A Study into the Understandability of Technical Illustrations Shown From Different Height Perspectives and Camera Positions

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Abstract
The study set out to determine the ease with which people without any specialised knowledge of visual communication or information design can understand technical images shown from different height perspectives and camera positions, with the aim of helping technical illustrators visually demonstrate physical orientation in procedural actions. The study was carried out as an in-class and homework activity by junior level students on an undergraduate degree in computer science at a Japanese technical university. The study participants were asked to look at body images shown from different height perspectives (waist and chest height) and camera positions (front, 1/3rd side, side, 1/3rd back, back) of a man holding a ball and throwing a ball, select matching overhead images and then rate their confidence in their selections. Overall, the study participants achieved high levels of accuracy in matching the body and overhead images and self-reported relatively high overall confidence in their choices. Specifically, the study participants found it slightly more difficult to match body and overhead images shown from the side camera position, and slightly easier to match body and overhead images shown from the back camera position, than the other camera positions (front, 1/3rd side, 1/3rd back). These findings could be useful in helping technical illustrators think about how to visually demonstrate physical orientation in procedural actions. Nevertheless, the results are preliminary and further work needs to be done to confirm them.

Keywords: camera positions * height perspectives * physical orientation * technical illustrations

Introduction

Ganier draws attention to the fact that technical illustrators have increasingly been using technical illustrations to complement or replace the text in procedural documents since the 1980s (2012). This can be, for example, to provide the reader with a visual rather than, or addition to, a text-based representation of specific procedural actions to be taken or not taken in a given situation. This increase in technical illustration usage can, in part, be explained by research undertaken by Mayer and Gallini that found the use of technical illustrations in procedural documents to be particularly beneficial for readers who had never seen or directly experienced the specific procedural actions that they were required to carry out (1990). This raises the question as to what kind of technical illustrations should be used to provide readers with understandable visual representations of physical orientation in physical actions?

The study described in this paper is, in part, a follow-up to a study conducted in 2003 by Krull, D'Souza, Roy and Sharp into the most effective way(s) to visually demonstrate physical orientation in procedural actions (2003, 2004). In this earlier study, the participants (North American university students) were asked to match body and overhead images of people doing various actions (driving a car, holding a box and performing a fencing lunge) that were shown from different camera positions (front, 1/3rd side, side, 1/3rd back, back). The study found that the participants were more successful at matching body and overhead images shown from the front and back camera positions than the 1/3rd side, side and 1/3rd back camera positions. The present study draws from, and expands upon, this earlier study to look at images of different actions shown from different camera positions and height perspectives, with the aim of helping technical illustrators visually demonstrate physical orientation in procedural actions.

Methodology

A total of 41 participants took part in the study. All of the participants were junior level students (age group: 18-20 years with a pre-intermediate level of English language proficiency) on an undergraduate degree in computer science at a Japanese technical university. The students undertook the study as an in-class and homework activity in two elective courses taught (primarily) in English. All the students had taken general English language courses (which focus mainly on language production and reception skills) and content-based courses taught in English at the university during previous academic years, thus had experience of courses taught In English. However, none of the students had taken courses in visual communication or information design during previous academic years. Furthermore, the study was undertaken at the outset of the two elective courses, thus the students had not yet acquired any specialised knowledge of visual communication or information design.

The study set out to determine the ease with which people without any specialised knowledge of visual communication or information design can understand images, with the aim of helping technical illustrators visually demonstrate physical orientation in procedural actions. The study participants were required to match body and overhead images shown from different height perspectives and camera positions and then rate their confidence in their matches.

