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Intervention Platform for Action Observation and Motor Imagery Training After Stroke: Usability Test

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Abstract. Action observation (AO) and motor imagery (MI) are considered as promising therapeutic approaches in the rehabilitation of patients after a stroke (PaS). Observing and mentally rehearsing motor movements stimulate the motor system in the brain and result in a positive effect on movement execution. To support patients in the early rehabilitation phase after a stroke, ANIMATE, a digital health intervention platform was developed. The platform guides the user through 6 activities of daily living by observing and imagining the corresponding movements. We conducted a scenario-based usability test with 9 PaS at a rehabilitation centre to identify existing usability issues. PaS found the app easy to use and they could interact with it without problems. Although they judged the app as useful, they stated to be not willing to use the app on a regular basis. Including features for customising ANIMATE regarding the individual rehabilitation goals and needs of PaS, as well as personalisation could help in increasing the motivation to use and the benefits of the platform.

Keywords. neurorehabilitation, stroke, smart device application, motor imagery, action observation, user-centered design, usability

1. Introduction

A stroke is a massively life-changing event [1]. Due to the aging population, the absolute number of strokes per year will increase to 1.5 million in Europe by 2025 [2]. Action observation (AO) and motor imagery (MI) are powerful training techniques in motor learning and motor control, facilitating brain plasticity. Both are easy to learn [3] mental processes, allowing individuals to train a given motor act by observation or rehearsal even if they cannot perform it physically, e.g. due to an injury or paresis. In rehabilitation of patients after a stroke (PaS), the combination of physical practice (PP) and AO or MI can improve motor function more than PP alone [3,4]. Recent developments combined AO and MI with promising results (AO+MI) [3]. To support patients in either AO or MI,

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several apps are available. 'Recognise'[2] and 'Orientate'[3] support practicing left/right discrimination of body parts. 'Recovery Exercises'[4] promotes exercising everyday tasks and arm movements by AO or by physical practice. 'ViaTherapy'[5] offers some exercises for AO, some for MI, and some for performing tasks physically. Mirror Therapy VR[6] requires virtual reality glasses; the app simulates mirror therapy. No app is available that provides AO+MI training for subacute PaS. The aim of this work is to develop the ANIMATE app, a prototype addressing this research gap, and to study its usability.

2. Methods

System development and ANIMATE app. An interdisciplinary team of researchers from rehabilitation and medical informatics iteratively developed the intervention platform ANIMATE in a user-centred design process. The current prototype implements 6 activities of daily living (ADL; walking, drinking from a cup, getting up from a chair, washing hands, climbing and descending stairs, drawing a line with ruler and pencil). After having selected an activity, the user watches a video of a person performing it (AO). Next, the user is asked to imagine this activity (MI) for a predefined time. To minimise accessibility issues, user input is kept simple (e.g., large buttons, no control gestures like swiping or pinching). In an onboarding tutorial, the user is introduced to the AO+MI concept and the structure of the app. ANIMATE is realised as a progressive web application (PWA). It is available here: *https://orange-sky-041267503.azurestaticapps.net/*.

Usability test. Following the maxim of user-centred design, we aimed at studying the target group's perception of ANIMATE. Since no qualitative analysis was intended, we aimed at recruiting 10 [5] inpatients at the rehabilitation centre in Rheinfelden after approval by the responsible ethics committee (EKNZ Req-2021-01158). Eligible for participating were PaS aged 18 or older, being able to sit upright without assistance, use at least hand to operate a smart device, and understand spoken and written instructions in German. Recruitment and test took place between 13th and 21th November 2021. Potential participants received an information leaflet at recruitment, and gave informed consent immediately before the test.

The study consisted of a pre-test interview, a scenario-based test and a post-test interview. First, their affinity for IT, their experience with smart devices and (health/exercise) apps, and their expectations regarding our app were inquired. For the test, two scenarios had been designed to sequentially address all features implemented in the app: 1) "Imagine yourself being between two rehabilitation therapy sessions and eager to exercise some more. Start the app, watch the onboarding sequence, and do an exercise of your choice." 2) "You want to watch the onboarding tutorial again. Find and run it." The test supervisor observed the PaSs' interactions with the app, and documented the observations for each view in the app. If patients encountered problems, they were encouraged to find solutions themselves. In the post-session interview, the participants were asked some open questions (about experiences during the test and for ideas for improvement), and were finally guided through a questionnaire of established rating

[2] https://www.noigroup.com/product/recogniseapp/
[3] https://apps.apple.com/de/app/orientate-pain-management/id479540062
[4] https://www.my-therappy.co.uk/app/reps-recovery-exercises
[5] https://www.viatherapy.org
[6] https://play.google.com/store/apps/details?id=com.sixdimensions.mirrortherapy&hl=en&gl=US

items. The System Usability Scale questionnaire (SUS) [6] and the User Version of the Mobile Application Rating Scale (uMARS) [7] were customised to address the peculiarities of our app. We used 6 out of 10 SUS items and 10 out of 20 uMARS items (plus another 2, by slightly rephrasing 2 of those 10). It was not feasible to deploy both questionnaires in their entirety, nor to rely on only one of them. Furthermore, it would have been too strenuous for most candidates to answer all 30 items of SUS and uMARS combined. The complete test concept (German) is available online[7].

