The Influence of Causal Knowledge on the Comprehension and Retention of Medical Information among Younger and Older Adults

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Abstract

Older adults are often susceptible to confusing or forgetting medical instructions. The purpose of the present study was to examine the effects of causal knowledge on the learning and retention of medical information among younger and older adults. Participants were asked to read about a fictitious disease with or without explanations on the cause-and -effects of illness management. A multiple-choice knowledge test was administered immediately and 1-week following the presentation of health booklets. Results demonstrated that causal knowledge facilitated the application and retention of novel medical knowledge across time for younger adults. In contrast, causal explanations did not seem to influence the test performances of older participants. After controlling for age, verbal ability, working memory, and health literacy, provision of causal explanation explained a significant amount of unique variance in test performance. Incorporating causal explanations in health education materials may have the potential to help patients acquire medical knowledge.

Keywords: Causal knowledge; Health education; Aging; Causal reasoning; Learning; Retention

Introduction

Poor acquisition of medical knowledge is common among older adults (65 years and older) and is linked to patient non-adherence to self-care recommendations as well as frequent hospital readmissions (Andrus & Roth, 2002; Cameron et al., 2009; Cline et al., 1999). A recurrent finding is that age-related changes in working memory, processing speed, and inhibitory control can render it difficult for older adults to connect unfamiliar health concepts and ideas (Brown & Park, 2002; Johnson, 2003; van der Lindin et al., 1999). Past efforts to mitigate age-related differences in learning have focused on using illustrations to structure the content, and ordering medical instructions to fit patient preferences (Brown & Park, 2003; Liu et al., 2009; Morrow et al., 1999). Although formatting strategies can aid memory performance (Morrow et al., 2005), they do not sufficiently address the range of elderly learning needs. Notably absent from the literature are effective ways to help older adults form a comprehensible mental representation of their illness condition.

Supporting evidence in the literature on clinical reasoning suggests that increasing knowledge of causal relationships helps individuals to retain and apply new medical information more easily (Woods, Brooks & Norman, 2005). Causal information refers to explanations about why an effect occurs or how things work (Keil, 2006; Murphy & Median, 1985). One study demonstrated that non-medical students were able to interpret respiratory exams better when they were given booklets with causal information that explained why different physical sounds were made during the medical test (Goldszmidt, Minda, Devantier, Skye & Woods, 2011). Similarly, it has been shown that experienced clinical psychologists and trainees integrated causal information about the etiology of a psychiatric condition to improve the accuracy their diagnostic and treatment decisions (de Kwaadsteniet, Kim & Yopchick, 2013). These findings suggest that providing causal information for medical concepts helps individuals form a coherent conceptualization of the presenting issue, which in turn enhances the diagnostic process.

The finding that causal information advances clinical judgment raises the question of whether explaining the cause-and-effects of disease management can similarly benefit patients' understanding of their medical conditions. According to Common Sense Model of Illness Representations (CSM), patients' emotional and cognitive processing of their condition depends on five attributes: 1) beliefs that they have an illness, 2) beliefs about the illness cause, 3) beliefs about illness course, 4) beliefs about the illness consequences, and 5) beliefs about the controllability of the condition (Leventhal, Meyers & Nerenz, 1984). The CSM posits that information from all attributes help form an individuals' illness representation and guide the development of subsequent health coping behaviors.

In light of the tenets in the CSM, patients' understanding of illness causes seems to be one of the key factors that shape their knowledge about the disease. In a meta-analysis of 45 empirical studies on the CSM, only the identity,

chronicity, curability, and controllability dimensions have been linked to illness perceptions and coping behaviors (Hagger & Orbell, 2003). The effects of causal beliefs on illness appraisals are less clear because of the inconsistent operationalization of this construct in the literature. However, the limited research on this dimension suggests that false beliefs about disease pathophysiology are linked to medication non-adherence (Jessop & Rutter, 2003). Addressing these inaccurate perceptions through the provision of causal information may strengthen patients' understanding of illness management.