The researchers first generated 3D computer graphics images of body positions for two kinds of actions: a man holding a ball and a man throwing a ball. The purpose of having two kinds of actions was to strengthen the robustness of the study findings. The images were generated using a 3D computer graphics programme called Poser 10 (http://poser.smithmicro.com). Each of these actions was shown from both chest and waist height perspectives. In other words, the man holding the ball was shown as holding the ball centered in front of the chest and the waist with the hands gripping the ball on both sides. The man throwing the ball was shown as throwing the ball with his left hand at chest and waist height. Each of these four height perspectives was then captured from five camera positions: front (0 degrees), 1/3 side (30 degrees), side (90 degrees), 1/3 back (120 degrees) and back (180 degrees). A total of twenty images were thus generated. By way of example, the top left-hand image in Figure 1 shows the man holding the ball centered in front of the chest and facing the camera head on.

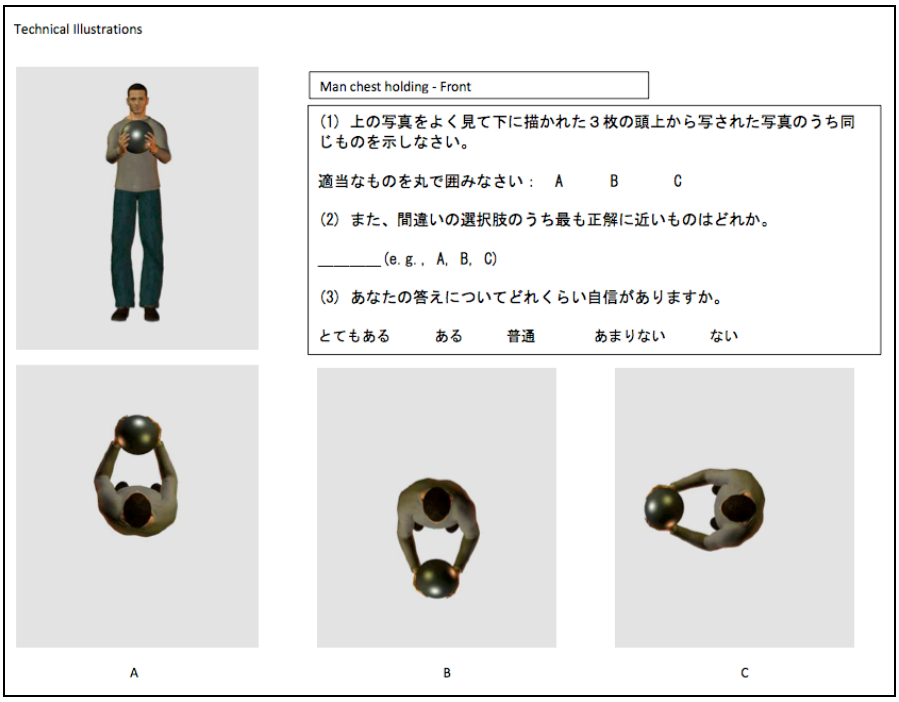

Figure 1 Screenshot of the man holding the ball centred in front of the chest and facing the camera head on with three matching overhead images

Once the twenty images had been generated, the researchers then positioned the camera to capture matching overhead images. A matching overhead image was generated for each of the twenty images, with a displacement along the y and z-axis to position the camera exactly overhead. Finally, the researchers created twenty test sheets, such as the one shown in Figure 1. Each test sheet contained one of the twenty body images, three potential matching overhead images and the three questions in Japanese shown (in translation) on the next page.

1 Identify which of the three overhead images most closely matches the man (three options provided).
2 Identify which of the three overhead images is the second closest match.
3 How confident are you about your response?

The participants were given oral and written instructions by the researchers in both English and Japanese. They were also allowed to ask questions about the study, and to raise any issues or concerns they had, in either English or Japanese. Finally, the instructions and questions on the test sheets were given in Japanese. This was done to ensure that that every participant understood exactly what he/she had to do.

The study was carried out as both an in-class and homework activity. The participants had 90 minutes in class to start matching the body and overhead images and then one week at home to complete matching them before the next course meeting. The participants were given a week to complete the matching exercises to ensure that they had time to think and re-think about the images and to change their responses if they wished. Specifically, they were asked to look at body images shown from different height perspectives and camera positions of the man holding the ball and throwing the ball, select matching overhead images and then rate their confidence in their selections. The e-learning platform Moodle was used for these matching exercises.

