ABSTRACT

Title of Thesis: EFFECTS OF REGULATORY MODE ON ORDER EFFECTS IN HEALTH INFORMATION PROCESSING

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The present research examined the influence of individuals' motivational tendencies, specifically, *regulatory mode* (Kruglanski et al., 2000), on information processing and the presence of *order effects* when recalling a given set of information (i.e. primacy/ recency effects, Murdock, 1962). Three studies investigated the effects of regulatory mode on attention and order effects using a free recall paradigm with both general and health information. Mediating variables included attention measured using eye tracking methods (Study 1) and willingness to search memory measured in time spent retrieving items for each list (Studies 1 & 2). Situational effects were also considered (Study 3, the moderating role of treatment information severity). The results generally did not support the hypotheses related to regulatory mode and order effects. Potential explanations, including considerations for theory and/or study design are discussed along with implications for future research directions.

EFFECTS OF REGULATORY MODE ON ORDER EFFECTS IN HEALTH INFORMATION PROCESSING

by

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Introduction

Individuals are constantly exposed to influxes of information in their daily lives which they must interpret and apply to subsequent decisions. This process, which is a focus of judgment and decision making (JDM) research, reveals that not all information is processed to the same extent due to a variety of motivational and cognitive tendencies that influence evaluative thinking (Baron, 2004). Understanding the influence of these tendencies in information processing is an important goal of JDM research across academic fields (e.g. behavioral economics, psychology, decision science, and consumer research) and applied settings (e.g. health decisions, voting behavior, and retirement savings choices) (Over, 2004).

Cognitive tendencies are often referred to as “cognitive biases” if they systematically influence judgments to deviate from an accepted norm or standard (Kruglanski & Ajzen, 1983). Although they have long been studied in the field of JDM, researchers have frequently debated how best to conceptualize their nature (Weber & Johnson, 2009). Whereas early researchers described certain cognitive biases as errors in human thought that deviated from normative thinking (Tversky & Kahneman, 1974), later researchers suggested that these biases may actually be adaptive to making quick decisions under constraints of finite time, attention, and computational processing capacities (Gigerenzer, 2001). Although these perspectives differ in their classification of cognitive biases, both perspectives recognize the influence of cognitive biases on individuals’ information processing and decisions. More recently, researchers have suggested connecting JDM research on cognitive biases to research on social psychology and motivation (Weber & Johnson, 2009).

Much of JDM work has focused on cognitive descriptions of why biases occur (e.g. memory retrieval and/or attentional processes, Dougherty, Franco-Watkins, & Thomas, 2008; Carmon & Ariely, 2000) as well as the effects of biases on decision outcomes (e.g. preferences in financial markets, Hilton, 2003). However, there is still a need to better understand the motivational aspects that influence the extent of information processing and when biasing heuristics are likely to be applied (Kruglanski & Gigerenzer, 2011).

The present research examines the motivational influence of regulatory mode (Kruglanski et al., 2000), on cognitive biases in information processing, specifically the order effect bias in recalling a given set of information (i.e. primacy/recency effects, Murdock, 1962).

The following sections review relevant literature related to information processing and motivated decision strategies, with a focus on the role of regulatory mode, attention, and willingness to search memory in generating the order effect bias (both in general and health information domains). Next, a set of hypotheses are presented followed by the results from three studies conducted to empirically test these predictions. The paper concludes with a discussion of potential implications from this research and future directions for continued study.

Review of the Literature

Information processing as motivated decision strategies

Early research, made famous by Tversky and Kahneman's (1974) work on heuristics and biases, described information processing heuristics and their subsequent biases as errors in judgment which often result in failures of the human mind to think rationally. From this perspective, individuals are passively subject to errors in otherwise rational decision making. By contrast, later research, such as Gigerenzer's (2001) "adaptive toolbox" suggests that heuristics may often serve adaptive functions, especially in real-world situations where humans use heuristics to navigate their environments and achieve proximal goals in the face of limited time, knowledge, and processing capabilities. In these models, individuals actively select information processing strategies (at either a conscious or unconscious level) based on situational factors (Fiedler & von Sydow, 2015). For example, a selected strategy might result in a cognitive bias, such as choosing information that is more easily retrievable or recognized, but may help serve other goals (e.g. to conserve cognitive efforts in decision processes, see Shah & Oppenheimer, 2008). In either outcome, individuals' motivation is a driving factor in the JDM process.

