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The effects of infographics and several quantitative versus qualitative formats for cardiovascular disease risk, including heart age, on people's risk understanding

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ABSTRACT

Objective: To study how comprehension of cardiovascular disease (CVD) risk is influenced by: (1) infographics about qualitative risk information, with/without risk numbers; (2) which qualitative risk dimension is emphasized; (3) heart age vs. traditional risk format.
Methods: For aim 1, a 2 (infographics versus text) x 2 (risk number versus no risk number) between-subjects design was used. For aim 2, three pieces of information were tested within-subjects. Aim 3 used a simple comparison group. Participants (45–65 yrs old) were recruited through an online access panel; low educated people were oversampled. They received hypothetical risk information (20%/61yrs). Primary outcomes: recall, risk appraisals, subjective/objective risk comprehension. Secondary outcomes: behavioral intentions, information evaluations.
Results: Infographics of qualitative risk dimensions negatively affected recall, subjective risk comprehension and information evaluations. No effect of type of risk dimension was found on risk perception. Heart age influenced recall, comprehension, evaluations and affective risk appraisals.
Conclusion: Infographics of hypothetical CVD risk information had detrimental effects on measures related to risk perception/comprehension, but effects were mainly seen in undereducated participants. Heart age influenced perceptions/comprehension of hypothetical risk in a way that seemed to support understanding.
Practice implications: Heart age seems a fruitful risk communication approach in disease risk calculators.

1. Introduction

Cardiovascular disease (CVD) risk calculators have become common in preventive care [1], but end-users are known to have difficulties in interpreting the results. One problem is that since the results are usually communicated via absolute risk percentages, people have difficulty deriving meaning from such numbers [2,3]. Many studies have concentrated on how to convey risk numbers, e.g. through visual icon arrays and bar graphs. Although such representations do help [4,5], difficulties remain, especially for low-literate people who have trouble interpreting bar graphs [6]. Perhaps as a result, risk numbers are sometimes omitted in risk calculators.

To make informed decisions, it is considered important that people are aware of their risk, which means that they understand both quantitative and qualitative risk dimensions [7,8]. Qualitative dimensions structure how laymen think about risks [7,9,10] and might be important in providing intuitive meaning to risk information. Cameron [10] suggested five key dimensions in risk understanding: *identity* (beliefs about certain characteristics and their risk potential), *causes* (beliefs about risk factors), *timeline* (beliefs about how risk increases/decreases when becoming older), *consequences* (beliefs about physical/psychosocial

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consequences), *control* (beliefs about personal control and treatment). Regarding CVD risk, we know from previous studies that people have knowledge gaps and misconceptions concerning timeline and consequences [11].

Although online risk calculators do provide information about qualitative risk dimensions (e.g., risk factors), this is usually done through much text, which may be ignored or misinterpreted by low-literate people. More sophisticated visualizations such as infographics, typically conveying some narrative [12], might be more appropriate. It is only recently that researchers have begun to explore infographics in risk communication (e.g.,'Visualizing health project' of the Robert Wood Johnson Foundation/University of Michigan Center for Health Communication Research), but much of this work focuses on visualizing *numerical* risk, rather than qualitative aspects. The use of infographics in online health communication more generally has expanded, though [13]. Infographics are embraced because they can rapidly grab attention, simplify complex concepts and connect components of complex concepts. [13,14] Infographics may thus be interesting to connect quantitative and qualitative dimensions in risk communication. Furthermore, if accompanied by numbers or other text, risk information may be processed through multiple information processing 'channels' (i.e. verbal/visual), which can improve information processing [13,15,16]. On the other hand, infographics may result in pitfalls such as wrong salience, distraction, ambiguity and overcomplexity [17,18]. Especially among undereducated people who lack experience with visual representations, these problems may occur [14].

Another means to tackle abstract risk numbers may be to use a different numerical concept. Concepts like 'real age' or 'heart age' as numerical metaphor have been attracting growing attention [19–21]. Heart age can be calculated by comparing individuals' absolute risk to the age at which they would reach that risk if they had 'ideal' risk factors [22]. Heart age seems to convey more intuitive meaning than risk numbers; because older age is probably quickly recognized an undesirable outcome. Qualitative work suggests that patients prefer heart age over traditional risk formats, but that risks are still questioned and misunderstood [2,23]. Only a few studies directly compared heart age to traditional risk formats. Soureti et al. [24] demonstrated a graded relationship between perceived and actual risk (suggesting better risk understanding) only in participants who received their heart age and not in participants receiving their 10-year absolute risk. Heart age was also found to be more emotionally impactful among younger participants with higher risk. Bonner et al. [22] compared heart age to 5-year absolute risk and found that heart age was better recalled, but also that it inflated risk perceptions in low-risk participants. Behavioral intentions did not improve when using heart age.