The investigators gave each participant a score of either 1 or 0 for questions 1 and 2, with a score of 1 for a correct answer and 0 for an incorrect or incomplete answer. For the question on confidence, the participants gave themselves a score in the range of 1 to 5 (1 being least confident and 5 being most confident), with a score of 0 being given by the investigators for an incomplete answer. The resulting data was then divided into the four data sets shown below.

1 Man holding the ball - chest height (front, 1/3rd side, side, 1/3rd back, back)
2 Man holding the ball - waist height (front, 1/3rd side, side, 1/3rd back, back)
3 Man throwing the ball - chest height (front, 1/3rd side, side, 1/3rd back, back)
4 Man throwing the ball - waist height (front, 1/3rd side, side, 1/3rd back, back)

This was then analysed using the statistical software SPSS, with the findings described in the next section.

Findings

The participants demonstrated a high overall level of accuracy (85 ~ 90%) in matching overhead images with body images. Table 1 shows the mean accuracy responses for the following:

- 5 camera positions (front, 1/3rd side, side, 1/3rd back, back) for the man holding the ball - chest height
- 5 camera positions (front, 1/3rd side, side, 1/3rd back, back) for the man holding the ball - waist height
- 5 camera positions (front, 1/3rd side, side, 1/3rd back, back) for the man throwing the ball - chest height
- 5 camera positions (front, 1/3rd side, side, 1/3rd back, back) for the man throwing the ball - waist height

The ‘Mean’ and ‘Standard Deviation’ columns reveal that there is little difference in the accuracy of the responses between the twenty images. In fact, overall, the study participants identified the matching overhead images for the different height perspectives and camera positions with 90% accuracy. Furthermore, the ‘0’ column

reveals that only between three and seven of the 41 study participants gave an incorrect or incomplete answer for each of the twenty images.

Table 1: Responses for the images of the man holding and throwing the ball: chest and waist height positions

	Mean	Standard Deviation	Frequency		
			0	1	
Holding chest front	.85	.358	6	35	
Holding chest 1/3rd side	.90	.300	4	37	
Holding chest side	.85	.358	6	35	
Holding chest 1/3rd back	.90	.300	4	37	Cochran's Q = 17.968
Holding chest back	.90	.300	4	37	
Throwing chest front	.93	.264	3	38	
Throwing chest 1/3rd side	.93	.264	3	38	
Throwing chest side	.93	.264	3	38	
Throwing chest 1/3rd back	.83	.381	7	34	
Throwing chest back	.88	.331	5	36	df = 19
Holding waist front	.83	.381	7	34	
Holding waist 1/3rd side	.88	.331	5	36	
Holding waist side	.88	.331	5	36	
Holding waist 1/3rd back	.88	.331	5	36	
Holding waist back	.93	.264	3	38	
Throwing waist front	.90	.300	4	37	
Throwing waist 1/3rd side	.88	.331	5	36	Asymp. Sig. = .525
Throwing waist side	.83	.381	7	34	
Throwing waist 1/3rd back	.90	.300	4	37	
Throwing waist back	.93	.264	3	38	

Figures 2 and 3 show the percentage of accurate responses for the man holding and throwing the ball at the chest and waist height perspectives. These figures visually highlight the high level of accuracy seen in Table 1.

