[1]Tümler J., [2]Mecke R., [3]Rößler T., [3]Schenk D., [3]Böckelmann I

EXAMINING THE AUGMENTED REALITY FUNNEL: DOES IT LEAD TO INATTENTIONAL BLINDNESS?

[1]Volkswagen AG, [2]Fraunhofer Institute for Factory Operation and Automation IFF, [3]Otto-von-Guericke University Magdeburg, Germany

Abstract. *The use of Mobile Augmented Reality in industry offers possibilities to provide relevant information at exactly the right time registered to the correct spatial position. Our previous studies demonstrated that even with today's rather prototypic Mobile Augmented Reality systems this potential can be used without raising the overall psychophysical strain of the user. One of the thereby identified helpful tools to support the worker is the "AR funnel" which can guide a user to a defined spatial position. While this tool technically works well it is still unknown how much it influences the user's perception of the surrounding. This paper describes a user study to examine the influence of the AR funnel on user's situation advertence.*
Key words: *models and principles, user/machine systems, human factors, information interfaces and presentation, user interfaces—user-centered design*

INTRODUCTION. Research on applications of Mobile Augmented Reality (MAR) are in focus of industry for several years now (e.g. projects ARVIKA [2] and AVILUS [6]). The main idea of MAR here is to support industrial workers with information they need at the right time in the right spatial position to achieve a higher productivity and less errors. At the same time these systems must neither harm nor negatively influence the well-being of the user.

A main focus of our previous research dealt with examination of user's strain while continuously working with MAR systems based on Optical See Through Head Mounted Displays (OST HMD) for several hours [10, 8, 4]: Users were assisted by different MAR systems to find correct positions of real items stored in numerous shelves of our reference scenario (fig. 1a). They had to pick the right object, put it into a basket and continue with the next work task. During their work the heart rate was analyzed to find objective clues on how much the use of the MAR system influences user's strain. All our experiments show that work with the used MAR systems results in strain levels comparable to work without the MAR system. For the planned industrial use of MAR this is an important finding for company doctors and a precondition for the ergonomic design of AR based assistance systems.

One of the techniques used in our studies was named “AR funnel” or “attention funnel” as explained by Biocca and Schwerdt-feger [1, 7]. This can be best understood as a hose of a vacuum cleaner starting a few centimeters in front of the eye and ending at the target position (fig. 1b). Its use led to a good work efficiency but questions arose concerning work saftey. When the user is highly concentrated and completely focused on the AR funnel it could result in inattentional blindness [9, 11]. For example, if it would be likely for the user to not realize a forklift crossing his way while working with the AR funnel this would make it inapplicable for industrial use. Therefore, we here report a study to examine if inattentional blindness is caused by use of an AR funnel.

a b

Figure 1. User working with a MAR system: Liteye Head Mounted Display, infrared tracking, AR funnel navigation.

CONTRIBUTION. It is the impression of the authors that today’s Augmented Reality research community has a main focus on new technologies and applications. Transfer of newly designed technologies and applications to real use seems to be a minor topic of interest today thus user studies that embed these new technologies are quite rare. This could be a reason for why MAR applications have such a low impact on industry today. Zhou et al. [12] present a state of the art report which confirms this impression: 313 publications from 1997-2007 were analyzed and sorted into eleven categories such as tracking, interaction and so on. Out of these analyzed literature sources only 18 papers (5.8%) deal with the evaluation of developed technologies and applications. Even lower is the number of citations which credits the value of a publication. Only five (1.8%) of these papers dealing with evaluations have been quoted in other publications. This low value is among the three lowest of the 11 categories. Our interpretation is that the value of reporting on an evaluation study needs to be raised within the research community. At least one important question that - from our point of view- should always be answered by user studies is: “What are challenges to bring this new technology to real practical use and how can we solve them?”

This paper contributes to the AR community by presenting a user study that helps to understand effects of a promising tool for industrial applications. We make use of the “attention funnel” which is a well known AR technology and examine if its application in a realistic work environment possibly results in hazardous side effects to the user.

Next to this an investigation on efficiency of the AR funnel is presented to demonstrate the value of this type of information visualization for industry.

INATTENTIONAL BLINDNESS. Through our eyes we get tons of data each moment. Our brain filters the data and only relevant information reaches our awareness [3]. Inattentional blindness describes the effect that when a person is totally focussed on one or more objects in his sight he does not notice other objects, even if they are well visible and probably don’t even belong to the current scene. What gets our attention focus depends on numerous factors, for example knowledge of the scene and the user’s intention.

While conducting our previous studies with OST HMDs and various forms of the AR funnel we realized that sometimes the subjects were totally focussed on their task. This of course was good for the study, because we wanted to make full use of the AR system. But questions arose if the users would be able to react on other events happening in their surrounding while they worked with the AR funnel. This demonstrated the need to examine whether or not inattentional blindness happens when using our AR system and especially the AR funnel.