The main purpose of this study was to elucidate whether the inclusion of causal information, which explicitly links illness management with symptoms, would improve health users' understanding of novel medical concepts. Building on Goldszmidt and colleagues' (2011) findings, the present study aims to determine the age-related effects of causal knowledge on the immediate and delayed retention of information presented in a health brochure. It was hypothesized that: 1) Causal explanations will enhance the ability for both younger and older adults to interpret and recall health information 2) Causal explanations will be a significant predictor of medical knowledge after controlling for demographic and cognitive factors.

Methods

Participants

Younger participants were 50 undergraduate students (% female = 68.0; mean age = 19.28; *SD* = 3.09) attending the University of Western Ontario (UWO) in London, ON. Thirty-five community-dwelling older adults (% female = 65.70; mean age = 71.47; *SD* = 7.19) also took part in the study. The inclusion criteria included fluency in English and no prior training in medical professions. Older adults were offered $20 (CAD) and younger adults were granted course credits for the completion of the 2-part study.

Materials

Health Information Booklets. The symptoms and self-care recommendations of three metabolic conditions (Urea Cycle Disorder, Biotin Deficiency and Short-chain acyl-CoA Dehydrogenase Deficiency) served as the design basis for the learning materials. The resultant health booklets described the triggers, prevalence, symptoms and self-care management of a fictitious disorder, 'Alphabet Disease'. The first two sections about the triggers and prevalence of the target illness were presented in the same fashion for both learning conditions. The sections about symptoms and self-care management were the testing components. For the causal-knowledge (CK) group, the health booklet explained self-care management in the context of the symptom it is intended to placate. Information about disease symptoms and self-care behaviors was not explicitly linked for participants in the no causal knowledge (NCK) condition. See Figure 1 for an example.

Sample Causal Information	Sample Non-Causal Information
[Presented on same page]: *What to do:* Consume 3-4 glasses of **high carbohydrate drinks** each day *Why:* Alphabet disease makes it difficult for your body to produce essential fats and carbohydrates that give you energy. Consuming high carbohydrate drinks will supply you with the energy you need.	Alphabet disease occurs when your liver has difficulty breaking down Alphabetin into vitamin ABC. Your body needs vitamin ABC to metabolize proteins, keep your immune system strong and produce fats and carbohydrates. As a result, individuals with Alphabet disease have a build up of proteins and not enough fats and carbohydrates. [Presented on a separate page]: Consume 3-4 glasses of natural juices and energy drinks each day

Figure 1. This figure shows an example of how the learning material was presented in a causal and non-causal way. The dotted line represents information that was shown on a separate page in the booklet.

Health Knowledge Quiz. A 25-item multiple choice health information quiz (HIQ) created in this study was used to test participants' understanding and retention of the health booklet. The measure included ten control items that gauged knowledge for content that was not dependent on presence of causal knowledge (i.e., questions about the triggers and prevalence of Alphabet disease). The remaining fifteen critical items tapped into the extent to which causal information influenced understanding of how to apply self-care management routines. All critical and control items included four response choices and a point was given for each correctly answered item (see Figure 2 for sample items). The total number of correct items was tallied for the control and critical items as well as for the entire scale. A higher total score on the knowledge questionnaire indicates better comprehension of the health information.

Sample Critical Item:

If you notice that your muscles are becoming 'loose' or 'floppy', it means that:

a. You should avoid fats in your diet
b. You should perform certain exercises
c. You should drink high carbohydrate drinks
d. You should only eat lean meats

Sample Control Item:

Who is more at risk for developing Alphabet Disease?

a. Women
b. Men
c. Men and women are equally affected
d. I don't know

Figure 2. This figure shows an example of one critical and one control item. The correct answers, which are not presented to participants, are shown in bold-face text.

Cognitive Measures. The Rapid Estimate of Adult Literacy in Medicine- Short Form (REALM-SF; Arozullah et al., 2007) was a 7-item word recognition task used to assess participant health literacy. The scoring for the questionnaire ranged from 0 (no words pronounced correctly) to 7(all the words are pronounced correctly). The Forward and Backward Digit Span task from the Weschler Adult Intelligence Scale-IV (WAIS-IV; Pearson, 2008) was used to assess working memory span. The task required participants to recall a progressively longer series of digits in either a forward or backward order. A higher number of correct trials recalled reflect a larger working memory capacity. Finally, two passages from the Nelson-Denny Reading Test (FORM H; Brown, Bennet & Hanna, 1993) were used to assess verbal ability skills of participants. The test required participants to read narrative passages and answer multiple-choice items, each with 5 answer choices.

