation 4 are experienced as relatively easy even in the first 10 minutes of game-play (answers ranging between 0 and 1 on the navigation item by inexperienced players). First-time navigation on the PC via WASD-keys is experienced as more difficult (answers of inexperienced players going down to -2).

C. Conclusion and Discussion

A joint, captivating game environment does not suffice as a means to induce a sense of togetherness. In particular, different levels of expertise in the game controls disrupt the experience,

Question	Answer Options
How easy or difficult was the **navigation** for you?	Very easy (2), rather easy (1), neutral (0), rather difficult (-1), very difficult (-2)
How strongly were you motivated by the **game goal**?	Not at all (-2), very little (-1), somewhat (0), considerably (1), very much (2)
How appealing and captivating did you find the **game environment**?	Not at all (-2), very little (-1), somewhat (0), considerably (1), very much (2)
How **personally connected** did you feel in the team?	Very unconnected (-2), rather unconnected (-1), something in between (0), rather connected (1), very connected (2)
How did you find your **team performance**?	Very poor (-2), rather poor (-1), something in between (0), rather good (1), very good (2)

TABLE I
THE DIGITAL EXPERIENCE QUESTIONNAIRE INCLUDING THE CODING OF ANSWERS

as it seems people cannot enjoy the game environment and game goal as much when they struggle with navigation issues.

Since we are looking for optimal conditions of team collaboration, the data directs our search towards playing scenarios with controllers rather than computer keyboards. While certainly testing with more people and other games could change numerical outcomes, theoretical arguments add to the empirical data. When people use a game controller, the embodiment of motion seems more straightforward compared to using a keyboard. In particular, both the PS4 and Switch controllers court relatively balanced motions of the right and left hand – while such bilateral motion patterns are known to have a favourable impact on individual cognitive capacities and team performance (cf. sect II). In the game Mario Kart on Nintendo Switch, the players can even perform driving gestures with the controller, which induces natural motion patterns of raising the left and right arm in alternation – a well-studied motion paradigm that is known to have most favourable effects [20]. Therefore, subsequent tests hone in on Mario Kart on the Switch console.

V. Pilot Study 3: Motion Interventions to Impact Individual and Collaborative Creativity

To conduct pilot study III, further methodological developments have been made. In terms of measuring the impact of remote experiences on people's cognitive performance, our methods focus on creative thinking capacities as addressed in section II.

A. C-Tracer: Automatic Creativity Measurement based on Digital Behaviour Traces

The assessment of people's creative thinking performance traditionally requires the judgement of human experts, which renders the assessment procedure time-intensive. Moreover, resulting creativity scores are to some degree subjective. Thus, we have developed the novel software *C-Tracer* to automate and objectify the process. The software uses a scoring method based on the Levenshtein distance. This method has been introduced and validated first for creativity measurements in the context of the video game *Immune Defense* [30], where it enabled experts to generate ”Levenshtein scores” without human judgement. However, at that point the approach was still confined to the specific use-case of analysing creative behaviour in a particular video game, and a lot of manual data handling was still necessary.

C-Tracer analyses any digital data that reflects human actions directed towards some end. For the software to work, (i) action steps need to be observed, (ii) it must be clear which action steps causally affect later actions or events and (iii) there must be some goal, which is either achieved or not achieved through the action steps. For instance, in playing some computer game the goal may be to defeat an opponent. Several action steps may be necessary towards that end, but when the opponent is defeated the goal is achieved. *C-Tracer* constructs causal chains of action steps leading to goal obtainment. Creativity scores are then calculated based on the average "differentness" of causal chains that actors use to achieve their goals. This corresponds roughly to the actors' flexibility in exploring and using different pathways towards their action goal. The metric is grounded in the definition of creativity, according to which a product is creative when it is novel and effective. Thus, by definition, an action strategy is creative when it is novel and effective, which is what *C-Tracer* discovers and quantifies.

