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How Working Memory Capacity and Induced Eye Movements Shape Persuasion: A Study on Defensive Reactions to Health Messages

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Abstract

Persuasive health messages intend to encourage healthier behaviors, yet the achieved effects are often diminished due to recipients defensive responses, which are especially prevalent if the message feels threatening. The Working Memory Approach of Persuasion (WMaP) conceptualizes this and suggests that all persuasive processes happen within the working memory, which has limited capacity and varies between individuals.

This study examined how exactly these individual differences in working memory capacity (WMC) influence the effectiveness of persuasive health messages and whether additional cognitive load can moderate these processes. The participants (N = 139) took part in an online experiment, in which they first completed a digit span task to measure individual WMC and then listened to a negatively framed health message. In the induced eye movement condition, participants followed a moving stimulus on the screen while listening to the message, for added cognitive taxation.

The results showed some unexpected effects that were likely caused by the main outcome variable being intention and not actual behavior, which has limited explanatory power. Nonetheless, the findings emphasized WMC's overall moderating impact on the processing of persuasive health messages, causing significant differences in individuals intentions and message acceptance, which were further influenced by EMi. Conclusively, the results support WMaP as an important framework for research in the persuasive context, underlining the importance of considering cognitive capacity when constructing effective persuasive health messages.

How Working Memory Capacity and Induced Eye Movements Shape Persuasion: A Study on Defensive Reactions to Health Messages

Serious health problems like cardiovascular diseases and cancer, which are caused by harmful dietary choices, result in an estimated 11 million preventable deaths every year (Afshin et al., 2019). Regardless of the proven beneficial impacts that healthy lifestyle changes can have, many individuals find it difficult to prioritize long-term health over instant gratification (Michaelsen & Esch, 2023).

To try and encourage healthier behaviors, public health campaigns make use of established behavior change theories (e.g., Bandura, 1989; Kwasnicka et al., 2016; Ryan & Deci, 2000) to ensure high threat and persuasiveness (Miller et al., 2007; Ruiter et al., 2001).

However, despite their efforts, such messages often show limited effectiveness or even backfire (Ringold, 2002; Van 'T Riet & Ruiter, 2013). Responsible for this are defensive reactions, which allow individuals to dismiss or disengage from negative emotions that are evoked by health threats, which compromises their persuasive intent (Van 'T Riet & Ruiter, 2013). Overcoming these defensive reactions is therefore essential to ensure the effectiveness of health communication.

Persuasive Processing and Working Memory

To be able to counter defensive reactions successfully, an understanding of the underlying persuasive processes is necessary. The Working Memory Approach of Persuasion (WMaP; Figure 1) provides insights that pinpoint the effectiveness of persuasion as dependent on the working memory (WM) (Dijkstra & Elbert, 2019, 2021). WM itself stands out from other cognitive systems because it has a limited capacity for holding, processing, and integrating new information with prior knowledge (Baddeley, 2000, 2012). This is especially important in persuasion, as its effectiveness depends on having sufficient WM resources (Dijkstra & Elbert, 2021).

Attending to a persuasive message initiates this process, which links the incoming information to long-term memory (LTM) content. This connection gives it personal and emotional meaning (Dijkstra & Elbert, 2021) by turning an initially abstract idea, in this case a health threat, into a mental image (MI). A vivid and emotional MI is impactful because it makes the message feel real and tangible (Savarimuthu & Ponniah, 2024). For example, listening to an ad that explains the consequences of unhealthy eating might cause a MI that shows oneself having gained weight and struggling to climb the stairs, making it feel like a personal threat.

Neuroscientific research shows that emotionally charged messages activate brain regions involved in behavioral change and decision-making (Falk et al., 2012), while imagining a situation activates brain areas that are involved during actual perception (Kosslyn et al., 2001), which emphasizes the importance of making these connections.

Altogether this points out how emotional intensity and the MI together make abstract health messages more persuasive. But while the process of forming a MI is thought to be similar across individuals (Savarimuthu & Ponniah, 2024), people tend to differ in how they respond to them.

Self-Regulation and Defensiveness

While emotionally intense messages have the ability to enhance persuasion, they can just as easily induce aversive feelings, especially when the evoked MI represents a discrepancy between an individual's behavior and their internalized values or health goals (Higgins, 1987).

The WMaP specifies two types of self-regulatory responses that are triggered when this discrepancy occurs, namely facilitative self-regulation (FSA) and defensive self-regulation (DSA) (Dijkstra, 2024; Van 'T Riet & Ruiter, 2013). When a message is threatening but the individual views themselves as capable of the advocated behavioral change, then FSAs are evoked (Witte, 1994), which reinforce behaviors that adhere to the health message (e.g., through increased motivation) (Rippetoe & Rogers, 1987). However, messages can also feel threatening because the communicated health threat is at odds with one's behaviors and values, which evokes defensiveness instead (DSAs; Van 'T Riet & Ruiter, 2013) and is often reinforced due to their focus on negative outcomes and use of controlling language (Miller et al., 2007), including directive words like "need to" or "should."

Generally, DSAs intend to protect the self from threat and reduce self-directed negative affect (Dijkstra & Buunk, 2008; Witte, 1992) by, for example, downplaying the threat or rationalizing one's contradictory habits (Van 'T Riet & Ruiter, 2013; Witte, 1992). For the persuasive process, this occurs through replacing the originally vivid MI with an

emotionally neutral version. As a result, it is easier to dismiss and less persuasive (Dijkstra, 2024; Gyurak et al., 2011), ultimately, any intention of behavioral change is lost.

Working Memory Capacity and Span

Since the persuasive process unfolds in WM, individuals with different working memory capacities (WMC) are able to allocate varying amounts of cognitive resources to the persuasive process (Kane & Engle, 2000). Due to this, simultaneous demands in WM, like maintaining a MI and being defensive, both take up and compete for the same resources (Dijkstra & Van Asten, 2014). If the demands are too high, this can cause some processes to be prolonged or not be supported completely (Oberauer & Göthe, 2006). Therefore, individuals are expected to show varying responses when encountering persuasive content.

Individuals with low WMC tend to rely on surface-level processing (Kane & Engle, 2000; Unsworth & Engle, 2007), struggle more with impulse control (Hofmann et al., 2009), and show heightened emotional reactivity and responsiveness (Hofmann et al., 2009; Schmeichel et al., 2008). These tendencies make them especially susceptible to emotionally intense MIs and consequently more prone to being persuaded (Schmeichel et al., 2008). Additionally, negative emotional states can further reduce cognitive resources (Figueira et al., 2017), which implies that individuals with already limited WMC might become even more susceptible to persuasive messages.