The aim of this study was threefold: (1) to evaluate the effects of using infographics about qualitative risk dimensions either with or without risk numbers (traditional risk percentage with natural frequency) on risk comprehension; (2) to investigate what type of qualitative risk dimension can be best emphasized in infographics: causes, timeline or consequences; (3) to test the effects of heart age – compared with a traditional risk number – on risk comprehension. We focused on how effects differed for people with lower cognitive skills versus higher cognitive skills. A broad range of variables related to risk comprehension was investigated, to be able to assess effects on different aspects of information processing, perceptions and beliefs. This was especially important for infographics because we had no a priori hypotheses as to what variables would be particularly influenced. We expected heart age to positively influence both subjective and objective risk comprehension because with heart age, the risk size and its meaning in terms of good/bad is probably clearer.

2. Methods

2.1. Design

Fig. 1 displays the design. For aim 1, an experimental 2 (infographics versus text, both with qualitative risk information) x 2 (risk number versus no risk number) between-subjects design was used, resulting in four conditions: (1) infographics with a risk number; (2) text with a risk number; (3) infographics only; (4) text only. For aim 2, we evaluated the differences between information within-subjects on: (1) causes of the risk; (2); timeline of the risk; and (3) consequences of the risk. A simple comparison group was used to test aim 3, (heart age versus traditional risk number), in which an additional group of participants was included provided with heart age, accompanied by infographics on qualitative risk dimensions. The total sample was randomized to 5 conditions, with additional randomization of the order in which participants saw three pieces of information (aim 2). All experimental materials were hypothetical, meaning that participants had to place themselves in a hypothetical risk profile and answer questions based on this situation.

2.2. Participants

Participants from the target population of CVD risk calculators were recruited through an online access research panel (FlyCatcher Internet Research, ISO 20252- and ISO 26362-certified). We approached people between 45 and 65 years, the target group for Dutch CVD risk tests [25]. The survey was disseminated among 1347 panel members and the final sample consisted of 727 participants.

2.3. Procedure

Participants received an invitation via email, were randomly assigned to one condition and asked to imagine that provided information was their own result from a risk calculator. Each participant saw three pieces of information presented as either infographic or text. Each piece emphasized either causes, consequences, or timeline of CVD risk and was provided in a random order. After each piece of information, participants answered two questions about risk perception and worry (T = 1, T = 2, T = 3). Finally, participants were shown complete information with the three pieces simultaneously; they then filled out an extended survey (T = 4). Before answering each set of questions, participants were again explicitly instructed to keep in mind the hypothetical result. Participants were thanked for participation and were once again told that the presented risk was not their own risk. In order to allow them to assess their own risk, we provided them with an online link to a Dutch national cardiometabolic risk calculator.

2.4. Materials

Appendix 1 shows the three pieces of information. Text versions were developed by the researchers and corresponded to typical information in CVD risk calculators. Information about the consequences was based on the Dutch Heart Foundation's website. All infographics were designed by a professional designer based on iterative sessions with researchers. Participants in conditions 1 and 2 received basic information stating:

	Risk number (percentage + natural frequency)	No risk number	Heart age
Infographics of qualitative risk information	CONDITION 1 (N=145) Each respondent received 3 pieces of information in a random order, followed by an overview of the complete information received Causes of the risk - Risk perception (T=1) - Worry (T=1) Timeline of the risk - Risk perception (T=2) - Worry (T=2) Consequences of the risk - Risk perception (T=3) - Worry (T=3) Complete info - Risk perception (T=4) - Worry (T=4) - All other variables (T=4)	CONDITION 3 (N=151) Each respondent received 3 pieces of information in a random order, followed by an overview of the complete information received Causes of the risk - Risk perception (T=1) - Worry (T=1) Timeline of the risk - Risk perception (T=2) - Worry (T=2) Consequences of the risk - Risk perception (T=3) - Worry (T=3) Complete info - Risk perception (T=4) - Worry (T=4) - All other variables (T=4)	CONDITION 5 (N=130) Each respondent received 3 pieces of information in a random order, followed by an overview of the complete information received Causes of the risk - Risk perception (T=1) - Worry (T=1) Timeline of the risk - Risk perception (T=2) - Worry (T=2) Consequences of the risk - Risk perception (T=3) - Worry (T=3) Complete info - Risk perception (T=4) - Worry (T=4) - All other variables (T=4)
Text about qualitative risk information	CONDITION 2 (N=168) Each respondent received 3 pieces of information in a random order, followed by an overview of the complete information received Causes of the risk - Risk perception (T=1) - Worry (T=1) Timeline of the risk - Risk perception (T=2) - Worry (T=2) Consequences of the risk - Risk perception (T=3) - Worry (T=3) Complete info - Risk perception (T=4) - Worry (T=4) - All other variables (T=4)	CONDITION 4 (N=133) Each respondent received 3 pieces of information in a random order, followed by an overview of the complete information received Causes of the risk - Risk perception (T=1) - Worry (T=1) Timeline of the risk - Risk perception (T=2) - Worry (T=2) Consequences of the risk - Risk perception (T=3) - Worry (T=3) Complete info - Risk perception (T=4) - Worry (T=4) - All other variables (T=4)	

Fig. 1. Overview of the study design*.
*Study aim 1: Between-subjects comparison between conditions 1, 2, 3 and 4 on all variables; Study aim 2: within-subjects comparison between risk perception and worry for each piece of information received; Study aim 3: Between-subjects comparison between conditions 1 and 5 on all variables.

