C Appendix: Student Interviews

The summarise of questions

What do you imagine is a (personal) Digital Twin?

Most participants had no initial idea of what a digital twin is (P1, P3, P4, P5, P6, P8).

Some imagined it as someone who looks like them (P2, P7).

What do you imagine is a (personal) Digital Twin now that you tried our system?

Participants generally understood a digital twin as something that looks like them after using the system (P1, P2, P3, P4, P5).

One participant saw it as an avatar she could identify with, although still not entirely clear (P6).

One participant could not answer (P7)

Another participant described it as someone you can do things with (P8).

Which of the games did you enjoy the most (and why)?

Enjoyment was spread across different games: Jump Jump (P1, P2, P4, P7), Bike (P1, P3), Tivoli (P1, P5), Animal Park (P1, P6), and amusement park settings (P1, P8).

One liked all (P1)

because he liked the movement/exercise aspect of it. (P2)

The bike game, because of the competition aspect. (P3)

Jump jump, because of the movement, but also because of the in-game world. (P4)

Tivoli game because of scenery (P5)

Liked all syncsense games the most (P6)

Jump jump. It was funniest to cycle. But the reason was that is was funnier to jump around (P7)

She likes all of them, but probably she likes the amusement park most, because of the settings with the animals and the amusement park. (P8)

Did you enjoy training with the games more than your normal exercises?

Majority preferred training with games due to fun and novelty (P1, P2, P5, P6, P7, P8).

The bike game was very motivating. (P1)

Some preferred traditional exercises for variety and motivation (P3, P4).

Were you more motivated than in your normal exercises? If so, what made it more motivating?

Majority felt more motivated with the games due to fun and exploration (P1, P2, P3, P5, P6, P7).

One participant preferred traditional exercises for their variety (P4).

One participant found it easier to use her disabled hand in the game (P8).

In the biking game, did you prefer playing against the default bike or playing against your digital twin?

Majority preferred playing against the digital twin (P1, P3, P5, P7, P8).

One participant had technical issues with the avatar (P2).

Mixed feelings about the avatar versus the other bike (P6).

Why did you prefer playing against the digital twin? What makes it so special?

Participants found it motivating and fun to play against themselves (P1, P3, P4, P5, P6, P7, P8).

Specific reasons included knowing they were competing against their past performance and the avatar's appearance.

Was it clear to you that in the HDT-version of the bike game you played against yourself? If so, what made it clear?

Majority found it clear due to visual and verbal cues (P1, P2, P3, P4, P5, P7, P8).

One participant's avatar was ahead most of the time, affecting interaction (P6).

Did you find the avatar confusing?

Most did not find the avatar confusing and identified with it (P1, P2, P3, P4, P5, P7, P8).

One participant had mixed feelings but appreciated the avatar's presence (P6).

Would you like to have systems like those in your daily rehabilitation process? If so, would you prefer to have the system with the digital twin or without?

Majority would like to incorporate the system into their daily rehabilitation, preferring the inclusion of their avatar (P1, P2, P3, P5, P6, P7, P8).

One participant preferred traditional rehabilitation but would include the avatar if using the system (P4).

Interview records

What do you imagine is a (personal) Digital Twin?

P1: Have no idea

P2: Someone looks like me

P3: Have no idea

P4: Have no idea

P5: Digital version of me

P6: Have no idea

P7: A digital twin when you saw yourself

P8: Have no idea

What do imagine is a (personal) Digital Twin now that you tried our system?

P1: Something that looks like her.

P2: Same with last question. Someone that looks like him.

P3: someone looks like me

P4: She feels the avatar was her

P5: She sees it as a digital version of herself.

P6: Still Not clear but nice with avatar

P7: No answer

P8: A better understanding now. Someone you can go together with and do stuff with.

Which of the games did you enjoy the most (and why)? (different table)

P1: She liked all games.

P2: Jump Jump, because he liked the movement/exercise aspect of it.

P3: Bike, coz competition

P4: Jump Jump, because other games all use cycles, the exercise way is monotonous for her.

P5: Tivoli game because of the scenery

P6: Animal park.

P7: Jump jump. It was funniest to cycle. But the reason was that is was funnier to jump around

P8: Difficult to choose, all good but liked the amusement part the most. The reason is no idea, but that you could try the roller coaster etc.（The settings of the environments with syncsense games）

Did you enjoy training with the games more than your normal exercises?

P1: Yes, it was fun to be in a digital world.

P2: Yes.

P3: No, but they can make him use body more

P4: No, she is more motivated with her daily exercises.

P5: Yes

P6: She liked the games more

P7: With the games

P8: I liked this very much, because it isn't always the same. It's new and different. But its also good to come back to the old. Some of this alternative and some of the old.

Were you more motivated than in your normal exercises? If so, what made it more motivating?

P1: The bike game was very motivating.

P2: Yes, because of the fact that you are moving and can explore the virtual world.

P3: Yes, making him work hard

P4: She likes traditional exercises more because there are more different exercises.

P5: Yes

P6: Yes, the games are more fun.

P7: She was more motivated. It was because it was inside an environment.

P8: It was not more motivated than normal. It was easier to use her disabled left hand when playing with the game.

In the biking game, did you prefer playing against the default bike or playing against your digital twin? (different table)

P1: She preferred playing against her Digital Twin.

P2: There was no avatar on the bike due to technical issues.

P3: Digital twin, but he didn't notice that, he know that coz we told him before games

P4: No, she is more motivated without.

P5: Yes

P6: She likes to see her avatar but she also likes to play against the other bike.

P7: It was funnier to play against my digital twin.

P8: It was much more fun playing against myself

(If they prefer playing against the Digital Twin) Why did you prefer playing against the digital twin? What makes it so special? (different table)

P1: Particularly because she knew she was playing against herself.

