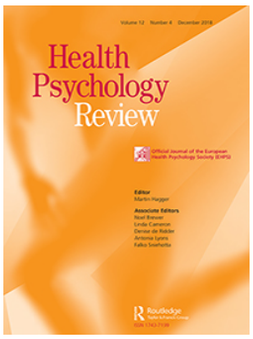

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Can you elaborate on that? Addressing participants' need for cognition in computer-tailored health behavior interventions

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ABSTRACT

Computer-tailored interventions, which deliver health messages adjusted based on characteristics of the message recipient, can effectively improve a range of health behaviours. Typically, the content of the message is tailored to user demographics, health behaviours and social cognitive factors (e.g., intentions, attitudes, self-efficacy, perceived social support) to increase message relevance, and thus the extent to which the message is read, considered and translated into attitude and behaviour change. Some researchers have suggested that the efficacy of computer-tailored interventions may be further enhanced by adapting messages to suit recipients' need for cognition (NFC) – a personality trait describing how individuals tend to process information. However, the likely impact of doing so, especially when tailored in conjunction with other variables, requires further consideration. It is possible that intervention effects may be reduced in some circumstances due to interactions with other variables (e.g., perceived relevance) that also influence information processing. From a practical point of view, it is also necessary to consider how to optimally operationalise and measure NFC if it is to be a useful tailoring variable. This paper aims to facilitate further research in this area by critically examining these issues based on relevant theories and existing evidence.

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Need for cognition; computer-tailoring; elaboration likelihood model; eHealth; behaviour change; health communication

Introduction

Digital health interventions have the potential to improve a range of health-related behaviours. They are often more accessible than face-to-face interventions and may be able to reach large target population groups that would otherwise be unlikely to participate in interventions (Fuller & Kroese, 2015). Evidence has consistently shown that digital interventions using computer-tailoring to present individuals with personalised health information are significantly more likely to improve health-related behaviours than those delivering generic information (Lustria et al., 2013; Short, James, Plotnikoff, & Girgis, 2011; Wolfenden, Nathan, & Williams, 2015). Nevertheless, as the overall effect sizes of

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computer-tailored health interventions remain small (Lustria et al., 2013), there have been recent calls for researchers to further investigate how to improve their effectiveness (Smit, Linn, & van Weert, 2015).

Computer-tailoring involves matching intervention messages to participant characteristics based on responses to one or more assessments. Software is used to automate the process, relying on algorithms that link individuals' assessment data to particular messages in a pre-specified message library (Kreuter, Farrell, Olevitch, & Brennan, 2000). To date, computer-tailored interventions have most often tailored the content of the message to match recipients' demographic factors, social cognitive determinants of behaviour (e.g., their self-efficacy, intentions, social support) and/or current health behaviour (Brug, Steenhuis, van Assema, Glanz, & De Vries, 1999; Spittaels, De Bourdeaudhuij, & Vandelanotte, 2007). More recently, there has been a push to focus not only on what information is included in the message but also on how the information is communicated, as this could impact on persuasion (e.g., attitude change) and potentially the magnitude of the behavioural change (Fuller & Kroese, 2015; O'Keefe & Jensen, 2007; Short et al., 2011; Smit et al., 2015; Vandelanotte et al., 2015). In particular, previous research suggests that matching health information to users' information processing style, such as their need for cognition (NFC), may be a promising avenue to pursue (Smit et al., 2015). However, several theoretical and practical considerations must first be considered before developing new interventions based on NFC.

NFC refers to an individual's tendency to engage in, and enjoy, effortful cognitive activities (Cacioppo & Petty, 1982). Those with a higher NFC tend to seek information actively and think deeply and critically about the arguments presented. Those with lower NFC tend to invest less cognitive effort when processing information, relying more on mental short-cuts such as cognitive heuristics (e.g., 'experts are correct') or the source of the information (e.g., celebrities, experts) to understand the information presented (Cacioppo, Petty, Feinstein, & Jarvis, 1996). In computer-tailored interventions, NFC could be used as a tailoring variable, with message style matched to recipients' processing style. However, the likely impact of doing so, especially when tailored in conjunction with other variables requires further consideration. It is possible that intervention effects could be reduced in some circumstances due to adverse interactions with other variables. From a practical point of view, further consideration of how to optimally operationalise and measure NFC is also needed. The usefulness of NFC, or any other variable, as a predictor of information processing and thus as a useful tailoring variable is only as good as its operationalization and our ability to measure it (Peters & Crutzen, 2017). This paper aims to facilitate further research in this area by addressing these considerations.

