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Incidental Learning From Science Journalism: The Effects of a Narrative Writing Style on the Comprehension and Situational Interest of Austrian Non-Experts in Health Sciences

Christian Ameseder*[1], Iztok Devetak[2] and Darija Skubic[2]

Austrian non-experts in health sciences often lack the scientific knowledge to make informed decisions that affect their daily lives and society as a whole. In general, their interest in current scientific knowledge is low, so it is unlikely that they will actively seek out information. Adult non-experts therefore need to acquire relevant scientific information incidentally, e.g., by reading journalistic articles. Journalistic articles traditionally follow an inverted pyramid structure, presenting the most important information first, while narratives unfold events chronologically with intentionally acting characters. Journalistic science narratives provide information that is usually missing in inverted pyramids. This additional information may increase situational interest in journalistic science narratives. Most people are confronted with narratives more often than with explanatory texts in everyday life and can therefore process them better. Due to the linear structure, relevant information elements are automatically activated at the same time, which further facilitates processing. An online study in the context of online science journalism on nutrition topics was conducted in Austria with 461 adult non-experts in health sciences recruited via online platforms. The dependent variables comprehension, cognitive load and situational interest were investigated using a multiple-tier test and self-reports. The results indicate significantly higher comprehension and general situational interest and significantly lower cognitive load after reading journalistic science narratives compared to inverted pyramids. However, situational interest in journalistic science narratives was significantly lower after participants had read the first paragraph. It then increased and was significantly higher than that for inverted pyramids for the rest of the article. Therefore, journalistic science narratives with a strictly chronological

1 *Corresponding Author. University of Applied Sciences Burgenland, Eisenstadt, Austria; and eLearning Academy for Communication, Eisenstadt, Austria; christian.ameseder@hochschule-burgenland.at.

2 Faculty of Education, University of Ljubljana, Slovenia.

structure should be used with caution. When initial situational interest is low, individuals may stop reading before they have enough information to fully comprehend the content. In addition, higher situational interest is correlated with a lower perception of cognitive load.

Keywords: incidental learning, narrative science journalism, cognitive load, comprehension, situational interest, storytelling

Naključno učenje iz znanstvenega novinarstva: učinki pripovednega sloga pisanja na razumevanje in situacijsko zanimanje avstrijskih nestrokovnjakov na področju zdravstvenih ved

Christian Ameseder, Iztok Devetak in Darija Skubic

Avstrijci, ki niso strokovnjaki na področju zdravstvenih ved, pogosto nimajo dovolj znanstvenega znanja za sprejemanje na informacijah temelječih odločitev, ki vplivajo na njihovo vsakodnevno življenje in družbo kot celoto. Na splošno je njihovo zanimanje za aktualno znanstveno znanje majhno, zato je malo verjetno, da bodo aktivno iskali informacije. Odrasli nestrokovnjaki morajo zato ustrezne znanstvene informacije pridobiti naključno, npr. z branjem novinarskih člankov. Novinarski članki tradicionalno sledijo strukturi obrnjene piramide in najprej predstavijo najpomembnejše informacije, medtem ko pripovedi kronološko razvijajo dogodke z namensko delujočimi liki. Novinarske znanstvene pripovedi zagotavljajo informacije, ki jih v obrnjenih piramidah običajno ni. Te dodatne informacije lahko povečajo situacijsko zanimanje za novinarske znanstvene pripovedi. Večina ljudi se v vsakdanjem življenju pogosteje srečuje s pripovedmi kot z razlagalnimi besedili in jih zato lahko bolje obdela. Zaradi linearne strukture se pomembni informacijski elementi hkrati samodejno aktivirajo, kar še dodatno olajša obdelavo. V Avstriji je bila izvedena spletna študija v okviru spletnega znanstvenega novinarstva o prehranskih temah, v kateri je sodelovalo 461 odraslih nestrokovnjakov s področja zdravstvenih ved, ki so bili pozvani prek spletne platforme. Odvisne spremenljivke razumevanja, kognitivnih obremenitev in situacijsko zanimanje so bile raziskane s večstopenjskim testom in samoporočanjem. Rezultati kažejo na boljše razumevanje in splošni situacijsko zanimanje ter bistveno manjšo kognitivno obremenitev po branju novinarskih znanstvenih pripovedi v primerjavi z obrnjenimi piramidami. Situacijsko zanimanje za novinarske znanstvene pripovedi je bilo bistveno manjše, ko so udeleženci prebrali prvi odstavek. Nato se je povečalo in je bilo v preostalem delu članka pomembno večje kot pri obrnjenih piramidah. Zato je treba novinarske znanstvene pripovedi s strogo kronološko strukturo uporabljati previdno. Kadar je začetno situacijsko zanimanje majhno, lahko posamezniki prenehajo brati, še preden dobijo dovolj informacij za popolno

razumevanje vsebine. Poleg tega je večje situacijsko zanimanje povezano z manjšim poznavanjem kognitivnih obremenitev.

Ključne besede: naključno učenje, narativno znanstveno novinarstvo, kognitivna obremenitev, razumevanje, situacijsko zanimanje, pripovedovanje zgodb

Introduction

Climate change, global insect extinction, individualised genomic medicine, the emergence of novel communicable diseases (e.g., the Covid-19 pandemic) and chronic non-infectious degenerative diseases (e.g., obesity, diabetes, cancer, cardiovascular disease) are just a few of the problems affecting people worldwide (Dunwoody, 2021; Hendriks et al., 2020; Kopp, 2019). Many of these socio-scientific challenges can have serious consequences for people's personal, social and civic lives (Feinstein & Waddington, 2020). In order to be literate citizens and to be able to participate in socio-scientific discussions, individuals need a certain level of scientific knowledge, especially in an increasingly technological world (Hofstein et al., 2011; Roth & Lee, 2004).

According to a PISA study (Organisation for Economic Co-operation and Development [OECD], 2023), the knowledge of Austrian 15-year-old students in the natural sciences decreased significantly between 2006 and 2022. Even if the level of knowledge is high at the end of formal education, science and its methods provide reliable knowledge but not ultimate truths. Other people – or the same person at a later time – can modify or refute previous findings (Weitze & Heckl, 2016). However, adults' self-reported interest in new scientific discoveries and technological developments is low (European Commission, 2010). As a result, many adults lack (self-reported) science literacy (Austrian Academy of Sciences, 2022; European Union, 2021). Taken together, even less informed individuals have to make decisions that sometimes have far-reaching consequences for themselves and for society as a whole. Although knowledge is not the only factor in decision making (e.g., emotions are another; Angie et al., 2011), it is unlikely that informed decisions can be made without the appropriate background knowledge.