In contrast, individuals with high WMC are more adept at regulating their emotional responses and processing persuasive information (Hofmann et al., 2009, 2012; Schmeichel et al., 2008), because their higher cognitive flexibility enables them to simultaneously hold competing ideas in mind (Kane & Engle, 2000), regulate responses (RepovŠ & Baddeley, 2006), and critically evaluate information (Barrett et al., 2004), as a result, they should be less affected by persuasion.

To assess WMC, the digit span task is a commonly used and established measure (Heled, 2024; Norris et al., 2019) that provides insight into different facets of WM. The participants complete several task rounds, where they are asked to remember and repeat ascending numbers of digits. It distinguishes between the forward digit span, which asks participants to solely retain the presented digits, indicating passive storage and maintenance (Baddeley, 2000; Cowan, 2001). While the backward digit span requires participants to mentally manipulate the digits, making it a more complex test of executive functioning and attention control (Miyake et al., 2000).

Research has linked the backward span with fluid intelligence and reasoning ability (Kane & Engle, 2000; Unsworth & Engle, 2007), making it especially important in cognitively demanding situations (Petty & Cacioppo, 1986; Unsworth & Engle, 2007). In the context of persuasion, having high capacity is especially important when the arguments are complex or counterattitudinal, to maintain multiple ideas, manage emotional reactions, or even evaluate conflicting information (Barrett et al., 2004; Petty & Cacioppo, 1986).

This suggests that not only natural differences in WMC but also induced ones, such as through extra cognitive load, should affect persuasion (Dijkstra & Elbert, 2021). For example, individuals low in capacity may be less persuaded if their WM is overloaded by additional taxation, as this may undermine the MI development. Conversely, individuals with high WMC might become more susceptible to persuasion in the same situation, since cognitive taxation might disrupt defensive processes (Dijkstra, 2024).

Induced Eye Movements

Understanding variations in WMC enables inferences about why people differ in information processing while raising questions about how capacity might influence a persuasive message's effectiveness. Consequently, induced eye movements (EMi) have been introduced as a way to potentially shape individual responses to persuasive messages

(Dijkstra & Elbert, 2019, 2021).

EMi was originally developed as part of Eye Movement Desensitization and Reprocessing (EMDR) therapy (Shapiro, 1989) and used to reduce the vividness and emotional impact that traumatic memories have (Driessen et al., 2024; Shapiro, 1989).

Although in persuasive contexts, the intention of EMi isn't to reduce emotionality or vividness but instead to disrupt DSAs that would otherwise interfere with the MI (Dijkstra & Elbert, 2021). This disruption helps keep the MI threatening and intense, which increases a message's persuasive effect.

However, research findings are not fully conclusive yet, showing EMi to be more effective for certain subgroups (Dijkstra, 2014; Dijkstra & Elbert, 2019, 2021), but nonetheless confirming WMaP as a promising way to study persuasion.

The present study

Building on the WMaP framework and previous research by Dijkstra and colleagues (Dijkstra, 2014, 2024; Dijkstra & Elbert, 2019, 2021), this study looks at how individual differences in WMC influence the effect of EMi on the effectiveness of persuasive health messages. Specifically, it aims to examine whether EMi alters persuasive effectiveness by disrupting cognitive processes involved in persuasive processing.

Participants in an online experiment listened to a threatening health message while assigned to either an EMi (following horizontal eye movements) or a control condition (without visual input). Persuasion itself was operationalised as the participants intentions to eat healthier after listening to the message and served as the primary outcome variable. The following hypotheses will be tested:

Hypothesis 1: In individuals with low WMC, EMi will lead to less persuasion.

Hypothesis 2: In individuals with high WMC, EMi will lead to more persuasion.

The study will look at several dependent variables, including the participants post-message intentions, their emotional responses, and message acceptance, to understand the exact impact EMi and WMC have on persuasive processing. Specifically, behavioral intention will be used as a measure of persuasion by asking how motivated the participants are to eat healthier in the near future. Emotional responses like perceived threat and experienced fear will help show whether and to what extent EMi changed the affective impact of the message. Lastly, message acceptance will be measured through ratings of how personally relevant the message felt, how credible the speaker seemed, and overall agreement to estimate what self-regulatory actions might have been evoked. Together, these variables will provide an overview of both the effects of EMi within each condition and how individual differences in WMC might interact with it.

Method

Participants

Participants for this study were recruited through posts on various social media platforms, including Facebook and Instagram. The promotional posts provided a link to the survey that directed them to the Qualtrics site, where they could then participate in the online experiment. This method allowed to recruit a sample that's more diverse and representative than a lab sample would have been. The participants themselves were under the impression that they were completing a questionnaire asking and informing them about the negative consequences caused by too little fruit and vegetable consumption. The recruitment period lasted approximately six weeks, starting at the end of October 2024 until the beginning of December 2024. To be eligible, participants needed to be a minimum of 16 years old as well as fluent in Dutch.

Design

The participants were randomly assigned to one of three possible conditions, of which

only two were used for the present study, which followed a 2 (Individual WMC: low/ high) x 2 (EMi/ no-EMi) design. The main dependent variable was the participants intention to consume fruits and vegetables, specifically their change in intention when comparing it to before and after the manipulation. Additionally, participants experienced emotions were measured to get an idea of personal threat and persuasion, while measuring message acceptance served as an indicator of defensiveness.

WMC acted as a moderating variable and was measured during the pre-test using a digit span task. Participants who were assigned to the EMi condition were told to simultaneously listen to the auditory message about the negative consequences of not eating adequate amounts of fruits and vegetables while following a red square moving horizontally across the screen (EMi). Those in the no-EMi condition were instructed to just listen to the message while seeing a blank screen. To calculate the required sample size, G*Power 3.1 (Faul et al., 2007) was used, which indicated that to find a medium-sized effect ($\eta p^2 = .15$), a sample size of at least 119 participants was required to achieve sufficient statistical power. The study was approved by the Ethical Committee Psychology of the Faculty of Behavioral and Social Sciences, University of Groningen (PSY-2425-S-0027).