P2: No avatar due to technical issues

P3: He didn't see the other bike as he was too fast, but knowing that the other bike was representing his last session motivated him.

P4: She could see that she was playing against the avatar which made it more fun.

P5: She enjoyed playing against her HDT.

P6: Because it looks like her and it has a dress on.

P7: It was nice to play against myself. And its also weird when there is no one on the bike

P8: More difficult.

Was it clear to you that in the HDT-version of the bike game you played against yourself? If so, what made it clear?

P1: Yes, it was clear, because both the fact that we told her and that she could see her avatar.

P2: Yes, because the difficulty of the opponent matched his capabilities better today.

P3: It was clear, because we told him at the beginning.

P4: She could see that it was her. (After asking if she felt like the avatar was her or just an avatar she created, she said that the avatar is her)

P5: Because she could see herself an knew that it was supposed to represent her.

P6: She wasn't interacting that much with her avatar today as the avatar was very much at front of her until the end. -> Asking her why she created the avatar that looked different from her (with red hair etc.): She said that she can identify with her figure and that she created the figure how she would like herself to look.

P7: It was clear.

P8: Was told but could also see it.

Did you find the avatar confusing?

P1: No, it was clear that the avatar was supposed to be her.

P2: They made the female version of him, so he knew that it was not representing him right now but it was clear for him that it was his figure. He did it female because he found it more motivating to have something nice to look at.

P3: It was not confusing, it was nice that he could see himself in the game.

P4: Nope, it was clear that it was supposed to be her and that she was playing against herself.

P5: It was clear to her, because she could see her avatar and identified with it. She strongly identified with her avatar

P6: Not a clear answer, but she liked that the avatar was there.

P7: It was clear because both I were told but also because I could see my avatar

P8: It was very clear that it was me

Would you like it to have systems like those in your daily rehabilitation process? If so, would you prefer to have the system with the digital twin or without?

P1: Yes, she would like to.

P2: Yes, but he would like to have the syncsense game.

P3: He would like to have a mix between traditional exercising and occasional exercising with the VR games, he would like to have his own avatar included.

P4: She is not really interested in doing it in her daily life, but if it was so, then with her avatar included. But she prefers traditional rehabilitation.

P5: She would love to use these games in daily rehabilitation and if so, with her avatar.

P6: She would appreciate having these games in her daily exercising and preferably with her Digital Twin, but she highlighted that she likes to win, so the avatar should not be better than her.

P7: Would play with the game and have the digital twin.

P8: Yes I would like to do it with both. Prefer the avatar (but was prompted a bit by the therapist towards that answer)

Student interviews (23.05.2024)

Participant 1 (P1)

Procedure: Students have played 3 sessions with the default system and 1 session with the HDT-version of the system.

Entry questions:

PQ0 (Asked at the beginning of the whole experiment session): What do you imagine is a (personal) Digital Twin?

No idea

PQ1: What do imagine is a (personal) Digital Twin now that you tried our system?

Something that looks like her.

PQ2: Which of the games did you enjoy the most (and why)?

She liked all games.

Questions addressing H1:

PQ3: Did you enjoy training with the games more than your normal exercises?

Yes, it was fun to be in a digital world.

PQ4: Were you more motivated than in your normal exercises? If so, what made it more motivating?

The bike game was very motivating.

PQ5: In the biking game, did you prefer playing against the default bike or playing against your digital twin?

She preferred playing against her Digital Twin, particularly because she knew she was playing against herself.

PQ6: (If they prefer playing against the Digital Twin) Why did you prefer playing against the digital twin? What makes it so special? (see above)

Questions addressing H2:

PQ7: Was it clear to you that in the HDT-version of the bike game you played against yourself? If so, what made it clear?

Yes, it was clear, because both the fact that we told her and that she could see her avatar.

PQ8: Did you find the avatar confusing?

No, it was clear that the avatar was supposed to be her.

Questions addressing H3:

PQ2, PQ3, PQ5

Questions addressing H4:

PQ9: Would you like it to have systems like those in your daily rehabilitation process? If so, would you prefer to have the system with the digital twin or without?

Yes, she would like to.

Participant 2 (P2)

Procedure: Students have played 3 sessions with the default system and 1 session with the HDT-version of the system.

(Participant is more cognitively impaired)

Entry questions:

PQ0 (Asked at the beginning of the whole experiment session): What do you imagine is a (personal) Digital Twin?

someone that looked like him

PQ1: What do imagine is a (personal) Digital Twin now that you tried our system?

Someone that looks like him.

PQ2: Which of the games did you enjoy the most (and why)?

Jump Jump, because he liked the movement/exercise aspect of it.

Questions addressing H1:

PQ3: Did you enjoy training with the games more than your normal exercises?

Yes.

PQ4: Were you more motivated than in your normal exercises?

Yes, because of the fact that you are moving and can explore the virtual world.

PQ5: In the biking game, did you prefer playing against the default bike or playing against your digital twin?

There was no avatar on the bike due to technical issues.

PQ6: (If they prefer playing against the Digital Twin) Why did you prefer playing against the digital twin? What makes it so special?

Questions addressing H2:

PQ7: Was it clear to you that in the HDT-version of the bike game you played against yourself? If so, what made it clear?

Yes, because the difficulty of the opponent matched his capabilities better today.

PQ8: Did you find the avatar confusing?

They made the female version of him, so he knew that it was not representing him right now but it was clear for him that it was his figure. He did it female because he found it more motivating to have something nice to look at.

Questions addressing H3:

PQ2, PQ3, PQ5

Questions addressing H4:

PQ9: Would you like it to have systems like those in your daily rehabilitation process? If so, would you prefer to have the system with the digital twin or without?

Yes, but he would like to have the syncsense game.

Participant 3 (P3)

Procedure: Students have played 3 sessions with the default system and 1 session with the HDT-version of the system.