"Your risk of developing CVD within now and the next 10 years is 20%. This means that 20 out of every 100 women/men with the same test result as you will develop CVD within 10 years. Your risk is thus increased." These risk numbers were accompanied by a visual icon array. The 20% risk was based on the following risk profile in the national risk calculator: someone being aged 56 years old, with a negative family history of type 2 diabetes, a positive family history of CVD, who is a non-smoker, has a BMI of 32,7 (obese), and a waist circumference of 87 cm. In conditions 3 and 4, the information said: "*Your risk of developing CVD within now and the next 10 years is increased*". In condition five, participants were presented with their 'heart age', accompanied by infographics. The information stated: *"You have an increased risk of developing cardiovascular diseases. We can express this by your 'heart age'. Your real age is 56, while your heart age is 61. This means your heart has the same condition as the heart of someone aged 61."* The heart age of 61 years old was derived by entering the same risk profile used in conditions 1 and 2 into two online heart age calculators (Telesofia and Cardiosecur), which resulted in heart ages between 60 and 62 years old, depending on the tool and the entered gender. We chose to expose all participants in condition five to a heart age of 61 years.

2.5. Measures

2.5.1. Primary outcomes related to risk comprehension

2.5.1.1. Information recall

2.5.1.1.1. Recall of quantitative information. "Based on the test results, my CVD risk within the next 10 years is . . . .%/my heart age is . . . ."; "Based on the test results, my CVD risk is: (1 = substantially reduced, 5 = substantially increased)".

2.5.1.1.2. Recall of qualitative risk information. Recall of causes: "Based on the test results, the main cause of my risk is (age, weight, stress level, smoking habits, family history of cardiovascular disease)"; participants had to choose one cause; 'age' was correct. Recall of timeline: "If I do nothing about my risk, in 20 years my risk will be (1 = lower than the present risk, 2 = about the same, 3 = higher than the present risk)". Participants had to choose one answer; answer 3 was correct. Recall of consequences: "Based on the test results, the long-term consequences of my CVD risk are (nothing, heart attack, claudication, chest pain, TIA (transient ischemic attack))". Participants could select multiple answers; answers that contained the option 'nothing' were incorrect.

2.5.1.2. Cognitive risk appraisals

2.5.1.2.1. Risk perception. Participants were asked to estimate their chance of developing CVD, the likelihood of developing CVD and the severity of CVD (7-point Likert scales).

2.5.1.2.2. Risk comprehension. Participants scored the following statements: "This risk means that something is going on with my health (1 = strongly disagree, 7 = strongly agree)"; "I think this risk is (1 = very unfavorable, 7 = very favorable)"; "This risk has (1 = no serious consequences, 7 = very serious consequences)"; "After seeing this information, I have a good indication of my CVD risk (1 = strongly disagree, 7 = strongly agree)". The latter item was considered to capture subjective risk comprehension, while the others were intended to objectively measure risk comprehension. A composite measure was constructed based on the three objective comprehension items.

2.5.1.3. Affective risk appraisals

2.5.1.3.1. Affect. Negative affect: feeling afraid, anxious, and worried (Cronbach's alpha = 0.94). Positive affect: feeling hopeful, optimistic, and enthusiastic (Cronbach's alpha = 0.81). All items were derived from the PANAS scale [26] with a scale of 0 ('none of this feeling') – 10 ('a lot of this feeling').

2.5.1.3.2. Worry. "I find the risk in the test result: 1 = not worrisome at all, 7 = very worrisome".

2.5.2. Secondary outcomes

2.5.2.1. Behavioral intentions

2.5.2.1.1. Lifestyle change. Participants scored the following statements (1 = certainly not, 7 = certainly): "After seeing this information, I would eat more healthily/exercise more/use medication".

2.5.2.1.2. GP visit. "After seeing this information, I would go to my doctor for further screening, such as measuring cholesterol and blood pressure" (1 = certainly not, 7 = certainly).

2.5.2.2. Information evaluations

2.5.2.2.1. Participants scored the following statements. "I find the information from the test results (a) 1 = completely unrealistic, 7 = very realistic), (b) 1 = completely irrelevant, 7 = very relevant, (c) 1 = very unclear, 7 = very clear, (d) 1 = very useless, 7 = very useful), (e) 1 = not at all useable, 7 = very useable" and "I would take these test results (1 = not at all seriously, 7 = very seriously)." We constructed a composite measure based on these items.

2.5.3. Cognitive skills

2.5.3.1. Numeracy. Dutch single-item version of the Berlin Numeracy Test [27].

2.5.3.2. Health literacy. Dutch version of the Newest Vital Sign (NVS) [28].

2.6. Statistical analyses

ANOVAs in SPSS were conducted to test effects of manipulations and their interaction on all outcomes (aim 1). Differences between the four conditions were also tested in ANOVA's with condition as independent variable. ANOVAs were also used to test effects of which qualitative risk dimension was emphasized (aim 2) and heart age (aim 3). Paired-sampled *t*-tests were employed to test differences in risk perception and worry between T1 and T4. Interactions between the two manipulations and educational level, numeracy, health literacy were tested using ANCOVAs.

3. Results

3.1. Participant characteristics

727 people (53.9%) responded. Table 1 describes participants' characteristics. No significant differences between conditions were found regarding variables listed.