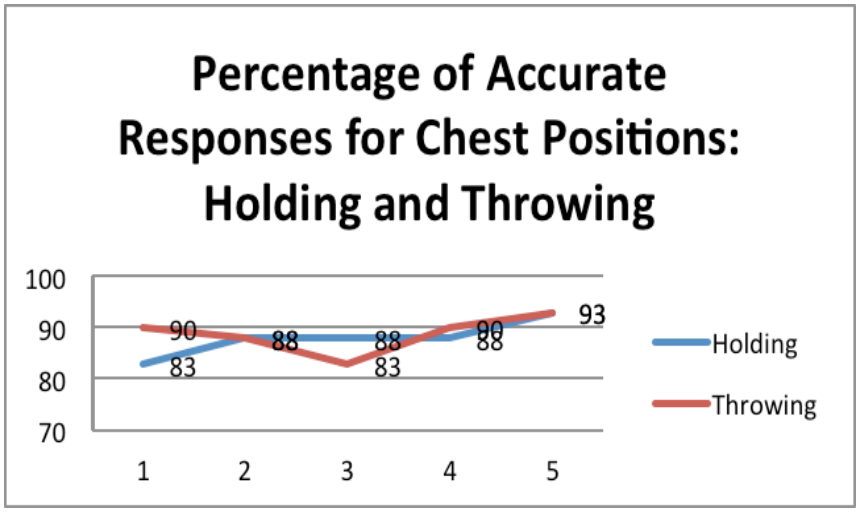

Figure 2. Percentage of accurate responses for the images of the man holding and throwing the ball: chest height positions

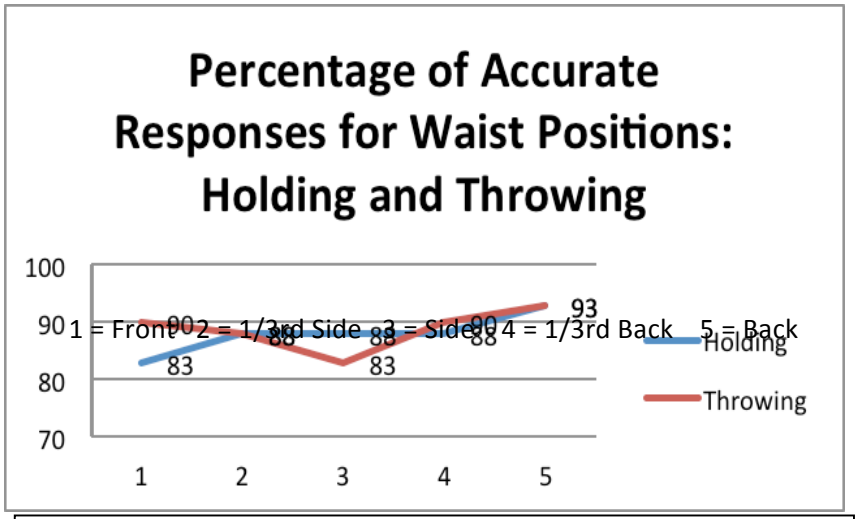

Figure 3. Percentage of accurate responses for the images of the man holding and throwing the ball: waist height positions

The researchers used a Cochran's Q Test to identify whether there were statistically significant differences in accurate responses. First, the Cochran's Q test revealed that there was no statistically significant difference in accurate responses across all the images (actions). The Cochran's Q value is 17.968, the Sig. value is .525 and p is less than 0.05. The researchers thus looked at the differences in accurate responses between the different actions.

First, Figure 4 shows the Cochran's Q Test across the five camera positions (front, 1/3rd side, side, 1/3rd back, back) for the man holding the ball centered in front of the chest. This shows that the Cochran's Q value is 3.200, the Sig. value is .525 and p is less than 0.05. There is thus no statistically significant difference in accurate responses across the five camera positions.

Visual Angles	Cochran's Q	df	Asymp. Sig.
Holding chest front Holding chest 1/3rd side Holding chest side Holding chest 1/3rd back Holding chest back	3.200	4	.525

Figure 4 Cochran's Q Test for the images of the man holding the ball: chest height position

Figure 5 shows the Cochran's Q Test across the five camera positions (front, 1/3rd side, side, 1/3rd back, back) for the man throwing the ball with his left hand at chest height. This shows that the Cochran's Q value is 7.111, the Sig. value is .130 and p is less than 0.05. There is thus again no statistically significant difference in accurate responses across the five camera positions.

