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Comprehension of Medication Dosage Instructions: A Comparison of Four Instruction Formats

ABSTRACT

Medication errors resulting from the misinterpretation of dosing instructions remain an important medication safety concern. Visually supported medication instructions may improve the clarity and comprehension of dosing information. This study compared four medication dosage instruction formats displayed on the packaging of a fictitious medicinal product: a conventional handwritten instruction, an action-oriented pictogram, a symbol-oriented dosing instruction, and an action-oriented pictogram accompanied by explanatory text. Sixty participants were randomly assigned to one of the four formats. Comprehension was assessed through response accuracy and confidence, while visual attention was recorded using eye-tracking. Response accuracy differed significantly between the instruction formats, with V3 and V4 achieving the highest accuracy (86.7%) and significantly greater odds of correct interpretation than the conventional handwritten format (46.7%). Eye-tracking measures also differed between formats, with V3 showing a lower proportion of fixation duration within the instruction area than V1. Overall, the findings indicate that the visual representation of medication dosage instructions can influence both comprehension and visual attention and support the potential use of appropriately designed visual and textual elements to improve medication instruction comprehension.

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KEY WORDS
Pictograms, dosage instructions, medication instructions, patient comprehension, medication safety

1. Introduction

Medicine packaging serves as the primary source of information required for the safe and appropriate use of the medicinal product. According to Article 54 of Directive 2001/83/EC, the outer packaging must include the name of the medicinal product, its strength and pharmaceutical form, the active substance, and the method and route of administration. It must also provide a designated space for recording the prescribed dosage. In addition, the packaging is required to display a special warning stating that the medicinal product must be kept out of the sight and reach of children, the expiry date, any special storage precautions, the name and address of the marketing authorization holder, the marketing authorization number, and the manufacturer's batch number (European Parliament and Council of the European Union, 2001). Clearly presented information facilitates the correct identification of the medicinal product, reduces the risk of medication errors, and contributes to the safety of both patients and healthcare professionals.

Medication dosing instructions are not standardized worldwide and vary considerably across countries and healthcare systems. One approach to improving the communication of medication-related information to patients with limited health literacy is the use of visual representations and pictograms on medicine labels and in the package leaflet (Dowse & Ehlers, 2005). The potential benefit of pictorial medication instructions can also be explained by the multimedia principle, according to which information presented through complementary

verbal and visual representations can facilitate comprehension compared with verbal information alone (Mayer, 2021). In medication communication, pictograms may therefore complement textual instructions by providing an additional visual representation of the required action or dosing schedule. Two of the best-known standardized pharmaceutical pictogram systems are the USP Pictogram Library, developed by the United States Pharmacopeia (USP), and PictoRx, developed by the International Pharmaceutical Federation (FIP). Both systems comprise validated pictograms designed to facilitate the communication of medication-related information, including dosage instructions, precautions, storage conditions, and safety warnings. Their primary objective is to improve patient comprehension but are not legally mandated and have not been universally adopted across healthcare system. In the Republic of Croatia like most of Europe, medication use instructions are commonly handwritten by pharmacists on the medicine packaging, a practice that may reduce their readability and hinder patient comprehension.

However, the presence of a pictogram alone does not guarantee correct interpretation. Previous research has shown that pictogram comprehension can depend on factors such as familiarity, design characteristics, cultural context, and health literacy (Dowse et al., 2023; Katz, Kripalani & Weiss, 2006; Menon et al., 2021). Nevertheless, a considerable body of research has examined the potential of pictorial representations to improve the comprehension of medication-related information, with recent evidence indicating that appropriately designed pharmaceutical pictograms can enhance the comprehension of textual medication instructions (Abdu-Aguye et al., 2023; Ferreira-Alfaya, Cura & Zarzuelo-Romero, 2025; Ferreira-Alfaya, Zarzuelo-Romero & Cura, 2024; Reijnen et al., 2022; Sharko et al., 2022). However, no published studies were found that evaluated users' comprehension of the medication instruction and labelling practices currently used in Europe and comparison within different instruction formats. The aim of this study was therefore to investigate how different visual representations of medication dosage instructions affect their comprehension and the allocation of visual attention. Four instruction formats were compared in terms of response accuracy, confidence, and eye-tracking measures, with the conventional handwritten instruction serving as the reference format.