Simons and Chabris demonstrate inattentional blindness in a simple yet impressive experiment [9]: In a video two teams, black and white, each consisting of four players, run in front of the camera. The white team has a ball. Study participants watch the video to count the number of passes made by the white team. While game in the video is going on and the viewer counts the number of passes, a man in an animal costume moonwalks slowly and clearly visible through the view. About half of the subjects used in the study did not realize this unexpected event at all!

Another study which is closer to our industrial target setup is described by Wickens [11]: Pilots had to follow a "3D flight path pathway" in a simulator environment. This pathway is a relative of our AR funnel. When using the 3D pathway four of eight pilots did not detect a blimp flying nearby, while only one of six pilots flying without the pathway was oblivious of the blimp. An interpretation for our application scenario would be that working with the AR funnel would cause inattentional blindness. This supports our initiative to further study the AR funnel and carry out an experiment as described in this paper.

USER STUDY: DUAL TASK. To find out if we can use the AR funnel in future industrial settings we have to study the perception of users when working with the AR funnel. We must know whether or not users can still perceive relevant information that is not directly related to their primary work task. In reality that kind of information can be warnings ("forklift crossing"), status information ("machine defective") or similar.

To examine if inattentional blindness occurs or not the following is required:

- controllable laboratory setting that is similar to a targeted real world scenario
- AR system with OST HMD and funnel visualization
- controllable stimuli somewhere in the surrounding of the user
- a system that controls the input variables and measures the result

There are different possibilities how a test could be set up. They have in common that it would be dual task where working with the AR funnel is the primary and reacting on a stimulus is the secondary task.

To generate statistically reliable results it would be necessary to show all subjects the exact same visual information. We could for example show a recorded video in egocentric view where the user sees an AR funnel in an industrial workplace and has to react on defined stimuli. But this would totally ignore the primary task and the actual physical strain caused by work which is a main influence on if the user is concentrated or not.

As another idea we could make the subjects work at a realistic reference workplace and show visual stimuli somewhere in the surrounding (e.g. a real forklift moves into the scene). It would take a lot of effort to capture the current position and orientation of the user, the forklift and the current funnel direction - and then finally correlate these inputs to find out if and how well the user can perceive the new situation. What happens if the user does not realize the forklift? Of course the subject must not be put in danger. Even if it's not a real forklift but a "red light" flashing somewhere we still could not control when and how the user looks into the direction of the light. It would also have the disadvantage that the OST HMD itself covers parts of the view on the real world if it has a wide frame (as the LitEye LE-750) which is an influence on perception of the real world.

The third possibility is to have the subjects work at a realistic reference workplace and show stimuli on the virtual display of the OST HMD. This gives us the possibility to have stimuli always in the user's field of view and always at the same position relative to the AR funnel's egocentric starting position. Of course this has the disadvantage that stimuli can only be shown within the (usually very limited) field of view of today's head mounted displays. We decided to realize this third possibility as it can give us a realistic physical strain as well as controllable stimuli and low risk for the user.

Test Setup

Reference Scenario

We have set up a reference scenario (fig. 2) that represents a picking area as used in automotive industry [10, 4]. It consists of 58 boxes, all containing 10 similar items equipped with RFID-tags, distributed over eight shelves. Test subjects are guided via

OST HMD and AR funnel from box to box to collect parts from the shelves one after another. After picking a single part the subject always has to confirm completion by pressing a button on the AR system and put the item into a basket. Then the next task would be displayed in the OST HMD. All jobs are bundled in "job lists", each job list contains 15 items. For each job list a subject has to walk approximately 60 m and then return the basket. After 45 minutes a subject would have completed roughly 15 job lists, thus picked about 225 items and walked about 0.9 km. A half-automated quality control station was used where the test supervisor could scan the RFID-tags of all collected items for correctness.

Figure 2. Layout of the test area

AR System

We used a LitEye LE-750 full color OST HMD (28◦ field of view) together with a Sony Vaio UX1 Ultra Mobile PC (UMPC). We mounted IR markers to the headband of the HMD so that a stationary OptiTrack tracking system would be able to track user's head within the work volume. The tracking result was delivered via WiFi to the UMPC which ran metaio Unifeye SDK 3.0 for AR visualization. This setup resulted in average frame rates of 20 frames per second and a latency of approximately 0.5 seconds. The optical see through calibration was performed with our MPAAM method as described in [5]. Figure 5 shows the work area and a subject working with the AR system.

Visualizations for Primary Work Task

Three visualizations were possible for the primary work task: Either “text only” or two variants of the AR funnel:

•**Text-only** provided information on the current job number and the part number of the item that had to be picked. No other AR visualization (funnel, square) was displayed. This presentation was used as control setup (fig. 4c).

•**Funnel A:** Rings of the funnel were equally distributed along a bezier curve. The distance between rings of funnel A was 120 mm (measured along the curve in 3D space). Text information on the target item was presented additionally as in text-only visualization (fig. 4a).

•**Funnel B:** All funnel parameters were the same as funnel A except for distance between rings which was 240 mm. It also included text information on the target item (fig. 4b).