Regulatory mode and information processing

In the field of motivation and goal pursuit, *regulatory mode theory*, describes two essential dimensions of self-regulation, *locomotion* and *assessment*, that have previously demonstrated effects on strategic preferences in decision making (Kruglanski et al., 2000; Avnet & Higgins, 2003). These two dimensions motivate behavior toward goal pursuit as chronic personality dispositions or situationally induced states. Whereas the assessment mode is comprised of the motivation to critically evaluate one's current situation, including careful consideration of information, goals, and means, the locomotion mode is comprised of the motivation to move from state to state in a straightforward and direct manner to make progress toward one's goals (Kruglanski et al., 2000).

Previous literature has connected regulatory mode to information processing through its effect on error detection in individual proofreading tasks (Kruglanski et al., 2000) and on favoring accuracy versus speed in group decision tasks (Mauro, Pierro, Higgins, & Kruglanski, 2009). Assessment positively predicted individuals' detection of errors in a given passage and was associated with slower, but more accurate decisions in a group task due to a greater extent of information sharing. Alternatively, locomotion did not predict the number of spotted errors in the individual proofreading task and was associated with less accurate decisions in the group task, due to consideration of fewer pieces of information.

Relatedly, evidence suggests individuals with locomotion concerns prefer decision strategies that favor progress (resulting in prioritization of speed over accuracy), whereas individuals with assessment concerns prefer decision strategies that favor thoroughness (resulting in prioritization of accuracy over speed) (Molden, 2012). These preferred strategies were also reflected in post-decisional satisfaction (Avnet & Higgins, 2003). Participants with locomotion concerns reported greater satisfaction with decisions when they used progressive elimination (i.e. comparing alternatives on one dimension and progressively eliminating the worst alternatives on that dimension) rather than exhaustive comparisons (i.e. simultaneously comparing all alternatives on all dimensions before selecting a choice). By contrast, participants with assessment concerns reported greater satisfaction when they used exhaustive comparisons.

Taken together, these findings suggest that regulatory mode should influence the use of heuristics and biases if the heuristics and biases align with their preferred decision strategies. To the extent that heuristics in general provide feelings of faster progress, the need to consider fewer pieces of information and increased movement through judgment and decisionmaking tasks, these strategies should be particularly desirable for individuals with locomotion concerns. However, since faster movement and consideration of fewer pieces of information may conflict with full, accurate and exhaustive comparisons of information, the use of heuristics and subsequent biases may be particularly undesirable for individuals with assessment concerns.

Potential overlap with other motivational constructs. In describing the proposed relationship between locomotion and heuristics, it is important to address concerns of potential overlap with another motivational tendency, need for cognitive closure ("NFC;" see Webster & Kruglanski, 1994). Previous studies indicate that NFC, defined as the desire for a definite answer to a question and aversion to ambiguity, can motivate heuristic processes where individuals "seize" and "freeze" on certain pieces of information to maintain certainty (Kruglanski & Webster, 1996). For example, when asked to evaluate a social target based on a given a set of contrasting characteristics, high NFC participants demonstrated greater influence from the first set of information than low NFC participants (Freund, Kruglanski, &

Schpitzajzen, 1985). Once individuals considered certain characteristics about the social target, the inconsistent information that followed threatened their levels of certainty and was not processed to the same degree.

At first, it may seem that high NFC and high locomotion are both associated with less exhaustive information processing, however the underlying motivations are separate and distinct. Whereas high NFC individuals are motivated to make quick judgments to minimize uncertainty, high locomotion individuals prefer to move quickly as it allows more time for movement and feelings of progress. Locomotion does not include a motivation to reduce uncertainty, and in fact, high locomotion individuals are comfortable with times of uncertainty and value change because it allows movement, whereas high NFC individuals are often threatened by change since it introduces uncertainty (Kruglanski et al., 2007). These distinctions suggest that NFC and locomotion are indeed conceptually and empirically different and studies on heuristics and cognitive biases should examine the underlying mechanisms of both motivational constructs.

Order effects (primacy and recency effects)

When presented with lists of items, individuals often demonstrate elevated memory for items presented earliest (primacy effects) and latest (recency effects) in the set of information (Morrison, Conway, & Chein, 2014). In psychological research, order effects or "serial position" effects, were observed as early as the 1960's, when researchers began using a free-recall paradigm of presenting lists of words to participants and asking them to freely recall them either written or verbally (Murdock, 1962; Postman & Phillips, 1965; Glanzer & Cunitz, 1966).