Journalistic science narratives

In a field in which they are not experts, people cannot usually acquire knowledge through primary experiences. They depend on the mediation of information through secondary experiences, such as mediated messages (Burkart, 2002). Although the language used in scientific journals enables efficient communication in scientific circles, it is difficult for non-experts in science to understand (Avraamidou & Osborne, 2009). Therefore, it is journalists who traditionally fulfil the task of keeping non-experts up to date.

Adult non-experts get their information about scientific topics mainly from the mass media, especially the internet (Dahlstrom, 2014; Austrian Academy of Sciences, 2022; Weitze & Heckl, 2016). According to the Reuters Digital

News Report (Newman et al., 2022), 76% of Austrian respondents indicated online platforms (including social media) as their main source of news. However, even the increasing digitalisation of communication and the increased use of these new forms of communication do not seem to be leading to habituation. Students understand better when reading on paper than when reading on desktop computers. The difference in comprehension between print and digital even increased between 2010 and 2017 (Delgado et al., 2018). As news readers become less willing – and perhaps less able (OECD, 2019) – to read difficult material, journalists need to communicate complex issues in simple ways (Yaros, 2011). As Delgado et al. (2018) found no difference between reading narratives on paper and in digital form, a narrative writing style could be particularly beneficial in digital environments.

A 'journalistic article' is a news item aimed at a general audience and written by employees of professional journalistic institutions. Journalistic articles are usually written in the so-called inverted pyramid, whereby information is arranged in descending order of perceived importance (van Dijk, 1986). The term 'news story' is commonly used to refer to journalistic articles without implying a particular writing style. Lugmayr et al. (2017) suggest that the creation of narratives whose purpose goes beyond entertainment should be called 'serious storytelling'. However, the notion 'storytelling' is also associated with economic calculations (Früh, 2014). As the present study examines writing style, and given that quality journalism should not be dictated by economic calculations, the notion 'journalistic science narrative' is used.

Different definitions of narration (and storytelling) have been used in previous research, which may explain the sometimes contradictory results (Frey, 2014; Früh & Frey, 2014). In a meta-analysis by Ettl-Huber et al. (2019), the most frequently mentioned elements of narratives were plot and characters, followed by space and time. Together with the topic, which can be taken for granted in a journalistic context, these elements form the core of narratives. For a narrative to have a plot, at least one state must change, while characters carrying out intended actions drive the plot forward. Articles written in the inverted pyramid already contain some elements of narratives (Frey, 2014), but unlike journalistic science narratives (JSNs), inverted pyramids lack a continuous, causal plot and characters who act intentionally.

In order to illustrate what a JSN might look like, the following is an outline of the fatty acid JSN used in the present study. The scientist is described in her laboratory, next to cages of mice. The article then briefly outlines the digestion of omega-3 and omega-6 fatty acids before returning to the scientist conducting her mouse study. She observes the initial effects of different diets, then

simulates Parkinson's disease in the mice. She then observes how the results of this simulation differ between mice with an omega-3-rich diet and mice with an omega-6-rich diet. The mice that were exposed to the omega-3-rich diet had less oxidative stress in their brains and their dopamine-producing neurons were protected.

Only a few studies (e.g., Yaros, 2006, 2011; Yaros & Cook, 2013; Kleemans et al., 2018) have investigated the effects of JSNs. However, studies of science narratives without a journalistic context mainly examine their persuasiveness or effects in the context of intentional learning (Ettl-Huber et al., 2019) and are compared to advertisements or textbooks (not inverted pyramids). The processing strategy (and consequently the effects) is likely to vary depending on the different processing goals in intentional and incidental learning (Slater, 1997). Studies on general journalism, on the other hand, do not take into account the specifics of science journalism (e.g., acquisition of scientific concepts).

Comprehension of journalistic science narratives

Comprehension should be distinguished from the function of memory and the learning process (Schnotz & Kürschner, 2007): *memory* refers to the mere storage of information in the long-term memory (LTM), while *comprehension* refers to task performance that takes place only in working memory (WM), where connections between different information elements are processed. The whole procedure of processing and storing information is called *cognitive learning*, which leads to an increase in expertise. Therefore, comprehension is a factor in learning.

Whereas individuals consciously acquire knowledge in intentional learning, they do not explicitly intend to learn in incidental learning. Incidental learning is thus a by-product of other activities, such as task performance (e.g., reading online journalism). It becomes more important as individuals age, as they are increasingly less likely to attend institutions that require intentional learning (Wagnon et al., 2019).

Individuals develop scientific concepts by: (1) distinguishing the characteristics of objects in a set from each other, (2) distinguishing characteristics that are common to a set from those that are specific to individual or few objects (characteristics that instances *can have*), and (3) identifying common characteristics (characteristics that each of their instances *must have*) and developing new concepts. After developing a concept, the individual has identified its crucial characteristics and is able to recognise it in every case (Krnel & Skubic, 2015; Layng, 2019).

Lawson et al. (2000) distinguish between *descriptive concepts* (which can be observed directly), *hypothetical concepts* (which could be observed if the time frame could be extended) and the most abstract *theoretical concepts* (in which causal agents cannot be observed). Similarly, Devetak and Glažar (2010), following the work of Johnstone (1991), differentiate the *macroscopic level* of chemical concept presentation (observed chemical phenomena), the *submicroscopic level* (interpretation of observed particle interactions) and the *symbolic level* (submicroscopic representations translated into symbols, e.g., symbols of chemical elements or schematic representations). The difficulty of acquiring and understanding a concept increases with its degree of abstraction. Even adults beginning to construct concepts in a new field of study need some descriptive (macroscopic) conceptual foundation before they can construct theoretical (submicroscopic) concepts (Lawson et al., 2000). When communicating with non-experts in a field, it is therefore important to address the macroscopic level (descriptive concepts) before introducing the submicroscopic level (hypothetical or even theoretical concepts).

Novel and inconsistent information (e.g., from science journalism) requires controlled – as opposed to automatic – information processing in working memory (Jiang & Kalyuga, 2020). To consciously comprehend information (e.g., construct scientific concepts), individuals must simultaneously hold all relevant (interacting) elements in their working memory. However, working memory – and thus controlled information processing – is limited in time and capacity (e.g., Cowan, 2001; Rouder et al., 2008).