Visual Angles	Cochran's Q	df	Asymp. Sig.
Throwing chest front Throwing chest 1/3rd side Throwing chest side Throwing chest 1/3rd back Throwing chest back	7.111	4	.130

Figure 5 Cochran's Q Test for the images of the man throwing the ball: chest height position

Figure 6 shows the Cochran's Q Test across the five camera positions (front, 1/3rd side, side, 1/3rd back, back) for the man holding the ball centered in front of the waist. This shows that the Cochran's Q value is 3.478, the Sig. value is .481 and p is less than 0.05. There is once again no statistically significant difference in accurate responses across the five camera positions.

Visual Angles	Cochran's Q	df	Asymp. Sig.
Holding waist front Holding waist 1/3rd side Holding waist side Holding waist 1/3rd back Holding waist back	3.478	4	.481

Figure 6. Cochran's Q Test for the images of the man holding the ball: waist height position

Figure 7 shows the Cochran's Q Test across the five camera positions (front, 1/3rd side, side, 1/3rd back, back) for the man throwing the ball with his left hand at waist height. This shows that the Cochran's Q value is 4.600, the Sig. value is .331 and p is less than 0.05. There is thus no statistically significant difference in accurate responses.

Visual Angles	Cochran's Q	df	Asymp. Sig.
Throwing waist front Throwing waist 1/3rd side Throwing waist side Throwing waist 1/3rd back Throwing waist back	4.600	4	.331

Figure 7. Cochran's Q Test for the images of the man throwing the ball: waist height position

The findings thus confirm that the study participants were consistently accurate in matching the overhead images with the body images.

Figure 8 shows the four body images (the man holding/throwing the ball at waist/chest height positions) from the front camera position. Figure 9 shows a higher level of matching accuracy for the man throwing the ball at both the waist and chest height position than for the man holding the ball at the waist and chest height position, with mean values of .93 and .90 compared with .85 and .83. This suggests that the study participants found it slightly more difficult to match images of the man shown holding the ball when the body images were shown from the front camera position.

Figure 8. The man holding/throwing the ball at waist/chest height positions from the front camera position

Visual Angles	Mean	Standard Deviation
Holding chest front	.85	.358
Throwing chest front	.93	.264
Holding waist front	.83	.381
Throwing waist front	.90	.300

Figure 9. Accurate responses for the images of the man holding/throwing the ball at waist/chest height positions from the front camera position

Figure 10 shows the four body images (the man holding/throwing the ball at waist/chest height positions) from the 1/3rd side camera position. Figure 11 shows a higher level of matching accuracy for the man throwing and holding the ball at the chest height position than for the man throwing and holding the ball at the waist

height position, with mean values of .93 (throwing) and .90 (holding) compared with .88 (both throwing and holding). This suggests that the study participants found it slightly more difficult to match images of the man shown throwing and holding the ball at the waist height position when the body images were shown from the 1/3rd side camera position.