Entry questions:

PQ0 (Asked at the beginning of the whole experiment session): What do you imagine is a (personal) Digital Twin?

Dont know

PQ1: What do imagine is a (personal) Digital Twin now that you tried our system?

Someone that looks like him. Someone who looks like him.

PQ2: Which of the games did you enjoy the most (and why)?

The bike game, because of the competition aspect.

Questions addressing H1:

PQ3: Did you enjoy training with the games more than your normal exercises?

No, because in regular exercises he uses the whole body more.

PQ4: Were you more motivated than in your normal exercises?

Yes, the games made him work harder.

PQ5: In the biking game, did you prefer playing against the default bike or playing against your digital twin?

He preferred the today's game.

PQ6: (If they prefer playing against the Digital Twin) Why did you prefer playing against the digital twin? What makes it so special?

He didn't see the other bike as he was too fast, but knowing that the other bike was representing his last session motivated him.

Questions addressing H2:

PQ7: Was it clear to you that in the HDT-version of the bike game you played against yourself? If so, what made it clear?

It was clear, because we told him at the beginning.

PQ8: Did you find the avatar confusing?

It was not confusing, it was nice that he could see himself in the game.

Questions addressing H3:

PQ2, PQ3, PQ5

Questions addressing H4:

PQ9: Would you like it to have systems like those in your daily rehabilitation process? If so, would you prefer to have the system with the digital twin or without?

He would like to have a mix between traditional exercising and occasional exercising with the VR games, he would like to have his own avatar included.

Participant 4 (P4)

Procedure: Students have played 3 sessions with the default system and 1 session with the HDT-version of the system.

(Participants answers contradicted a bit

Entry questions:

PQ0 (Asked at the beginning of the whole experiment session):

No answer

PQ1: What do imagine is a (personal) Digital Twin now that you tried our system?

Felt the avatar was her

PQ2: Which of the games did you enjoy the most (and why)?

Jump jump, because of the movement, but also because of the in-game world.

Questions addressing H1: (She seemed a bit concerned that she would offend the therapist)

PQ3: Did you enjoy training with the games more than your normal exercises?

She likes traditional exercises more because there are more different exercises.

PQ4: Were you more motivated than in your normal exercises?

No, she is more motivated without.

PQ5: In the biking game, did you prefer playing against the default bike or playing against your digital twin?

It was a lot more fun against her Digital Twin.

PQ6: (If they prefer playing against the Digital Twin) Why did you prefer playing against the digital twin? What makes it so special?

She could see that she was playing against the avatar which made it more fun.

Questions addressing H2:

PQ7: Was it clear to you that in the HDT-version of the bike game you played against yourself? If so, what made it clear?

She could see that it was her. (After asking if she felt like the avatar was her or just an avatar she created, she asked that the avatar is her)

PQ8: Did you find the avatar confusing?

Nope, it was clear that it was supposed to be her and that she was playing against herself.

Questions addressing H3:

PQ2, PQ3, PQ5

Questions addressing H4:

PQ9: Would you like it to have systems like those in your daily rehabilitation process? If so, would you prefer to have the system with the digital twin or without?

She is not really interested in doing it in her daily life, but if it was so, then with her avatar included. But she prefers traditional rehabilitation.

Participant 5 (P5)

Procedure: Students have played 3 sessions with the default system and 1 session with the HDT-version of the system.

Entry questions:

PQ0 (Asked at the beginning of the whole experiment session):

Dont know

PQ1: What do imagine is a (personal) Digital Twin now that you tried our system?

She sees it as a digital version of herself.

PQ2: Which of the games did you enjoy the most (and why)?

Tivoli game because of the scenery

Questions addressing H1: (She seemed a bit concerned that she would offend the therapist)

PQ3: Did you enjoy training with the games more than your normal exercises?

Yes

PQ4: Were you more motivated than in your normal exercises?

Yes

PQ5: In the biking game, did you prefer playing against the default bike or playing against your digital twin?

She enjoyed playing against her HDT.

PQ6: (If they prefer playing against the Digital Twin) Why did you prefer playing against the digital twin? What makes it so special?

Because she could see herself an knew that it was supposed to represent her.

Questions addressing H2:

PQ7: Was it clear to you that in the HDT-version of the bike game you played against yourself? If so, what made it clear?

It was clear to her, because she could see her avatar and identified with it. (She strongly identified with her avatar)

PQ8: Did you find the avatar confusing?

Questions addressing H3:

PQ2, PQ3, PQ5

Questions addressing H4:

PQ9: Would you like it to have systems like those in your daily rehabilitation process? If so, would you prefer to have the system with the digital twin or without?

She would love to use these games in daily rehabilitation and if so, with her avatar.

Participant 6 (P6)

Procedure: Students have played 3 sessions with the default system and 1 session with the HDT-version of the system.

Entry questions:

PQ0 (Asked at the beginning of the whole experiment session):

PQ1: What do imagine is a (personal) Digital Twin now that you tried our system?

No idea

PQ2: Which of the games did you enjoy the most (and why)?

Syncsense game

Questions addressing H1:

PQ3: Did you enjoy training with the games more than your normal exercises?

She liked the games more

PQ4: Were you more motivated than in your normal exercises?

Yes, the games are more fun.

PQ5: In the biking game, did you prefer playing against the default bike or playing against your digital twin?

She likes to see her avatar but she also likes to play against the other bike.

PQ6: (If they prefer playing against the Digital Twin) Why did you prefer playing against the digital twin? What makes it so special?

Because it looks like her and it has a dress on.

Questions addressing H2:

PQ7: Was it clear to you that in the HDT-version of the bike game you played against yourself? If so, what made it clear?

She wasn't interacting that much with her avatar today as the avatar was very much at front of her until the end.
-> Asking her why she created the avatar that looked different from her (with red hair etc.): She

said that she can identify with her figure and that she created the figure how she would like herself to look.