Procedures

Participants were randomly assigned to one of two booklet conditions. The study was completed individually or in groups of up to three individuals in two sessions that were held one week apart. Testing took place either in the Categorization Lab at UWO or at a seniors' community center. Upon obtaining informed consent, participants were asked to read and study the health information booklet to the best of their ability. They were told that the material will not be shown again during testing and that they can take as much time as they need to learn the information. Following the methodological design used in a study of same construct (Goldszmidt et al., 2011), the HIQ was administered immediately after participants returned the booklet (Test 1), and after 1-week delay (Test 2). The administration of the remaining battery of cognitive measures either took place during the first or second testing session depending on the participant flow. Most younger adults took between 20 and 30 minutes to complete each testing session, while older adults took around 30-45 minutes to get through the material.

Statistical Analyses

The mean proportion correct on the HIQ was calculated for control and critical set of items at both Test 1 and Test 2 (see Table 1). Independent *t*-tests were used to determine overall age group differences on test performance across time. Due to the unequal sample sizes, test performance differences were analyzed separately for each age group using 2x2x2 mixed factorial ANOVAs with Bonferroni correction. Booklet condition (CK/NCK) was entered as the between subjects factor, and the within-subject factors comprised of time (Test 1/Test 2) and item type (Control/Critical). Pearson-moment correlations and hierarchical regressions were also conducted to determine the effects of booklet condition on knowledge retention after controlling for demographic and cognitive predictors. Age was entered in the first step, verbal ability, working memory and health literacy were entered in the second step, and provision of causal information was dummy coded and entered in the final step.

Results

Of the participants enrolled in the study, one younger and two older adults did not complete Time 2. As such, data analyses were conducted on 49 younger and 33 older adults.

Table 1 shows the mean proportion correct on critical and control items across age group and time. Younger adults significantly outperformed older adults in the HIQ for both Test 1 ($t(83) = -7.81$, $p < .001$) and Test 2 ($t(54.31) = -9.14$, $p < .001$). Among younger adults, there was a significant three way interaction of booklet condition x item x time, $F(1,47) = 5.32$, $p = .026$. Both CK and NCK groups did equally well on control items but participants who received causal information scored significantly higher on critical items than the comparison group, $F(1, 47) = 19.45$, $p < .001$. Pairwise t-tests were conducted for each booklet condition to determine the effects of time on the proportion of correct critical and control items. The CK group showed no change in proportion of correct control ($t(23) = 1.80$, $p = .086$) and critical items ($t(23) = .72$, $p = .480$) between Test 1 and Test 2, indicating that performance did not decline over time for this group. However, the NCK group demonstrated a decrease in performance for control items after the 1-week delay, $t(24) = 2.40$, $p = .026$. In comparison to the CK group, those without causal information made significantly more errors with critical items for both time points, $t(23) = -5.38$, $p = .002$. These findings demonstrated that difficulty with answering critical items and failure to retain information over time contributed to the comparatively poorer performance of the NCK group.

With regards to older adults, significant main effects of time and item were found, such that performance was significantly better during Test 1, and for control items, $F(1, 21) = 4.13$, $p = .05$, $F(1, 21) = 14.83$, $p = .001$, respectively. However, the interaction between time and item type was not significant, $F(1, 21) = .68$, $p = .418$. Contrary to our predictions, there was no effect of booklet condition, suggesting that causal information did not facilitate retention of medical information for older adults, $F(1, 21) = .075$, $p = .786$.

Table 1
Mean Proportion Correct on Health Information Quiz at Time 1 and Time 2

	Item Type	Group	Time 1 *M (SD)*	Time 2 *M (SD)*	*N*
Younger Adults	Critical	NCK	.66 (.18)	.67 (.18)	25
		CK	.85 (.09)	.82 (.10)	24
	Control	NCK	.88 (.10)	.84 (.11)	25
		CK	.90 (.11)	.89 (.11)	24
Older Adults	Critical	NCK	.48 (.14)	.42 (.19)	11
		CK	.48 (.21)	.46 (.13)	12
	Control	NCK	.66 (.25)	.59 (.20)	11
		CK	.61 (.25)	.52 (.14)	12

Note. NCK = Non-causal knowledge; CK = Causal Knowledge; *M* = mean; *SD* = standard deviation.