Procedure

When the participants accessed the experiment via the internet, they first encountered an information page that outlined the study's purpose, procedures, devices that could be used to participate, confidentiality, and contact details. They were then reminded that their participation was entirely voluntary and that withdrawal would stay possible throughout the whole duration of the study. With giving their informed consent, they proceeded further, hereby confirming to have read and understood the study details, estimated duration (10-15 minutes), and the opportunity to enter a lottery for a 50-euro prize. Afterward, the participants filled out the pre-test questionnaire and a digit span task, which was separated into five trials for assessing forward and backward span each, to measure individual WMC.

This was followed by the experimental part of the study, which started by listening to a short 15-second audio sample to give time for volume adjustments before each participant was randomly assigned to one of the conditions. If assigned to the EMi condition, the participant received some additional information, while those in the no-EMi condition directly started listening to the health message.

Immediately after, all participants completed a post-test, and those in the EMi condition additionally rated how well they were able to follow the moving dot. To allow for a longitudinal understanding, the participants could provide their email addresses to receive the short follow-up questionnaire, which reassesses individual fruit and vegetable consumption, although technical difficulties made this data unavailable, hence, it won't be included. Finally, participants received access to a debriefing document explaining the actual purpose behind the study.

The persuasive message

In both experimental conditions, participants listened to a persuasive health message in Dutch, which was negatively framed and emphasized the adverse effects of too little fruit and vegetable consumption (Dijkstra & Elbert, 2021). The 90-second-long message, was delivered by a female speaker with normal intonation and a moderate speaking pace, lasted and comprised 207 words. It focused on the long-term health risks associated with low fruit and vegetable intake (e.g., "Furthermore, scientific research shows that a lack of vegetables and fruit increases the risk of cancer"), including physical health issues (e.g., "This leads to higher blood pressure and higher cholesterol levels. Eating too few vegetables and fruits, therefore, increases the risk of cardiovascular diseases") and visible effects (e.g., "More free radicals mean more aging, resulting in unhealthy skin and hair"). Additionally, the message stated that these consequences are direct outcomes of personal dietary habits, which are

independent of inherited traits or external influences, to make personal influence more salient.

Importantly, the same message was used for both conditions, the only difference being participants in the EMi condition following a horizontally moving square on the screen. The full transcript of the message can be found in Appendix B.

The EMi manipulation

In the EMi condition the participants were informed that they were about to listen to a 90-second-long clip about the negative consequences caused by too little fruit and vegetable consumption (Dijkstra & Elbert, 2021). They were given a five-second preview of the moving dot before the message started playing automatically. The dot continued moving horizontally across the screen (36 cm) at a consistent speed (1.8 seconds per movement), assuming it was seen on a 38 cm laptop screen.

Participants were instructed to listen to the auditory message while tracking a moving square on the screen with their eyes ("Please turn on the audio and listen to the fragment once, from the beginning. At the same time, a red block will move back and forth on your screen. Keep looking at the red block, don't let go of the block with your eyes", and "So listen to the fragment, but keep looking at the block the whole time."). Before the task actually began, the participants were advised to exit the questionnaire if they suffered from epilepsy. Participants in the no-EMi condition listened to the message without visual input.

Measures

Pretest

The questionnaire started with asking some general demographic information, such as age, gender, and level of education. This was followed by a digit span test to assess each participant's WMC, essentially a simplified and shorter version of the one used in the Wechsler Intelligence scales (Wilde et al., 2004). In each round, a sequence of numbers was shown for five seconds before disappearing, after which the participants entered the sequence as they recalled it from memory. The present digit span test included five forward and five backward digit span tasks, which were completed without training trials. In the forward digit span task, the participants were instructed to remember and repeat the sequences as they were presented. In the backward digit span task, they were instructed to enter them in reverse order. The number of digits that needed to be memorized increased each round, alternating between adding two and then one digit per round, starting with a three-digit-long span and ending at nine digits.

The total correct score is one of the most frequent and accepted ways to interpret this test (Heled, 2024) and was used here to assess individual WM abilities. All fully correctly recalled digit spans were added up separately for the forward and the backward span to obtain their independent WM scores.

After completing this, participants were asked to answer questions about their current fruit and vegetable consumption to see whether there's a discrepancy between an individual's dietary habits and personal expectations (Dijkstra & Van Asten, 2014), the average of those two indicators gave a discrepancy score. The corresponding questions could be answered on a five-point Likert scale (e.g., "Do you eat enough fruit?" In general, I eat: far too little fruit (1) to more than enough fruit (5). And, "Do you eat enough vegetables?") In general, I eat: far too few vegetables (1) to more than enough vegetables (5). Both questions correlated significantly $r = .357$, $p = <.001$.

Afterward, participants estimated their own health sufficiency and answered CSAI-related questions, which were not analyzed in this study. Then the participants were asked about their general interest in healthy lifestyle choices and whether they actively engage with health-related information or if they prefer to avoid such topics, to assess their initial defensiveness. Additionally, their general attitude towards health messages was evaluated (e.g., "I prefer to avoid information about healthy lifestyles, it stands out to me", "Information

about healthy lifestyles often exaggerates the benefits“, and “I read information about healthy lifestyles even if it scares me (a little)“). Responses were given on a five-point Likert scale from completely disagree (1) to totally agree (5).

Lastly, the participants answered two concluding questions about their future intentions regarding living a healthier lifestyle, with internal consistency ($\alpha = .843$), and how likely their adherence to such intentions is (e.g., “Do you plan to eat enough fruit and vegetables in the next 3 months?“ and “How likely is it that you will eat enough fruit and vegetables in the next 3 months?“), followed by the answer options not planning at all (1) to very strong plan (7) and not at all likely (1) to very likely (7), respectively, to assess persuasion. These items were also significantly correlated $r = .735$, $p = <.001$.

Immediate Posttest

To conclude the first part of the questionnaire, after listening to the auditory message, the participants answered some final questions. First, to make sure that participants had attended to the message, they were asked about their level of attention throughout (“Were you able to listen to the text?“), which was rated on a seven-point Likert scale ranging from didn’t listen at all (1) to listened successfully (7). Due to missing data on the actual exposure times, there is no objective verification of whether the participants were exposed to the audio message and EMi for the full duration.