Each subject had to work with each visualization for 45 minutes in a row. The order of visualizations was randomized between the subjects. The AR funnel consists of a variable number of rings that are aligned along a bezier curve. The funnel is characterized by the density of all rings as well as the width of each single ring. These properties can be configured in the AR system. When the user reaches a predefined distance to the target (60 cm) a green square fades in to highlight the box (see fig. 4d) and the funnel fades out.

Visualizations for Secondary Work Task

To contribute to our main question we designed the secondary work task: Will the user be able to react correctly on other stimuli when working with the AR funnel? Therefore it was required to embed stimuli such that the user has to detect them, decide what to do and then react. In addition we did not want to stop the primary work task when presenting the stimuli of the secondary work task. That’s why we decided to use landolt rings that open to left, top, right and bottom (fig. 3a) and are presented to the user in one corner of the OST HMD. To where the ring opened and in which corner it would be presented both was randomized.

The user would have to react on the presentation of the landolt ring by first pressing the "A" button of a Nintendo Wiimote to tell the system the stimulus was detected. Then the landolt ring would instantly disappear and the user would press the cross button of the Wiimote showing the direction to where the landolt ring opened (fig. 3b). For example if the ring was shown in the top-left corner with its opening to the right side then the subject would have to press "right" on the Wiimote. It was recorded

•when the landolt ring appeared,

•when (and if) the user pressed the "A" button,

•when he pressed the cross,

•if he detected the opening correctly,

•and a screenshot of the currently displayed image.

A strong indicator for occurance of inattentional blindness would be if subjects miss to react on the appearance of landolt rings.

In addition the display was divided into four equally sized quadrants. It was recorded in what quadrant the landolt ring appeared and what quadrant the funnel currently laid in during that moment.

a b

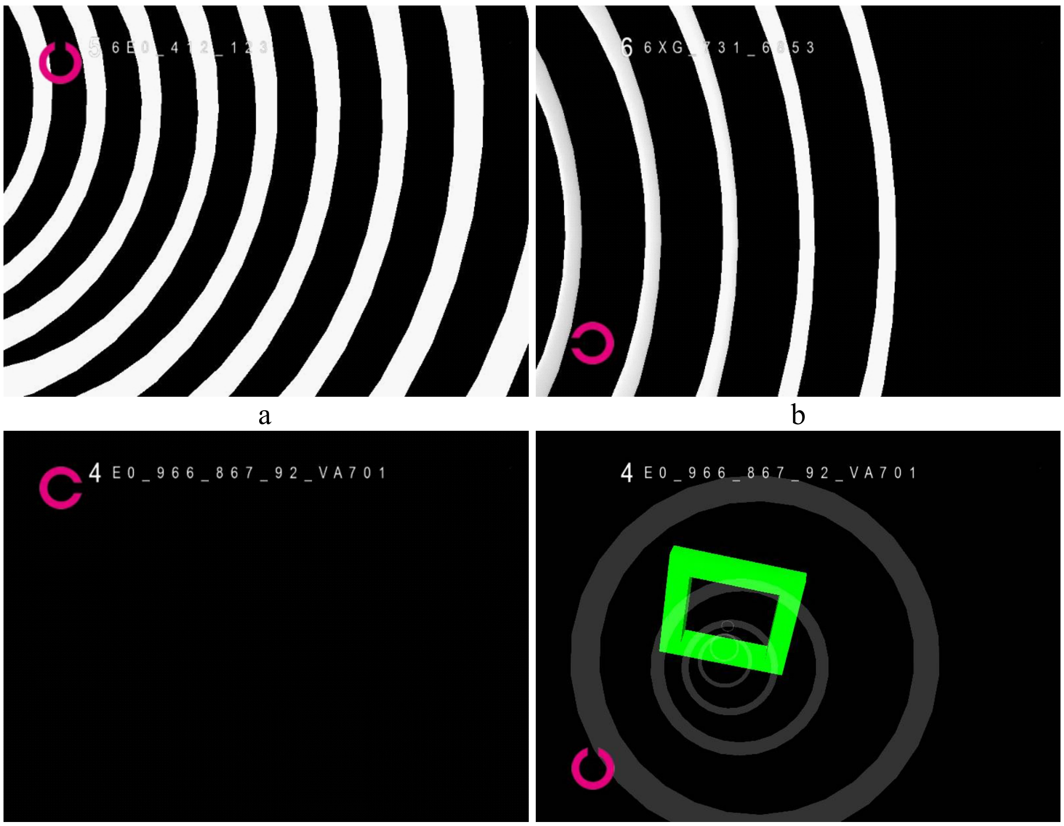
Figure 3. Landolt rings used in secondary task and user pressing Wiimote cross button

Altogether for each text or funnel visualization 80 landolt rings were presented in the corners of the HMD. The average time between showing landolt rings was 30 seconds. Each ring was presented up to 5 seconds during which the subject would have to react ("A" button). This "long" presentation time was chosen, because in a real world application a dangerous situation would not suddenly disappear as well.