Bivariate correlations showed that several cognitive and demographic factors were also associated with performance on the knowledge questionnaire (Table 2). Results from a hierarchical regression (Table 3) illustrated that age explained 37.4% of variance in overall performance on critical items in Test 1, F (1, 75) = 44.81, p < .001. The inclusion of verbal ability, working memory span and health literacy in the second step significantly improved the model by adding 9% unique variance, F (2, 72) = 4.04, p = .010. Finally, the provision of causal information accounted for a significant amount of variance (5%) in health information recall above and beyond age and other cognitive factors, F (1, 71) = 6.89, p = .011. Combined, the predictors explained 51.20% of the variance in knowledge of critical items for Test 1, which was a large effect.

At Time 2 (Table 4), age accounted for 43.3% of the variance in critical item performance, F (1, 70) = 53.39, p < .001. Interestingly, the addition of other cognitive predictors did not add significant explanatory variance ($F\Delta$ (3, 67) = 2.31, p = .085). The provision of causal information remained a significant predictor of Test 2 performance on critical items, contributing 3.5% of unique explanatory variance, ($F\Delta$ (1, 66) = 4.80, p = .032). The overall model has a R^2 of 52.1%, which is a large effect.

Table 2

Bivariate Correlations between Predictor and Outcome Variables

	1	2	3	4	5	6	7	8	9
1. Age		.24*	-.48**	-.20	-.18	-.60***	-.58***	-.66***	-.74***
2. Years of Education			.14	.25*	-.03	-.03	.11	-.28*	-.18
3. Verbal Ability				.34**	.18	.45***	.35**	.36**	.46***
4, Health Literacy					.22	.27*	.39**	.20	.42***
5. Working Memory Span						.30**	.29*	.25*	.19
6. Time 1 Test Items							.69***	.85***	.67***
7. Time 1 Control Items								.59***	.74***
8. Time 2 Test Items									.73***
9. Time 2 Control Items									

Note. *p< .05, **p < .01, *** p < .001

Table 3

Hierarchical Regression Analysis on the Predictors of Performance on Critical Items for TIME 1 (N = 77)

	Step 1		Step 2		Step 3	
Predictors	β	SE (B)	β	SE (B)	β	SE (B)
Age	-.61***	.035	-.49**	.001	-.50***	.001
Verbal ability			.22*	.012	.17	.011
Working Memory	--	--	.16	.004	.14	.004
Health Literacy	--	--	.06	.023	.09	.022
Causal Information	--	--	--	--	.22*	.037
Total R^2	.37***		.46***		.51***	
$R^2\Delta$	.37***		.09**		.05**	
F	44.83***		4.04*		6.89*	

Note. SE (B)= standard error of unstandardized coefficient; $R^2\Delta$ = change in R^2; * p < .05; **p < .01; *** p < .001

Table 4

Hierarchical Regression Analysis on the Predictors of Performance on Critical Items for TIME 2 (N = 72)

	Step 1		Step 2		Step 3	
Predictors	β	SE (B)	β	SE (B)	β	SE (B)
Age	-.66***	.001	-.60**	.001	-.60***	.001
Verbal ability			.22*	.015	.18	.015
Working Memory	--	--	.09	.024	.09	.004
Health Literacy	--	--	-.05	.024	-.02	.024
Causal Information	--	--	--	--	.19*	.037
Total R^2	.43***		.49		.52*	
$R^2\Delta$	.43***		.05		.04*	
F	53.39***		2.31		4.80*	

Note. SE (B)= standard error of unstandardized coefficient; $R^2\Delta$ = change in R^2; * p < .05; **p < .01; *** p < .001

Discussion

Performance on a test of novel health information was significantly enhanced for younger adults who received patient education booklets that explained the cause and effects of illness self- management. Specifically, the provision of causal information led to higher accuracy on items that required individuals to make inferences about the application of medical knowledge. As well, younger adults in the CK group retained more medical knowledge across time than their same age NCK comparisons, suggesting that causal explanations helped with the consolidation of unfamiliar health information.