3.2. Effects of infographics and numbers

Table 2 displays percentages of people reporting correct answers and mean values on outcome variables for the four conditions (study aim 1).

Differences between conditions were found for recall of risk causes, subjective risk comprehension and information evaluations. In general, more correct answers and more positive evaluations were given when text was used, as opposed to infographics. Table 3 describes the ANOVA's findings.

The interaction between infographics and risk numbers was not significant for any outcome variable except one, namely evaluations of information clarity ($F = 5.44$; $p = 0.020$). Infographics negatively affected evaluations when no risk number was provided. When a risk number was provided, infographics had no effect (Fig. 2).

ANOVAs showed several main effects of infographics; they negatively influenced recall of risk causes ($F = 7.73$; $p = 0.006$) and subjective risk comprehension ($F = 10.14$; $p = 0.002$). Furthermore, participants provided with infographics evaluated information more negatively (composite ($F = 8.83$; $p = 0.003$) and five of the six individual items). The provision of risk numbers negatively affected recall of the verbal label ($F = 8.90$; $p = 0.003$) and intentions to become more physically active ($F = 3.89$; $p = 0.049$).

3.3. Effects of infographics and numbers in different subgroups

3.3.1. Numeracy

Using infographics significantly interacted with numeracy in influencing recall of risk consequences ($F = 4.84$; $p = 0.028$). With infographics, there was a 14% difference in correct recall between the high numerate (99% correct) and the low numerate (85% correct). Without infographics, there was no difference (89% versus 90%, respectively).

3.3.2. Health literacy

An interaction between infographics and health literacy was found on evaluations of usability of information ($F = 3.52$; $p = 0.03$). When provided with an infographic, 67% of those with adequate health literacy and 54% of those with inadequate health literacy considered information useable. When no infographic was provided, these percentages were 73% and 76%, respectively.

3.3.3. Educational level

Several interaction effects between educational level and provision of risk numbers were demonstrated. First, an interaction was found on recall of risk causes ($F = 3.63$; $p = 0.027$). When a number was provided, lower educated (13% correct) and intermediately educated participants (17% correct) particularly had trouble with recalling the main cause of CVD risk, while higher-educated participants showed more correct responses (29%). When no number was provided, the differences between the three groups were smaller, and intermediately educated people recalled the information best (26%). A slightly different effect was found on worry, where risk numbers were associated with lower levels of worry among lower-educated participants. Among this group, 49% (no numbers) versus 36% (numbers) found the risk worrisome/very worrisome, while this difference was much smaller among

Table 1
Participants' characteristics.

	Condition 1 (infographic and risk number) N = 145	Condition 2 (text and risk number) N = 168	Condition 3 (infographic and no risk number) N = 151	Condition 4 (text and no risk number) N = 133	Additional condition 5 (infographic and heart age) N = 130	Total
Gender n (%)						
Male	84 (57.9)	83 (49.4)	78 (51.7)	66 (49.6)	65 (50.0)	376 (51.7)
Female	61 (42.1)	85 (50.6)	73 (48.3)	67 (50.4)	65 (50.0)	351 (48.3)
Age n (%)						
45 t/m 49	28 (19.3)	35 (20.8)	29 (19.2)	32 (24.1)	26 (20.0)	150 (20.6)
50 t/m 54	37 (25.5)	42 (25.0)	31 (20.5)	40 (30.1)	36 (27.7)	186 (25.6)
55 t/m 59	37 (25.5)	35 (20.8)	37 (24.5)	25 (18.8)	38 (29.2)	172 (23.7)
60 t/m 64	38 (26.2)	45 (26.8)	45 (29.8)	31 (23.3)	24 (18.5)	183 (25.2)
>65	5 (3.4)	11 (6.5)	9 (6.0)	5 (3.8)	6 (4.6)	36 (5.0)
Educational level n (%)						
Low	45 (31.0)	59 (35.1)	47 (31.1)	47 (35.3)	42 (32.3)	240 (33.0)
Intermediate	68 (46.9)	71 (42.3)	69 (45.7)	53 (39.8)	49 (37.7)	310 (42.6)
High	32 (22.1)	38 (22.6)	35 (23.2)	33 (24.8)	39 (30.0)	177 (24.3)
Numeracy*						
Low	101 (69.7)	130 (77.4)	113 (74.8)	102 (76.7)	93 (71.5)	539 (74.1)
High	44 (30.3)	38 (22.6)	38 (25.2)	31 (23.3)	37 (28.5)	188 (25.9)
Health literacy#						
Limited	7 (4.8)	6 (3.6)	6 (4.0)	10 (7.5)	5 (3.8)	34 (4.7)
Possibly limited	14 (9.6)	22 (13.1)	23 (15.3)	12 (9.0)	13 (10.0)	84 (11.5)
Adequate	124 (85.5)	140 (83.3)	122 (80.8)	111 (83.5)	112 (86.2)	609 (83.8)

* We used the Dutch single-item version of the Berlin Numeracy Test to measure objective numeracy (Cokely et al., 2012): 'Out of 1000 people in a small town, 500 are members of a choir. Out of these 500 members in the choir, 100 are men. Out of the 500 inhabitants that are not in the choir, 300 are men. What is the probability that a randomly drawn man is a member of the choir? Please indicate the probability in a percentage'. The correct answer is 25% and this was considered adequate numeracy; all other responses were considered to indicate inadequate numeracy.