Theoretical considerations

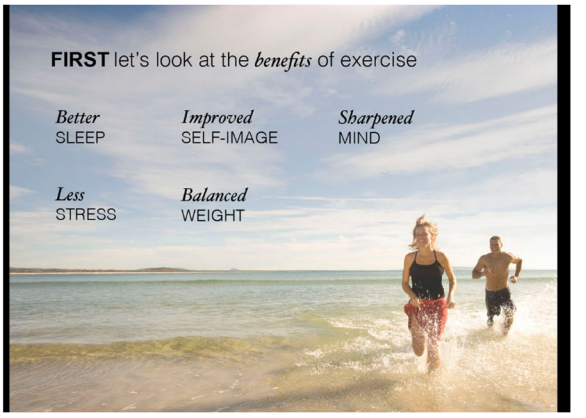
Computer-tailored interventions are commonly based on the premise that behaviour change is driven by changes in social cognitive determinants (e.g., attitudes, efficacy beliefs, intentions; Lustria et al., 2013; Wolfenden et al., 2015). There are many psychosocial models of health behaviour that have informed this view, including the Theory of Planned Behaviour (Ajzen, 1985), Social Cognitive Theory (Bandura, 1986) and the Health Belief Model (Abraham & Sheeran, 2015). Although there are nuanced differences between these models in terms of the determinants specified and the mechanisms for which they work, there is also considerable overlap. For the most part, each suggests that people make behavioural intentions based on deliberation of their beliefs (e.g., attitudes and self-efficacy beliefs) and behaviour change occurs through the translation of intention into action (Bandura, 2004). The primary strategy for influencing these determinants in computer-tailored interventions has been the provision of information. For example, an intervention may provide details about the benefits of a healthy diet. The underlying assumption is that such information may persuade a person to have more valued attitudes of the benefits of eating well and therefore lead the person to make intentions to eat more fruit and vegetables or to strengthen their commitment to enacting their intentions than if they had not received that information. This in turn, according to

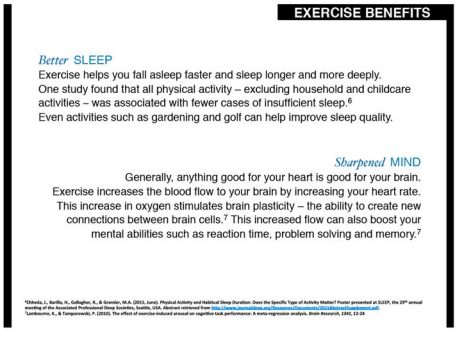
the theories outlined above, should lead to increased behaviour change. There is experimental evidence to support this proposition (i.e., that intentions causally influence behaviour), however, it should be noted that medium-large changes in intentions have typically resulted in small-medium changes in behaviour (Webb & Sheeran, 2006). This has led to an increased interest into how to ensure computer-tailored interventions have a large impact on intentions, and/or how to influence behaviour via other mechanisms (e.g., habitual processes, Kwasnicka et al., 2017). Consideration of the Elaboration Likelihood Model (ELM) of persuasion (Petty & Cacioppo, 1986) and other dual process theories are important to consider in this context.

The ELM is an information processing theory often applied to explain why computer-tailored interventions that adapt message content to increase message relevance are more effective at changing behaviour than generic, one-size-fits-all interventions (Kreuter et al., 2000; Short, James, & Plotnikoff, 2013). According to the ELM, there are two routes to persuasion, the central route and the peripheral route. Information is processed via the central route when participants have the ability, opportunity, resources and motivation to process information more elaborately. It involves in-depth information processing and thoughtful consideration of the information presented. Conversely, information processed via the peripheral route requires fewer resources and less motivation to process information, as it relies on the use of simple cognitive processes, such as the use of heuristics, biases, and affect (Petty & Cacioppo, 1986). Although persuasion can occur via either route, computer-tailoring interventionists have focused almost exclusively on persuasion via the central route. Petty, Barden, and Wheeler (2009) argue that this should result in longer lasting intervention effects since attitude change that occurs via the central route should be relatively enduring and resistant to counter persuasion compared to attitudes formed based on peripheral cues. This proposition is based on the implication that greater elaboration occurs in central route processing, which is thought to result in the new information, or one's personal translation of the new information, being integrated into the individuals underlying belief structure and committed to memory. The integration of information into one's belief structure increases the likelihood that incongruent messages will be disregarded or critiqued.

In most computer-tailored interventions, efforts to induce central route processing involve increasing the personal relevance of the health messages provided. For example, in a physical activity intervention, superfluous information about exercising at work can be omitted if it is known that the message recipient is unemployed. Likewise, information of interest to the individual can be added if their main motivation for exercise is known (e.g., weight loss). According to the ELM, perceived personal relevance is the primary factor for increasing motivation to process information elaborately (Cacioppo et al., 1996). When perceived personal relevance is high, message recipients are more likely to engage in central route processing. When perceived personal relevance is low motivation for elaborate processing wanes and recipients are more likely to engage in peripheral route processing. On this basis, the goal of computer-tailored interventions has been to ensure that the relevance of the health messages provided is high. Consistent findings showing that computer-tailored interventions are more likely to be read, remembered, discussed and perceived by the reader as interesting than non-tailored interventions support this practice (Brug et al., 1999; Kreuter et al., 2000; Spittaels, De Bourdeaudhuij, Brug, & Vandelanotte, 2006). However, it is possible that tailoring messages based on other factors that influence motivation and ability to process information may yield similar or even greater results.