We recorded initiation time and movement time. Initiation time (IT) is the time from appearance of the landolt ring to press of button “A” on the Wiimote (i.e. “There is something!”). Movement time (MT) is the time from pressing the “A” button to pressing the cross on the Wiimote (i.e. “It was a landolt ring opening towards ...”). The overall reaction time (RT) is the summation of IT and MT.

$$RT = IT + MT \qquad (1)$$

Figure 4 demonstrates examples of the used visualizations together with landolt rings.



c d

Figure 4. Red landolt rings in display corners overlayed on different visualizations of the primary task: (a) funnel A, (b) funnel B, (c) text-only, (d) green square fading in to show position of item to pick

Test Procedure

To create valid and reliable results we would have to use a common AR system in a common AR work environment - both don’t exist yet. We agree to Schwerdtfeger’s opinion [8, chapter 1.1] that even though we don’t know those “future AR systems” or “real AR work environments” we nevertheless have to carefully carry out experiments with systems and environments we have today. Here this happened to the best of our knowlege. Thus 26 subjects (aged 25.5 ± 4.0, 12 female) voluntarily took part in the test. Most were students without experiences in the field of AR/VR.

Figure 5: Subject in the reference scenario using the AR system

The display condition (text-only, funnel A, funnel B) was randomized so that one third of the subjects started with text-only, the 2nd third started with funnel A and the last third had to begin with funnel B.

Before beginning the test each subject was informed on work safety. Medical anamnesis was recorded and a test for visual acuity (left and right eye, hand card in distance of 30 cm) took place. As in our last publications we again incorporated analysis of heart rate variability (not to be reported about in this publication), so each subject was equipped with an ECG recorder. Then the AR system was put on, usually the Wiimote controller was to be held in the dominant hand. The task for the subjects was explained and questionnaires for analzying subjective strain were filled out. After a 5-10 minute break a test run (one job list, funnel A) took place to familiarize subjects with the AR system (fig. 5). Finally the actual test could be started (funnel A, funnel B, text; randomized; each 45 minutes). The work tasks were to pick items from the shelves and to react on the visualization of landolt rings. At the end a 5-10 minutes relaxation phase followed.

Critical Comments

One might say, when working with the AR funnel you are focused on the OST HMD all the time. Thus reacting on something displayed on the virtual display of the HMD can not be compared to a situation where the user has to react on something happening in his surrounding. The reason might be that the user has to shift his perception focus (as well as the visual focus) from the funnel to an object in the reality. This of course would question the usefulness and validity of our evaluation. In contrast to this we think that this evaluation is suited for a first estimation to find clues towards if inat-tentional blindness happens when working with the funnel. This is because our users of the AR system had to have their main perception focus on the primary work task (picking items) together with the AR funnel. That means a shift of perception focus would happen continuously anyways which allows for presentation of stimuli on the HMD to solve the secondary work task.

While designing the study another question was important: Would working with the funnel be comparable to working with text visualization? The study design had to avoid that the textual information would be easy to remember and easy to interpret. If with text visualization the user would only look at the display once and be able to instantly find the right box to pick the right item from, then reacting on the secondary stimuli would definitely not be comparable to using the funnel visualizations. When using the funnels we realized that users would from time to time focus the tunnel but mostly watch the surrounding. Because both funnel visualizations were very prominent users would mostly not focus the funnel but walk through the test area focusing the spacial target position in real world. The text information was designed in a similar manner such that users would not be able to easily interpret or learn the spacial positions corresponding to their textual descriptions (compare fig. 4c). This could not completely avoid learning effects but made the subjects use the virtual screen multiple times for each item that had to be picked. Thus both with funnel as well as with text visualization every user would switch between real world and HMD screen during each single picking task. This lets us believe both types of visualizations are comparable in our setup.

Hypotheses

The intention of this study is to examine the occurrence of inattentional blindness when working with AR funnel visualizations. Our main question is if the use of the AR funnel would highly focus subjects on their primary work task so they would become blind for other things happening in their surrounding.

Therefore our first hypothesis describes the assumption that reaction times with text visualization in general would be lower than with any funnel visualization. This could be due to the completely empty display screen where one might think that "if something appears on the screen you can instantly see and react on it".

H1: Reaction times for reacting on appearance of a stimulus are lowest for text visualization.

Two funnel visualizations were presented to guide the user through the primary work task. Even though the parameters of the AR funnels are different we expect no difference in reaction times between them.

H2: Reaction times of funnel A and B are equal.

Our third hypothesis is that the AR funnel visualization shifts users perception focus into direction of the AR funnel.

H3: When working with AR funnel reaction times are lowest when funnel and stimulus lay in the same display quadrant.

We think the very dominant AR funnel visualizations keeps subjects focused on their main work task. So we conclude they would make more errors in detecting landolt rings with any of the AR funnels.

H4: Working with an AR funnel visualization results in more detection errors than with text visualization.