3. Results

From 10 volunteering PaS, 1 withdrew his consent before the test. The remaining 9 completed the entire test. Average Extended Barthel Index (EBI) was 44.8 (min: 32 - median: 44 - max: 60), Functional Independence Measure (FIM) 95.6 (62-101-124). Most PaS said they use smartphones, but some almost exclusively as telephones. Only 1 PaS deemed themselves notably interested in technology, and apps, and used a health app (steps counter). Few at least had heard of health apps, like fitness or diabetes apps.

Table 1 provides an overview on all 18 items of the questionnaire. All PaS felt confident in using the app, and they deemed the app easy to use (items 1,2,6). However, 4 PaS claimed they would need help to use the app. Most rated the provided information as useful and of good quality (items 9,10). In contrast, PaS could not imagine to use the app on a regular basis (item 12): 2 PaS indicated they would hardly use the app and 2 estimated they would certainly not use it within the next 7 days. Almost all PaS were not willing to pay for the app (item 13).

Table 1: Results from the customised usability questionnaire.

no.	Question	patient ID								Median	Average
		p1	p2	p3	p4	p5	p7	p8	p9	p10	
1	I managed well and felt confident while using the app.	4	2	5	5	4	4	5	5	4	4	4.2
2	I find the app very cumbersome to use.*	4	4	4	5	4	2	5	5	4	4	4.1
3	I'd need help while using the app.*	5	1	5	5	2	1	5	1	4	4	3.2
4	Most people will quickly learn to use the app.	2	4	4	4	4	5	3	3	3	4	3.6
5	The app is well adapted to the target user's needs.	3	5	5	4	2	5	5	5	3	5	4.1
6	Navigation works fine and is easy.	4	3	5	5	4	1	5	5	4	4	4.0
7	Layout is good (position and size of text, buttons, etc).	5	4	4	5	3	2	5	3	4	4	3.9
8	The app looks good and engaging.	3	NA	4	4	2	5	4	4	4	4	3.8
9	Provided information is important and understandable.	3	NA	5	4	4	5	5	5	4	5	4.4
10	Amount of provided information is good.	3	NA	4	5	4	5	5	5	4	5	4.4
11	Would you recommend the app to other patients?	3	4	2	4	3	5	4	5	4	4	3.8
12	How often would you use the app in the next 7 days?	2	2	4	4	4	1	5	1	3	3	2.9
13	Would you pay for the app?	2	3	4	5	1	1	5	2	3	3	2.9
14	Should the health insurance or the clinic pay for the app?	3	1	5	5	4	5	5	3	1	4	3.6
15	What is your overall opinion of the App? (stars)	4	3	3	4	3	4	4	4	4	4	3.7
16	What is your overall opinion of the App? (statements)	3	4	5	4	3	5	4	4	4	4	4.0
17	I'm better aware of how helpful solo, mental training is.	4	4	5	5	5	2	5	2	4	4	4.0
18	I'm more motivated for solo, mental training.	4	5	4	4	2	4	5	2	5	4	3.9
	SUS (x/60)	43	35	53	55	38	30	55	30	45	43	42.5
	uMARS (x/5)	3.2	3.2	4.2	4.4	3.1	3.7	4.7	3.8	3.5	4	3.7

Legend: * = answers reversed for this analysis (1=worst, 5=best); NA = not available (p02 said he had seen too little of the app to be able to rate items 8 to 10). Questions 5-16 contribute to the uMARS score, the others to the SUS score. For comparison, our total score needs to be adapted for SUS (x/60 instead of originally x/100), as a uMARS score is the average of all valid items anyway. The questions are shortened for depiction here.

[7] https://www.researchgate.net/publication/357543052_

The average SUS and uMARS values (42.5 out of 60 (normalised to the original SUS score maximum: 71.66/100), and 3.7 out of 5) can be interpreted as meaning "above average" to "good" (for interpreting SUS results, see [6]).

From our observations during the scenario-based tests we identified some usability issues: 1) sometimes navigation buttons were difficult to find and 2) PaS found it hard to follow text- or symbols-based directives in the app (in line with perceiving the voice-based instructions in the onboarding tutorial as helpful). While 1 PaS preferred the motor tasks suggested for the AO+MI training to be much simpler, like a basic finger exercise, another PaS considered that more complex AO+MI movements would be more valuable for the therapy process.

4. Discussion and conclusion

The results show that this current prototype is well received by patients. Since AO+MI are known to improve stroke rehabilitation outcome, the ANIMATE app may become a helpful instrument in further meliorating PaS chances of regaining autonomy in their lives. However, our study has some limitations. Variability in the scorings per item is wide. 5 out of 18 items received both extremes of the rating scale (1 and 5). For other items, however, the result is clear (e.g., overall impression, items 16 and 17). Although working with 9 participants is within the range of existing studies on the effectiveness of MI+AO, correlating user perceptions to clinical parameters was out of reach. Reasons for reservations against using the app still have to be assessed in more detail. Participants dismissed the idea of having to pay for the ANIMATE app; it might be that they expect the health insurance to pay for the app (item 14 in Table 1).

Potential for improvement resides mainly in providing customisation options, e.g. provide every activity for deficits on either body side. Further, GUI controls should be fine-tuned, and the range of ADLs widened. Gamification aspects (e.g. personalised avatar) may increase the time spent doing exercises, which is obviously crucial for rehabilitation outcome. A later step might include adding meta features that could help increasing the overall usefulness in daily routine, like user accounts, statistics of use, diary and/or self-assessment options, or superuser access (e.g., for managing and monitoring user access, changing global settings, exchanging components).

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