The ELM states that NFC also influences motivation and ability to process information. Typically, those with a higher NFC are predisposed to process information via the central route and those with a lower NFC tend to process information via the peripheral route. Thus, to tailor information based on NFC, one could provide high NFC individuals with materials optimised for central route processing (e.g., messages containing statistics and facts) and those with a lower NFC with materials optimised for peripheral route processing (e.g., messages containing strong affective or credibility cues, see Figure 1). This may facilitate deeper processing among those inclined to process information via the central route (i.e., those with high NFC), and ensure appropriate and persuasive peripheral cues





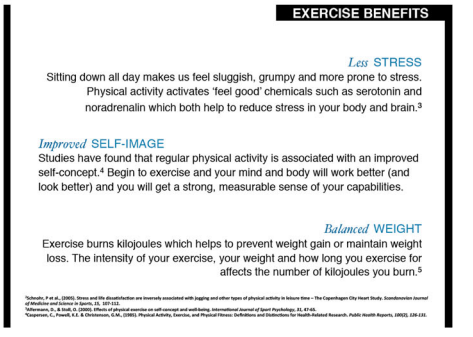


Figure 1. Top left. Webpage designed for individuals with low NFC. Reducing cognitive load and relying on image to convey positive benefits. Bottom images. Webpages designed for individuals with high NFC. Use of factual explanation to convey positive benefits of exercise.

are available to those most likely to rely on these cues to form their attitudes and beliefs (i.e., those with low NFC). While some have argued that peripheral messages may lead to shorter-lasting intervention effects due to less ingrained attitude formation (Petty et al., 2009), this is not necessarily the case. Early behaviourist theories such as classical conditioning (Staats & Staats, 1958) as well as more contemporary dual process theories (Strack & Deutsch, 2004), are especially relevant to consider. According to these theories, attitudes (e.g., physical activity is pleasurable) and/or behavioural influences (e.g., habits) may be formed and potentially sustained through exposure to repeated pairings of two concepts. It may be possible to design peripheral route messages based on this concept. It is also possible that peripheral route messages could reduce non-usage attrition in computer-tailored intervention through increased enjoyment (e.g., through use of humour as an affective cue, Zhang, 1996) and/or a reduction in cognitive burden (associated with elaborative information processing; Petty & Cacioppo, 1986). These theory-based ideas are worth exploring in today's context, where the delivery of tailored messages using websites and mobile applications allows for repeated exposure at a low cost, and where non-usage attrition issues with central route style interventions are consistently noted (and often attributed to a boring or taxing user experience; Short, Rebar, Plotnikoff, & Vandelanotte, 2015).

Some studies, described in more detail below, suggest that tailoring messages based on NFC alone may enhance persuasion and produce positive intervention effects on behaviour. However, a major limitation of this work, and arguably the tailoring field in general, is that the interaction between NFC and personal relevance has rarely been considered. This is necessary as processing differences based on NFC are only hypothesised to exist when health promotion materials are

perceived as moderately relevant (Cacioppo et al., 1996). When messages are very high in relevance, all recipients are hypothesised to engage in elaborate processing, regardless of NFC. Likewise, when relevance is very low, all recipients are thought to employ peripheral route processing. Therefore, if computer-tailored interventions are effective in increasing relevance, then providing messages tailored based on NFC (especially with low NFC recipients) may become less persuasive. This would suggest that a detrimental interaction between NFC and relevance could be observed. Ultimately, this will depend on how much improvements in perceived relevance can be achieved via computer-tailoring.

Another thing to consider is that the central route and peripheral route processing systems may operate in parallel and interact to influence each other. According to some dual process theories, Cognitive Experiential Self-Theory (Epstein, 2003) for example, non-conscious information processing, which is automatic, affect-based, and intuitive can bias conscious and rationale reasoning, including among those with high NFC. This implies that peripheral cues, which are automatically assessed when viewing a stimuli, are still likely to have an impact on those with high NFC, albeit more indirectly. For example, when a person with high NFC receives a message, automatic processing of peripheral cues (e.g., heuristics about source, affective response) may bias message elaboration and in turn affect judgement (Epstein, 2003; Petty, Briñol, Loersch, & McCaslin, 2009; Wegener, Clark, & Petty, 2006). This would suggest that to optimise intervention materials for individuals with a high NFC both central route and peripheral route information processing should be considered.

Practical considerations for future research

Is tailoring on NFC likely to be effective?

While dozens of randomised trials have examined the efficacy of tailoring based on demographics, psychosocial variables and behaviour (e.g., Lustria et al., 2013; Short et al., 2011; Wolfenden et al., 2015), to the best of our knowledge there are no randomised trials examining the impact of tailoring based on NFC compared to a control (e.g., usual care, wait-list). Research on this topic so far has focused on examining the impact of receiving matched versus mismatched NFC messages (which is referred to as testing the 'matching hypothesis'). Exploring this research is valuable for considering the likely impact of tailoring based on NFC alone (i.e., where everyone receives a message matched to their NFC). To this end, we conducted a narrative review of the literature. To identify key articles we searched 10 databases (Google Scholar, PsycINFO, Scopus, PubMed, Embase, Psychology & Behavioural Sciences Collection, Medline, ClinicalKey Australia, CINAHL and Academic OneFile), using keywords (e.g., 'need for cognition', and 'health' or 'behavior'), and names of authors published in this area. From this, we identified eight relevant studies (see Table 1). With one exception (Conner, Rhodes, Morris, McEachan, & Lawton, 2011), all examined whether tailoring messages based on NFC has an impact on social cognitive determinants of behaviour (e.g., intentions, attitudes, norms). However, only four assessed the impact on behaviour. One of these studies used an objective measure (Williams-Piehota, Schneider, Pizarro, Mowad, & Salovey, 2003), the remaining three utilised self-reported health behaviour measures (Conner et al., 2011; Latimer et al., 2008; Williams-Piehota, Pizarro, Navarro Silvera, Mowad, & Salovey, 2006).