The NVS-D was used. This measurement is based on a nutrition label from an ice cream container. Participants were given the label and were asked six questions. Based on the number of correct responses, participants' health literacy level was assessed (0–1 answers correct: high probability (50% or more) of limited health literacy, 2–3 answers correct: possible limited health literacy, 4–6 answers correct: almost always adequate literacy).

highly educated participants (49% versus 43%), and in the opposite direction (34% versus 37%) for those with intermediate educational level. Provision of risk numbers did not affect subjective risk comprehension of highly-educated participants: 26% (numbers) versus 25% (no numbers) reported having a good indication of their risk. Among lower educated people, these percentages were 34% (numbers) and 30% (no numbers), whereas among those with intermediate education 24% (numbers) versus 30% (no numbers).

3.4. Effect of the qualitative risk dimension emphasized

No significant effect of emphasizing either causes, timeline or consequences of CVD risk was found on risk perception ($F = 1.74$; $P = 0.177$). Neither did such an effect occur within any of the individual experimental conditions. We did find that the type of dimension emphasized influenced worry ($F = 5.78$; $p = .003$). After seeing risk consequences, people were more worried than after seeing the risk timeline ($p = .002$). This effect was also demonstrated within the first experimental condition (infographics with risk numbers; $F = 5.18$; $p=.007$). We also demonstrated an effect of being provided with just one risk dimension initially versus being three dimensions eventually; both risk perception ($t = 6.74$; $p < .0001$) and worry ($t = 7.07$; $p < .001$) were higher after seeing all three dimensions.

3.5. Effect of heart age

Table 4 described the results of the ANOVAs. Heart age influenced likelihood perceptions ($F = 8.98$; $p = 0.003$), perceptions of low versus high risk ($F = 8.60$; $p = 0.004$), worry ($F = 5.66$; $p=.018$), negative affect ($F = 9.87$; $p=.002$), the composite score for risk comprehension ($F = 5.32$; $p = 0.022$), one individual risk comprehension item ($F = 10.29$; $p = 0.001$) and subjective risk comprehension ($F = 4.76$; $p=.030$). These effects all indicated that risk perceptions and affect were higher and that comprehension was better with heart age. Furthermore, heart age positively influenced recall of the verbal label ($F = 7.16$; $p = 0.008$), intention to visit a GP for further screening ($F = 5.23$; $p = 0.023$), and intention to become more physically active ($F = 6.29$; $p = 0.013$).

No interactions were found between heart age and participants' cognitive skills. We only demonstrated one trend for risk comprehension ("I think this risk is (very unfavorable – very favorable") suggesting an interaction between heart age/risk number and numeracy ($F = 3.87$; $p=.050$). With heart age, the percentage of participants with inadequate numeracy stating that their risk was unfavorable/very unfavorable was 53%, and 31% with risk numbers. Among those with adequate numeracy, these percentages were 46% versus 45%.

Table 2
Percentages of correct answers or mean values on all outcome variables in the four conditions of our 2 (infographic/text) x 2(risk number yes/no) design.