Participants also reported their negative self-evaluative emotions, which were not included in the current exploration. To assess proper understanding and acceptance of the message, the experienced vividness of the health message was rated. This was simultaneously used to get an insight into self-regulatory actions and whether they were caused by the messages content (e.g., “How clear was the picture of the consequences of too little fruit and vegetable consumption that you had while listening?“ and “While listening, how well could you imagine the consequences of too little fruit and vegetable consumption?“), which could be answered on a seven-point Likert scale of not at all clear/not lively at all (1) to very clear/very lively (7).

To get an inclination of the participants defensiveness, message acceptance was used as an indirect indicator, which combined four questions (two about the speaker and two about the persuasive outcome reliability), which showed good internal consistency ($\alpha = .78$). First, the participants perceptions of the speaker were examined through rating niceness and knowledgeability (e.g., “How nice do you think the person who provided the information about the fruit and vegetable consumption is in the audio clip?“ and “How knowledgeable do you think the person in the audio clip is?“), which was answered from not nice at all/not at all knowledgeable (1) to very nice/very knowledgeable (7). The latter questions explored the perceived reliability and convincingness of the message by rating the overall understanding of the discussed health consequences and how accurate they perceived the information to be (“How reliable do you find the audio text about fruit and vegetable consumption?“) from not very reliable (1) to very reliable (7) and (“How strong is the association between fruit and vegetable consumption and disease?“) from not strong at all (1) to very strong (7). If the information was seen as unreliable, participants likely weren’t convinced by the health message, and as a consequence, persuasion might not have occurred. Together, the four item means comprised the message acceptance score.

To measure the persuasiveness of the message, participants were asked about their future fruit and vegetable consumption intentions, which was the main dependent variable (e.g., “Do you plan to eat enough fruit and vegetables in the next 6 months? “ and “How likely is it that you will eat enough fruits and vegetables in the next 6 months?“) on a seven-point Likert scale from Definitely not planning to/not likely (1) to very strong plan/very likely (7). These items were significantly correlated ($r = .743$, $p = <.001$). At the pre-test, the participants were asked the same question, only referring to a time frame of three months

instead of six. This change was intended to prevent the participants from just repeating their earlier answer and avoid strategic consistency.

Lastly, a device check was included to see whether an appropriate device was used to complete the questionnaire ("What kind of device did you answer the questions on?") with the answer options PC, Laptop, Tablet, or Smartphone.

Posttest follow-up

Two weeks after completing the initial questionnaire, participants who had provided their email addresses received the follow-up questionnaire. This questionnaire investigated their fruit and vegetable consumption over the past two weeks (Dijkstra & Elbert, 2019, 2021). Participants were instructed to reflect on their previous consumption when answering how often they ate or drank a certain fruit or vegetable and the average quantity (Bogers et al. 2004), which had to be omitted for this paper.

At the end, participants could provide their email again to finalize their entry into the lottery for a chance to win 50 euros and to also link their responses from the post-test questionnaire to the pre-test questionnaire. Finally, a debriefing section that offered insight into the true purpose of the study was provided.

Results

Participant Characteristics

The sample consisted of 139 participants, of these, 68.3% identified as female, 30.2% as male, and 1.4% did not disclose their gender, with a mean age of 34.4 years (SD = 17.97). Participants had a mean forward working memory span (FWspan) of 3.31 (SD = 0.86) and backward working memory span (BWspan) of 3.01 (SD = 0.92), which corresponds to approximately one additional digit being recalled on average in the FWspan task.

Participant selection

Initially, the dataset included 339 participants, but several exclusions were made in a stepwise manner. First, participants assigned to a third condition (complex EMi, n = 78) were removed due to their irrelevance to this study. In the case of duplicate IP addresses, only the first entry was retained unless it lacked manipulation exposure, in which case a completed case was kept instead (n = 36). Next, incomplete data was removed, which included missing responses for the dependent variables (n = 75). Lastly, participants who failed to follow the manipulation or followed it insufficiently (i.e., indicating a minimum of 5 on the scale) also led to exclusion (n = 11).

Randomization

The final sample of 139 participants was randomly assigned to one of the two experimental conditions, with 63 participants in the EMi condition and 76 in the no-EMi condition, showing a small difference in group sizes. To confirm that the randomization was successful, independent samples t-tests were conducted to compare the two groups on demographic and baseline variables. No significant differences were found between age, gender, education, pre-test intention, discrepancy, and BW span (all ps > .25). Additionally, chi-square test examined potential conditional differences in level of education, $\chi^2(1, N = 139) = 0.079$, p = .961, and gender, $\chi^2(1, N = 137) = 0.239$, p = .625 neither showing significant differences. One exception to this was FWspan with significantly higher scores in the no-EMi condition (M = 3.45, SD = 0.89) when compared to the EMi condition (M = 3.14, SD = 0.80), $F(137) = 2.11$, p = .037, which is no problem, as it is included in all models regardless. Apart from this, randomization was successful.

Manipulation Check

Participants in the EMi condition were asked to indicate on a 7-point Likert scale to what extent they successfully followed the moving dot with their eyes throughout the auditory message. The majority of participants (85%) answered with a score of at least 5 and were

therefore kept as part of the final sample. This ability to follow the manipulation was not related to WMC, and neither the correlation of FWspan (p = .71) nor BWspan (p = .92) showed a significant correlation to it.

Pre-Analyses

Before testing the main hypotheses, some preliminary analyses were conducted to examine the relationships among the studies variables. Correlation analyses showed that discrepancy was significantly related with all three dependent variables (*ps* ≤ .003), as such, it was included in all subsequent models as a covariate. Similarly, pre-intention was significantly correlated with post-intention ($p < .001$) and therefore included as a covariate in the model that had post-intention as the dependent variable. Demographic variables such as gender (*ps* > .625), education (*ps* > .097), and age (*ps* > .164) were not significantly related to either FWspan nor BWspan.

To explore the effects of EMi on persuasion, a consistent baseline model was used across all following analyses. Analyses of covariance (ANCOVA) were conducted for each dependent variable, including FWspan and BWspan as possible moderators. The model included two interaction terms, condition x FWspan and condition x BWspan. Since these span measures were significantly correlated ($p < .05$), they were also entered in the model along with the experimental condition (EMi/ no-EMi) as lower order factors, following the moderation analysis framework described Yzerbyt et al. (2004). Discrepancy was consistently included as a covariate to control for baseline individual differences.