2. Methods

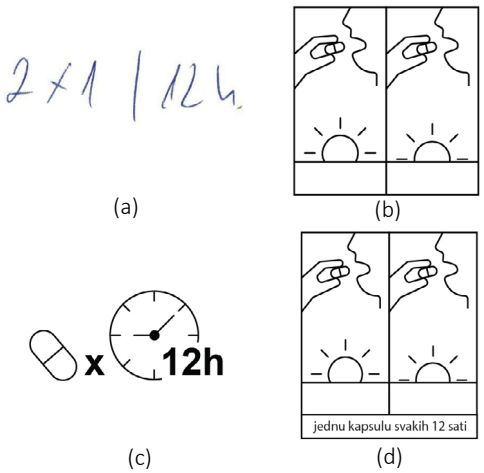
2.1. Samples

A packaging prototype of a medication was developed specifically for the purposes of this study. To minimize the potential influence of prior product or brand familiarity, the designs did not contain any identifiable brand names or commercial product references (Fig. 1). All textual information was presented in Croatian, thereby reflecting the language context of packaging encountered by the target population.



» **Figure 1:** *Packaging prototype*

Together with the conventional handwritten instruction, three alternative visual coding formats were developed, as illustrated in Fig. 2. All four formats were intended to communicate the same dosing instruction: “Take one pill every twelve hours.” The instruction was presented as a handwritten dosing instruction, representing the conventional format commonly used in Croatia and neighboring countries (Fig. 2a); an action-oriented pictogram depicting the intake of one pill in the morning and one in the evening (Fig. 2b); a symbol-oriented dosing instruction combining a pill symbol with a clock symbol and a 12-hour interval (Fig. 2c); and the action-oriented pictogram supplemented with explanatory text (Fig. 2d).



» **Figure 2:** *Four experimental instruction formats: a) Handwritten instructions (V1); b) Action-oriented pictogram (V2); c) Symbol-oriented dosing instruction (V3); d) Action-oriented pictogram and text (V4)*

2.2. Apparatus

The visual stimuli were displayed on a 17.3-inch IPS screen (1920 × 1080 px) of an Acer Nitro 5 laptop, with a maximum luminance of 300 cd/m² and a refresh rate

of 144 Hz. A constant viewing distance of 60 ± 1 cm was maintained throughout the experiment. Before data collection, display color characteristics were calibrated with a Datacolor SpyderX2 Ultra colorimeter to maintain consistent visual presentation across all participants. Eye-tracking data were acquired using a Tobii Pro Fusion system at a sampling frequency of 120 Hz. Stimulus presentation and eye-tracking data acquisition were managed in Tobii Pro Lab (version 26.10).

2.3. Experiment

Prior to the experiment, demographic data was collected and participants were introduced to the experimental procedure. Before presenting one of the four samples each participant was instructed to examine the packaging and the medication instructions displayed on the screen. Viewing time was unrestricted, allowing participants to proceed once they had formed their interpretation. After the stimulus was removed, participants verbally reported their interpretation, which was classified by the researcher as either correct or incorrect. If the initial response was incomplete, a neutral follow-up question was used to clarify the participant's interpretation without suggesting the correct answer. They subsequently rated their confidence in the response on a 10-point scale (1 = not confident at all; 10 = completely confident). Each participant was exposed to only one of the four experimental variants, thereby avoiding potential learning effects between different representations of the same information.

3. Results and discussion

A total of 61 participants were recruited for the study. One participant was excluded after failing the Ishihara color vision test, resulting in a final sample of 60 participants (14 male and 46 female), of whom 24 used vision correction (glasses or contact lenses) during the experiment. Regarding age distribution, 49 participants were aged 18–29 years, 7 were aged 30–45 years, 3 were aged 46–61 years, and 1 participant was aged 62–80 years.