Variable	Condition 1 (infographic, and risk number)	Condition 2 (text and risk number)	Condition 3 (infographic and no risk number)	Condition 4 (text and no risk number)
% correct answers				
Information recall (T = 4)#				
Recall risk percentage (20%)	55.2%	51.2%	–	–
Recall verbal label (increased risk)	50.3%	50.0%	62.9%	61.7%
Recall causes	**16.6%[a]**	**29.2%[ab]**	**15.9%[b]**	21.8%
Recall timeline	68.3%	75.6%	73.5%	77.4%
Recall consequences	86.9%	92.3%	90.1%	87.2%
Mean values (SD)				
Cognitive risk appraisals (T = 4)#				
Risk perception likelihood	4.20 (1.49)	4.27 (1.28)	4.39 (1.31)	4.48 (1.31)
Risk perception low-high	4.32 (1.46)	4.38 (1.32)	4.56 (1.23)	4.55 (1.29)
Overall risk comprehension score (1 + 2 + 3)	4.85 (1.18)	4.75 (1.06)	4.91 (1.06)	4.95 (1.26)
Risk comprehension 1 (risk means something is going on with my health)	4.66 (1.57)	4.62 (1.40)	4.76 (1.39)	4.71 (1.66)
Risk comprehension 2 (risk is very unfavorable-very favorable)	4.99 (1.33)	4.90 (1.32)	5.02 (1.26)	5.14 (1.35)
Risk comprehension 3 (risk has no serious consequences-very serious consequences)	4.88 (1.41)	4.74 (1.18)	4.95 (1.16)	5.01 (1.37)
Subjective risk comprehension (I have a good indication of my risk)	**4.54 (1.49)[a]**	4.84 (1.25)	4.61 (1.29)	**5.02(1.33)[a]**
Affective risk appraisals (T = 4)#				
Worry	4.94 (1.49)	5.08 (1.29)	5.01 (1.32)	5.25 (1.33)
Positive affect	16.60 (6.12)	16.61 (5.98)	15.30 (5.70)	16.22 (6.09)
Negative affect	17.39 (7.45)	18.45 (6.90)	18.46 (6.59)	18.77 (7.04)
Behavioral intentions (T = 4)#				
Intention to visit GP	4.88 (1.87)	5.20 (1.65)	5.09 (1.69)	5.10 (1.70)
Intention to eat more healthily	5.21 (1.41)	5.17 (1.43)	5.32 (1.25)	5.38 (1.26)
Intention to become more physically active	5.14 (1.48)	5.37 (1.30)	5.46 (1.22)	5.47 (1.21)
Intention to use medication	3.77 (1.71)	4.00 (1.73)	3.71 (1.79)	3.97 (1.74)
Evaluations of the information (T = 4)#				
Overall evaluation score	5.03 (1.21)	5.19 (1.06)	**4.89 (1.14)[a]**	**5.29 (1.16)[a]**
Evaluation 1: Info realistic	4.96 (1.31)	5.14 (1.24)	**4.82 (1.31)[a]**	**5.33 (1.29)[a]**
Evaluation 2: Info relevant	5.10 (1.26)	5.08 (1.28)	5.01 (1.15)	5.22 (1.34)
Evaluation 3: Info clear	**5.01 (1.38)[a]**	**5.15 (1.35)[b]**	**4.55 (1.54)[abc]**	**5.23 (1.36)[c]**
Evaluation 4: Info helpful	5.08 (1.42)	5.23 (1.17)	5.05 (1.22)	5.36 (1.31)
Evaluation 5: Info useable	4.97 (1.44)	**5.21 (1.14)[a]**	**4.83 (1.37)[ab]**	**5.21 (1.40)[b]**
Evaluation 6: Would take info seriously	5.08 (1.50)	5.32 (1.15)	5.05 (1.40)	5.38 (1.28)

[ab]Means per row with the same superscript differ significantly ($p < 0.05$), tested with Bonferonni's post hoc tests in ANOVAs with condition as an independent variable. A total of 6 post hoc tests were done (1vs 2, 1vs3, 1 vs4, 2vs3, 2vs 4, 3 vs 4).
#This concerns the variable measured at T = 4, i.e. after receiving the complete information (see Fig. 1).

4. Discussion and conclusion

4.1. Discussion

Infographics of qualitative risk dimensions negatively influenced risk recall, subjective risk comprehension and information evaluations, in an experiment using hypothetical CVD risk information. Participants showed higher levels of worry with information about CVD risk consequences than with information about CVD risk timeline. Heart age positively affected multiple outcome variables.

It was notable that infographics had negative effects. At least for two outcome variables, infographics had particularly detrimental effects among people with lower numeracy/health literacy. This might suggest that effects were due to information overload, although it should be said that textual variants also contained much information. Considering that it was particularly recall of *causes* that was negatively affected, we might conclude that the specific infographic showing risk causes was suboptimal. This infographic had high information density, conveying information on what the main causes were, which of these were applicable, their relative importance, and whether these could be influenced. This density also existed in the text, so apparently only the visual variant was ambiguous or over-complex. It may be that the communication of 'age' was ambiguous in the infographic. In text, this was communicated as "this plays a very big role for you", which may be more straightforward than using a pictogram's size to judge importance. It can also be that simultaneous use of size and color was confusing (wrong salience/ambiguity [18]). Based on these findings, one may conclude that qualitative risk information is simply better processed through text. However, there are several reasons why we think we should be careful in drawing this conclusion. First, the risk communication literature suggests that textual risk information accompanied by visual representations can support understanding [5,6]. Second, in cognitive/communication sciences evidence exists that visual representations support understanding [29–31]. However, multimodal communication research has also demonstrated that especially visuals/text *combinations* improve information processing [32,33]. Our infographics contained little text, and it might well be that they would have been more helpful had these been accompanied by elaborated text.

Another important finding was that risk numbers negatively influenced intentions to become more physically active. In the informed decision-making literature, it is emphasized that risk numbers should be provided, even in light of the poor numeracy problem. This is largely based on studies about medication benefits and side-effects, where numbers positively influence risk comprehension and willingness to take medications [8,34]. Moreover, using verbal labels can lead to variability in interpretations and risk overestimation [8,35,36]. In this context of CVD risk calculators, in which risks are typically underestimated rather than

Table 3
Main findings from the ANOVAs testing the between-subjects manipulations of infographics and provision of a risk number and their interaction on all outcome variables.