The final hypothesis deals with the quality of this study. It was important for us to design the study close to an actual industrial picking setup as in our last studies. The secondary work task should not negatively influence the primary work task. A possible control variable is the numbers of parts collected per minute. If these are similar to our previous study then this would be a usable indicator to verify that the study did not negatively influence the work process. Another option would be to analyze picking errors. We decided against that because we expected the dual-task paradigm to highly disturb the users concentration. Thus comparing mistakes made here and made in our other studies would not be possible.

H5: The numbers of parts collected per minute for both funnel visualizations are similar to results of our previous study [4].

Results and Discussion

Reaction Times (general)

First of all we analyzed reaction times (fig. 6) to check H1. For all three visualizations the movement time was very similar. This was an expected result as the movement time does not depend on the current visualization type.

The initiation time of text-only was slightly higher than for the AR funnel visualizations. We found that funnel B had best results probably because it did not cover as much of the display as funnel A, allowing a better sight on the remaining display space. The result is statistically significant (Initiation Time of text and funnel B, p = 0.04, t-test).

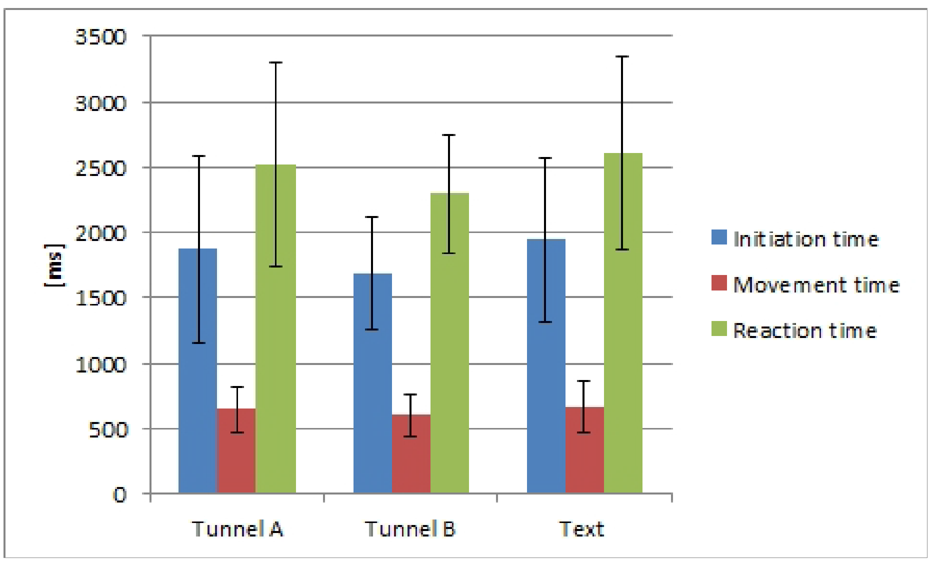


Figure 6. Reaction times of the three conditions funnel A, funnel B, text visualization including wrong ring identifications

The result does not support H1. In general we can not confirm larger reaction times when working with the AR funnel. H2 is not confirmed either - reaction times of both visualizations are not similar even though the difference in values is not statistically significant.

Position of stimulus vs. AR funnel heading

To see if user's attention is pushed towards direction of the funnel (H3) we examined if there's a correlation between the position of the landolt ring and the current heading of the AR funnel. Therefore we separated the data in three groups:

Group 1: Landolt ring and direction of AR funnel are in the same display quadrant.

Group 2: AR funnel directs to a direct neighbor of the landolt ring quadrant. (e.g.: landolt ring is shown top right - neighbor quadrants are top left and bottom right)

Group 3: AR funnel and landolt ring are in opposite quadrants. (e.g.: landolt ring is shown top right, tunnel heads towards bottom left quadrant)

The design of this study did not allow to exactly control where the funnel would be displayed when the stimulus appeared. This was because we could not make all users walk along exactly the same path while at the same time having each user's head in the same position and orientation. Users would look around while fulfilling their primary work task, they would walk at different distances from the shelves and so on. The condition "Group 1" happened for 22% ± 4.5% of all landolt ring appearances over all users. The acceptably low standard deviation shows a quite similar movement behaviour of the users. This makes us believe the generated data can be used for our interpretation.

The lowest average initiation time of 1639 ms could be seen in Group 1 where AR funnel B and landolt ring appeared in the same display quadrant (fig. 7). We think the reason is that the user's focus of perception already was in the right direction so that stimuli could be perceived and reacted to earlier. Group 2 and Group 3 of funnel B had 20% and 30% larger initiation times which supports H3 - but only for funnel B. Interestingly this did not apply for funnel A for which we recorded an average IT of 2050 ms in Group 1. This could be due to the larger number of rings which covered a lot of the screen and thus would make detection of stimuli difficult in that display area. The difference between funnel A and B (Group 1) is statistically significant (p = 0.03, Wilcoxon-test). Funnel B covered less display space, thus probably allowed for better detection of the landolt ring. The design used for funnel A did not answer H3.