Post-Intention

Before testing the hypotheses, the statistical outcomes of the model were examined in more detail, including inspection of the P-P plot of standardized residuals to assess the normality of residuals, which showed approximate normality, with minor deviations at the tails (see Appendix C, Figure C1). As prior expected, significant interactions were found between FWspan and condition, $F(1, 131) = 6.54$, $p = .012$, $\eta^2 = .048$, and BWspan and condition, $F(1, 131) = 4.87$, $p = .029$, $\eta^2 = .036$.

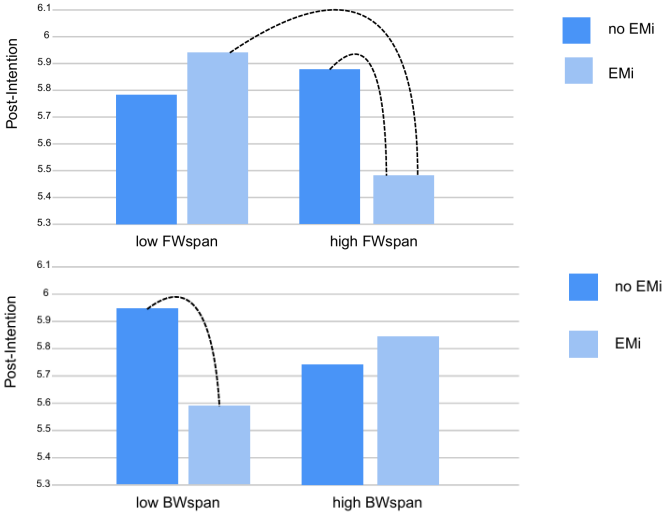
To further explore these moderating effects, all participants were modeled into high and low WMC subgroups by adding or subtracting 1 from the standardized span scores, as described by Cohen et al. (2014) and Siero et al. (2009). This method allowed the examination of how individuals with varying WMC respond to EMi.

When FWspan was modeled as low, the effect of EMi on post-intention was not significant, $F(1, 131) = 1.183$, $p = .279$, $\eta^2 = .009$. However, when FWspan was modeled as high, EMi led to a significantly lower post-intention ($M = 5.49$) compared to the no-EMi condition ($M = 5.88$), $F(1, 131) = 7.922$, $p = .006$, $\eta^2 = .057$. More specifically, the partial correlations (controlling for BWspan, discrepancy, and pre-intention) showed a significant negative association between FWspan and post-intention in the EMi condition, $r(58) = -.352$, p = .006, but no relation to the no-EMi condition, $r(71) = .089$, p = .452.

A different pattern was found for BWspan, as when it was modeled as low, EMi led to significantly lower post-intention ($M = 5.59$) compared to the no-EMi condition ($M = 5.94$), $F(1, 131) = 6.87$, $p = .010$, $\eta^2 = .050$. However, when BWspan was modeled as high, the effect of EMi on post-intention was not significant between EMi and no-EMi, $F(1, 131) = 0.576$, p = .449, $\eta^2 = .004$. Partial correlations for BWspan and post-intention were not significant in both the EMi condition, $r(58) = .153$, $p = .253$, and the no-EMi condition, $r(71) = -.153$, $p = .196$.

Figure 2

Forward and backward capacity moderating the effects of EMi on post-intention



Note. The dotted line indicates significant effects.

Emotions

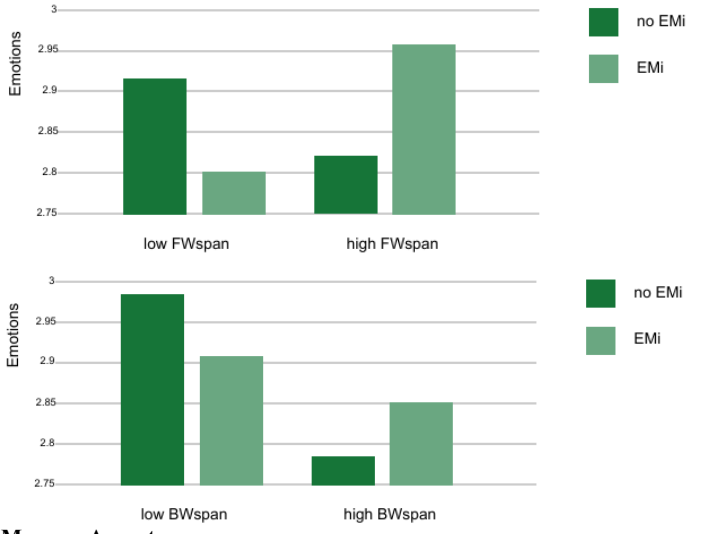
While the main focus of this study was on post-intention, additional analyses were conducted to explore whether EMi and WMC influenced a participant's emotional response to the message, which would be indicative of persuasive processing. Again, the P-P plot of standardized residuals was examined, which revealed an approximately normal distribution (see Appendix C, Figure C2). An ANCOVA was performed using the same predictors and interaction terms as the previous model, now with emotional response as the dependent variable. The results showed no significant effect of EMi, $F(1, 132) = 0.00$, $p = .98$, $\eta^2 = .000$.

To further explore the possible moderating effect of WMC, FWspan and BWspan were again modeled into high and low groups, as described in the prior section. Additionally, EMi showed no significant effects in any subgroup, neither for high FWspan, $F(1, 132) = .19$, $p = .660$ $\eta^2 = .001$, low FWspan, $F(1, 132) = 0.19$, $p = .665$, $\eta^2 = .001$, high BWspan, $F(1, 132) = 0.06$, $p = .814$, $\eta^2 = .000$, or low BWspan, $F(1, 132) = 0.05$, $p = .833$, $\eta^2 = .000$. Emotional responses were quite consistent across groups, with mean values ranging just between M = 2.80 and M = 2.97, indicating minimal emotional variability regardless of the condition.

No further details were found when conducting the partial correlations analyses. In the no-EMi condition, FWspan was not significantly associated with negative emotions when controlling for BWspan, $r(72) = -.04$, $p = .754$, the same held true in the EMi condition, $r(59) = .06$, $p = .624$. Comparably, BWspan showed no significant relation with emotion when controlling for FWspan in either the no-EMi condition, $r(72) = .07$, $p = .535$, nor the EMi condition, $r(59) = -.02$, $p = .861$.