	Infographics Effect size[†]	Risk number Effect size[†]	Infographics[*] risk number Effect size[†]
Information recall (T = 4)[#]			
Recall risk percentage (20%)	0.000	**0.055**[**]	0.000
Recall verbal label (increased risk)	0.000	**0.015**[**]	0.000
Recall causes	**0.013**[**]	0.002	0.002
Recall timeline	0.004	0.002	0.000
Recall consequences	0.000	0.000	0.004
Cognitive risk appraisals (T = 4)[#]			
Risk perception likelihood	0.001	0.005	0.000
Risk perception low-high	0.000	0.006	0.000
Overall risk comprehension score (1 + 2 + 3; α = 0.77)	0.000	0.003	0.001
Risk comprehension 1 (risk means something is going on with my health)	0.000	0.001	0.000
Risk comprehension 2 (risk is very unfavorable-very favorable)	0.000	0.002	0.001
Risk comprehension 3 (risk has no serious consequences-very serious consequences)	0.000	0.004	0.002
Subjective risk comprehension (I have a good indication of my risk)	**0.017**[**]	0.002	0.000
Affective risk appraisals (T = 4)[#]			
Worry	0.005	0.002	0.000
Positive affect (α = 0.81)	0.002	0.005	0.001
Negative affect (α = 0.94)	0.002	0.001	0.001
Behavioral intentions (T = 4)[#]			
Intention to visit GP	0.002	0.000	0.002
Intention to eat more healthily	0.000	0.004	0.000
Intention to become more physically active	0.002	**0.007**[*]	0.002
Intention to use medication	0.005	0.000	0.000
Evaluations of the information (T = 4)[#]			
Overall evaluation score (1–6; α = 0.93).	**0.015**[**]	0.000	0.003
Evaluation 1: Info realistic	**0.018**[**]	0.000	0.004
Evaluation 2: Info relevant	0.001	0.000	0.002
Evaluation 3: Info clear	**0.020**[**]	0.005	**0.009**[*]
Evaluation 4: Info helpful	**0.008**[*]	0.000	0.001
Evaluation 5: Info useable	**0.013**[**]	0.001	0.001
Evaluation 6: Would take info seriously	**0.011**[*]	0.000	0.000

[†] Partial eta squared, which is a measure of effect size for use in analyses of variance. The common thresholds for the magnitude of effect are 0.01 = small; 0.06 = medium; 0.14 = large.
[*] Significant effect with significance level of 0.05.
[**] Significant effect with a significance level of 0.01.
[#] This concerns the variable measured at T = 4, i.e. after receiving the complete information (See Fig. 1).

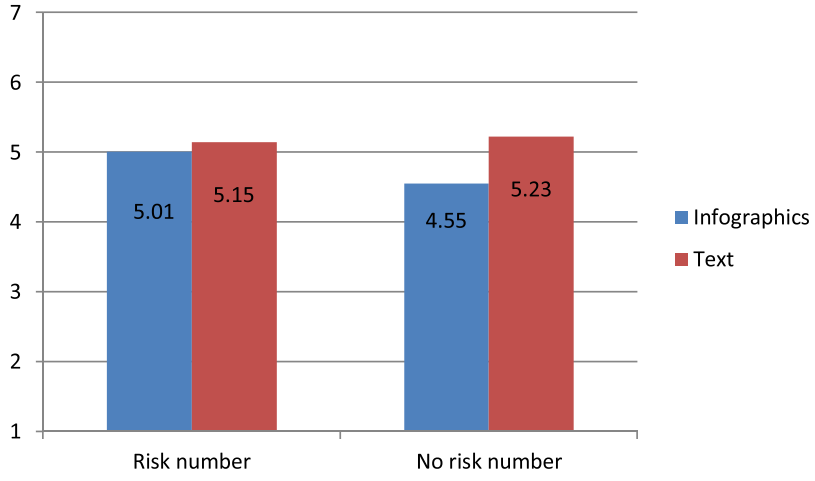

Fig. 2. Interaction effect between infographics and provision of a risk number on evaluations of the clarity of information.[*].
*The exact item was: "I find the information from the test result: 1 = very unclear, 7 = very clear.

overestimated, numbers may have had a reassuring effect. Previous qualitative studies have shown that increased CVD risks expressed by numbers are not typically experienced as large risks [3]. So, providing a number like 20% might demotivate rather than motivate people to take preventive action.

We found that heart age positively affected many outcome variables. A number of other studies have compared absolute CVD risks versus heart age. Soureti et al. [24] compared heart age to an absolute 10 years risk percentage, and included actual CVD risk results (n = 413), rather than hypothetical risks. They found more accurate risk perceptions among those who received heart age. Bonner et al. [20] also compared risk formats using actual, rather than hypothetical 5 year CVD risk, and found that heart age was better recalled, and also that it inflated risk perceptions in low-risk participants. So both in hypothetical and in 'actual risk' experiments, heart age seems to

Table 4
Percentages of correct answers or mean values on all outcome variables in the two conditions of our simple comparison (risk number versus heart age).