When processing the information in a message, the available cognitive resources are divided between the processes of 'encoding', 'storage' and 'retrieval' (Lang, 2006; Wise et al., 2009). If any of these processes requires more resources than are available or allocated to it, the message will be processed poorly (Lang, 2006). The mental resources required to perform a particular task are referred to as *cognitive load* (CL), while *mental effort* refers to the mental resources individuals actually allocate to a task. If the CL of a task exceeds the mental effort, performance will be poor (Schnotz & Kürschner, 2007). By integrating multiple information elements into a schema as a result of learning, experts can increase the number of information elements that can be activated simultaneously (Sweller et al., 2011). As science journalism is aimed at non-experts in the field, it is crucial not to rely on established schemas and to take into account the number of single information elements that readers have to activate simultaneously. Due to the linear structure of narratives, related information elements are automatically activated simultaneously while reading (van den Broek et al., 1996). Therefore, even non-experts may require fewer mental resources to retrieve information elements when reading JSNs.

Mayer (2009, pp. 79–82) further distinguishes between different types of encoding. Essential processing is required to represent the essential material (text base) in working memory, whereas generative processing refers to the utilisation of essential information (mental models), which involves integration with existing knowledge. The combination of essential and generative processing leads to comprehension and meaningful learning. Finally, extraneous processing is not related to the goal of the task.

With each encounter with certain text structures, individuals improve their ability to read them (Norris et al., 2005). Therefore, science journalism should employ text structures to which the majority of its audience is accustomed. It is assumed that non-experts are more familiar with a narrative structure than a non-narrative structure. Narratives play a prominent role in individual development and human history and resemble everyday life experiences (Mar et al., 2021). Therefore, non-experts should understand JSNs better than inverted pyramids. However, content is more complex in science journalism than in general journalism, while 'seductive details' can lead to extraneous processing and reduce comprehension and learning (van den Broek, 2010).

Zabrucky and Moore (1999) found that, in an *educational context*, adults' recall of idea units and comprehension were higher for narrative texts than for expository texts, despite the fact that they reread fewer passages of narrative texts than expository texts. Similarly, a study by Thorndyke (1977) found that comprehension increased when a prose text contained more plot structure, while Fernald (1989) found that students who read narrative textbook chapters achieved significantly higher test scores. These findings are consistent with the results of a meta-analysis by Mar et al. (2021) in a general education context. However, Cunningham and Gall (1990) found no influence of writing style on test performance.

In the context of *general journalism*, individual studies have found trends in perceived comprehensibility in different directions for different topics (Früh & Frey, 2014; Zerba, 2008). Machill et al. (2007) found that narrative television news was more successful in conveying information than inverted pyramids, especially among younger participants with low knowledge and low interest in the topics, while Kleemans et al. (2018) found increased information recognition in online journalistic narratives (one of the four article topics was science). However, Sternadori (2008) found no significant differences in comprehension between narratives and inverted pyramids.

In a study by Yaros (2011) on *science journalism*, individuals performed best in a comprehension test after having read a JSN with linear links. Similarly, Yaros and Cook (2013) found higher learning success as well as less eye fixation and shorter viewing time for narratives. In both studies, however, terms with

which participants were likely unfamiliar were only explained in the narrative conditions, which may have contributed to this effect.

Situational interest in journalistic science narratives

In order to understand a message and gain information from it, individuals first need to receive it (Früh & Frey, 2014), which means they need to be interested in it. The *Four-Phase Model of Interest Development* (Hidi & Renninger, 2006; Renninger & Hidi, 2019) distinguishes between individual and situational interest. *Individual interest* refers to the uninterrupted engagement of an individual in a specific domain. It develops over time and influences an individual's knowledge and values in the long run. *Situational interest,* on the other hand, refers to the perceived 'interestingness' of a message that arises suddenly during exposure to that message and is of short duration (Yaros, 2011).

As the present study investigates the effects of individual messages, the focus is on situational interest. According to the four-phase model, the emergence of long-lasting individual interest results from situational (text-based) interest in four phases (Hidi & Renninger, 2006; Renninger & Hidi, 2019): (1) triggered situational interest – individuals start consuming a message because of a trigger; (2) maintained situational interest – interest persists for more than a few seconds or recurs in similar activities; (3) emerging individual interest – individuals engage repeatedly with the topic and ask themselves questions about it; and (4) well-developed individual interest – the engagement has become permanent. When interest is sustained, these four distinct and sequential phases describe how it develops progressively (Hidi & Renninger, 2006).

Situational interest is assumed to increase the attention directed to a task, which in turn should lead to higher comprehension and learning: according to the level of processing framework, shallow encoding is disadvantageous for retrieval compared to deep encoding (Wagnon et al., 2019). Research shows that there is a statistically significant correlation between situational interest and the knowledge that individuals develop during a particular activity (Durik & Harackiewicz, 2007; Snětinová et al., 2018; Slapničar et al., 2024).

In an *educational* context, students in the aforementioned study by Fernald (1989) preferred narrative material to traditional textbook material. Research also found that the ratings for narrative and expository writing styles in a history textbook chapter did not differ significantly, although most of the students surveyed preferred the narrative style in a direct comparison (Cunningham & Gall, 1990). Moreover, preference for narrative over expository writing styles was found to be more pronounced for a less interesting topic (Arya & Maul, 2012).

In the context of *general journalism*, there are findings on situational interest in both directions. In some studies, narratives were rated as less interesting (Kelly et al., 2003) and were less appreciated (Kleemans et al., 2018) than inverted pyramids. Sternadori (2008) found no difference, but in a study by Zerba (2008), narratives were rated as more interesting and more enjoyable, although the difference was only significant for one of three topics. On the other hand, Knobloch et al. (2004) concluded that ratings of suspense and reading enjoyment were significantly higher for narratives than for inverted pyramids. Similar results were also described by Yaros (2011), who concluded that *journalistic science narratives* also increase situational interest.

Research problem, research question and hypotheses

The Austrian Nutrition Report (Rust et al., 2017) emphasises that, compared to the recommended intakes, Austrian citizens eat too much of some nutritional ingredients (e.g., saturated fatty acids or added sugars), while eating too little of others (e.g., polyunsaturated fatty acids or fibre). It is therefore not surprising that 51.1% of the Austrian population aged 15 and over is overweight or obese and 38.3% has chronic diseases (Statistik Austria, 2020). Moreover, Gensthaler et al. (2022) found a steady increase in body mass index and cardiovascular risk in Austrian male adolescents over 15 years.

In order for an adult's diet to provide all of the necessary nutrients, different foods need to be combined and dosed appropriately (Pudel & Westenhöfer, 2003). For non-experts, it is difficult to grasp the connections between dietary behaviour and future outcomes (e.g., long-term health effects) because of the long intervening period, which cannot be experienced directly (Pudel & Westenhöfer, 2003; see also hypothetical concepts above). Non-experts therefore depend heavily on nutrition information. However, more than half of Austrians have an inadequate or problematic general health literacy (Sørensen et al., 2015) and lack general nutrition knowledge (Gruber et al., 2022). For this reason, the present study used journalistic science articles on nutrition as the research object and the research question was formulated accordingly: *"What effects does a narrative writing style compared to an inverted pyramid writing style have on the comprehension of and situational interest in journalistic online nutrition science articles among Austrian non-experts in the health sciences?"*

Schiefele and Krapp (1996) showed that topic interest positively influences free recall of expository texts. Therefore, individual interest must be taken into account when studying comprehension and CL.