Of the seven studies examining impact of matched interventions on changes in social cognitive constructs, four reported increased persuasion when messages were matched based on NFC on at least one social cognitive outcome (Bakker, 1999; Braverman, 2008; Carnaghi, Cadinu, Castelli, Kiesner, & Bragantini, 2007; Conner et al., 2011; Vidrine, Simmons, & Brandon, 2007). However in one study this was observed for one sub-group only (occasional versus daily smokers; Vidrine et al., 2007), and in three of the studies it was observed for some social cognitive outcomes but not others (Bakker, 1999; Carnaghi et al., 2007; Vidrine et al., 2007). Furthermore, one study reported findings to the contrary of the matching hypothesis. Specifically, Latimer et al. (2008) found that detailed messages were more effective with those with low NFC for increasing intentions than

Table 1. A review of studies assessing the effect of matching health messages to individuals' NFC on persuasion and behaviour change.

First author (date)	Intervention target	NFC measure	Psychometric properties of NFC measure	Cut-off measure	Mode of intervention	Message type	Relevant outcome variables of interest	Main findings
Studies assessing whether tailoring messages based on need for cognition has an impact on the antecedents of behaviour								
Bakker (1999)	Condom use	18-item, 5-point NFC scale (John T. Cacioppo et al., 1984)	Cronbach's $\alpha = .81$	Median split	Brochures	High NFC message: concise, written information. Low NFC message: cartoon that was airy, humorous and less detailed. Control condition: no message.	Knowledge about AIDS; attitude toward condom use; and subjective norms regarding condom use. All assessments conducted in same sitting.	Message type × NFC interaction was significant for attitude toward condom use ($F(2, 113) = 3.06$, $p < .05$)*† and subjective norms ($F(2, 113) = 7.23$, $p < .001$)*† but not for knowledge ($F < 1$).
Braverman (2008)	Water consumption	18-item, 5-point NFC scale (Cacioppo et al., 1984)	Cronbach's $\alpha = .92$	Median split	Written and audio	Informational message: factual, impersonal, medically and professionally written. Testimonial message: contained the same information, presented as a story.	Emotional absorption All assessments conducted in same sitting.	Message type × NFC interaction was significant for emotional absorption ($F(1, 150) = 4.42$, $p < .04$, $d = .34$).†§
Carnaghi et al. (2007)	Safe sex behaviour	18-item, 5-point NFC scale (John T. Cacioppo et al., 1984), translated in Italian	Cronbach's $\alpha = .97$	Median split	Pamphlets	High NFC message: text only. Low NFC message: comic strip format. Control condition: no message.	Instrumental attitude (knowledge and attitudes toward HIV-preventable behaviours); instrumental norm (subjective norms regarding safe sex behaviours and motivation to comply with them).	Message type × NFC interaction was significant for instrumental attitudes ($F(2, 102) = 327.99$, $p < .001$)*† and instrumental norms ($F(2, 102) = 343.36$, $p < .001$).*†
Vidrine et al. (2007)	Smokers' health-risk perceptions	18-item NFC scale (John T. Cacioppo et al., 1984)	Not assessed in study.	N/A	Pamphlets	Factual pamphlet: described health risks associated with smoking using logical, well-documented, and objectively verifiable information. Evaluative pamphlet: described the risks in terms of emotional, impressionistic and subjective statements. Control pamphlet: unrelated to smoking.	Smoking relevant knowledge; primary smoking-relevant risk-perception outcomes (perceptions of absolute general and specific personal risk); secondary perception outcomes (perceptions of specific personal risk relative to other smokers, perceptions of risk specific to women and men and perceptions of general risk); behavioural expectations of adopting the behaviour. All assessments conducted in same sitting.	For occasional smokers, NFC × message type interaction significantly predicted perceptions of absolute general personal risk (($\beta = -.74$), $t(90) = -2.49$, $p < .05$) and perceptions of specific risk relative to other smokers (($\beta = -.74$), $t(87) = -2.30$ $p < .05$).*† No interaction effects on pamphlet-relevant knowledge and behavioural expectations of changing smoking behaviour. For daily smokers, NFC × pamphlet type interaction was not related to any risk perception outcomes, or pamphlet-relevant knowledge and behavioural expectations of changing smoking behaviour.