PQ8: Did you find the avatar confusing?

Not a clear answer, but she liked that the avatar was there.

Questions addressing H3:

PQ2, PQ3, PQ5

Questions addressing H4:

PQ9: Would you like it to have systems like those in your daily rehabilitation process? If so, would you prefer to have the system with the digital twin or without?

She would appreciate having these games in her daily exercising and preferably with her Digital Twin, but she highlighted that she likes to win, so the avatar should not be better than her.

Participant 7 (P7)

Procedure: Students have played 3 sessions with the default system and 1 session with the HDT-version of the system.

Entry questions:

PQ0 (Asked at the beginning of the whole experiment session): What do you imagine is a (personal) Digital Twin?

One that looks like me

PQ1: What do imagine is a (personal) Digital Twin now that you tried our system?

No answer

PQ2: Which of the games did you enjoy the most (and why)?

Jump jump. It was funniest to cycle. But the reason was that is was funnier to jump around

Questions addressing H1:

PQ3: Did you enjoy training with the games more than your normal exercises?

With the games

PQ4: Were you more motivated than in your normal exercises? If so, what made it more motivating?

I was more motivated. It was because it was inside an environment.

PQ5: In the biking game, did you prefer playing against the default bike or playing against your digital twin?

It was funnier to play against my digital twin.

PQ6: (If they prefer playing against the Digital Twin) Why did you prefer playing against the digital twin? What makes it so special?

It was nice to play against myself. And its also weird when theres no one on the bike

Questions addressing H2:

PQ7: Was it clear to you that in the HDT-version of the bike game you played against yourself? If so, what made it clear?

It was clear.

PQ8: Did you find the avatar confusing?

It was clear because both I were told but also because I could see my avatar

Questions addressing H3:

PQ2, PQ3, PQ5

Questions addressing H4:

PQ9: Would you like it to have systems like those in your daily rehabilitation process? If so, would you prefer to have the system with the digital twin or without?

Would play with the game and have the digital twin.

Participant 8 (P8)

Procedure: Students have played 3 sessions with the default system and 1 session with the HDT-version of the system.

Entry questions:

PQ0 (Asked at the beginning of the whole experiment session):

No idea

PQ1: What do imagine is a (personal) Digital Twin now that you tried our system?

Someone that you can do your exercises together.

PQ2: Which of the games did you enjoy the most (and why)?

She likes all of them, but probably she likes the amusement park most, because of the settings with the animals and the amusement park.

Questions addressing H1: (She seemed a bit concerned that she would offend the therapist)

PQ3: Did you enjoy training with the games more than your normal exercises?

Yes, the games are more fun, because it's a different experience.

PQ4: Were you more motivated than in your normal exercises?

She was not really more motivated than usual (but therapist also mentions that she in general is a very motivated person also during the traditional exercises)

PQ5: In the biking game, did you prefer playing against the default bike or playing against your digital twin?

The DT was more fun, primarily because it was more difficult.

PQ6: (If they prefer playing against the Digital Twin) Why did you prefer playing against the digital twin? What makes it so special? See above

Questions addressing H2:

PQ7: Was it clear to you that in the HDT-version of the bike game you played against yourself? If so, what made it clear?

Yes, it was clear, because we told her but also because she saw the avatar. She also felt that the DT opponent's performance matched her performance more and was a good challenge.

PQ8: Did you find the avatar confusing?

It was very clear to her that the avatar was supposed to represent her and that it was her workout partner.

Questions addressing H3:

PQ2, PQ3, PQ5

Questions addressing H4:

PQ9: Would you like it to have systems like those in your daily rehabilitation process? If so, would you prefer to have the system with the digital twin or without?

Yes, she would like to and she would also prefer it with the avatar since it reminds her of herself.

D Appendix: Therapist Interviews

The summarise of questions

What do you imagine is a (personal) Digital Twin?

Most participants had some initial idea of what a digital twin is, being an online copy (T1, T2, T4, T5, T6)

Some had no idea what it was (T3)

What do you imagine is a (personal) Digital Twin now that you've worked with our system?

Participants generally understood a digital twin as something that looks like them after using the system (T2, T3, T4, T5, T6)

Some went further and understood it as something you could evolve with (T1)

T1: But she couldn't have imagined the option that you could play against your digital twin.

T4, T6: Some virtual person that you can create. It doesn't necessarily look like you.

Compared to traditional rehabilitation, how would you rate our system's usefulness for rehabilitation?

Found the system useful (T1, T2, T3, T4, T5, T6)

T1: concerned that many colleagues might not be very technically experienced, so it should have a very detailed introduction.

T2: 'Now, I don't need to remind them all the time.'

T4: depending on their cognitive capabilities.

T5, T6: only covers a little bit of what they usually train.

What were the elements that made it particularly useful?

Data visualisation and collection (T1, T4)

Making exercise more enjoyable (T2, T3, T5, T6)

T1, T4: The data visualizations would help have a quantified overview of patients' capabilities on a daily basis (usually they only have yearly assessments).

T3: It is more motivating for the students.

T5: The competition fosters motivation and the biking game was easy to understand and intuitive.

T6: Particularly the games because they can challenge themselves and it motivates them.

Does the system have any particular benefits for you as a therapist?

Monitoring progress on a daily basis (T1, T2, T3, T4, T5, T6)

T2: Monitoring progress and performance on a daily basis instead of yearly assessments could be beneficial.

T4: In traditional rehabilitation, they observe and assess performance by counting repetitions, which is easier with our system as it automates it.

T5: The dashboards are very suitable for documentation and performance/progress monitoring purposes.

Is the visualization of the students' performance data within the therapist dashboard a useful extension to the system? If so why?

Simple to understand (T1, T2, T3, T4, T5, T6)

T1: Yes, the visualizations were obvious and intuitive.