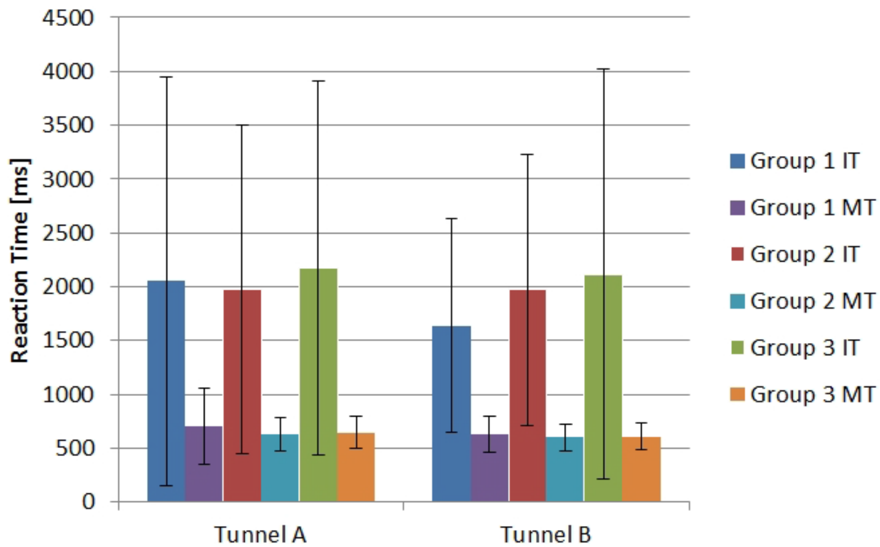


Figure 7. Reaction times depending on display position of funnel and landolt ring (IT: Initiation Time; MT: Movement Time)

Text visualization resulted in a general IT of 1947 ms, values for Group 2 and Group 3 are similar to this for both AR funnel visualizations. No statistically significant differences could be found for Group 2 and Group 3 compared to text visualization.

Errors in identifying landolt rings

Next to reaction times it is important to know how often the type of ring was identified wrong. For each visualization 2000 landolt rings were presented to each subject. Not a single landolt ring was missed throughout all subjects and visualization methods. When using text visualization 60 wrong identifications were recorded in total, funnel A had 54 and funnel B caused 55 identification errors. In average 2.4 ± 1.73 mistakes were made by each subject with text visualization, 2.16 ± 2.03 with funnel A and 2.2 ± 1.89 with funnel B (fig. 8). These numbers are not significantly different.

Interpreting the data means to first point out that only 3% wrong identifications were recorded for any of the used visualizations. The funnel visualization in general did not cause higher identification error rates; error rates were even a bit lower when working with the funnels as compared to text visualization. This is in contrast to our assumption described in H4, thus H4 can be declined.

Again we split the recorded data into three groups as in the previous chapter. Interestingly the absolute number of mistakes for Group 1 when working with funnel

A was about twice as high as when working with funnel B (20 vs. 8). In avarage each subject working with funnel A caused 0.8 ± 1.0 mistakes while working with funnel B caused only 0.32 ± 0.56 wrong identifications. This difference is statistically significant (p = 0.02, t-test). We think this is due to the relatively large density of funnel A's rings which could have disturbed the user.

On the other hand this finding means the numbers of errors for Group 2 and Group 3 were larger with funnel A (1.36 ± 1.38) than with funnel B (1.88 ± 1.56). The differences are not statistically significant (p = 0.11, t-test) so they can not be used to decide whether or not funnel A performs better than funnel B.

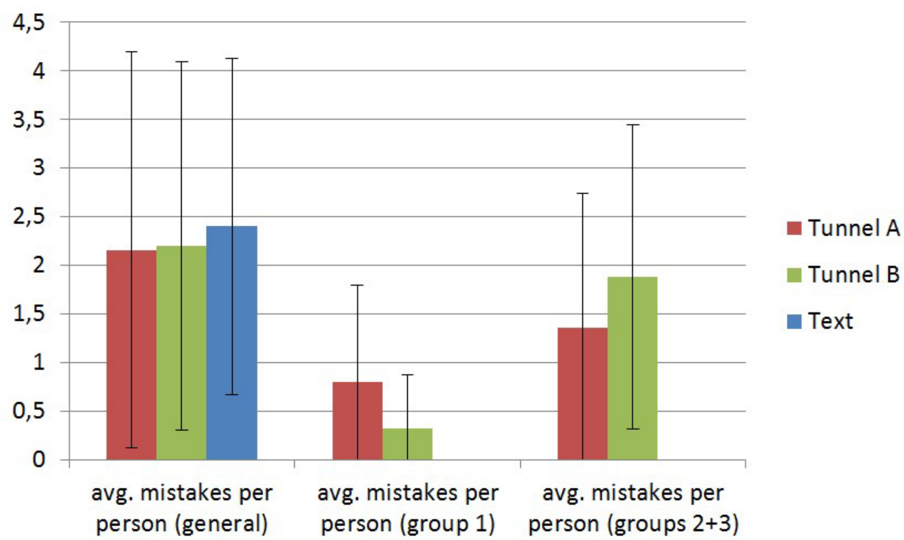


Figure 8. Mistakes in detecting landolt rings

Picking Outcome

The average number of parts collected by use of funnel A was 20% (p = 0.007, t-test) better than with text-only, funnel B outperformed text visualization by 16% (p = 0.005, t-test). The number of items collected per minute was on a similar level compared to our previous study [4] (fig. 9). This result supports H5. The test setup we used to analyze inattentional blindness did not negatively influence the main work task of picking.