Studies assessing whether tailoring messages based on need for cognition has an impact on behaviour								
Latimer et al. (2008)	Discussing cancer clinical trials with physicians	Three items from the NFC scale (Cacioppo et al., 1984) (baseline measure); 18-item, 5-point NFC scale (John T. Cacioppo et al., 1984) (mailed survey)	Cronbach's $\alpha = .72$ (3-item scale); Cronbach's $\alpha = .86$ (mailed survey)	Low NFC was −1 SD from mean NFC score and high NFC was +1 SD from mean NFC score	Phone messages and information booklets	Detailed message: included more statistics and in-depth descriptions of clinical trials. Non-detailed message: provided basic information and message cues (e.g. celebrity advocacy).	**Social Cognitive Determinant** Intention of discussing clinical trials with their physician; participants' understanding of clinical trials **Behaviour** Whether participants had discussed clinical trial information with their physicians). Assessed three points in time (baseline, 1 week, 6 weeks post-baseline).	**Social Cognitive Determinant** Message type × NFC interaction was not significant for understanding. However, the interaction was significant for intentions ($R^2_{change} = .03$, $\beta = -.23$, $p = .02$).[‡§] Low NFC individuals in the detailed condition had greater intentions than low NFC individuals in the non-detailed condition. No differences in intention observed for individuals with High NFC based on message type. **Behaviour** No NFC × message interaction on behaviour.
Conner et al. (2011)	Exercise behavior	18-item, 5-point NFC scale (John T. Cacioppo et al., 1984)	Cronbach's $\alpha = .81$	Median split	Not specified	Cognitive message: stated instrumental benefits of exercise (e.g. regular exercise reduces risk of cancer). Affective message: stated affective benefits of exercise (e.g. regular physical activity reduces anxiety). No-message control condition.	**Behaviour** Self-reported exercise behaviour. Assessed at baseline and three weeks post-baseline.	**Behaviour** Time × condition × NFC interaction was significant ($F(2, 110) = 4.89$, $p < .01$, $d = 0.60$). In the low NFC group, exercise behaviour significantly increased across time points in the affective message condition ($t(14) = 6.23$, $p < .001$), but not in the control or cognitive message conditions ($t < 1.4$). This was observed among individuals with high NFC as well, but was due to baseline exercise differences between the three conditions. It was concluded that the impact of affective messages on exercise behaviour was only consistent for individuals with low NFC.
Williams-Piehota et al. (2003)	Mammography utilization	Three items from the NFC scale (John T. Cacioppo et al., 1984)	Cronbach's $\alpha = .69$	Median split	Phone messages, refrigerator magnets and pamphlets.	High NFC messages: emphasised the facts, included statistics and encouraged mammography utilization in a detailed manner. Low NFC messages: fewer details on each subtopic, included celebrity advocacy.	**Social cognitive determinants** Intention of getting a mammography **Behaviour** mammography utilization. Assessed immediately after phone message, six months and 12 months later.	**Social cognitive determinants** No main effects. NFC × message type interaction not significant. **Behaviour** At 6-month follow-up participants receiving matched messages were 2.77 times more likely to get a mammogram than participants with mismatched messages, however NFC × message type interaction not significant ($p = .07$). Also no significant interaction at 12 months.

(*Continued*)

Table 1. Continued.

First author (date)	Intervention target	NFC measure	Psychometric properties of NFC measure	Cut-off measure	Mode of intervention	Message type	Relevant outcome variables of interest	Main findings
Williams-Piehota et al. (2006)	Fruit and vegetable intake	Three items from the NFC scale (Cacioppo et al., 1984)	Cronbach's $\alpha = .77$	Median split	Phone messages, brochures; '5 a day' pencil; refrigerator magnets; recipe cards; tip card. Participants in received a brief educational message and three mailings over four months.	Complex messages: emphasised facts and was detailed, provided more scientific evidence and less pictures compared to low NFC message. Simple messages: contained more pictures than the high NFC condition and included celebrity advocacy.	**Social Cognitive determinants** Motivation to increase fruit and vegetable; intention to consume more fruit and vegetables; knowledge of current fruit and vegetable guidelines. Assessed at baseline, one month and four months follow-up. **Behaviour** Fruit and vegetable intake measured using food frequency questionnaire at baseline, one month and four months follow-up.	**Social Cognitive determinants** Main effect at 1 months but not 4 months on intentions, with more complex messages resulting in greater intentions. No main effect of message type on knowledge. No NFC × message interaction on any outcomes. **Behaviour** Main effect at 1 and 4 months, with participants receiving more complex messages reporting greater behaviour change. No NFC × message type interaction at either time-point.

Notes: NFC: need for cognition; SD: standard deviation.
* Individuals high in need for cognition were more persuaded by the central route message than the peripheral route message.
† Individuals low in need for cognition were more persuaded by the peripheral route message than the central route message.
§ Individuals high in need for cognition were equally persuaded by the central route and peripheral route messages.
‡ Individuals low in need for cognition were more persuaded by the central route message.

simple messages. Of the four studies assessing behavioural outcomes, only one reported a significant interaction between NFC and message type on behaviour. This study partially supports the matching hypothesis. Conner et al. (2011) reported that affective messages were overall more effective than cognitive messages at increasing exercise participation for those with low NFC. However, message type was not associated with behaviour change among those with high NFC.

Overall, the results of these studies suggest that tailoring based on NFC may have an impact on intervention persuasion (changes in social cognitive determinants) and possibly efficacy, however, the evidence-base is mixed and inconclusive. Further investigation is needed as to why the matching hypothesis has not been supported in some studies. This may be due to differences in intervention modality (e.g., print versus telephone), targets (determinants of behaviour versus behaviour change; and differences in behaviours) and/or content, including how peripheral cues are used in each condition (Epstein, 2003). It could also be a function of the way NFC is operationalised (e.g., 'affective' vs 'cognitive', 'simple message' vs 'complex message'), measured (e.g., questionnaire using three items or 18 items) and/or categorised (e.g., median split versus distance from mean; see Table 1). The intervention content can impact directly on the persuasion process (based on the communication strategies chosen), and thus future research in this area is particularly needed. Consideration of the Cognitive Experiential Self Theory (Epstein, 2003) is recommended.