Suggested mechanisms in order effects. Order effects are often attributed to memory models, attention-based models, or a combination of both. Some memory models suggest that (i) primacy effects occur because early items are encoded and rehearsed to a greater degree and are subject to less interference from previous items; and that (ii) recency effects occur because they are still accessible from memory, less influenced by decay and subject to less interference from subsequent items (Oberauer, 2003; Wixted & Ebbesen, 1991). Alternatively, attention-based models suggest that attention determines recall, both in the beginning of the list and the end of the list. For primacy, researchers suggest that greater attention is paid to early items in a list and the strength of attention declines as the list of items progresses (Brown, Preece, & Hulme, 2000). For recency, evidence using event-related brain potential (ERP) demonstrated increased neural activity for both early *and* late items (Azizian & Polich, 2007). Additional analyses revealed that participants sensed the end of the list, therefore the authors suggested that certain temporal cues can reactivate attention and produce recency effects.

However, from the combined perspective, it may be that memory and attention processes work together during recall tasks. For example, research measuring neural activity through scalp electroencephalogram (EEG) during a free-recall task found that full attention allowed for stronger encoding in memory, whereas divided attention results in larger primacy effects (Sederberg et al., 2006). Though it is debated whether memory versus attention contribute more heavily to order effects, the role of attention can be observed in both perspectives.

Order effect, attention and regulatory mode. Given that individuals' motivation often influences how they direct their attention when processing information (Molden & Higgins, 2004), attention should be relevant when applying regulatory mode to order effects.

Attention is comprised of two main components: the focus or concentration on specific stimuli or information (Ruff & Rothbart, 1996) and selectively attending to stimuli while ignoring other potential distractions (Anderson, 2005). Since assessment involves careful and exhaustive consideration of information, high (versus low) assessment should predict greater attention to a full set of information resulting in lower susceptibility to order effects. By contrast, locomotion is often associated with less attention to detail and consideration of fewer pieces of information, therefore high (versus low) locomotion should result in paying less attention to a full set of information and greater susceptibility to order effects.

Second, selective attention to stimuli while ignoring distractions likely relates to locomotion. Locomotion involves concerns for forward movement through tasks, therefore upcoming tasks may serve as a distraction. Consequently, high (versus low) locomotion should be associated with less focused attention during a given task due to the potential distraction from upcoming tasks. This prediction is further supported by evidence that locomotion is associated with preferences for multitasking (i.e. dividing attention among multiple tasks), as it allows individuals to perceive increased movement across simultaneous tasks (Pierro et al., 2013).

Order effects, regulatory mode and willingness to search memory. Finally, participants' willingness to search their memories when recalling information should be considered, especially during recall tasks with open-ended retrieval times (i.e. participants press a button when they finish retrieving items rather than a fixed retrieval time). Given that open-ended retrieval allows participants to choose the time and effort they spend recalling items before moving to the next list, motivational tendencies should likely influence the decision to terminate memory search. For example, participants' decisiveness was negatively associated with the length of time they spent retrieving during the recall task (Dougherty & Harbison, 2007).

Drawing on these findings related to motivation, it is likely that regulatory mode should also influence memory search and order effects. Output order during free-recall often begins with items from the beginning or end of the list (Bhatarah, Ward & Tan, 2008), therefore longer retrieval times should increase the probability that items are also being retrieved from the middle of the list. Since locomotion concerns are focused on movement, high locomotion individuals should choose to spend less time retrieving words allowing for faster movement through the task. By contrast, assessment concerns prioritize accuracy over speed, therefore high assessment individuals should be more willing to continue memory search in efforts to recall an exhaustive list of items. Consequently, greater overall time spent retrieving should increase the likelihood of recalling middle words and should decrease the likelihood of demonstrating order effects.

Drawing on both perspectives above (i.e. attention and retrieval time), regulatory mode should influence both the information processing phase (i.e. careful consideration of all pieces of information), as well as the recall phase (i.e. participants' willingness to continue searching their memory during the retrieval process). Therefore, together, both attention and retrieval time suggest a relationship between regulatory mode and order effects. For assessment, greater attention paid to the full list of information should decrease likelihood of order effects (both primacy and recency), given that equal attention should be paid to each item in the list. Furthermore, as noted above relating to output order and retrieval time, longer retrieval times should increase the probability that items are being retrieved from the middle of the list. By contrast, for locomotion, stronger attention should be paid to the early items in the list before attention shifts due to distraction from the upcoming task. As a result, locomotion should be associated with primacy effects due to attention mechanisms. Concerning recency effects, individuals high in locomotion should prefer to move quickly through the retrieval phase and their quick movement into recalling words should reduce delay between the presentation of later words and their recall. Consequently, given that recency effects are progressively reduced as a function of time (Postman & Philips, 1965), locomotion should be related to greater primacy effects through attention and greater recency effects due to shorter delay before retrieval.