The analysis of picking errors revealed a 30% larger error rate for funnel A compared to funnel B (fig. 9, right ordinate). The result is not statistically significant (p = 0.19, t-test) but clearly shows that there is a notable difference between both visualizations as we already found in the results of the secondary work task.

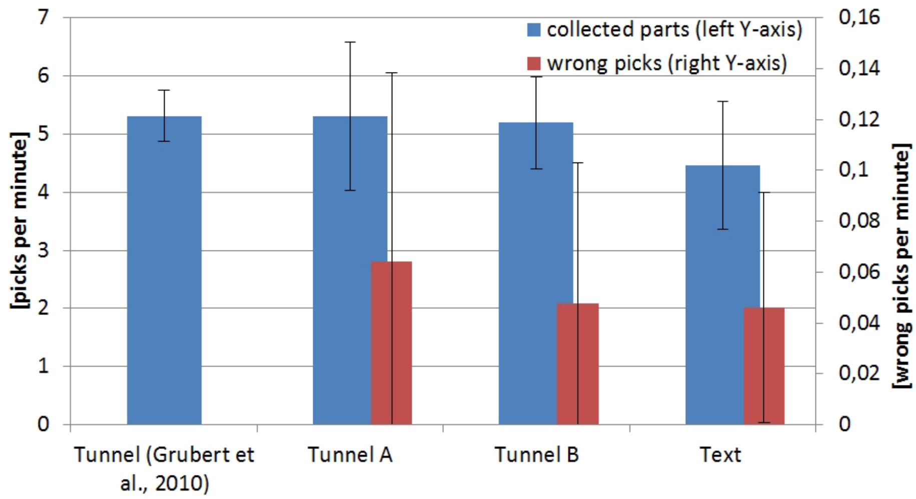


Figure 9. Items collected per Minute (left ordinate; this publication compared to our publication in 2010 [4], left ordinate) and number of wrong picks per minute (right ordinate)

SUMMARY AND CONCLUSION

From a general point of view working with AR funnel visualizations did not cause significantly different reaction times or detection error rates compared to working with text visualization. But we found that this general statement is only partially true as the system's efficiency also depends on the actual design of the funnel. Our visualization named "funnel B" performed better than "funnel A" in most categories.

The user's focus of attention seems to lay in direction of the funnel. Especially with funnel B reactions were faster, when the stimulus was shown in the same display quadrant the funnel visualization currently laid in. When the landolt ring appeared in other quadrants reaction times were larger - as well as with text visualization. We conclude that - under similar conditions - especially AR funnel B does not cause inattentional blindness because reaction times with text visualization were not larger than with AR funnel.

All subjects detected all rings that were presented on the HMD screen. Once a ring was detected it had to be identified. At first glance we found no important difference between text and AR funnel. But after we looked closer we saw that funnel B had significantly better results than funnel A, especially when stimulus and funnel were presented in the same display quadrant.

From these results our recommendation for application of AR funnels is to use a design that is similar to our funnel B. “Less is more”: It should cover as little of the display as possible as long as it still can be clearly detected.

In general we could not find clues for that AR funnel visualizations cause inattentional blindness. This lets us believe the AR funnel has a chance to be implemented in real industrial scenarios that are supported by mobile Augmented Reality.

ACKNOWLEDGEMENTS. This work was initiated by a grant of the German Federal Ministry of Education and Research (AVILUS project, grant no. 01IM08001)

References.

1. F. Biocca, A. Tang, C. Owen, and F. Xiao. Attention funnel: omnidirectional 3d cursor for mobile augmented reality platforms. In Proceedings of the SIGCHI conference on Human Factors in computing systems, CHI ’06, pages 1115–1122, New York, NY, USA, 2006. ACM.

2. W. Friedrich, editor. ARVIKA Augmented Reality fur Entwicklung, Produktion und Service. Publicis Corporarte Publishing Verlag, Er-langen, 1 edition, 2004. http://www.arvika.de/.

3. E. B. Goldstein. Sensation and Perception. Cengage Learning Services, 2003.

4. J. Grubert, D. Hamacher, R. Mecke, I. Bockelmann, L. Schega, A. Huckauf, M. H. Urbina, M. Schenk, F. Doil, and J. Tumler. Extended investigations of user-related issues in mobile industrial AR. In Proceedings of the 9th IEEE/ACM International Symposium on Mixed and Augmented Reality, ISMAR ’10, pages 229–230, Washington, DC, USA, 2010. IEEE Computer Society.