Did you find the therapist dashboard intuitive and easy to use?

Intuitive to understand(T1, T2, T5, T6)

Difficult to understand (T3, T4)

T3: They are a little bit confusing. She would need some minutes to learn how to read the graphs.

T4: Not really, but she's also not great with technical systems. Would need a better introduction to the system.

Overall did you like the system? What could have been improved?

More statistical data (T1, T3, T4)

More difficulty adjustment (T2)

More in game guidance (T5, T6)

T4: Have the possibility to not only state the physiological facts but also add context such as mood and cognitive condition, as these can significantly influence daily performance. And ROM visualization is not make a lot sense now, because one degree's mobility with straight arms cannot really show the mobility of arms/shoulders of students.

T6: The in-game instructions of Jump Jump in the VR glasses were difficult to understand. Cycle is good

Would you want to use similar systems on a daily basis in your job as a therapist?

Yes would like to (T1, T5, T6)

Yes but with further improvements (T2, T3, T4)

T2: If the technology works fine, particularly because the system motivates and somewhat automates the rehabilitation process for the students.

T3: Yes, it would be nice because it's something new and an easy way to provide students with an engaging experience without having to come up with creative ideas themselves.

T4: It could be nice to use the system sometimes as an addition to traditional rehabilitation, but a dashboard like the one we have would be nice.

What do you imagine is a (personal) Digital Twin?

T1: A copy of yourself in a digital world.

T2: An online me.

T3: No idea what it is.

T4: Something like the Sims Game.

T5: An avatar that looks like her.

T6: Some kind of figure in the computer that looked like her.

What do you imagine is a (personal) Digital Twin now that you've worked with our system?

T1: Probably kind of the same. But she couldn't have imagined the option that you could play against your digital twin.

T2: Doesn't change her impression.

T3: Your own character in the game. A virtual entity that looks like you and with which you can interact.

T4: Some virtual person that you can create. It doesn't necessarily look like you.

T5: An avatar that looks like her.

T6: An avatar that looks like her. An avatar that people can design to look as much like them as possible.

Compared to traditional rehabilitation, how would you rate our system's usefulness for rehabilitation?

T1: It is useful especially for the motivation of the students and concentration. She would use the system but is concerned that many colleagues might not be very technically experienced, so it should have a very detailed introduction.

T2: It is useful for the students because it challenges them and offers more options for rehabilitation than traditional methods. She feels students perform better than usual. For the cycle game, she said 'Now, I don't need to remind them all the time.'

T3: It is nice as it is more modern and new, giving context to the exercises for the students.

T4: Yes, overall the system would be useful for some students, depending on their cognitive capabilities.

T5: It is very useful but at the moment it only covers a little bit of what they usually train.

T6: Yes, it would be useful for some of the students, depending on their cognitive condition. For therapists, it would also be useful for some of the students.

What were the elements that made it particularly useful?

T1: The data visualizations would help have a quantified overview of patients' capabilities on a daily basis (usually they only have yearly assessments).

T2: The digital environments in the games because they give the exercises context.

T3: It is more motivating for the students.

T4: For therapists, the big benefit is having the results to compare with when the students started (progress). For students, it is more motivating and gives the exercise context.

T5: The competition fosters motivation and the biking game was easy to understand and intuitive.

T6: Particularly the games because they can challenge themselves and it motivates them.

Does the system have any particular benefits for you as a therapist?

T1: The data visualizations provide a quantified overview of patients' capabilities on a daily basis.

T2: Monitoring progress and performance on a daily basis instead of yearly assessments could be beneficial.

T3: It is very nice to get an overview of the patient's condition and progress.

T4: In traditional rehabilitation, they observe and assess performance by counting repetitions, which is easier with our system as it automates it.

T5: The dashboards are very suitable for documentation and performance/progress monitoring purposes.

T6: For the students that would use these kinds of exercises, it is useful to monitor and compare their performances and progress.

Is the visualization of the students' performance data within the therapist dashboard a useful extension to the system? If so why?

T1: Yes, the visualizations were intuitive and easy to understand.

T2: Yes, the visualizations were obvious and intuitive.

T3: Both the possibility to manage students and track progress makes it useful.

T4: The visualizations themselves are intuitive and easily understandable.

T5: The visualizations in the dashboards were intuitive.

T6: Yes, the visualizations were very intuitive.

Did you find the therapist dashboard intuitive and easy to use?

T1: It was intuitive. The visualizations etc. were not confusing and easy to understand.

T2: The dashboard was easy to use and the visualizations were obvious and intuitive.

T3: They are a little bit confusing. She would need some minutes to learn how to read the graphs.

T4: Not really, but she's also not great with technical systems. Would need a better introduction to the system.

T5: It was very intuitive and easy to use.

T6: It was relatively easy to use. The visualizations were very intuitive.

Overall did you like the system? What could have been improved?

T1: She liked it and knows that many students liked it, particularly the competitive component in the bike game. In the dashboard, it would have been nice to see a weekly performance summary for every game to see the progress.

T2: The games could have more diverse challenges (e.g., go uphill and downhill in the bike game). And for the dashboard, she wants to choose the difficulty level when adding games tasks.

T3: She would like to see more stats about the individual sessions (e.g., performance duration).

T4: Have the possibility to not only state the physiological facts but also add context such as mood and cognitive condition, as these can significantly influence daily performance. And ROM visualization is not make a lot sense now, because one degree's mobility with straight arms cannot really show the mobility of arms/shoulders of students.

T5: Maybe adding something about a goal system. This would be more interesting for the students so that they can see that they achieved something.

T6: The in-game instructions of Jump Jump in the VR glasses were difficult to understand. Cycle is good

Would you want to use similar systems on a daily basis in your job as a therapist?

T1: Yes, absolutely.