B. The Online Game ”CollabUse”: Measuring Creative Performance of Individuals and Teams

In creativity testing, an approach that is used very often is the *Alternative Uses Task (AUT)*. Here participants are confronted with everyday objects, such as a paper clip. Participants shall think up as many uncommon uses for the object as they can in a given time, such as two minutes. For instance, a paper clip can be used as an earring, to scratch ornaments into cookies, as a racetrack for ants, as the magic treasure in an absurd story and so forth. The resulting data is evaluated by experts. Counting the number of ideas that test-takers produce in the given time yields a score of *fluency*: More ideas correspond to a higher level of ideational fluency. However, test takers could produce many ideas that are very similar to each other. E.g., one person could think of many different ways how a paper clip may be used as jewellery, proposing ”earring”, ”finger ring”, ”necklace”, ”brooch”... Such repetitions are captured by the metric of *flexibility*. Here experts count the number of different usage categories that test-takers think up. All usage ideas in the realm of jewellery add one category only in the flexibility metric.

To provide more objective and automated measures, we have developed *CollabUse*, which builds on the logic of the *AUT*. Once again the test provides everyday objects, for which test takers shall think up uncommon uses. We have developed a list of (so far) 70 objects – making sure that all of their names are short and common. The list includes items like ”fork”, ”hat”, ”nail” or ”rope”. In addition, there are (so far) ten design prompts, such as ”decorating items for a science fiction movie", "expensive lifestyle gadgets" or "tools to survive in the wilderness". Based on random selection, test takers are provided with one design prompt and ten items out of the list.

Participants are instructed as follows: "In this game, you obtain 10 items. Each of these items can be re-used as often as you like. Your task is to create novel objects by recombining the items you have. A design challenge tells you what kind of objects to create, e.g. furniture, vehicles... Your goal is to think up as many novel objects in the design category as you can in 90 seconds. Try to combine multiple items at once to create new objects. Aim for wild, creative, clever new objects. Example – Your items are: apple, glass, tire, diamond, lamp, pillow, book, nail, curtain, desk. Design challenge: Create new pieces of furniture. Possible solution: Tire + pillow = chair."

The test is implemented as an online game. Answers of test-takers are analysed automatically via C-Tracer. In our study, four objective measures of team performance are derived.

The number of different ideas/objects that test-takers propose yields their *fluency* score.

C-Tracer analyses each idea as a chain of events. Items that get combined are treated as "action steps" that lead to "success", i.e. the formulation of an idea. For instance, the chain "tire, pillow, chair" contains three elements, with the last one counting as success. The algorithm compares different chains produced by a test-taker. For instance, the chains "pillow, tire, chair" and "curtain, tire, chair" only need one change – replace "pillow" by "curtain" – to be transformed into one another; these two chains are very similar to each other. By contrast, to transform the chain "pillow, tire, chair" into "apple, lamp, cosy light", three elements need to be replaced; there is a greater difference between these chains. The average number of chain differences of a test taker yields their *C-Score*.

Fluency-values and the C-Score tend to be anti-correlated; they capture complementary creative strategies and capacities. In the *CollabUse* game, test takers can easily speed up the listing of ideas by naming many simple and similar ideas, such as a paper clip used as a finger ring, earring, belly ring etc., thus fostering a high fluency score. However, due to the repetition and the low number of items, this strategy entails a low C-Score. Conversely, by thinking up complex solutions that integrate multiple different items from the available list, test takers can obtain a high C-Score. This ideation process is more complex and, by tendency, fewer ideas are produced in the given time. Since both kinds of capacities matter for creativity in general, *Combined-C* provides an integrative measure. It is obtained by adding up z-standardised fluency values and C-Scores.

Finally, we include a comparison of team performance with individual performance. Teams are considered to collaborate well together when they perform better together than any of the team members alone. For instance, partner A may have a fluency of 3 ideas in 90 seconds and partner B a fluency of 5 ideas. What is their fluency when they work together over 90 seconds? When their joint fluency is below or equal to 5, there is no benefit of team collaboration. This logic of analysis is inspired by neuroscientific studies [15]. The metric *team benefit* is calculated as "number of ideas achieved by the team" minus "the number of ideas achieved by the most fluent team member in an individual trial".

C. Procedure — Motion Synchrony as a Causally Relevant Measure of Team Formation

Pilot study III deploys a repeated-measures design. Three teams of two persons undergo a series of different remote interaction experiences.

In the control condition (a), participants watch a video on geology rock formations jointly for five minutes. This is a well-established control condition in creativity-and-motion research [22]. In our study context, the situation of watching the geology video jointly without talking resembles the situation at work where colleagues meet online via videoconferencing and then listen to someone's presentation jointly without talking.