5. J. Grubert, J. Tumler, R. Mecke, and M. Schenk. Comparative user study of two see-through calibration methods. In Proceedigns of the IEEE Virtual Reality Conference 2010 (VR 2010), Waltham, Mas-sachusetts, USA, 2010.

6. W. Schreiber and P. Zimmermann, editors. Virtuelle Techniken im industriellen Umfeld: Das AVILUS-Projekt - Technologien und An-wendungen. Springer, 2011. http://www.avilus.de/.

7. B. Schwerdtfeger, G. Klinker, R. Reif, and W. Gunthner. Pick-by-vision: There is something to pick at the end of the augmented tunnel. Technical Report TUM-I0921, TU Munchen, 2009.

8. B. Schwerdtfeger, R. Reif, W. A. Gunthner, G. Klinker, D. Hamacher, L. Schega, I. Bockelmann, F. Doil, and J. Tumler. Pick-by-vision: A first stress test. In Proceedings of the 10th IEEE/ACM International Symposium on Mixed and Augmented Reality, ISMAR ’10, pages 115–124, Washington, DC, USA, 2010. IEEE Computer Society.

9. D. J. Simons and C. F. Chabris. Gorillas in our midst: Sustained inattentional blindness for dynamic events. Perception 28, 1999.

10. J. Tumler, R. Mecke, M. Schenk, A. Huckauf, F. Doil, G. Paul, E. A. Pfister, I. Bockelmann, and A. Roggentin. Mobile augmented reality in industrial applications: Approaches for solution of user-related issues. In Proceedings of the 7th IEEE and ACM International Symposium on Mixed and Augmented Reality 2008, ISMAR ’08, pages 87–90, Washington, DC, USA, 2008. IEEE Computer Society.

11. C. D. Wickens. Attentional tunneling and task management. Technical report, University of Illinois, Aviation Human Factors Division, AHFD-05-23/NASA- 05-10, 2005.

12. F. Zhou, H. B.-L. Duh, and M. Billinghurst. Trends in augmented reality tracking, interaction and display: A review of ten years of is-mar. In Proceedings of the 7th IEEE/ACM International Symposium on Mixed and Augmented Reality, ISMAR ’08, pages 193–202, Wash-ington, DC, USA, 2008. IEEE Computer Society.

[1]Тюмлер Дж., [2]Меке Р., [3]Рослер Т., [3]Шнек Д., [3]Бёкельман І.

Використання воронки додаткової реальності: веде це до перцепціоної сліпоти?

[1]Фольксваген АГ, [2] Інститут промислової експлуатації та автоматизації імені Фраунгофера, [3] Магдебурзький університет імені Отто фон Геріке, Німеччина

Резюме. Використання рухомої додаткової реальності (РДР) в промисловості дає можливість надати відповідну інформацію в потрібний час, зареєстроване в правильному просторовому положенні. Наші попередні дослідження показали, що навіть сьогодні потенціал систем РДР може бути використаний без підвищення загальної психофізичної напруги користувача. Встановлено, що одним з корисних інструментів для підтримки оператора є "воронка додаткової реальності", яка може допомогти користувачеві визначити правильне просторове положення. При тому, що даний інструмент технічно добре працює, досі невідомий його вплив на сприйняття користувачем оточення. Дана стаття присвячена дослідженню впливу воронки додаткової реальності на уважність користувача.

Ключові слова: моделі і принципи, системи користувач / машина, людські фактори, інформаційні інтерфейси і презентація, інтерфейси користувача, орієнтовані на користувача.

[1]Тюмлер Дж., [2]Меке Р., [3]Рослер Т., [3]Шнек Д., [3]Бёкельман И.

Использование воронки дополнительной реальности: ведет ли это к перцепционной слепоте?

[1]Фольксваген АГ, [2]Институт промышленной эксплуатации и автоматизации имени Фраунгофера, [3]Магдебургский университет имени Отто фон Гуерике, Германия

Резюме. Использование подвижной дополнительной реальности (ПДР) в промышленности дает возможность представить соответствующую информацию в нужное время, зарегистрированное в правильном пространственном положении. Наши предыдущие исследования показали, что даже сегодня потенциал систем ПДР может быть использован без повышения общего психофизического напряжения пользователя. Установлено, что одним из самым полезных инструментов для поддержки оператора является "воронка дополнительной реальности", которая может помо**чь** пользователю определ**и**ть правильное пространственное положении. При том, что данный инструмент технически хорошо работает, до сих пор неизвестно его влияние на восприятие пользователем окружения. Данная статья посвящена исследованию влияния воронки дополнительной реальности на внимательность пользователя.

Ключевые слова: модели и принципы, системы пользователь / машина, человеческие факторы, информационные интерфейсы и презентация, пользовательские интерфейсы, ориентированные на пользователя.

Received: 28.04.2015 *Accepted: 17.06.2015*