Whether or not NFC should be tailored in conjunction with other state or person-level factors are another area requiring further investigation. Our search did not identify any studies in this area, although one study examined the moderating role of NFC in a smoking cessation intervention in which tailoring was based on psychosocial determinants of behaviour and smoking behaviour (Haug et al., 2010). In this study, NFC was assessed at baseline and found to moderate intervention effects on smoking cessation self-efficacy, with the tailored intervention resulting in higher self-efficacy in high NFC individuals only. These findings suggest that tailoring psychosocial messages to increase relevance and thus increase central route processing, may not be as effective at persuading individuals with a low NFC. For them, messages that evoke positive emotions and rely on other peripheral cues may be more effective (Chartrand, van Baaren, & Bargh, 2006). To examine this further, future tailoring studies should assess NFC, personal relevance and current states such as affect, emotions, and self-control. Additionally, it is important for future efforts to explore moderating effects on intervention outcomes. Experimental studies comparing different types of tailoring (e.g., NFC only versus various other variables or both) should also be conducted. Studies exploring tailoring based on affective state are particularly encouraged, given that affect can influence information processing outside of conscious awareness, and that this may manifest in different ways among those with high and low NFC (Epstein, 2003; Petty et al., 2009; Wegener et al., 2006). As such, it may be necessary to adapt messages based on both affective state and NFC. A greater understanding of how these two variables interact (and the influence of other possible state or trait moderators) is needed to guide further research in this area. Such research may help to guide the development of more persuasive computer-tailored interventions. This may boost the efficacy of these interventions through larger changes in social cognitive determinants than has previously been achieved, however additional strategies (e.g., self-monitoring, point-of-decision prompts) may be needed to help bridge the intention-behaviour gap (Webb & Sheeran, 2006).

How to assess NFC: decreasing or eliminating response burden

Tailored messages are usually selected based on users' responses to one or more assessments. Ideally, questionnaires should be short to reduce the response burden of participants and ensure a positive user experience of the intervention (Rolstad, Adler, & Rydén, 2011). The most commonly used self-report measure of NFC, as indicated in Table 1, is the 18-item NFC scale (Cacioppo, Petty, & Feng Kao, 1984). Higher values on the NFC scale represent higher NFC. While this scale has strong psychometric properties (Cacioppo et al., 1984; Cacioppo et al., 1996; Forsterlee & Ho, 1999; Petty, Cacioppo, & Kao, 1984; Sadowski, 1993; Waters & Zakrajsek, 1990), the length is suboptimal for a

computer-tailored intervention, especially if other tailoring variables also need to be measured prior to providing personalised feedback. To address this issue, some researchers have used only three items from the 18-item scale, selected for their high factor loadings (Latimer et al., 2008; Williams-Piehota et al., 2003; Williams-Piehota et al., 2006). As the 3-item scale's psychometric properties were previously unknown, we compared the internal structure of the 18-item scale to the 3-item scale.

Cross-sectional data for these analyses were collected during November–December 2014 from individuals who are part of the Longitudinal Internet Studies for the Social Sciences (LISS) Panel (Wave 7) for CentERdata in Tilburg University, Netherlands. Every year, a large Internet-based survey is administered to the LISS Panel. The Panel is representative of the Dutch population aged 16 years or older as it is based on a probability sample of households drawn from the population register (Bruinsma & Crutzen, 2018; De Vos, 2010). Panel members provided informed consent and the confidentiality of participants' responses was maintained. While the survey assesses a number of domains (such as education, personality and political views) for the purposes of these analyses, only demographics and responses to the 18-item NFC scale scored on a 7-point Likert scale (response options range 0–6; scale range 0–108) were used. Analyses were conducted using Stata version 11 (StataCorp, 2009) and R (Team, 2015). LISS panel members, consisting of 7739 individuals, were invited to complete the survey and 6561 (84.8%) responded. Respondents who omitted one or more items from the NFC scale were excluded from the analyses ($N = 116$, 1.77%), producing a dataset of 6445 participants. This sample consisted of 53% females. Respondents, on average, were 45 years of age (SD = 17.58) and the NFC mean sum score was 59.79 (SD = 16.66; range = 0–108; see Figure 2).

The results revealed that there was a strong positive correlation between the 18-item and 3-item NFC scales ($r = .86$, $p < .001$). Unidimensionality of the 3-item scale was confirmed through exploratory factor analysis (see Appendix 1). Interestingly, a two-factor solution was identified as the best fit for the 18-item scale, consisting of a dominant first component with nine positively framed items and a second component based on nine negatively framed items. This has been observed previously (Bors, Vigneau, & Lalande, 2006; Vigneau & Lalande, 2006), and has been attributed to the impact of vocabulary when interpreting the negatively worded items (Bors et al., 2006). This may have implications for tailoring based on NFC scores when using the 18-item scale, especially in populations where verbal abilities are low. In such cases, it may be more desirable to use the 3-item scale.