3.1. Eyetracking

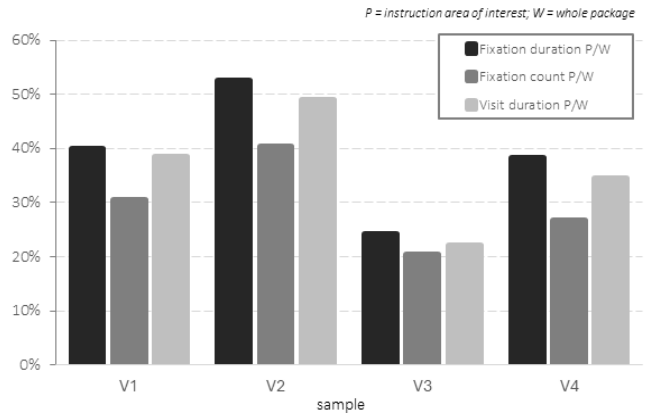
Eye-tracking data were analyzed to examine whether the different instruction formats affected participants' visual attention during information processing. The analysis focused on fixation- and visit-based measures within the instruction area of interest (P). In addition to the absolute eye-tracking measures, the proportion of visual attention allocated to the instruction area relative to the whole package (P/W) was calculated. This normalization was used to indicate how much of the overall visual attention directed toward the package was specifically allocated to the medication instruction. Differences among the four instruction formats were evaluated using the Kruskal–Wallis test. The results are presented in Table 1.

As shown, the instruction format significantly affected several measures of visual attention within the instruction AOI. Significant differences among V1–V4 were found for fixation duration, $H(3) = 9.89$, $p = .020$, $\varepsilon^2 = .123$, fixation count, $H(3) = 8.21$, $p = .042$, $\varepsilon^2 = .093$,

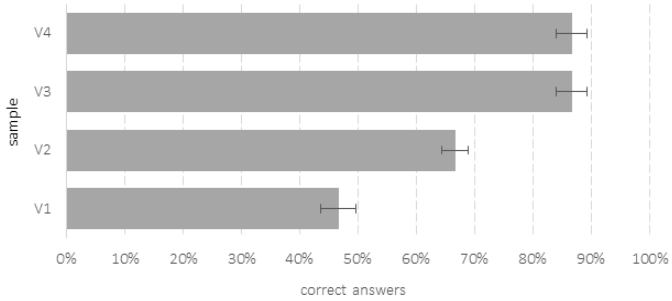
Table 1:
Eye-tracking measures across the four instruction formats

	V1 Median [Q1–Q3]	V2 Median [Q1–Q3]	V3 Median [Q1–Q3]	V4 Median [Q1–Q3]	H(3)	p	ε²
Fixation duration – P	4.650 [2.532–6.717]	6.442 [5.464–7.648]	3.667 [2.642–4.824]	5.145 [3.838–6.325]	9.89	0.020	0.123
Fixation count – P	14 [7.0–15.0]	17 [15.5–21.0]	12 [9.5–15.0]	14 [11.5–17.0]	8.21	0.042	0.093
Time to first fixation (TTFF) – P	2.795 [1.855–3.675]	2.131 [1.572–3.565]	3.102 [1.688–4.598]	2.798 [1.911–3.846]	1.79	0.617	0.000
Visit duration – P	4.792 [2.970–7.001]	6.733 [5.768–8.367]	4.022 [2.912–5.257]	5.810 [4.288–6.838]	10.14	0.017	0.127
Visit count – P	4 [2.5–5.5]	4 [3.0–5.0]	5 [4.0–7.5]	4 [3.0–5.0]	3.16	0.367	0.003
Proportion of fixation duration (P/W)	0.400 [0.306–0.590]	0.525 [0.419–0.596]	0.242 [0.188–0.316]	0.383 [0.246–0.570]	13.86	0.003	0.194
Proportion of fixation count (P/W)	0.304 [0.260–0.382]	0.405 [0.317–0.461]	0.205 [0.178–0.290]	0.268 [0.190–0.414]	10.55	0.014	0.135
Proportion of visit duration (P/W)	0.384 [0.282–0.527]	0.490 [0.392–0.557]	0.220 [0.181–0.300]	0.346 [0.216–0.518]	14.35	0.002	0.203

P = instruction area of interest; W = whole package ($p < .05$)



» **Figure 3:** *Relative visual attention to the instruction area across the four instruction formats*



» **Figure 4:** *Percentage of correct responses across the four instruction instruction formats (n = 15 per group, N = 60)*

and visit duration, H(3) = 10.14, p = .017, ε^2 = .127. In contrast, no statistically significant differences were observed for time to first fixation or visit count (p > .05).