Order effects in the health context. Just as evidence in psychology demonstrates individuals' order effect biases when recalling general lists of information, evidence from health decisionmaking studies reveal both primacy and recency effects in health treatment information (Blumenthal-Barby & Krieger, 2015; Ley, 1972; Ubel, 2010). For example, participants presented with a series of medical statements were more likely to remember the earlier statements than the later statements (Ley, 1972). Alternatively, women given information about the risks and benefits of taking a specific medication, tamoxifen, viewed the medication more favorably when the information ended with benefits rather than risks (i.e. women attributed more weight to the information presented at the end of the information) (Ubel, 2010).

Additional studies in the health context suggest that more careful and systematic consideration of a given set of treatment information is associated with less order effect biases (Bergus, Levin, & Elstein, 2002) which is aligned with regulatory mode predictions for a general set of information. Just as in the general recall of information, individuals with high assessment (versus low assessment) should be less likely to demonstrate order effect biases in health information recall due to their tendency for critical evaluation, whereas individuals with high locomotion (versus low locomotion) should be more likely to demonstrate order effect biases, due to their tendency to move quickly through the information processing stage.

Treatment severity/level of risk and order effects

Previous research indicates that order effects affect evaluations of treatments, but that it may differ based on the severity of treatment/level of overall risk (Bergus, Levin, & Elstein, 2002). For example, patients demonstrated order effects in evaluating low-risk aspirin therapy treatments, but not when evaluating high-risk surgical procedures, presumably because high-risk information causes patients to be more careful when reviewing the information resulting in more informed decisions. This evidence suggests that high risk procedures may be acting as a situational enhancement of the assessment mode. Therefore, in high-risk situations, where high assessment is situationally induced, there should be lesser demonstration of regulatory mode influence on order effects (due to a likely saturation, or ceiling effect). In contrast, in cases of low-risk information, differences in regulatory mode should be more pronounced. This might be particularly important for treatment decisions where the probability of risk is low, but the risk itself could be serious (e.g. patients may overlook risks of elective surgery if they perceive the treatment as low-risk, when in fact, the potential side effects could be very serious (e.g. death)).

Hypotheses and Overview of Studies

Hypotheses

Drawing from the literature review, the proposed hypotheses were investigated:

1. *Individuals with high (versus low) locomotion will be significantly more likely to demonstrate order effects (primacy and/or recency) in a set of information.*
2. *Individuals with high (versus low) assessment will be significantly less likely to demonstrate order effects (primacy and/or recency) in a set of information.*
3. *Individuals' attention during the presentation of information will mediate the relationship between locomotion and susceptibility to order effects. High (versus low) locomotion will be associated with less attention and greater susceptibility to order effects.*
4. *Individuals' attention during the presentation of information will mediate the relationship between assessment and susceptibility to order effects. High (versus low) assessment will be associated with greater attention and less susceptibility to order effects.*
5. *Individuals' time spent retrieving words will mediate the relationship between locomotion and susceptibility to order effects. High (versus low) locomotion will be associated with less time spent retrieving words and greater susceptibility to order effects.*
6. *Individuals' time spent retrieving words will mediate the relationship between assessment and susceptibility to order effects. High (versus low) assessment will*

be associated with greater time spent retrieving words and less susceptibility to order effects.

7. *Treatment severity will moderate the relationship between regulatory mode and susceptibility to order effects. For low-risk treatment information, individuals with high (versus low) locomotion will be significantly more likely to demonstrate order effects, whereas individuals with high (versus low) assessment will be significantly less likely to demonstrate order effects. These differences will not be present in high-risk information as the strength of the situation will cause all individuals to carefully attend to information and therefore be less susceptible to order effects (i.e. saturation, ceiling effects).*

<u>Overview of studies.</u>

In a set of three studies, participants' assessment and locomotion were measured using the Regulatory Mode scale. In Study 1, participants engaged in a open-ended retrieval free-recall task with high-frequency English words (see Dougherty & Harbison, 2007). Eye tracking software was used to measure "dwell time" on each word (established as an indicator of attention, Klein et al., 2015) along with time spent retrieving during recall. Study 1 was conducted in the UMD Motivated Cognition Laboratory.