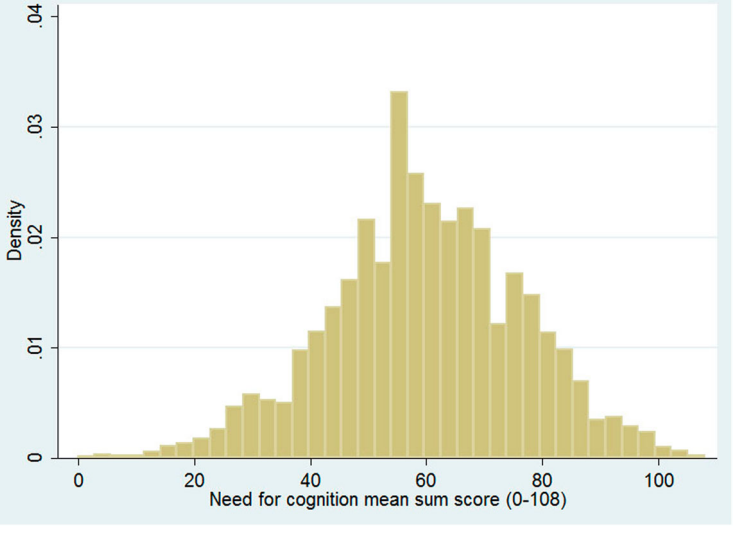


Figure 2. The distribution of NFC scores among participants in the LISS Panel ($N = 6445$). Scale range is 0–108. Mean = 59.79 (SD = 16.66), Median = 59.

Overall, the internal structure of the 3-item scale, based on Omega (McDonald, 2013), appears reasonable. While all studies reported in Table 1 used Cronbach's alpha to assess the internal structure of the NFC scale, except for Vidrine et al. (2007), Omega is a more accurate index of a scale's internal structure (Crutzen & Peters, 2017; McNeish, 2018) as its assumptions are more likely to be met (i.e., alpha relies on the essentially tau-equivalent model, which assumes unidimensionality and equal variances of, and covariances between, items). The Omega of the 3-item scale was 0.76. (95% CI: .75, .77). This was lower than the Omega of the 18-item scale (Omega = .89, 95% CI: .89, .90), but remains satisfactory. On balance, this reduction in reliability may be outweighed by the advantage of the 3-item scale to reduce survey fatigue in participants, and possibly be less confounded by participants' verbal abilities. Given this, the 3-item scale seems a suitable measure to use in computer-tailored health behaviour interventions studies, although further research is needed to assess its other psychometric properties, including the content validity and test–retest reliability of the scale (DeVellis, 2016).

Another option for reducing response burden would be to avoid self-administered NFC surveys and simply allow participants to self-select the type of health behaviour message they would like to receive (Carnaghi et al., 2007). This could be facilitated by showing a preview of message options or by describing options to users (e.g., '*Would you prefer motivational or factual messages?*' Or '*Would you prefer to read a comic or a health brochure to learn about HIV?*'). This would allow users to select messages based on their processing preferences (Ferguson, Chung, & Weigold, 1985), and also based on their current state (e.g., mood and level of fatigue). This may improve attention to the message and increase the likelihood of positive affect when processing. With individuals free to select the version that appealed to them most, feelings of autonomy may be greater, which may then increase internal motivation to engage with the intervention (Morrison, 2015). The appropriateness of this approach will depend on whether or not it is possible to communicate clearly the message type. In some circumstances, it may be better for participants to be naïve of the messaging strategy (e.g., to reduce demand characteristics, whereby participants change their behaviour to conform to researcher expectations). It will also depend on whether or not message preferences map to processing tendency, and the relationship between current affective state, NFC, and message type. This requires further examination.

How to determine cut-off points based on the (continuous) NFC variable

Researchers using a self-report measure to assess NFC, such as the 18-item or 3-item NFC scales, face the problem of determining rational cut-points to tailor the content (e.g., when are participants

Table 2. Cut-point methods and values of population data to categorise participants based on need for cognition.

Method	Cut-point description (assuming a normal distribution)	Cut-points using LISS Panel data ($N = 6445$).
Median split		
Low NFC	Median and below	≤59
High NFC	Above median	>59
Three categories based on SDs		
Low NFC	< −1 SD; 16% of population	0–43.13
Moderate NFC	1 SD < 0 > −1 SD; 68% of population	43.14–76.46
High NFC	> 1 SD; 16% of population	76.47–108
Five categories based on SDs		
Very low NFC	< −2 SD; 2.5%	0–26.47
Low NFC	13.5%	26.48–43.13
Moderate NFC	1 SD < 0 > −1 SD; 68% of population	43.14–76.46
High NFC	13.5%	76.47–93.12
Very high NFC	>2 SD; 2.5%	93.13–108
Tertile		
Low NFC	1/3 of population	0–53
Moderate NFC	1/3 of population	54–67
High NFC	1/3 of population	68–108

Notes: NFC: need for cognition; SD: standard deviation.

considered as having a high NFC?). Table 2 presents several possible cut-point methods (e.g., median split, standard deviation from the mean, tertiles) and their respective values, based on the LISS panel data described above.

As indicated in Table 1, the most common method of categorising individuals as low versus high in NFC has been the median split. However, given that NFC is a continuous variable that is likely to be normally distributed (see Figure 2), this approach is problematic. It ignores that most individuals have a moderate NFC, and treats those that fall on either side of the median as quantifiably and artificially different when, in reality, they are very similar. Although Table 1 demonstrates that some studies were able to find a statistically significant effect of NFC categorisation on the target health behaviour or its antecedents, it is arguable that the effect size of these findings would have been greater had another (more appropriate) approach been used to categorise participants (Fitzsimons, 2008). The median-split approach also provides little insight into how those with a moderate NFC respond to materials optimised for central or peripheral route processing.