T2: If the technology works fine, particularly because the system motivates and somewhat automates the rehabilitation process for the students.

T3: Yes, it would be nice because it's something new and an easy way to provide students with an engaging experience without having to come up with creative ideas themselves.

T4: It could be nice to use the system sometimes as an addition to traditional rehabilitation, but a dashboard like the one we have would be nice.

T5: Yes, definitely.

T6: Yes, for some of the students.

Summarizing:
Dashboard:

Add tasks:
The buttons for adding tasks in Manage Tasks page is hard to be found.

When adding tasks, one therapist mentioned that it would be good to have difficulty level to choose

Client detail pages
ROM visualization is too simple to show the real status of upper limbs' mobility.

Tasks could have more details about status, like Weekly status

Therapist Interviews (23.05.2024)

Therapist 1

Procedure: Therapists supervised the students during their sessions with the system. During the third session, they interacted with the therapist dashboard, where they were able to monitor the student's condition through data visualizations.

Entry Questions:

TQ0 (Asked at the beginning of the whole experiment session): What do you imagine is a (personal) Digital Twin?

A copy of yourself in a digital world.

TQ1: What do imagine is a (personal) Digital Twin now that you've worked with our system?

Probably kind of the same. But she couldn't have imagined the option that you could play against your digital twin.

Questions addressing H1:

TQ2: Compared to traditional rehabilitation, how would you rate our system's usefulness for rehabilitation? It is useful especially for the motivation of the students and concentration. She would use the system, but she is concerned about that many colleagues might not be very technically experiences, so it should have a very detailed introduction.

TQ3: What were the elements that made it particularly useful? The data visualizations would help them have a quantified overview of patients' capabilities on a daily basis (usually they only have yearly assessments)

TQ4: Does the system have any particular benefits for you as a therapist? See above

TQ5: Is the visualization of the students' performance data within the therapist dashboard a useful extension to the system? If so, why?

Questions addressing H2:

TQ6: Did you find the therapist dashboard intuitive and easy to use? It was intuitive. The visualizations etc. were not confusing and easy to understand.

TQ7: Did the therapist dashboard add any clarity to the rehabilitation process? See above.

Questions addressing H3:

TQ8: Overall, did you like the system? What could have been improved?

She liked it and she knows that many of the students liked it, particularly she feels like the competitive component in the bike game was very motivating for students. In the dashboard, it would have been nice to see a weekly performance summary for every game, so that you can see the progress.

Questions addressing H4:

TQ9: Would you want to use similar systems on a daily basis in your job as therapist? Yes, absolutely.

Therapist 2

Procedure: Therapists supervised the students during their sessions with the system. During the third session, they interacted with the therapist dashboard, where they were able to monitor the student's condition through data visualizations.

Entry Questions:

TQ0 (Asked at the beginning of the whole experiment session): What do you imagine is a (personal) Digital Twin? An online me.

TQ1: What do imagine is a (personal) Digital Twin now that you've worked with our system? Doesn't change her impression.

Questions addressing H1:

TQ2: Compared to traditional rehabilitation, how would you rate our system's usefulness for rehabilitation? It is useful for the students, because its challenges them and she feels like these games offer more options for rehabilitation than the traditional rehabilitation. Also she feels like the students perform better than usual.

TQ3: What were the elements that made it particularly useful? In the games, it's mostly the digital environments because it gives the exercises a context.

TQ4: Does the system have any particular benefits for you as a therapist? It's hard to answer as she hasn't really worked much with the system. But she mentioned that she could imagine the system allowing her to monitor progress and performance on a daily basis instead of a yearly assessments could be beneficial.

TQ5: Is the visualization of the students' performance data within the therapist dashboard a useful extension to the system? If so, why?

Questions addressing H2:

TQ6: Did you find the therapist dashboard intuitive and easy to use? The dashboard was easy to use and the visualizations were obvious and intuitive.

TQ7: Did the therapist dashboard add any clarity to the rehabilitation process? See above.

Questions addressing H3:

TQ8: Overall, did you like the system? What could have been improved? The games could have more diverse challenges (e.g., go uphill and downhill at the bike game etc.)

Questions addressing H4:

TQ9: Would you want to use similar systems on a daily basis in your job as therapist?

If the technology works fine she would, particularly because the system motivates and somewhat automates the rehabilitation process for the students.

Therapist 3

Procedure: Therapists supervised the students during their sessions with the system. During the third session, they interacted with the therapist dashboard, where they were able to monitor the student's condition through data visualizations.

Entry Questions:

TQ0 (Asked at the beginning of the whole experiment session): What do you imagine is a (personal) Digital Twin? No idea what it is.

TQ1: What do imagine is a (personal) Digital Twin now that you've worked with our system? Your own character in the game. A virtual entity that looks like you and with which you can interact.

Questions addressing H1:

TQ2: Compared to traditional rehabilitation, how would you rate our system's usefulness for rehabilitation? Yes, I think it is nice as it is more modern and new, because it gives context to the exercises (for the students).

TQ3: What were the elements that made it particularly useful? That it is more motivating for the students.

TQ4: Does the system have any particular benefits for you as a therapist? It is very nice to get an overview of the patient's condition and progress.

TQ5: Is the visualization of the students' performance data within the therapist dashboard a useful extension to the system? If so, why? Both the possibility to manage students as well as tracking progress makes it useful.

Questions addressing H2:

TQ6: Did you find the therapist dashboard intuitive and easy to use? They are a little bit confusing, she would need to use some minutes to learn how to read the graphs

TQ7: Did the therapist dashboard add any clarity to the rehabilitation process? See above.

Questions addressing H3:

TQ8: Overall, did you like the system? What could have been improved? She would like to see more stats about the individual sessions (e.g., performance, duration etc.)

Questions addressing H4:

TQ9: Would you want to use similar systems on a daily basis in your job as therapist?