The present findings are consistent with previous reports that incorporating basic sciences in medical curriculums helps to emphasize causal connections in medical exams; hence, improving the diagnostic skills of inexperienced trainees (Goldszmidt et al., 2011; Woods et al., 2009). This study is unique in showing that causal information also benefits the learning of disease management for health users. It is likely that information about self-care strategies becomes more salient for individuals who receive explanations about the connection between illness causes and outcome. As discussed in past studies (Jessop & Rutter, 2003; Price et al., 2013), understanding of illness pathophysiology was associated with greater knowledge about medication purpose and higher treatment compliance. There is, therefore, compelling evidence that causal explanations are a valuable component to be included in medical training and patient education tool for younger adults.

To the best of our knowledge, this is the first study to evaluate the effects of causal explanations on the learning and memory of medical information in older adults. Contrary to our predictions and in contrast to the results with younger adults, there were no significant differences in test performance between elderly individuals in the CK and NCK group. This raises an interesting question as to why the advantages of including causal explanations in health information materials disappeared with age.

The current results showed that older adults in both groups achieved an accuracy of around 50% on both tests, which was significantly lower than the performance of younger participants. One possible explanation for the general low performance of older adults could be that the task of learning about an artificial disease contradicted their prior medical knowledge. Past research shows that older adults are more resistant to adopting new accurate medical information that disconfirms previous beliefs (Adams, Rogers & Fisk, 2011; Hancock, Fisk & Rogers, 2005; Okun & Rice, 2001; Rice & Okun, 1994). The intended novelty of the health booklets may have inadvertently interfered with any potential benefits of causal explanations for older adults. Using medical conditions that are common among a geriatric population as the target health learning material may serve to elucidate the value of causal knowledge in a patient context.

Bearing in mind that the present study was not designed to equally sample from each subgroup of old age, it would be premature to conclude that all elderly individuals failed to benefit from learning causal information. Research has shown that there are marked differences in cognitive function between young-old (65-74 years), middle-old (75-84) and oldest-old (85+) individuals (Newson, Kemps & Luszcz, 2003). This study may have misrepresented the test performance of the older sample by collapsing all participants above 65-years into a single group. The present findings illustrated that the provision of cause-and-effect linkages predicted Test 1 and 2 performances above and beyond age and other cognitive variables. This suggests that there may be merit to further examine the utility of causal explanations for reducing age-related differences in acquisition of medical information. Distinguishing between varying levels of medical knowledge among subgroups of a geriatric sample may better explain the impact of causal information on older adults.

There were several other limitations that may have affected the interpretation of the current study results. First, it is difficult to gauge the intrinsic motivation for participants to learn the health information. Patients in clinics, unlike research participants, may be more inclined to learn about an actual diagnosis and therefore, may be more sensitive to the presentation of health information. Second, the present study did not control for the effects of metacognition among participants. It has been documented that older adults lack confidence in their ability to acquire new information (Price, Hertzog & Dunlosky, 2010), which suggests that some elderly individuals may not be performing at their fullest potential in this study. As well, it could be that the use of a multiple-choice survey is not the best measure of medical knowledge for older adults who are unaccustomed to this testing format. Efforts to minimize the artificial nature of the testing environment may help to reduce these confounding factors.

It also should be mentioned that the differences in performance between the younger adult groups could not be attributed to the inclusion of causal information alone. The CK, but not the NCK, group received information about disease management and symptomology on the same page. It is plausible that this style of organization contributed to the higher retention seen in the CK condition. Previous studies have cited the importance of layout design of health materials for patient education (Morrow et al., 2005). As such, the effect of presenting causal information in different formats is an area that warrants further study.

In conclusion, the present study has highlighted that causal explanations can improve the comprehension and retention of novel health information. This effect is salient even after controlling for existing verbal memory, working memory span and health literacy. The benefit of using cause-and-effect descriptions in health information resources for older adults has yet to be determined. The development of health education materials tailored to the learning needs of elderly individuals has significant implications for patient-centered care.

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