In order to address the different aspects of the research question, five

research hypotheses were defined. Each hypothesis was derived from the findings of the literature review presented above. Since it is assumed that the narrative structure is more familiar and less additional information elements need to be retrieved, it is hypothesised that comprehension will be higher with the narrative style than with the inverted pyramid style. If reading JSNs requires less cognitive resources to retrieve information elements, it should also result in less CL. To apply the previous considerations more generally (independent of JSNs), the correlation between comprehension and CL is assessed. JSNs provide information that is usually missing from inverted pyramid articles (continuous causal plot and intentionally acting characters), which is hypothesised to increase situational interest. Finally, it is hypothesised that situational interest increases attention to a task, so comprehension should also increase with situational interest.

H1: After controlling for individual interest, journalistic online science articles on nutritional issues lead to significantly *higher comprehension* in non-experts when they are written in narrative compared to inverted pyramid style.

H2: After controlling for individual interest, non-experts' *cognitive load* is significantly *lower* when reading journalistic online science articles on nutritional issues written in narrative compared to inverted pyramid style.

H3: There is a significant *negative correlation* between non-experts' *comprehension* of journalistic online science articles on nutritional issues and their *cognitive load* while reading.

H4: After controlling for individual interest, non-experts' *situational interest* in journalistic online science articles on nutritional issues is significantly *higher* when they are written in narrative compared to inverted pyramid style.

H5: There is a significant *positive correlation* between non-experts' *comprehension* of journalistic science articles on nutritional issues and their *situational interest* while reading.

Method

In this cross-sectional research, a 2 (writing style: narrative, inverted pyramid) × 3 (topic: fatty acids, fructose, amino acids) mixed factorial design was used. To increase external validity, the effect was analysed in different settings (i.e., articles on different nutrition topics).

Participants

The inclusion criteria for participants in the research are: (1) they were native speakers of German, (2) they were over 18 years of age, and (3) they were not nutrition experts. In addition, demographic information (age, gender, education) was collected.

Participants were recruited via the University of Applied Sciences Burgenland newsletter and the online survey platforms surveycircle.com and surveyswap.io. A total of 604 respondents participated in the research. For quality reasons, responses with incorrect attention test items (65) and participants who read an article for 25 seconds or less (111) were excluded (the cut-off point was chosen beforehand based on the reading time of two fast readers). Due to a technical problem, the complete self-reports of 123 participants were not fully recorded. The final sample size therefore amounts to 461 participants for the comprehension test and 338 participants (213 female, 125 male; 171 under 30 years old, 167 equal to or above 30 years old; 148 with an educational level below or equal to secondary school, 196 above secondary school) for the self-reports (see instruments).

The participants in the study were all volunteers, so no statements can be made about those who chose not to participate. Furthermore, only subscribers to the UAS Burgenland newsletter or individuals who participate in the two online platforms could take part. Therefore, the study sample is not representative of the Austrian population and the results should be extrapolated with caution. However, the purpose of the study was to make relative statements about how the dependent variables change as a result of different stimuli. Therefore, the aim was not to obtain a representative sample (Brosius et al., 2012), but rather to achieve a comparable distribution of the demographic characteristics of the participants in the different groups. In support of this aim, all *p*-values for comparisons of demographic data between writing style groups were > .05.

Instruments

Individual interest was measured using five self-report items from Appel et al. (2002). All of the self-report items in the present study are 5-point Likert-type items. One of the items loaded equally (weakly) on two factors and was therefore excluded, resulting in a four-item scale (Cronbach's $\alpha = .89$). An example of the items is shown in Figure 1. The mean of the four items was calculated so that the participants' ratings ranged from one to five points.

Perceived cognitive load was measured using the mental effort rating scale and the perceived task difficulty rating scale (based on the German version by

Schmeck et al., 2015). Furthermore, five items on perceived processing fluency and topic knowledge were administered (based on Shulman & Sweitzer, 2017). One item was excluded due to cross loadings, and two items were excluded to increase internal consistency (final Cronbach's α = .86). An example of the items is shown in Figure 2. As the mean of the items was calculated, the participants' ratings ranged from one to five points.

Situational interest was measured using three self-report items from Yaros (2006; 2011), which asked about the reader's desire to continue reading at different points in time, allowing for an estimation of changes in interest levels during reading (Ainley et al., 2002). Since readers had to read the entire article, an item was added asking them whether they would have read the entire article if they had read it outside the study. Finally, two items from Appel et al. (2002) and Früh and Frey (2014) were added. The first item (presented after the first paragraph of the article) did not load sufficiently on the factor and was excluded. The remaining five items have excellent internal consistency (Cronbach's α = .91). An example of the items is shown in Figure 3. The mean of the items was calculated so that the participants' ratings ranged from one to five points.

Figure 1

Example of items from the individual interest questionnaire (translated from German)

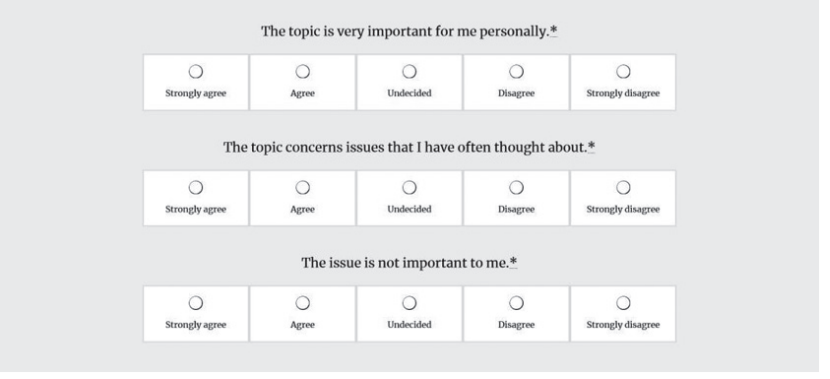


Figure 2
Example of items from the perceived cognitive load questionnaire (translated from German)