Yes, it would be really nice because it's something new and it's an easy way to provide students with an engaging experience without having to come up yourself with creative ideas. (So apparently it is a challenge for therapists to always create new exercises especially with the limited equipment they have. This is easier with the games)

Therapist 4:

Procedure: Therapists supervised the students during their sessions with the system. During the third session, they interacted with the therapist dashboard, where they were able to monitor the student's condition through data visualizations.

Entry Questions:

TQ0 (Asked at the beginning of the whole experiment session): What do you imagine is a (personal) Digital Twin? Something like the Sims Game.

TQ1: What do imagine is a (personal) Digital Twin now that you've worked with our system? Some virtual person that you can create, it doesn't necessarily looks like you.

Questions addressing H1:

TQ2: Compared to traditional rehabilitation, how would you rate our system's usefulness for rehabilitation? Yes, overall the system would be useful for some of the students (depending particularly on their cognitive capabilities)

TQ3: What were the elements that made it particularly useful? For therapists, the big benefit is that you have the results and you can compare it with when the students started (=progress). For the students, that it is more motivating and gives the exercise some context. Some students are very excited to compete with themselves.

TQ4: Does the system have any particular benefits for you as a therapist? In traditional rehabilitation, they observe and assess performance by counting repetitions, which is easier with our system as it automizes it.

TQ5: Is the visualization of the students' performance data within the therapist dashboard a useful extension to the system? If so, why?

Questions addressing H2:

TQ6: Did you find the therapist dashboard intuitive and easy to use? Not really, but she's also not great with technical systems. Would need better introduction into the system. But the visualizations themselves are intuitive and easily understandable.

TQ7: Did the therapist dashboard add any clarity to the rehabilitation process? See above.

Questions addressing H3:

TQ8: Overall, did you like the system? What could have been improved? Have the possibility to not only state the physiological facts by also add context, such mood, cognitive condition, as that can have a big influence on their daily performance. Also, the exercise summaries in the dashboard could show more stats, e.g., distance completed, session duration etc.

Questions addressing H4:

TQ9: Would you want to use similar systems on a daily basis in your job as therapist?

It could be nice to use the system sometimes as an addition to the traditional rehabilitation (regarding the games), but a dashboard like the one we have would be nice.

Therapist 5:

Procedure: Therapists supervised the students during their sessions with the system. During the third session, they interacted with the therapist dashboard, where they were able to monitor the student's condition through data visualizations.

Entry Questions:

TQ0 (Asked at the beginning of the whole experiment session): What do you imagine is a (personal) Digital Twin? An avatar that looks like her.

TQ1: What do imagine is a (personal) Digital Twin now that you've worked with our system? An avatar that looks like her.

Questions addressing H1:

TQ2: Compared to traditional rehabilitation, how would you rate our system's usefulness for rehabilitation? Yes, it would be useful for some of the students (depending on the cognitive condition). For therapists, it would also be useful for some of the students.

TQ3: What were the elements that made it particularly useful? Particularly the games, because they can challenge themselves and it motivates them.

TQ4: Does the system have any particular benefits for you as a therapist? For the students that would use these kinds of exercises, it is useful to monitor and compare their performances and progress.

TQ5: Is the visualization of the students' performance data within the therapist dashboard a useful extension to the system? If so, why?

Questions addressing H2:

TQ6: Did you find the therapist dashboard intuitive and easy to use? It was relatively easy to use. Also the visualizations were very intuitive.

TQ7: Did the therapist dashboard add any clarity to the rehabilitation process?

Questions addressing H3:

TQ8: Overall, did you like the system? What could have been improved? The in-game instructions in the VR glasses were difficult to understand.

Questions addressing H4:

TQ9: Would you want to use similar systems on a daily basis in your job as therapist?

Yes, for some of the students.

Therapist 6:

Procedure: Therapists supervised the students during their sessions with the system. During the third session, they interacted with the therapist dashboard, where they were able to monitor the student's condition through data visualizations.

Entry Questions:

TQ0 (Asked at the beginning of the whole experiment session): What do you imagine is a (personal) Digital Twin? Some kind of figure in the computer that looked like her.

TQ1: What do imagine is a (personal) Digital Twin now that you've worked with our system? An avatar that looks like her. An avatar that people can design that looks as much like them as possible.

Questions addressing H1:

TQ2: Compared to traditional rehabilitation, how would you rate our system's usefulness for rehabilitation? It is very useful, but at the moment it only covers a little bit of what the usually train.

TQ3: What were the elements that made it particularly useful? The competition which fosters motivation and the biking game was easy to understand and intuitive.

TQ4: Does the system have any particular benefits for you as a therapist? The dashboards are very suitable for documentation and performance/progress monitoring purposes, which can be very difficult for some of the students. Because some students don't understand when they do manual assessments and their supposed to do their best, but with our system they're so motivated that they always gave their best and their performance is aggregated automatically over multiple sessions.

TQ5: Is the visualization of the students' performance data within the therapist dashboard a useful extension to the system? If so, why?

Questions addressing H2:

TQ6: Did you find the therapist dashboard intuitive and easy to use? It was very intuitive and easy to use. The in-game visualizations in the jump jump game were not so intuitive. The visualizations in the dashboards were intuitive.

TQ7: Did the therapist dashboard add any clarity to the rehabilitation process?

Questions addressing H3:

TQ8: Overall, did you like the system? What could have been improved? Maybe adding something about a goal-system. This would be more interesting for the students so that they can see that they achieved something

Questions addressing H4:

TQ9: Would you want to use similar systems on a daily basis in your job as therapist?

Yes, definitely.

E Appendix: Therapist Usability Test

Scenario-Based Usability Testing for Therapist Dashboard

The client information provided below is intended only for testing purposes.