Figure 3

Forward and backward capacity moderating the effects of EMi on emotions



Message Acceptance

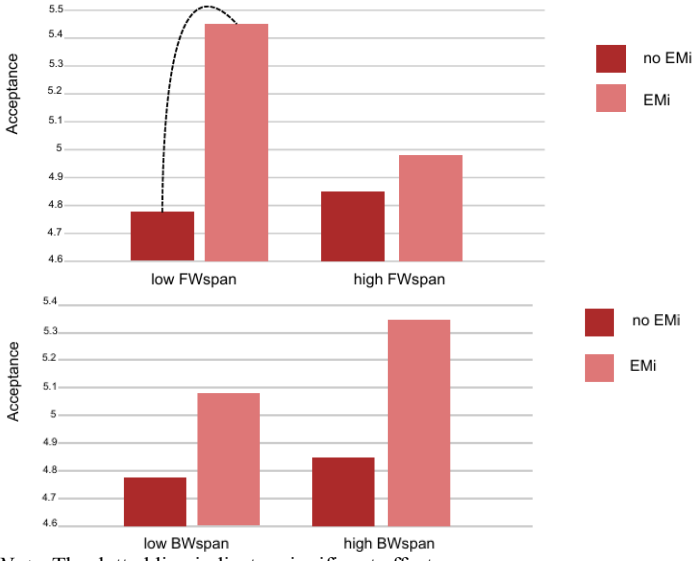
Lastly, to look at further effects of EMi and WMC, the ANCOVA model was rebuilt using the same baseline predictors and interaction terms, with message acceptance as the dependent variable. The visual inspection of the P-P plot of standardized residuals for message acceptance showed that the assumption of normality was not violated (see Appendix C, Figure C3). The ANCOVA itself showed that neither the interaction between condition x FWspan, F(1, 132) = 1.44, p = .233, η^2 = .011, nor condition x BWspan, $F(1, 132) = .172$, $p = .679$, $\eta^2 = .001$, were significant. Interestingly, in contrast to the previous models, EMi did show a significant main effect on message acceptance, $F(1, 132) = 4.82$, $p = .030$, indicating that message acceptance was significantly higher in the EMi condition ($M = 5.24$) compared to the no-EMi condition ($M = 4.83$).

To get a more nuanced understanding of this effect, FWspan and BWspan were again modeled into high and low groups. There was no significant effect of EMi on message acceptance within the high FWspan group, $F(1, 132) = .22$, $p = .641$, $\eta^2 = .002$. However, for participants with low FWspan, EMi had a significant effect, $F(1, 132) = 5.657$, $p = .019$, $\eta^2 = .041$. Specifically, participants with low FWspan showed higher message acceptance in the EMi condition ($M = 5.44$) compared to those in the no-EMi condition ($M = 4.79$). Apart from that, no significant effects were found for BWspan, neither in the high BWspan group, $F(1, 132) = 2.98$, $p = .087$ $\eta^2 = .022$, nor the low group, $F(1, 132) = 1.22$, $p = .271$, $\eta^2 = .009$. To pinpoint where the significant effect is coming from, partial correlations were computed within each condition.

In the no-EMi condition, neither FWspan nor BWspan correlated significantly with message acceptance (FWspan: $r(72) = .02$, $p = .850$; BWspan: $r(72) = .03$, $p = .801$). In contrast, in the EMi condition, FWspan showed a negative correlation with acceptance, $r(59) = -.22$, $p = .093$. Within the BWspan group EMi showed no significant correlation, $r(59) = .12$, $p = .343$.

Figure 4

Forward and backward capacity moderating the effects of EMi on message acceptance



Note. The dotted line indicates significant effects.

Discussion

This study's aim was to explore whether individual differences in WMC influence how persuasive health messages are processed, specifically in interaction with EMi. Based on the WMaP, it was hypothesized that EMi would interfere with defensive responses if the individual had high WMC but interfere with MI development in those with low WMC. Since the FWspan and BWspan distinguish between storage and manipulation processes, they were analyzed separately to accurately capture individual WMC. Through exploring this interaction, the study adds to previous research on cognitive load and persuasion by introducing EMi as a method to change persuasive processing while also taking WMC into account.

The Role of Backward Capacity

The BW capacity, which reflects an individual's executive control and manipulation capabilities (Kane & Engle, 2000; Redick et al., 2012), was expected to take a discernible role in persuasive processing, particularly when interacting with EMi.

Surprisingly, only individuals with low BWspan were in line with this expectation, as they showed a significant reduction in post-intention when EM were induced. According to WMaP, individuals with low WMC are more vulnerable to cognitive load, and as a result, EMi likely affected the vividness and emotionality of their MI (Gunter & Bodner, 2008; Dijkstra, 2024), which decreased persuasion due to a loss of affective threat.

However, individuals with high BWspan were unaffected by EMi, contrasting the hypothesis and suggesting that their greater capacity allowed them to maintain both MI and defensiveness while following EMi, resulting in similar post-intentions for both conditions.

The Role of Forward Capacity

The FW capacity reflects storage and maintenance of information (Baddeley, 2000; Cowan, 2001) and was therefore assumed to be especially important for the preservation of the message's content.

Unexpectedly, however, in the EMi condition, participants with high FWspan reported lower post-intentions than those with low FWspan, which not only contradicts the present hypothesis, predicting persuasion to increase with a higher capacity, but also previous research (e.g., Dijkstra, 2014; Dijkstra & Elbert, 2019, 2021). Although this initially seems to be inconsistent with WMaP, these findings might show EMi disrupting facilitative rather than defensive processes. Specifically, high capacity individuals likely had enough resources to develop a vivid MI and engage in FSAs, which usually enhance persuasion as the individuals behavioral intentions are changed to align with those of the health message (Arndt & Goldenberg, 2017; Rippetoe & Rogers, 1987). However, when following EMi, FSAs might have been disrupted, reducing their persuasive impact.

In contrast, high capacity individuals in the no-EMi condition likely still developed vivid MIs and engaged in uninterrupted adaptive self-regulation (FSAs), which led to higher intentions. The pattern found within the EMi condition showed the impact of FSAs when interrupted or left as is, further supports the prior interpretation. Here, individuals with low FWspan reported significantly higher post-intentions than those with high FWspan.