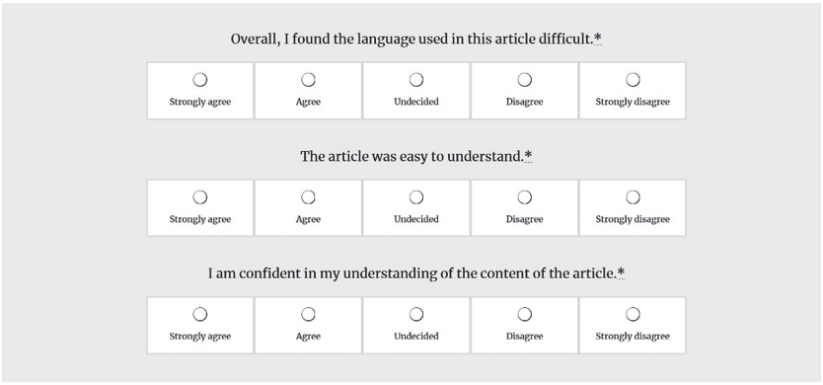
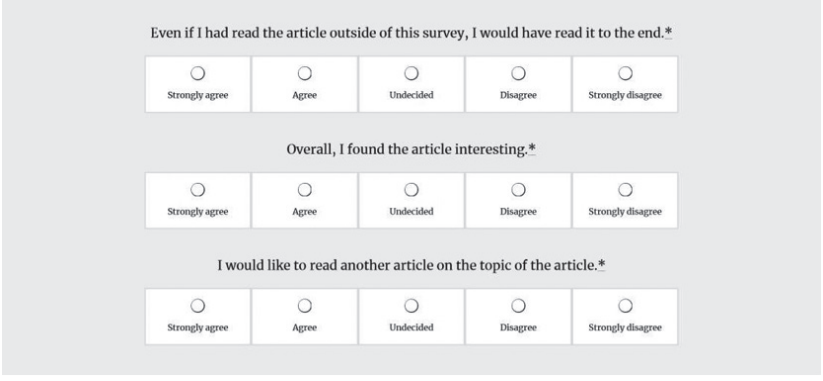


Figure 3
Example of items from the situational interest questionnaire (translated from German)



Confirmatory factor analysis (CFA) of the self-reports was performed using SPSS AMOS (27.0.0). Comparison of the Akaike Information Criterion (AIC) of the models including and excluding the item 'Situational Interest 1' supported the exclusion of this item (Eaton & Willoughby, 2018). The χ^2 statistic is affected by sample size, so the result does not necessarily oppose a good fit (Babyak & Green, 2010). All other indices indicate that the model fits the data (RMSEA, CFI, TLI (Hair et al., 2014); χ^2/df (Cole, 1987); see Table 1 for details). Internal validity (CR > .70), convergent validity (AVE > .50) and discriminant

validity (square roots of AVEs > inter-construct correlations) were achieved for both latent variables (Hair et al., 2014).

Table 1

Fit indices for CFA of self-reports

Sig. χ^2	χ^2/df	RMSEA	CFI	TLI
$p < .01$	137.57/74 = 1.86	< .06	.97	.96

Note. RMSEA – root mean square error of approximation; CFI – comparative fit index; TLI – Tucker-Lewis index

Comprehension was measured using the 15 four-tier multiple-choice items from Ameseder et al. (2022). Using four-tier test questions makes it possible to identify comprehension (Gurel & Eryılmaz, 2015). For the purposes of the present paper, only the answer (first tier) and the reason for the answer (third tier) were used. CFA was conducted for each topic separately (FACTOR 12.01.02; Ferrando & Lorenzo-Seva, 2017). Since the data are binary, Robust Unweighted Least Squares estimators based on polychoric correlation matrices were used. After excluding one item per topic, reliability was good for topics 1 and 3 (>.80; Ferrando & Lorenzo-Seva, 2018) and the factor determinacy index was adequate (>.90; Grice, 2001). However, the reliability and the factor determinacy index remained unsatisfactory for topic 2 (.47 and .69, respectively). In addition, the Kaiser-Meyer-Olkin measure (Kaiser, 1974) and Bartlett's test of sphericity were not acceptable for topic 2 (.58 and $p = .14$, respectively), which was therefore excluded. The fit indices for the remaining 4-item scales are shown in Table 2.

Table 2

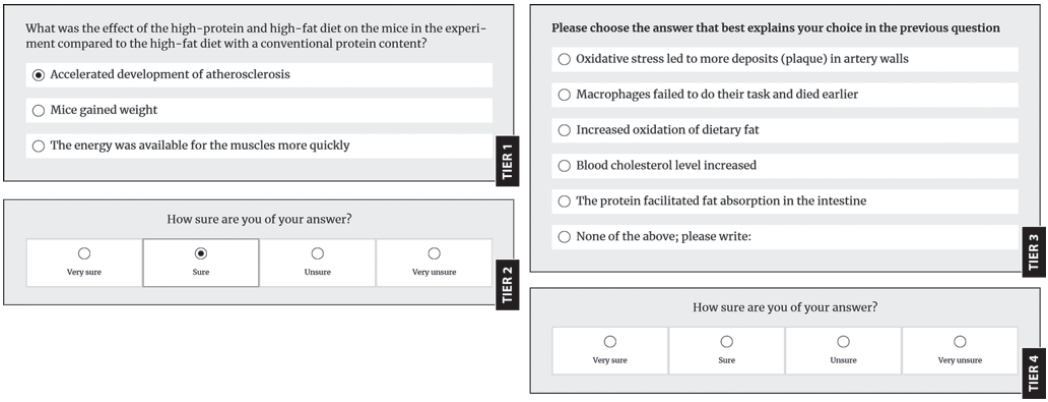
Fit indices for CFA of comprehension tests

Topic	Sig. χ^{2*}	χ^{2*}/df	RMSEA	AGFI	CFI	TLI
1	$p = .39$	1.87/2 = .93	< .01	.99	1.00	1.00
3	$p = .37$	1.99/2 = .10	< .01	.98	1.00	1.00

Note. * Robust mean- and variance-adjusted χ^2; RMSEA – root mean square error of approximation; AGFI – adjusted goodness-of-fit index; CFI – comparative fit index; TLI – Tucker-Lewis index

Figure 4 shows an example of the items in the comprehension test. The items were summed up so that the participants could obtain a minimum of zero and a maximum of four points.