You have a new student attending a therapy session. He will come for therapy sessions once a week and mainly exercise at home. You need to add him to the system and assign tasks for him.
Please follow the guide below to complete two tasks:

Task 1: Add the New Student to the System

Basic Information
Name: Jack Jensen
Birth Date: 12-03-2009
Phone Number: 43000000
Email: Jack12@gmail.com
Biological Sex: Male

Recovery Plan
Type of Movement Impairment*: (You can leave this empty)*
Dominant Arm: Left
Therapy Goals: *(You can leave this empty)*

Contact Person
Name: Allison
Email: allison123@gmail.com
Phone Number: 45000000

Task 2: Add Weekly Tasks for Jack

You have completed the first therapy session with Jack, and he has learned how to use the system and devices. Now, you need to add tasks for him. He will exercise by himself at home before the next therapy session.
Please input the following details into the dashboard and save:

Jump Jump
Total Sets: 4
Task Period: 23-5-2024 to 31-5-2024

Cycle
Total Sets: 2
Task Period: 23-5-2024 to 31-5-2024

Survey for Therapist Dashboard

Part 1: Add client and add tasks

Adding a new client to the system was straightforward and easy to complete.

☐ 1 (Strongly Disagree)
☐ 2 (Disagree)
☐ 3 (Neutral)
☐ 4 (Agree) x x
☐ 5 (Strongly Agree) x x x x

Assigning tasks for clients was intuitive and efficient.

☐ 1 (Strongly Disagree)
☐ 2 (Disagree)
☐ 3 (Neutral) x
☐ 4 (Agree) x x x x
☐ 5 (Strongly Agree) x

Part 2: Client Details page

The **Range of Motion (ROM)** display is clear and helps me understand the student's physical progress.

☐ 1 (Strongly Disagree)
☐ 2 (Disagree) x
☐ 3 (Neutral) x x x
☐ 4 (Agree)
☐ 5 (Strongly Agree) x x

The **Tasks** and **Exercises Completion Rate chart** in the dashboard are easy to read and effectively shows the client's exercise performance.

☐ 1 (Strongly Disagree)
☐ 2 (Disagree)
☐ 3 (Neutral)
☐ 4 (Agree) x x x x x
☐ 5 (Strongly Agree) x

Part 3: System Effectiveness

When the goal is to enhance daily exercise effectiveness, how well does the system:

The system would help me ensure that students can follow their daily exercise routines effectively.

☐ 1 (Strongly Disagree)
☐ 2 (Disagree) x
☐ 3 (Neutral) x

☐ 4 (Agree) x x
☐ 5 (Strongly Agree) x x

When the goal is to enhance daily exercise effectiveness, how well does the system:
The system would improve the management of client exercise plans for me.
☐ 1 (Strongly Disagree)
☐ 2 (Disagree)
☐ 3 (Neutral) x
☐ 4 (Agree) x x x x
☐ 5 (Strongly Agree) x

When the goal is to enhance daily exercise effectiveness, how well does the system:
The system effectively motivates students to complete their exercises regularly.
☐ 1 (Strongly Disagree)
☐ 2 (Disagree)
☐ 3 (Neutral) x x x
☐ 4 (Agree) x x
☐ 5 (Strongly Agree) x

The system has the potential to be widely used in the daily exercise routines of students in the future.
☐ 1 (Strongly Disagree)
☐ 2 (Disagree)
☐ 3 (Neutral) x
☐ 4 (Agree) x x x x x
☐ 5 (Strongly Agree)

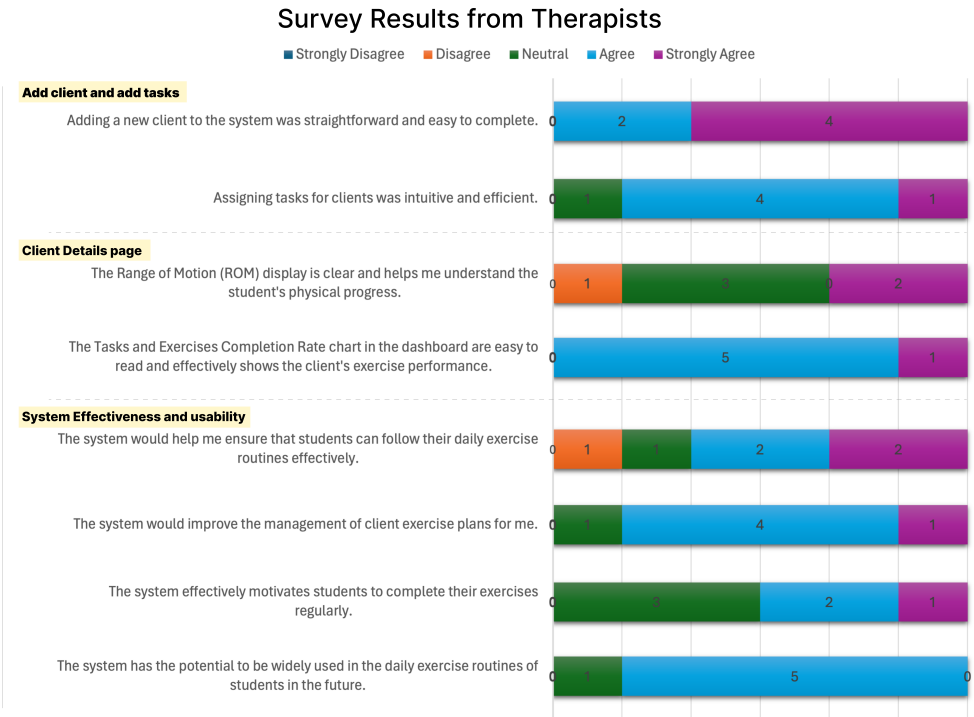

Figure E.1: Survey results data from therapist usability test visualised as a stacked bar graph.