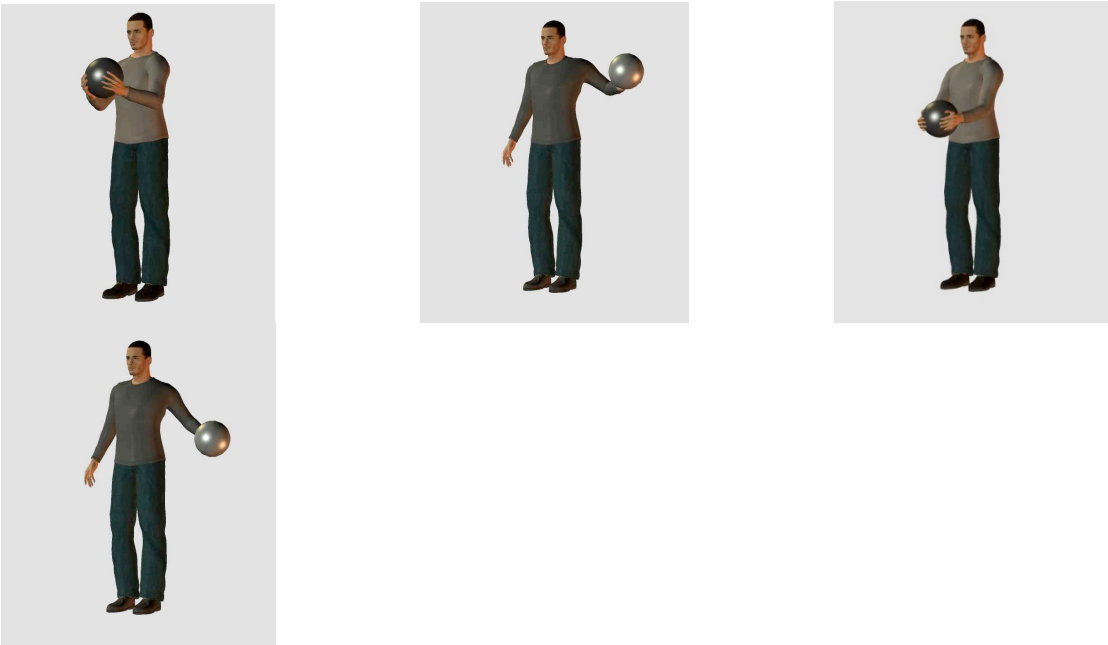

Figure 10. The man holding/throwing the ball at waist/chest height positions from the 1/3rd side camera position

Visual Angles	Mean	Standard Deviation
Holding chest 1/3rd side	.90	.300
Throwing chest 1/3rd side	.93	.264
Holding waist 1/3rd side	.88	.331
Throwing waist 1/3rd side	.88	.331

Figure 11. Accurate responses for the images of the man holding/throwing the ball at waist/chest height positions from the 1/3rd side camera position

Figure 12 shows the four body images (the man holding/throwing the ball at waist/chest height positions) from the side camera position. Figure 13 shows a high level of matching accuracy for the man throwing the ball at the chest height position. However, there are lower levels of accuracy for the man holding the ball at waist/chest height positions and throwing the ball at waist height position. This suggests that the study participants found it slightly more difficult to match images shown from the side camera position than from other camera positions.

Figure 12. The man holding/throwing the ball at waist/chest height positions from the side camera position

Visual Angles	Mean	Standard Deviation
Holding chest side	.85	.358
Throwing chest side	.93	.264
Holding waist side	.88	.331
Throwing waist side	.83	.381

Figure 13. Accurate responses for the images of the man holding/throwing the ball at waist/chest height positions from the side camera position

Figure 14 shows the four body images (the man holding/throwing the ball at waist/chest height positions) from the 1/3rd back camera position. Figure 15 shows a high level of matching accuracy for the man holding the ball at the chest height position and the man holding the ball at the waist height position. However, there is a 2% drop in accuracy for the man holding the ball at the waist height position and a 7% drop in accuracy for the man throwing the ball at the chest height position. There is thus no discernible pattern in this data.

Figure 14. The man holding/throwing the ball at waist/chest height positions from the 1/3rd back camera position

Visual Angles	Mean	Standard Deviation
Holding chest 1/3rd back	.90	.300
Throwing chest 1/3rd back	.83	.381
Holding waist 1/3rd back	.88	.331
Throwing waist 1/3rd back	.90	.300

Figure 15. Accurate responses for the images of the man holding/throwing the ball at waist/chest height positions from the 1/3rd back camera position

Figure 16 shows the four body images (the man holding/throwing the ball at waist/chest height positions) from the back camera position. Figure 17 shows a high level of matching accuracy for the man holding the ball at the waist/chest height positions and the man throwing the ball at the waist height position. This data suggests that the study participants found it slightly easier to match images shown from the back camera position than from other camera positions.