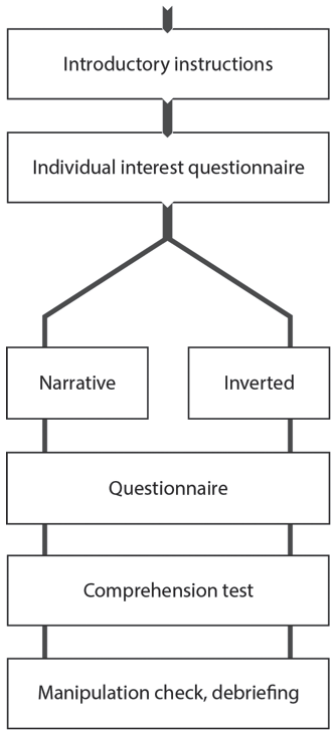
Figure 4
Example of a four-tier item from the comprehension test (translated from German)



Research design

The present study used a cross-sectional, between-subjects design. Two factors were used, one with two levels (writing style: narrative and inverted pyramid) and the other with three levels (topic: fatty acids, fructose and amino acids). Varying the topic should enable the external validity to be increased by examining the effect in different settings (see Figure 5 for the procedure). A pilot study was conducted to ensure the smooth flow of data collection, the comprehensibility of the technical terms used in the stimulus texts and self-reports, and the successful manipulation of the stimulus type.

Figure 5
Schematic illustration of the procedure



Before reading the science journalistic article (stimuli), the participants were exposed to the individual interest questionnaire and were instructed to read the stimuli at their own pace, just as they would read journalistic articles in everyday life. To avoid influencing their reading behaviour, there was no prior knowledge test and the comprehension test was not mentioned in advance. The participants were randomly assigned to one of six groups (e.g., inverted pyramid science journalistic article on the topic fatty acids; for the other groups see Table 3). There were no significant differences in individual interest ($U = 14{,}036.50$, $p = .70$), gender ($X^2(2, N = 461) = 1.18$, $p = .55$), age ($U = 26{,}169.00$, $p = .76$), or education ($X^2(7, N = 461) = 4.42$, $p = .73$) between the narrative and inverted pyramid conditions. Thus, random assignment to the conditions seems to have been successful.

Table 3
Participants randomly assigned to six groups according to the science journalistic article writing style and nutrition topic; word count of individual articles

Writing style	Topic 1 Fatty acids	Topic 2 Fructose	Topic 3 Amino acids
Narrative	Group 1 (*N* = 67) 564 words	Group 3 (*N* = 80) 518 words	Group 5 (*N* = 86) 527 words
Inverted pyramid	Group 2 (*N* = 67) 506 words	Group 4 (*N* = 79) 508 words	Group 6 (*N* = 82) 507 words

One of the six stimulus articles was then presented at random. Three of the articles were written in narrative style and three in inverted pyramid style (one narrative and one inverted pyramid per topic). Topics were chosen in which existing knowledge and individual interest had already proven to be low (Ameseder et al., 2020). As a basis for the stimuli, articles published in 2019 by the three major online news providers in Austria (Highest reach in 2019 according to http://www.oewa.at/plus/medienanalyse [accessed 10 February 2020]) were selected. The articles covered the three macronutrients that are important for a healthy human diet: carbohydrates (fructose), fats (fatty acids) and proteins (amino acids). Each of the articles was adapted so that there was a narrative version and an inverted pyramid version. To ensure comparability, the stimuli: (1) are (re-)written by the same authors (Shen et al., 2014); (2) are of comparable length in terms of word count (van Krieken et al., 2015; see Table 3); (3) have a comparable readability index (LIX; Björnsson, 1983); (4) use the same scientific terms (Yaros, 2011); (5) have the same number of headlines, and (6) are written in the same grammatical tense.

A (neutral) visual appearance was maintained for all of the stimuli (no logo/masthead, same typeface and layout, no images), so that they could not be assigned to existing journalistic websites. The text properties were adapted to the real conditions (based on all articles on the topic of nutrition from orf.at and derstandard.at from 2019; $N = 104$).

While the participants read the article, their reading time was measured and they had to answer two situational interest items. After reading, they completed the remaining situational interest items and the cognitive load items. They then answered comprehension questions on the topic they had read. To reduce order effects, the order of the items was randomised. Finally, the participants had to complete a manipulation check and provide demographic information. They were then thanked and received a debriefing.

Correlation with the dependent variables is a prerequisite for including individual interest as a covariate in the analyses of hypotheses H1, H2 and H4 (Bortz & Schuster, 2010). Therefore, the correlations between individual interest and the dependent variables were assessed in advance. There was a significant correlation between individual interest and perceived cognitive load (Pearson's r = -.20, p < .01; Spearman's r = -.21, p < .01) and between individual interest and situational interest (Pearson's r = .37, p < .01; Spearman's r = .37, p < .01). However, there was no significant correlation between individual interest and comprehension (Pearson's r = .03, p = .69; Spearman's r = .04, p = .60). It is therefore assumed that the covariate has no effect on the variable comprehension.

Normal distribution was assessed using Kolmogorov-Smirnov tests, z-score tests of skewness and kurtosis, and visual inspection, but was not detected for comprehension, cognitive load or situational interest. Therefore, an independent-samples Mann-Whitney U test was used to analyse comprehension. To be able to use general linear model procedures (ANCOVAs) with individual interest included as a covariate for perceived cognitive load and situational interest, the data were transformed (taking the square root for perceived cognitive load and the square root of (largest value + 1 - value) for situational interest). Perceived cognitive load was normally distributed after the transformation. Based on z-score tests, transformed situational interest was also normally distributed, but not based on the Kolmogorov-Smirnov test. As parametric tests have been shown to be robust to non-normality (Blanca et al., 2017), an ANCOVA was also used for situational interest. Means and standard deviations are reported from untransformed data. Effect sizes were calculated and interpreted according to Cohen (1988). Finally, Pearson's and Spearman's correlation coefficients were computed to assess the correlations in hypotheses H3 and H5.

The research was conducted in accordance with the ethical guidelines for pedagogical research. The research study was approved by the Academic and Scientific Committee for Research and Doctoral Studies at the University of Applied Sciences Burgenland.

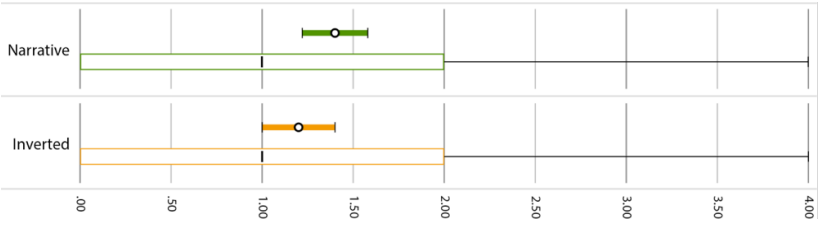
Results

The Mann-Whitney U test indicated that *comprehension* test scores were significantly higher for readers of narratives (*Mdn* = 1.00, mean rank = 160.98) than for readers of inverted pyramids (*Mdn* = 1.00, mean rank = 141.76), U = 12,849.50, p < .05. Consequently, the test scores support hypothesis H1, which predicts that comprehension is significantly higher when journalistic

science articles are written in narrative style than when they are written in inverted pyramid style, with a small effect size (r = .11; see Figure 6).