	Risk number (percentage and natural frequency)	Heart age	
	% correct answers	% correct answers	p-level[$]
Information recall (T = 4)[#]			
Recall risk number (%/heart age)	55.2	60.8	0.350
Recall verbal label (increased risk)	50.3	66.2	**0.008**[**]
Recall causes	16.6	12.3	0.321
Recall timeline	68.3	77.7	0.081
Recall consequences	86.9	91.5	0.219
	Mean value (SD)	**Mean value (SD)**	**p-level**[$]
Cognitive risk appraisals (T = 4)[#]			
Risk perception likelihood	4.20 (1.49)	4.72 (1.35)	**0.003**[**]
Risk perception low-high	4.32 (1.46)	4.80 (1.20)	**0.004**[**]
Overall risk comprehension score (1 + 2 + 3;; α = 0.77)	4.85 (1.18)	5.17 (1.18)	**0.022**[*]
Risk comprehension 1 (risk means something is going on with my health)	4.66 (1.57)	5.25 (1.44)	**0.001**[**]
Risk comprehension 2 (risk is very unfavorable-very favorable)	4.99 (1.33)	5.19 (1.48)	0.242
Risk comprehension 3 (risk has no serious consequences-very serious consequences)	4.88 (1.41)	5.08 (1.36)	0.228
Subjective risk comprehension (I have a good indication of my risk)	4.54 (1.49)	4.92 (1.31)	**0.030**[*]
Affective risk appraisals (T = 4)[#]			
Worry	4.94 (1.49)	5.35 (1.29)	**0.018**[*]
Positive affect (α=0.81)	16.60 (6.12)	15.88 (5.56)	0.313
Negative affect (α = 0.94)	17.39 (7.45)	20.08 (6.63)	**0.002**[**]
Behavioral intentions (T = 4)[#]			
Intention to visit GP	4.88 (1.87)	5.38 (1.69)	**0.023**[*]
Intention to eat more healthily	5.21 (1.41)	5.51 (1.45)	0.083
Intention to become more physically active	5.14 (1.48)	5.57 (1.31)	**0.013**[*]
Intention to use medication	3.77 (1.71)	4.09 (1.71)	0.115
Evaluations of the information (T = 4)[#]			
Overall evaluation score (1–6; α = 0.93).	5.03 (1.21)	5.28 (1.09)	0.080
Evaluation 1: Info realistic	4.96 (1.31)	5.21 (1.21)	0.104
Evaluation 2: Info relevant	5.10 (1.26)	5.27 (1.19)	0.245
Evaluation 3: Info clear	5.01 (1.38)	5.16 (1.36)	0.372
Evaluation 4: Info helpful	5.08 (1.42)	5.42 (1.17)	**0.033**[*]
Evaluation 5: Info useable	4.97 (1.44)	5.25 (1.27)	0.088
Evaluation 6: Would take info seriously	5.08 (1.50)	5.36 (1.32)	0.105

[$] P-level from ANOVAs testing the effects of our manipulation (risk number versus heart age).
[*] Significant effect with significance level of 0.05.
[**] Significant effect with a significance level of 0.01.
[#] This concerns the variable measured at T = 4, i.e. after receiving the complete information (See Fig. 1).

increase perception and/or recall of risk. Although our hypothetical study can arguably have drawbacks, it seems that our participants perceived risk results quite similar as participants in the other studies. We used a 10-years absolute risk of 20%/heart age of 61, which might have been sufficiently realistic for participants (all between 45 and 65 yrs old).

Our heart age information contained comparative information, as heart age formats inherently do, while the traditional risk percentage format did not convey any comparative information. It must be said that some risk calculators do provide comparisons in risk percentages, e.g., the risk of someone with 'ideal' risk factors. It might thus be that our heart age effects were, in part, attributable to its comparative nature. However, we explicitly chose not to include comparative information in traditional risk number format, because no effective formats for such information have been demonstrated yet.

An important strength of our study is that we used an efficient controlled experimental design to disentangle effects of infographics, risk numbers, different risk dimensions emphasized, and heart age. Low-educated participants were oversampled, to study effects in different subgroups. We acknowledge the a hypothetical setting with members of the general public. Participants were not actually invited by their GP; they did not complete a risk calculator and we do not know their actual CVD risk profiles. It might be that participants, perhaps especially the less literate/numerate people, had trouble placing themselves in our hypothetical situation. We only invited people from the target group of CVD risk calculators (45–65yrs), so we believe that the hypothetical situation they were put in was, in general, realistic. However, we acknowledge that the heart age of 61 may have come across as a 'younger' result for people aged 62–65, in case they did not pay enough attention to the age mentioned in the scenario. An additional limitation is that there is a lack of validated measures of disease risk comprehension and that we thus constructed these items ourselves. It is also important to mention that in the provided information, cholesterol and blood pressure were not mentioned as risk factors, while these are taken into account in many risk calculators. We do not know how people would have responded, if such more 'medical' risk factors would have been included.

4.2. Conclusion

Infographics of qualitative risk dimensions in an online risk calculator negatively influenced participants' risk recall, subjective risk comprehension and information evaluations. Heart age positively affected multiple outcomes related to risk comprehension and behavioral intentions. It seems useful to use heart age in CVD risk calculators. However, we should keep in mind that heart age can inflate risk perceptions and negative affect. For a CVD risk calculator, this might not be problematic because CVD risk is typically underestimated, but this might be different for other disease risks.

4.3. Practice implications

Using infographics in CVD risk calculators to undereducated individuals was not beneficial in this study, in the absence of a comparison of hypothetical increased risk with average risk. More research is needed on infographics for low versus high numerate/literate people, before definite conclusions as to their use can be made. If the aim of a CVD risk calculator is to increase users' worry, one might consider emphasizing risk's consequences. An important question is whether we could provide more dynamic materials, such as dynamic infographics or audiovisual materials, where there is more room for explanations.

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