Figure 17. The man holding/throwing the ball at waist/chest height positions from the back camera position

Visual Angles	Mean	Standard Deviation
Holding chest back	.90	.300
Throwing chest back	.88	.331
Holding waist back	.93	.264
Throwing waist back	.93	.264

Figure 17. Accurate responses for the images of the man holding/throwing the ball at waist/chest height positions from the back camera position

The participants also demonstrated high overall confidence levels in their matching choices. These confidence levels were calculated based on the 1 ~ 5 Likert scale, with 1 being least confident and 5 being most confident.

Figure 18 shows the mean confidence levels across the five camera positions (front, 1/3rd side, side, 1/3rd back, back) for the man holding the ball at the chest height position.

Visual Angles	Mean	Standard Deviation
Holding chest front	3.80	1.159
Holding chest 1/3rd side	3.68	1.071
Holding chest Side	3.80	1.091
Holding chest 1/3rd back	3.80	1.181

Holding chest Back	3.73	1.154

Figure 18. Mean confidence levels for the images of the man holding the ball: chest height position

This reveals that the study participants had high overall mean confidence levels (3.68 ~ 3.80) across all the camera positions for matching the body and overhead images of the man holding the ball at the chest height position.

Next, Figure 19 shows the mean confidence levels across the five camera positions (front, 1/3rd side, side, 1/3rd back, back) for the man throwing the ball at the chest height position.

Visual Angles	Mean	Standard Deviation
Throwing chest front	3.53	1.281
Throwing chest 1/3rd side	3.63	1.079
Throwing chest side	3.70	1.018
Throwing chest 1/3rd back	3.85	1.051
Throwing chest back	3.73	1.132

Figure 19. Mean confidence levels for the images of the man throwing the ball: chest height position

This reveals that the study participants also had high overall mean confidence levels (3.53 ~ 3.85) across all the camera positions for matching the body and overhead images of the man throwing the ball at the chest height position.

Figure 20 shows the mean confidence levels across the five camera positions (front, 1/3rd side, side, 1/3rd back, back) for the man holding the ball at the waist height position.

Visual Angles	Mean	Standard Deviation
Holding waist front	3.93	0.917
Holding waist 1/3rd side	3.93	1.023
Holding Waist Side	3.80	1.043
Holding Waist 1/3rd back	3.90	1.008
Holding Waist Back	3.73	1.176

Figure 20. Mean confidence levels for the images of the man holding the ball: waist height position

This reveals that the study participants also had high overall mean confidence levels (3.73 ~ 3.93) across all the camera positions for matching the overhead and body images of the man holding the ball at the waist height position.

Finally, Figure 21 shows the mean confidence levels across the five camera positions (front, 1/3rd side, side, 1/3rd back, back) for the man holding the ball at the waist height position.

Visual Angles	Mean	Standard Deviation
Throwing waist front	3.95	0.876
Throwing waist 1/3rd side	3.78	1.121
Throwing waist side	3.78	1.143
Throwing waist 1/3rd back	3.80	1.043
Throwing waist back	3.83	1.083

Figure 21. Mean confidence levels for the images of the man throwing the ball: waist height position

This also reveals that the study participants had high overall mean confidence levels (3.78 ~ 3.95) across all the camera positions for matching the overhead and body images of the man throwing the ball at the waist height position.

Finally, Figure 22 shows the mean confidence levels across the five camera positions (front, 1/3rd side, side, 1/3rd back, back) for the images of the man holding and throwing the ball at chest and waist height positions.