Figure 6

Difference in comprehension



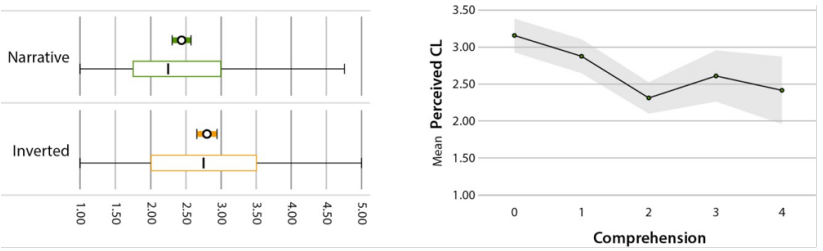
Note. Mean (95% CI) and boxplot

The ANCOVA indicated that *perceived cognitive load* was significantly lower for readers of narratives than for readers of inverted pyramids, after controlling for individual interest, $F(1, 335) = 14.65$, $p < .01$, with $M = 2.45$ ($SD = .88$) for narratives and $M = 2.81$ ($SD = .93$) for inverted pyramids. Therefore, the data support hypothesis H2, which states that, after controlling for individual interest, cognitive load is significantly lower when journalistic science articles are written in narrative style compared to inverted pyramid style, with a small effect size (Cohen's $f = .21$; see Figure 7).

There was a significant negative *correlation between comprehension and perceived cognitive load* (Pearson's $r = -.29$, $p < .01$; Spearman's $r = -.31$, $p < .01$). Decreases in perceived cognitive load were correlated with increases in comprehension test achievements, thus supporting hypothesis H3, which hypothesised a significant negative correlation between comprehension of journalistic science articles and the cognitive load while reading (see Figure 7).

Figure 7

Difference in perceived CL and correlation with comprehension (untransformed data)



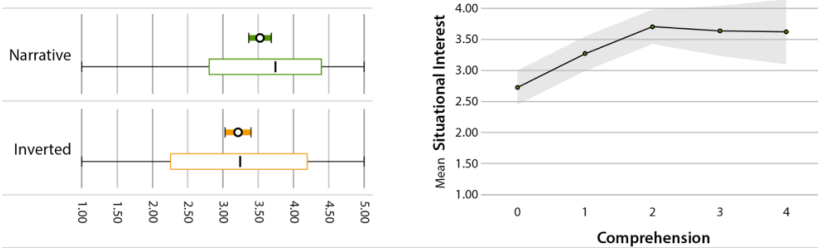
Note. Mean (95% CI) and boxplot

The ANCOVA indicated that *situational interest* was significantly higher for readers of narratives than for readers of inverted pyramids, after controlling for individual interest, $F(1, 335) = 7.34$, $p < .01$, with $M = 3.52$ ($SD = 1.06$) for narratives and $M = 3.21$ ($SD = 1.19$) for inverted pyramids. The data therefore support hypothesis H4, which predicts that, after controlling for individual interest, situational interest is significantly higher when journalistic science articles are written in narrative style compared to inverted pyramid style, with a small effect size (Cohen's $f = .15$; see Figure 8). As the first situational interest item (participants' desire to continue reading after the first paragraph) did not correlate sufficiently with the other items, the responses at the three different stages of reading (after the first paragraph, after two thirds of the article and after reading the article) were compared. The first rating was significantly lower for narratives than for inverted pyramids ($U = 12{,}213.00$, $p = .02$, $r = -.13$). In contrast, the second and third ratings were significantly higher for narratives ($U = 17{,}521.00$, $p < .01$, $r = .20$ and $U = 16{,}157.00$, $p = .03$, $r = .12$, respectively).

There was a significant positive *correlation between situational interest and comprehension* (Pearson's $r = .31$, $p < .01$, Spearman's $r = .33$, $p < .01$). Increases in situational interest were correlated with increases in test scores, thus supporting hypothesis H5, which hypothesised a significant positive correlation between comprehension of journalistic science articles and situational interest while reading (see Figure 8).

Figure 8

Difference in situational interest and correlation with comprehension



Note. Mean (95% CI) and boxplot

Discussion and conclusions

The present online study investigates the effect of journalistic science narratives (JSNs) on reading comprehension and situational interest of non-experts in health sciences.

The comprehension test shows that reading JSNs leads to higher comprehension compared to the inverted pyramid writing style, suggesting that incidental learning is more likely to occur when reading JSNs than inverted pyramids. The increased comprehension is consistent with previous studies on general journalism (Kleemans et al., 2018) and science journalism (Yaros, 2011; Yaros & Cook, 2013). However, the results contradict previous studies on textbooks (Cunningham & Gall, 1990) and general journalism (Sternadori, 2008; DeAngelo & Yegiyan, 2019). The use of a diagnostic (multiple-tier) test in the present study extends the research of Kleemans et al. (2018) by examining higher levels of cognitive processes and knowledge. It also extends the research of Yaros (2011) and Yaros and Cook (2013) by providing evidence that a narrative writing style improves comprehension in science journalism, even when controlling for unfamiliar vocabulary. The present findings, in conjunction with those of Sternadori (2008), suggest that causal links between events may be crucial for the effects of JSNs on comprehension. Finally, DeAngelo and Yegiyan (2019) did not use a forced-reading design (participants could decide how much of an article to read). Therefore, requiring participants to read the entire article may have contributed to the effect of JSNs on comprehension in the present study.

In the present study, the perceived cognitive load (CL) was significantly lower for JSNs compared to inverted pyramids. This finding contradicts the results of previous studies that have investigated perceived comprehensibility (Früh & Frey, 2014; Zerba, 2008), where the direction of the effect varied depending on the topic. The means and medians of perceived CL in the present study suggest that reading the articles was not a high CL task. Therefore, the higher test scores in the narrative condition with 'seductive details' (plot and characters) are consistent with the results of the low CL conditions of Park et al. (2011). The additional details appear to increase processing motivation, as indicated by higher situational interest. The negative correlation between comprehension of the information presented in the texts and perceived CL is consistent with the Landscape Model of Reading. In inverted pyramids, related information may not be automatically activated simultaneously by textual cues, so more mental effort is needed to activate related information and identify crucial relationships. Lower CL combined with higher comprehension may

indicate that relevant information was automatically activated to a greater extent than when CL was high and comprehension was low.