Another option is to split NFC into three levels. This could be achieved by using tertiles (each containing one-third of the population) or it could be based on the standard deviation from the mean of the population. Those close to the boundaries will still be similar to one another, however, this approach at least allows confidence that those categorised as being low and high in NFC will be dissimilar. As such, both of these approaches would allow developers to better match messages to NFC level than the median split (at least for very low and very high scores). Of the two methods, using the standard deviation to categorise NFC into three parts may be preferable. This approach recognises that NFC is normally distributed in the population (see Figure 2), whereas the tertile split erroneously assumes that there are an equal proportion of individuals with low, moderate and high NFC in the population. However, it should be noted that using this approach will result in the majority of participants (68% based on Table 2) being categorised as moderate in NFC, and thus most participants receiving the same messages.

Additional categories (e.g., using five categories by including a 'very low NFC' group and a 'very high NFC' group) may assist researchers to better capture the individual variability of the NFC construct. However, it is unclear how such tailored messages could be operationalised, and whether the additional time and cost of creating additional sets of messages would be warranted. Given this, the use of three categories appears to strike the best balance between capturing the individual variability of the NFC construct, while ensuring the feasibility of designing a health promotion message for each NFC category. This requires further investigation. To this end, researchers are encouraged to provide a detailed rationale of the cut-point used and to perform *post hoc* analyses exploring their validity. For example, where a median split is used, researchers could conduct a receiver operating characteristic (ROC) analyses *post hoc* to determine how the utilised cut-point (i.e., median split) differs from the cut-point deemed optimal (in terms of specificity and sensitivity) for detecting intervention effects (Lasko, Bhagwat, Zou, & Ohno-Machado, 2005).

Operationalising health promotion messages tailored based on NFC

To develop health promotion messages for each NFC category, researchers first need to operationalise the NFC construct. As indicated in Table 1, there is considerable variability in how this can be achieved. This is particularly so for messages targeting low NFC individuals, as there are several possible cues to focus on, including simple cues (e.g., source credibility, visual appeal, emotions) as well as mental shortcuts (e.g., 'experts are correct'). As previous studies have favoured some cues over others, or focused on different combinations of cues when designing messages, low NFC materials have varied considerably between studies. Vidrine et al. (2007), for example, considered low NFC individuals to rely more on emotional responses when evaluating information, and hence designed their low NFC smoking cessation materials to communicate health risks via emotional, impressionistic and subjective statements rather than facts. In contrast, Williams-Piehota et al. (2003) described individuals with low NFC as low in motivation to employ cognitive effort to process detailed health information,

and thus designed mammogram screening materials that were simplistic, and used a celebrity endorsement to reinforce the limited details presented. Owing to the heterogeneity of studies (in terms of intervention targets, length and methodological quality), it is difficult to determine if certain peripheral cues or combinations of peripheral cues are more persuasive than others. This is likely to depend on the context of the intervention. To help advance knowledge in this area, it is recommended that researchers describe in detail the theory and evidence-base behind the strategies they use, provide examples of messages to facilitate replication of findings and conduct more experimental studies to investigate what peripheral cues may be most salient for whom and in what circumstances.

Another factor needing further consideration is how to design messages for those with moderate NFC, and in particular, to determine whether a hybrid approach can be used. When considering this point, it is important to recognise that the same content can be processed via either the peripheral or central route, depending on the cues being exploited. For example, information on the source of a message can have an impact on attitudes because it has been carefully considered and the recipient finds it credible (central route processing) or because the recipient has used a mental short cut, such as 'information from scientists is trustworthy' (peripheral route processing). As such, it may be possible to design messages in a way that allow for both peripheral and central route processing. This could be ideal for those with a moderate NFC, or indeed may reduce the overall need for tailoring based on NFC when personal relevance is moderate to high. This is an important area for future research, given that the LISS panel data suggest that the majority of the population may have moderate levels of NFC, and given that computer-tailored interventions tend to be perceived as at least moderately personally relevant (Short et al., 2017; Ezendam, Noordegraaf, Kroeze, Brug, & Oenema, 2012; Hayman et al., 2017; Kanera et al., 2016). The extent to which this can be achieved will ultimately depend on how compatible the two messaging approaches are. Though persuasion is often discussed as occurring by two distinct routes, in practice processing via these routes stretches across a continuum, ranging from subconscious processes to minimal conscious processes to more elaborate conscious processes (Petty, Barden, & Wheeler, 2002). How strategies exploiting the processing across this continuum could be combined to better persuade individuals with low, moderate and high NFC, as well as the implications of doing so, clearly requires further investigation. It may be possible to design a single set of materials that appeal to all levels of NFC.

Conclusion

This paper has discussed key theoretical and practical considerations regarding the tailoring of health behaviour messages based on an individual's level of NFC. It is hoped that the information presented within will assist researchers to operationalise and measure NFC and consider the implications of developing and evaluating a new generation of tailored interventions; that is, interventions that adapt not just the message content, but also *how* the message is presented. To progress science in this area, researchers developing such interventions are encouraged to describe clearly their messaging approach (including theoretical reasoning), consider the role of perceived personal relevance and affect on message processing, factor in those with moderate NFC when designing intervention materials (given that they likely represent the majority of the population), and to examine intervention efficacy in terms of both persuasion (changes in determinants) and behaviour change. Research focused on behaviour change outcomes is particularly needed, given the paucity of efficacy studies conducted to date, and the mixed nature of the evidence available.

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