Yet, interpreting the results this way raises the question as to why participants didn't exclusively show defensiveness in regard to the health threat. It is possible that FSAs and DSAs differ in the WMC they need, or that the persuasive message lacked sufficient personal relevance or threat to trigger defensive responses. Hence, high FWspan individuals not getting defensive wasn't due to a theoretical inconsistency in WMaP but rather because the evoked threat or emotions weren't engaging enough (Dijkstra, 2024). Nonetheless, these interpretations remain speculative.

It is important to look at the role that intention formation takes in the context of health messages. Health messages that evoke threat can lead to intentions that are either precursors toward actual behavioral change (FSA) (Arndt & Goldenberg, 2017; Faries, 2016) or, as a form of regulatory relief, that provides immediate ease without lasting commitment (DSA) (Arndt et al., 2003; Higgins, 1998; Van 'T Riet & Ruiter, 2013). The present findings could reflect either of these functions. For example, high capacity individuals in the no-EMi condition might have formed genuine intentions in line with the message, while low capacity individuals in the EMi condition might have formed shallow, short-term intentions to alleviate the emotional discomfort. This would explain why their intention patterns don't match prior predictions of persuasion and why those might not translate into lasting behaviors (Routledge & Vess, 2018).

According to the literature, once the immediate emotional response wears off, such intentions often subside, while generally only accounting for a small portion of actual health behaviors (Rhodes & De Bruijn, 2013), especially when intention strength is not taken into account (Conner & Norman, 2022).

Consequently, given the lack of confirmation through follow-up behavioral data, the present results should be interpreted as a combination of both responses. Importantly, WMaP itself has only been shown to affect long-term persuasive outcomes and behavioral change (Dijkstra, 2024), and not short-term or momentary intentions. Thus, while it offers a relevant framework for understanding how cognitive load and WMC influence persuasion, it cannot fully explain the ambiguity that comes with interpreting intentions. Despite this, the findings emphasize that individuals' differences in WMC not only shape how people are persuaded but also whether they are persuaded genuinely, temporarily, or at all.

Emotions

Overall, there were no significant results when looking at emotions across conditions,

which contrasts previous findings (Dijkstra & Elbert, 2021). As aforementioned, the persuasive message likely didn't evoke sufficiently strong emotional or defensive responses, which may have restricted the potential effect both WMC and EMi could have. The moderation effect of WMC would ultimately be minimal if the participants didn't experience the message as particularly threatening or self-relevant in the first place.

Alternatively, participants might have reacted differently to varying parts of the message. For example, some might have experienced predominantly self-evaluative emotions like shame and guilt in response to the discussed existential threats (e.g., cancer), yet others may have felt overwhelmed or afraid instead (Breitbart, 2017; Higgins, 1987; Schimel et al., 2019). These mixed emotional appraisals and regulation strategies could have resulted in inconsistent measurements across participants that essentially contradict each other and conceal any group-level effects. These variations likely also affected the present study's emotion score, especially as it combined multiple emotional dimensions (e.g., fear, threat, and self-efficacy) into one.

Message Acceptance

To gain further insight into the participants' regulatory mechanisms, message acceptance was assessed as an indirect indicator of defensiveness (Good & Abraham, 2007). From the perspective of WMaP, EMi should interfere with DSAs, thereby taking cognitive resources and leaving the emotional threat of the message more salient (Dijkstra & Elbert, 2019). This especially applies to individuals with high capacity, as they should show increased message acceptance once their defenses are interrupted.

Surprisingly, significantly higher message acceptance was found for low FWspan individuals in the EMi condition, despite their theoretical lack of resources to be defensive. One interpretation is that low capacity individuals might show more implicit and generally negative reactions when encountering threatening health messages (Dillard & Shen, 2005) due to their reliance on heuristics (Kane & Engle, 2000; Unsworth & Engle, 2007). For them, health messages might be automatically associated with unpleasant feelings, leading to immediate rejection (Dillard & Shen, 2005). As a result, during the development of the MI, such associations may have been interrupted in the EMi condition, leading to more elaboration and openness (Petty & Cacioppo, 1986). Therefore, higher message acceptance isn't a sign of persuasion or reduced defensiveness, as initially assumed, but instead a sign of less rejection by default and decreased negative associations.

Contrary to this, neither high FW nor BW WMC individuals showed increased message acceptance, which might indicate remaining defensiveness (Petty & Cacioppo, 1986), a pattern similar to the one observed in the prior intention results. No significant effects were found for BWspan in relation to message acceptance, suggesting that information storage (FWspan) might be more relevant than manipulation capacity (BWspan) for message acceptance.

Summary

Altogether, the results revealed that WMC shapes how individuals respond to persuasive health messages under cognitive interference, an interaction that hasn't been studied before. Although the emerging patterns aren't easy to understand given the current theories, behavioral intentions were clearly affected by EMi depending on the available WMC resources, offering a thought-provoking starting point for future research.

Limitations and Future Directions

The present findings should be interpreted in light of several limitations. A main challenge was the online setting, which reduced experimental control and likely caused variability across the participants' environments, such as differing screen sizes, background distractions, or inconsistent adherence to instructions. In addition, the loss of the exposure time data prevented any objective verification of participants exposure to the audio message

and EMi, while there were self-reports, they cannot reliably substitute actual time measurement. Especially EMi is vulnerable to such variations, as its effectiveness depends on the participants' visual tracking and sustained attention. Similarly, the WMC assessment might have been compromised because of external distractions, multitasking, or cheating, possibly leading to inflated or deflated scores.

Additionally, the study's operationalization of emotion regulation solely distinguished between FSA and DSA, which likely oversimplified emotional regulation, since the participants might have used other cognitive or behavioral strategies that weren't included (Van 'T Riet & Ruiter, 2013). As seen in previous studies, this issue might also be reflected in the emotion variable, which combined several constructs into one overall score, potentially concealing singular effects, especially for self-evaluative emotions (Dijkstra & Elbert, 2021), hence, keeping the emotion variables separate could provide more accurate insights.

Another limitation is the sample containing a higher percentage of female participants, as males are typically more defensive and susceptible to EMi and the present composition might have skewed the results (Dijkstra & Elbert, 2021), which could be avoided with a more balanced sample.

The last limitation is the ambiguity that comes with analyzing intentions (Michaelsen & Esch, 2023), since it's impossible to differentiate between heightened intentions that indicate genuine starting points for behavioral change and those merely serving as temporary emotional relief (Schimel et al., 2019).