JSNs triggered higher situational interest than an inverted pyramid style, which is consistent with findings in the context of textbooks (Arya & Maul, 2012; Fernald, 1989), general journalism (Zerba, 2008; Knobloch et al., 2004) and science journalism (Yaros, 2011). However, the result contradicts studies on general journalism (Kelly et al., 2003; Kleemans et al., 2018), which found journalistic narratives to be less interesting, as well as studies on textbooks (Cunningham & Gall, 1990) and general journalism (Sternadori, 2008), which found no difference between the writing styles.

The time-based analysis indicates a gradual increase of situational interest for JSNs. Situational interest was lower than in inverted pyramids after reading the first paragraph, but higher for the remaining text. This finding may explain the different results of earlier studies and is also consistent with the selective exposure design in a study by DeAngelo and Yegiyan (2019). When situational interest is low in the beginning, as in the JSNs of the present study, individuals may not continue reading, i.e., they may not read all of the information necessary for comprehension.

Significant positive correlations between situational interest and comprehension of science information were found for topics 1 (fatty acids) and 3 (amino acids), but not for topic 2 (fructose). This is consistent with the findings of Durik and Harackiewicz (2007), Snětinová et al. (2018), Slapničar et al. (2024) and Yaros (2011), all of whom found positive correlations between situational interest and the knowledge that individuals develop during a particular activity. Yaros reported significant correlations for three out of four conditions ($.32 \leq r \leq .43$). In the present study, the overall correlation was $r = .23$, with higher individual correlations for topics 1 ($r = .37$) and 3 ($r = .27$). The individual correlations also correspond to the average correlation ($r = .33$) found in a meta-analysis by Schiefele (1996). This result and the negative correlation between perceived cognitive load and situational interest ($r = -.48$, $p < .01$) provide further evidence that there is a cognitive component to the triggered situational interest, as described in the Four-Phase Model (Hidi & Renninger, 2006; Renninger & Hidi, 2019).

As the material that was better understood in the present study required less cognitive load and elicited more situational interest, it can be concluded that incidental learning from science journalism involves situational interest and cognitive load. The study further suggests that a narrative writing style with a continuous, chronological plot and intentionally acting characters can improve comprehension of and overall situational interest in science journalism

and reduce participants' perceived cognitive load. It may therefore increase the likelihood of message selection at the next encounter with science journalism, thus creating new opportunities for incidental learning.

Situational interest in JSNs was significantly lower after the first paragraph than in the inverted pyramid, indicating a slow build-up of tension. One challenge for narrative journalism is therefore to create situational interest from the outset in order to facilitate incidental learning. Journalists may achieve this by using a 'reversal type' structure (Knobloch et al., 2004), a combination of a narrative and an inverted pyramid, or engaging images. In practice, journalists could, for example, start from an interesting point in the present and then jump back in time to describe an experiment chronologically. In addition, the build-up of tension suggests that journalists can use JSNs to maintain readers' situational interest. This is particularly important when dealing with complex information in long-form journalism, where it is important that readers read the whole article to understand the topic.

One limitation of the present study is the sampling method, which limits the generalisability of the findings. Online studies offer a less controllable environment than studies in which participants are physically present (e.g., no control over environmental influences or mindless choice of options, and no opportunity to check the accuracy of demographic information or answer clarification questions). However, in an anonymous study with few restrictions on participation, it is likely that most of the information provided is accurate. Attention controls were used to check whether the participants made arbitrary decisions. Another factor is that an online study can only reach participants who use the internet. However, internet use is high in Austria (95.3%; Statistik Austria, 2024) and 76% of Austrians appear to use online platforms (including social media) as their main source of news (Newman et al., 2022), so conducting a study online does not seem to be a major limitation in terms of access to relevant participants and ecological validity. In the present study, however, the resulting sample consisted mainly of Austrian students, which means that the educational level was higher than average with regard to the Austrian population. The sample also contained fewer male than female participants. As the participants in Yaros (2011) and Yaros and Cook (2013) were also students (from the USA), further research should use other samples (e.g., with lower levels of education or from non-Western cultures) as the magnitude of the effect may be different.

As the comprehension test was slightly delayed (shown after the self-reports), it may have assessed a combination of comprehension and memorisation (i.e., learning) rather than comprehension alone. Therefore, future studies

should also examine comprehension and cognitive load over time (e.g., by administering the comprehension test at different time points, as was done with situational interest in the present study) to control for the influence of the participants' memory abilities. There was no prior knowledge test in the present study, as such a test might have influenced the participants' reading behaviour and, consequently, their test performance. Although all of the participants in the study were non-experts in the field, future studies could also investigate the influence of prior knowledge on the dependent variables according to writing style.

The forced reading design limits the generalisability of the results. Individuals outside the study would stop reading if they lost interest in reading and thus miss out on information. As the present study only investigated journalistic articles on nutrition, generalisations to other science topics should be made with caution, which means that further research is needed.

The present study only compared JSNs with inverted pyramids, so future studies should investigate how a combination of writing styles or the use of images affects comprehension and situational interest at all stages of reading. Another direction for further research is to compare JSNs and inverted pyramids with other types of text (e.g., explanatory) and to investigate the motivation to engage with further science journalistic articles on the same or similar topics after reading JSNs compared to inverted pyramids (or other text types).

The correlation between situational interest and perceived cognitive load leaves open the interpretation that subjective ratings of CL may be confounded by high situational interest. Future studies should therefore use different and more objective measures of CL.

As the present study used a forced-reading design (i.e., the participants were asked to read the whole article and not stop when they lost interest), the results also shed light on the use of science journalistic texts in science education. The participants learned the topic by reading journalistic texts, which means that journalistic texts, especially JSNs, can also be beneficial in an intentional learning context. For example, when students are required to read JSNs as part of their homework, situational interest is likely to occur in a similar way as in the present study. This may increase students' motivation to finish reading the article, thereby increasing the likelihood of learning. In an educational application, journalistic articles could also be discussed in the classroom to help students understand the importance of scientific literacy so that they can understand such texts more easily and correctly.

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Biographical note

Christian Ameseder, PhD, is a lecturer at the University of Applied Sciences Burgenland, Austria, and Head of Online Learning Technology at the eLearning Academy for Communication, Austria. His research interests include learning experience design, public understanding of science, incidental science learning, storytelling, and data visualization.

Iztok Devetak, PhD, is a full professor in the field of chemistry education at the Faculty of Education, University of Ljubljana, Slovenia. His research interest covers the triple nature of chemical concepts, chemical concepts misconceptions, chemical knowledge assessment, environmental chemistry education, and scientific literacy.

Darija Skubic, PhD, is Associate Professor of Didactics of Slovenian language at the Faculty of Education, University of Ljubljana, Slovenia. Her research interests include language development of preschool children, early literacy, the role of preschool teachers in early literacy, and Slovenian as a second/foreign language.