Experimental conditions are based on the game Mario Kart, where participants play avatars of game figures driving around in race cars. The navigation is based on controllers that players move around physically like a steering wheel, turning left or right. During remote interaction, players see their avatar and the avatar of their remote interaction partner. In regular gameplay, the goal is to win the race by driving faster than everyone else. In our study, the following experimental conditions are implemented, and each one lasts for ca. five minutes:

(b) No remote interaction – everyone drives a solo race by time, choosing the map that they want to play. (Game settings: Offline, time trials – no computer-controlled opponents [coms] and no items for defeating opponents, league 100CC.)

(c) Remote interaction, competition condition – the team members play a regular Mario Kart game where they drive on the same map and each person tries to win against the other. (Game settings: Online, no coms, normal items, 100CC.)

(d) Remote interaction, synchrony condition – the team members drive together on the same map. Their task is to drive synchronously, next to each other. (Game settings: Online, no coms, no items, 100CC.)

After each intervention, participants answer the *DEQ* and subsequently take the *CollabUse* test. The order of interventions is randomized across teams. Team 1: c, d, b, a. Team 2: c, a, d, b. Team 3: d, a, b, c.

After all team trials, study participants take the *CollabUse* individually (*single-control*). Since participants may get more experienced in conducting the *CollabUse* over time and therefore creativity scores might increase slightly, we seek to ensure that the best possible creativity measures are obtained in the individual assessment. Given that team performance is measured as improvement of team scores compared to best individual scores, this study design helps to ensure that experimental interventions must be extra-effective in order to elicit measurable benefits in team performance.

As in pilot studies I and II, we seek to ensure favourable conditions for online collaboration. Participants in this study know each other well prior to the experiment and they are

condition	navigation	motivation	togetherness
geology (a)	1,83	0,0	-2,00
solo-drive (b)	1,33	1,17	-1,67
versus (c)	0,0	1,83	0,17
synch (d)	-0,67	0,33	1,67

TABLE II
ARITHMETIC MEANS OF THE ITEMS "EASE OF NAVIGATION", "MOTIVATION TO ACHIEVE THE GAME GOAL" AND "TOGETHERNESS: EXPERIENCED CONNECTEDNESS IN THE TEAM" FROM THE DEQ

condition	fluency	benefit	C-Score	Combined-C
single-control	4,50	-	2,1	-0,929
geology (a)	5,67	0,33	2,097	-0,327
solo-drive (b)	6,67	1,33	2,067	0,084
versus (c)	6,67	1,00	2,144	0,3823
synch (d)	7,00	1,67	2,2048	0,7892

TABLE III
ARITHMETIC MEANS OF OBJECTIVE TEAM PERFORMANCE DATA: IDEATION FLUENCY, TEAM-BENEFIT, C-SCORE AND COMBINED-C

familiar with Mario Kart. One participant is male, the others female, the average age is 24,25 years.

D. Hypotheses

In the joint-playing conditions (c & d) team members adapt their own motion to the movement of the other player. After this mutual motion coordination, improved team collaboration is predicted.

Study condition (d) is devised to induce the highest levels of motion synchrony among team members. Based on synchrony research (cf. sect. II), we expect the highest levels of team cohesion ("togetherness") and the best creative team performance.

Study conditions (a) and (b) do not involve joint playing, which means no mutual motion-coordination occurs. We expect that in both conditions team performances will be similar to, or minutely better than individual creative performance. Since the team members know each other well, which eases their collaboration, there may be a subtle benefit of working together. However, study conditions (a) and (b) will provide no further increase in collaboration performance.

Moreover, in comparing the two conditions without joint motion-coordination, it can still be noted that intervention (b) induces motion, while (a) does not. The motion occurring in (b) may suffice to increase individual creative performance momentarily (cf. sect. II), and this also benefits the team. Therefore, team scores after condition (b) can be expected to be slightly better than team scores after condition (a).

Overall, we expect increasing measures of team cohesion and team performance in the order (a) $<$ (b) $<$ (c) $<$ (d).