Despite these limitations, the study provides valuable contributions supporting the idea that persuasive messages are moderated by individual differences in WMC and shows that EMi can both enhance and hinder persuasive outcomes depending on the cognitions of the recipient. Notably, FWspan and BWspan take a more differentiated role than initially assumed, showing that FWspan might be more predictive of message acceptance than BWspan. This suggests that for persuasion, the ability to retain the message's content plays a more important role than the ability to mentally manipulate it.

It is also worth noting that, while the online experiment introduces some limitations, it simultaneously reflects how health messages are typically consumed in real life, often happening via screens, while multitasking or confronted with distractions, thereby increasing ecological validity. Moreover, this allowed access to a far more diverse sample than is usually available for lab settings, enhancing the findings generalizability.

Future research should address these limitations and build upon the current findings. Expanding it by more diverse or robust measures of WMC, like the Operation Span task (OSPAN; Redick et al., 2012), or increasing the number of trials in the digit span task. This study could also be replicated or expanded in a lab setting to minimize noise and allow for better experimental control, although possibly at the cost of reduced sample diversity. Additionally, it should include behavioral follow-up data or at least measures of intention strength to better distinguish between short-term emotional coping and meaningful behavioral commitment while also taking the sample characteristics more into consideration.

In conclusion, this study supports the role of WMC as a moderator in the effectiveness of persuasive health messages, especially in the context of EMi. The distinct impact of FWspan and BWspan shows that persuasion doesn't only depend on a message's content but also on individual cognitive resources and regulatory mechanisms, and can be further shaped by EMi. Conclusively, the current findings emphasize the importance of taking individual cognitive capacities into account when designing health interventions. Further research could help develop cognitively adapted health communication strategies that offer a higher chance for behavior change.

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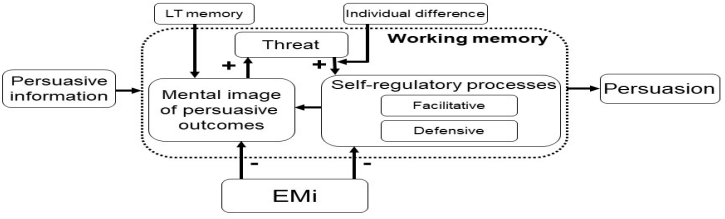
Appendix A

Figure 1

The Working Meomory Approach of Persuasion



Appendix B

Dutch (Original)

Wat je eet, heeft invloed op hoe gezond je bent. Vooral het eten van onvoldoende groente en fruit draagt bij aan een slechte gezondheid. Dit blijkt uit een onderzoek van de Universiteit van Maastricht in 2007. Een voedingspatroon met te weinig groente en fruit bevat onvoldoende vitamines en mineralen. Dit leidt tot een hogere bloeddruk en een hoger cholesterolgehalte. Het eten van onvoldoende groente en fruit vergroot zo de kans op hart- en vaatziekten. Daarnaast leidt het tot een slechtere conditie. Iemand die te weinig groente en fruit eet, krijgt namelijk onvoldoende antioxidanten binnen, zoals bètacaroteen, vitamine C en vitamine E. Deze stoffen spelen een belangrijke rol bij processen waarbij zuurstof wordt verbruikt, zoals lichamelijke inspanning. Verder blijkt uit wetenschappelijk onderzoek dat een tekort aan groente en fruit leidt tot een grotere kans op kanker. Dat komt onder andere doordat antioxidanten de werking van de zogenaamde vrije radicalen niet tegengaan. Dit is ook de reden waarom mensen er minder gezond uitzien als ze onvoldoende groente en fruit eten. Meer vrije radicalen betekent meer veroudering, en dus een ongezonde huid en ongezonder

haar. Deze effecten van groente en fruit zijn onafhankelijk van erfelijkheid en omgevingsfactoren.

English version

What you eat influences how healthy you are. In particular, eating insufficient amounts of vegetables and fruit contributes to poor health. This was demonstrated in a study by Maastricht University in 2007. A diet with too few vegetables and fruits contains insufficient vitamins and minerals. This leads to higher blood pressure and higher cholesterol levels. Eating too few vegetables and fruits, therefore, increases the risk of cardiovascular diseases. Additionally, it leads to poorer physical fitness. Someone who eats too little fruit and vegetables does not consume enough antioxidants, such as beta-carotene, vitamin C, and vitamin E. These substances play an important role in processes where oxygen is used, such as physical activity. Furthermore, scientific research shows that a lack of vegetables and fruit increases the risk of cancer. This is partly because antioxidants do not counteract the effects of so-called free radicals. This is also the reason why people appear less healthy if they do not eat enough vegetables and fruit. More free radicals mean more aging, resulting in unhealthy skin and hair. These effects of vegetables and fruit are independent of hereditary and environmental factors.

Appendix C

Figure C1

P-P plot of standardized residuals for post-intention scores

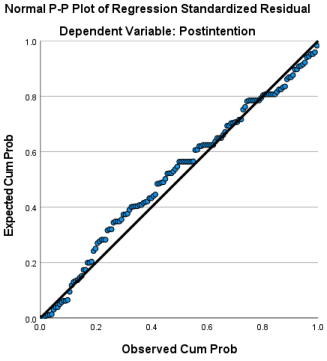


Figure C2
P-P plot of standardized residuals for emotion scores

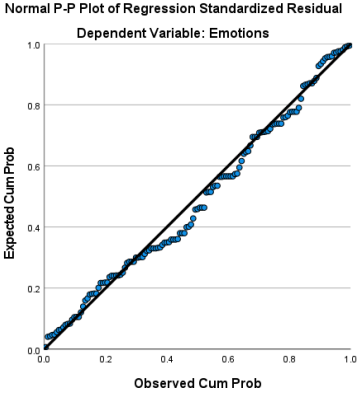
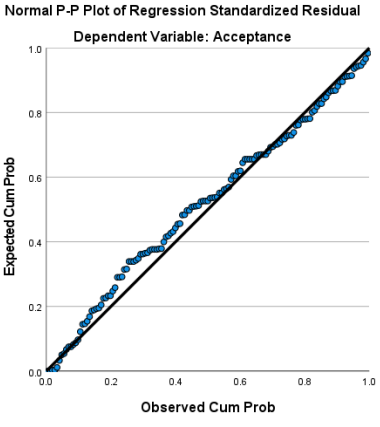


Figure C3
P-P plot of standardized residuals for message acceptance scores


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Acceptance
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0