Differences between the instruction formats became more pronounced when visual attention to the instruction was considered relative to overall package viewing. Significant differences were found for the proportion of fixation duration, H(3) = 13.86, p = .003, ε^2 = .194, fixation count, H(3) = 10.55, p = .014, ε^2 = .135, and visit duration, H(3) = 14.35, p = .002, ε^2 = .203. V2 consistently showed the highest median proportion of visual attention directed toward the instruction area, whereas V3 showed the lowest values across all three measures.

Post hoc comparisons further showed that V2 had a significantly greater proportion of fixation duration than V3 (p = .002), while V1 also showed a greater proportion than V3 (p = .049). Compared with V3, V2 also resulted in a significantly greater proportion of fixation count (p = .008) and visit duration (p = .001).

The relative distribution of visual attention across the four instruction formats was calculated as P/W × 100 and expressed as a percentage of the corresponding eye-tracking measure and is illustrated in Fig. 3. V2 showed the highest proportion of attention directed toward the instruction area across all three measures, whereas V3 consistently showed the lowest values. The median proportion of fixation duration was 0.525 for V2 compared with 0.242 for V3, while the corresponding proportions for fixation count were 0.405 and 0.205, and for visit duration 0.490 and 0.220, respectively. These differences were statistically significant for fixation duration (p = .003), fixation count (p = .014), and visit duration (p = .002).

3.2. Accuracy of responses and confidence results

Four different instruction formats of the same medication instructions (V1–V4) were evaluated. Each instruction format was assessed by a separate group of 15 participants. Comprehension was evaluated based on response accuracy (correct/incorrect) and participants' self-reported confidence in their response, rated on a scale from 1 to 10. The proportion of correct responses differed across the four instruction formats. For V1, 7 of 15 participants (46.7%) provided a correct response. This increased to 10 of 15 participants (66.7%) for V2 and to 13 of 15 participants (86.7%) for both V3 and V4 (Fig. 4).

Pearson's chi-square test indicated a statistically significant association between the instruction format and response accuracy, $\chi^2(3) = 8.13$, p = .043. Cramér's V was 0.368, indicating a moderate association between instruction format and correct interpretation of the instructions.

Differences between individual instruction formats were further examined using odds ratios (OR), with V1 used as the reference condition. Compared with V1, participants presented with V3 had significantly greater odds of correctly interpreting the instructions, OR = 7.43, 95% CI [1.23, 45.01], p = .029. The same result was obtained for V4 compared with V1, OR = 7.43, 95% CI [1.23, 45.01], p = .029. Thus, the odds of a correct response were approximately 7.4 times higher for V3 and V4 than for V1. In contrast, the increase in the odds of a correct response for V2 compared with V1 was not statistically significant. Therefore, the results provide evidence of a difference between V1 and V3 and between V1 and V4, but not between V1 and V2. The results indicate that the way medication instructions are visually represented can substantially influence their comprehension. Compared with the conventional handwritten instruction (V1), both V3 (symbol, pictogram, and text) and V4 (pictogram and text) resulted in significantly higher odds of correct interpretation. The high comprehension accuracy observed for V3 (symbol, pictogram, and text) and V4 (pictogram and text) supports previous findings that combining visual and verbal information can facilitate comprehension (Ferreira-Alfaya, Zarzuelo-Romero & Cura, 2024; Mayer, 2021).