E. Results and Discussion

Table II provides an overview of how different interventions impact the participants' experiences, measured via the *DEQ*. Experiences of team cohesion ("togetherness") change across study conditions as hypothesised. Motion synchrony as fostered in study condition (d) induces a strong sense of togetherness: on average 1,67 on a scale ranging from -2 (min) to 2 (max). Notably, such high levels of team cohesion obtain in condition (d) even though study participants do not find the game goal of driving synchronously most motivating, and even though participants report navigation challenges when trying to drive synchronously.

To complement these subjective scores, table III provides four different objective measures of team performance, assessed with the *CollabUse* after each study intervention. In the case of all measures reported in table III, higher numbers indicate higher levels of creative performance.

Fluency measures how many ideas people produce in 90 seconds. In this study, the lowest number of ideas was 3 and the highest 11. Table III provides averages across the study conditions. As hypothesised, people perform better together than alone (conditions a, b, c, d compared to the single-control). Motion seems beneficial (conditions b, c, d compared to the single-control & a). The highest number of ideas is achieved in the synchrony condition (d compared to the rest).

Team benefit (abbreviated as "benefit" in table III) measures how teams perform compared to the best individual team member. Once again, the strongest benefit of interventions is observed in the synchrony condition. The versus-game-condition is a bit ambiguous. It includes some joint motion coordination, however in a spirit of competition rather than collaboration. Empirical implications of this need to be elucidated with larger samples of study participants to render small data trends statistically interpretable.

The *C-Score* measures people's flexibility in achieving creative solutions. As expected, this measure is elevated after interventions where team members coordinated their motion (conditions c & d). The *C-Score* is highest in the synchrony condition.

As discussed in section V-B, *fluency* and the *C-Score* reflect to some degree complementary creative strategies, and the variables tend to be anti-correlated. In our study this is the case with $r=-.362$, $p<.05$. Both strategies matter for overall creative performance and *Combined-C* provides an integrative measure. As it results from z-standardised fluency and C-Scores, *Combined-C* can have both negative and positive values. This highlights how remote interaction impacts team performance: Some scenarios have a negative impact, while others influence team performance positively. As hypothesised, scenarios without motion have a negative impact (single-control and a). The impact of conditions with motion is positive (b, c, d), in particular, coordinated forms of motion are beneficial (c, d). Synchronous movement (d) has the greatest positive impact on creative team performance.

Overall, in terms of research design, it can be recommended to test with greater numbers of participants. At the same time, the arrays of findings in line with hypotheses, and consistent with previous neuroscientific research, go beyond any data pattern that would be expected to emerge accidentally. So this pilot study including methodological developments may already provide orientation to inspire (much needed) subsequent research in the field.

VI. Conclusion and Outlook

Body motion has a notable impact on processes of team formation and performance. Online video games provide useful environments for team members to coordinate motions with remote interaction partners, with ensuing benefits for team collaboration. Video games can be used for small warm-ups in online work sessions. In particular, the task of driving synchronously for five minutes has been found very effective in increasing feelings of togetherness and remote creative team collaboration.

In the design of IT solutions for remote work, it can be recommended to encourage more body motion, in particular, coordinated and synchronous motion. This could be done by experimenting with game controllers in the context of video-conferences. Another option might be the use of touchpads that allow people to physically move around pieces of information to remote team members during a video call, an approach that would entail coordinated motion as well.

Moreover, in this research, it has been found very beneficial to build on neuropsychological research in the context of game studies, as this has helped to make pinpoint observations and predictions. Domains with pertinent research findings include the impact of body motion and posture, next to effects of virtual environments and avatars on people's physiology, cognitive performance and inclinations to collaborate. In pilot study III, the existing video game Mario Kart on Nintendo Switch was used to host the unusual task of people driving next to each other. In line with expectations, this motion synchrony of two players increased their creative thinking performance afterwards. However, study participants indicated that they found the game goal less motivating than a regular Mario Kart match, and navigation was more difficult. Future games can be straightforwardly designed to foster specific motion patterns – such as bilateral, fluid and synchronous motion – to increase collaborative creativity. New game designs can present the task in a motivating way, with easy navigation.

Overall, we hope to have contributed fruitful methodological developments for the study of remote interaction and look forward to (even more) exchange between the communities that study video games and IT solutions for remote work.

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