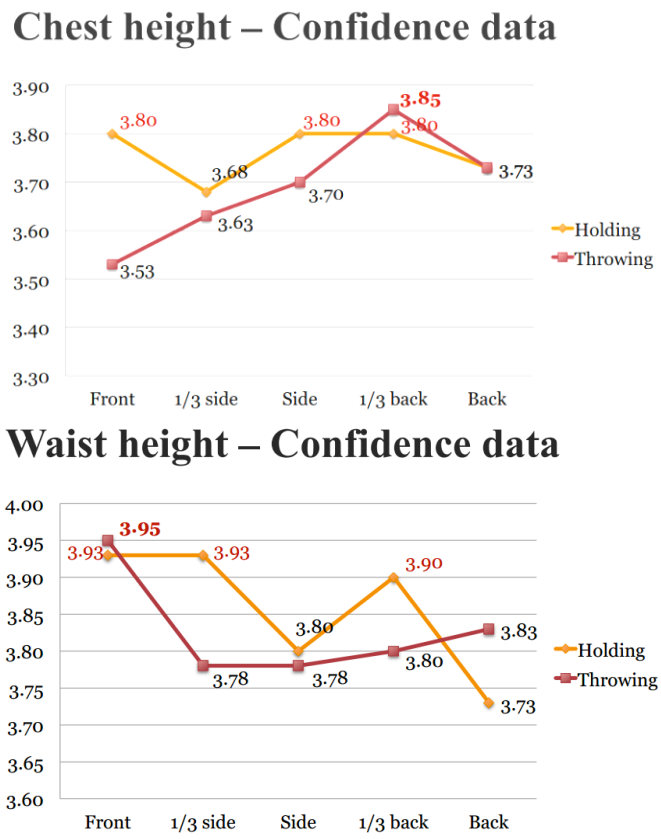

Figure 22. Mean confidence levels for the images of the man holding and throwing the ball: chest and waist height positions

It is clear from figure 22 that there are some differences in mean confidence levels across the images. The researchers thus used a (non-parametric) Friedman Test to

identify whether these differences are statistically significant. The Chi-square value is 25.172 and the asymp. Sig. value is .155 > .05 ($p > 0.05$). The Friedman Test thus reveals that there is no statistically significant difference in confidence levels across all the images.

Conclusion

The study was developed in order to investigate whether and how well people without any specialised knowledge of visual communication or information design can understand images demonstrating physical orientation when they are shown from different height perspectives (waist and chest height) and camera positions (front, 1/3rd side, side, 1/3rd back, back). Overall, the study participants achieved high levels of accuracy in matching the body and overhead images, although they found it slightly more difficult to match body and overhead images shown from the side camera position, and slightly easier to match body and overhead images shown from the back camera position, than the front, 1/3rd side, and 1/3rd back camera positions. The participants also self-reported relatively high overall confidence in their choices despite not having any specialised knowledge of visual communication or information design.

The high accuracy and confidence levels of the participants might, in part, reflect the fact that they were given a week to complete the matching exercises. A potential follow-up study could thus investigate whether there is a correlation between the time taken to match the body and overhead images and, first, the accuracy of the participants' matches and, second, their confidence in their matches.

This was a preliminary study with a limited sample size. However, the researchers hope that the findings could be useful in helping technical illustrators think about how to visually demonstrate physical orientation in procedural actions.

References

Ganier, F. (2012). Enhancing the Design of Instructions for Use; A Contribution of

Cognitive Psychology. In M. Torrance, D. Alamargot, M. Castello, F. Ganier, O.

Kruse, A. Mangen, L. Tolchinsky and L. van Waes (Eds.), *Learning to Write Effectively: Current Trends in European Research*. Bingley: Emerald Group Publishing Limited, 323-325.

Krull, R., Sharp, M. and Roy, D. (2003). *Canonical views in procedural graphics*.

Proceedings of the International Professional Communication Society, Orlando, FL, 22-28.

Krull, R., D'Souza, S., Roy, D. and Sharp, M. (2004). Designing Procedural Illustrations. *IEEE Transactions on Professional Communication*, 47(1), 27-33.

Mayer, R.E. and Gallini, J. K. (1990). When is an illustration worth ten thousand words? *Journal of Educational Psychology*, 82 (4), 715-726.

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