In addition to objective response accuracy, participants' subjective confidence in their responses was evaluated. The median confidence scores were 8 for V1, 9 for V2, 9 for V3, and 10 for V4. Although the descriptive results suggest an increase in confidence across the instruction formats, the Kruskal–Wallis test showed no statistically significant difference in confidence between the four groups, H(3) = 2.18, p = .535. However, when participants were grouped according to whether their response was correct or incorrect, a significant difference in confidence was observed. Participants who provided correct responses reported significantly higher confidence than those who provided incorrect responses (Mann–Whitney U = 143.5, p < .001). Furthermore, response confidence was positively associated with response accuracy (Spearman's ρ = .499, p < .001), which is in accordance with other research (Jin, Verhaeghen & Rahnev, 2022).

When considered together with the eye-tracking results, V3 showed a particularly notable pattern. Compared with V1, V3 combined higher comprehension accuracy (86.7% vs. 46.7%) with a lower proportion of fixation duration within the instruction AOI (24.2% vs. 40.0%), with both comparisons reaching statistical significance. V4 likewise showed significantly higher comprehension accuracy than V1 (86.7% vs. 46.7%), while no significant increase in relative visual attention was observed. In contrast, V2 showed a numerical increase in accuracy (66.7% vs. 46.7%), but this improvement was not statistically significant.

At the individual participant level, the amount of visual attention allocated to the instruction area was not significantly associated with response accuracy after correction for multiple comparisons. Thus, greater fixation duration or fixation count should not be interpreted as directly corresponding to better comprehension. Rather, the combined results indicate that high comprehension accuracy can be achieved without a corresponding increase in visual attention to the instruction area.

Longer visual attention should not necessarily be interpreted as an indication of better instruction performance, as increased fixation duration and fixation count may also reflect greater processing demands. In this context, the results for V3 are particularly noteworthy. Despite receiving a lower proportion of visual attention, V3 achieved a high level of comprehension accuracy. This combination may indicate that the instruction could be extracted with less visual processing, suggesting a potentially more efficient presentation of the instruction. Although ocular metrics have been widely investigated in relation to cognitive load, there is still insufficient understanding of how these measures change with task difficulty (Ekin, Krejtz & Krejtz, 2025). Therefore, fixation-based measures alone cannot determine cognitive processing difficulty, which was not measured directly in the present study, and the interpretation of these findings should be considered with caution.

Although no eye-tracking measure remained significantly associated with comprehension accuracy after correction for multiple comparisons, visit count showed a potentially relevant pattern. Participants who correctly interpreted the instruction tended to revisit the instruction area less frequently. The observed lower number of revisits to the instruction area may indicate that participants were able to integrate the textual and pictorial information more efficiently during the initial inspection, reducing the need for subsequent verification. Eye-tracking research in educational settings has shown that successful learners typically exhibit more goal-directed visual attention patterns and fewer unnecessary transitions between information sources (Jarodzka, Holmqvist & Gruber, 2017). Similarly, van Gog and Scheiter argue that eye movements reflect cognitive and metacognitive processes during learning, with repeated shifts between information sources often indicating ongoing integration or verification of information. Holmqvist et al. (2011) further note that a higher number of visits to an area of interest generally reflects repeated consultation of that information, which may occur because the information is important or because it requires additional processing (Holmqvist et al., 2011). Therefore, the reduced revisit frequency observed in the present study may suggest more efficient processing of the instructional material rather than a need for repeated consultation.

4. Conclusions

This study demonstrated that the instruction format of medication dosage instructions can significantly influence their comprehension. The symbol-oriented instruction (V3) and the pictogram accompanied by explanatory text (V4) resulted in the highest comprehension accuracy, with significantly greater odds of correct interpretation compared with the conventional handwritten instruction (V1). V3 showed a particularly favorable overall pattern, combining high comprehension accuracy with a lower proportion of visual attention directed toward the instruction area. However, eye-tracking measures alone were not associated with comprehension accuracy at the individual level, indicating that visual attention and comprehension should be considered together when evaluating medication instructions.

Overall, the findings support the use of appropriately designed visual elements combined with textual information as an alternative to conventional handwritten dosing instructions.

The findings of this study provide a basis for further investigation of visually supported instructions. Future research could extend the present approach by including larger and more age-diverse participant samples and by evaluating a broader range of dosing instructions and packaging designs. Testing the instruction formats on physical packaging and in more realistic use conditions could further establish their applicability in everyday medication use.

5. Acknowledgments

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