Studies 2 and 3 were conducted with an online sample to increase generalizability as i) health information processing and decisions are often made outside of the laboratory setting and ii) because studies suggest that young adults (under 25 years of age) have significantly lower utilization of the health care system relative to adults 26 years of age and above (Institute of Medicine & National

Research Council, 2014). Study 2 replicated the free recall paradigm using a set of health statements. Study 3 examined the moderating effect of treatment severity using random assignment to a high or low-risk information condition. In all three studies, the dependent variable was participants' recall of information. Order effects were determined by more accurate recall of information presented at the beginning or end of the sequence.

Conscientiousness, impulsivity and NFC were included as control variables given their potential to influence attention and/or willingness to search memory (Kelley, 2001; Dougherty & Harbison, 2007). It was predicted that conscientiousness would be positively related to recall, impulsivity would be negatively related to recall, and there would be no relationship with NFC given competing possibilities (i.e. individuals with low accessibility of words would likely move on quickly to reduce times of uncertainty, whereas those with high accessibility might seek to recall all words for a sense of closure).

Study 1: Regulatory Mode Effects on General Information Processing

Study 1 Methods

Objective

Study 1 investigated order effects as predicted by regulatory mode, including mediators (attention and time spent retrieving words). Locomotion and assessment were measured using the 12-item locomotion and assessment scales. Attention was measured as dwell time on each word as measured by eye tracking using the *Tobii X60* Eye Tracking System. Willingness to search memory was operationalized as time spent recalling words during the recall period for each list measured in seconds. Order effects were established if serial position of the word within the list significantly predicted recall.

Participants

190 participants were recruited through the University of Maryland SONA system (with an over-recruitment of 30 participants to account for attrition in only completing the online session and not the in-person lab session and/or technical difficulties with the eye tracking software). The sample size was determined using a priori power analyses for mediation using a small-medium effect size (.26) and guidance from previous studies using multilevel multiple mediation analysis (Fritz & MacKinnon, 2007; Schein, Ritter, & Gray, 2016).

The final sample of participants who attended both sessions, met the inclusion criteria (aged 18 years and older and native English speaking), and passed attention checks in the online survey was 161 participants (122 females; mean age of 20.93 years, *SD*=5.06).

Participants were recruited from both the credit SONA and the paid SONA systems and were provided with class credit or monetary compensation ($10/hour) for their participation.

Materials and Procedure

One week prior to attending their lab session, participants completed an online survey including the 12-item assessment and locomotion regulatory mode scales (Kruglanski et al., 2000), as well as control variables (i.e. *Need for Closure* (Need for Closure scale, Webster & Kruglanski, 1994), *impulsivity* (Barratt Impulsiveness Scale, BIS-11; Patton, Stanford & Barratt, 1995), and *conscientiousness* (Ten Item Personality Measure, Gosling, Rentfrow, & Swann, 2003)). Participants also completed demographic questions.

One week after completing their online survey, participants visited the University of Maryland Motivated Cognition Laboratory. Participants were instructed that they would complete two tasks (i.e. a recall task and a visual processing task), were given a practice list, and then began the recall task.

The presentation of stimuli was based on previous studies using a basic free-recall paradigm (Murdock, 1962; Azizian & Polich, 2007; Dougherty & Harbison, 2007). Participants were presented with 13 lists of 12 common English words (as determined by high frequency use, see Kučera and Francis, 1967). This number of lists was based on previous eye tracking studies (Dougherty & Harbison, 2007) as well as pilot studies ensuring that the task would not lead to excessive fatigue. The words were randomly ordered across the entire set of stimuli (156 words in total), such that any word could appear on any list and no words systemically occurred together. Each word was presented at the center of the screen for 1 second with 3 second intervals in between each word and short rest periods between lists.

Following the presentation of each list, participants were asked to freely recall as many words as possible from the list in any order. After they finished retrieving as many words as they could recall, they pressed a button to finish retrieval and moved on to the next list.

Measures for attention and time spent searching memory

Tobii X60 eye tracking equipment and software were used to measure dwell time on each word, a previously established indicator of attention (Klein et al., 2015). Areas of interest were applied to each word and dwell time was captured as percentage of gaze time within the area of interest. Time spent searching memory was measured as the total time in seconds that participants spent recalling each list.

Control variable for memory ability/working memory

Following the recall task, participants completed the counting span task as a measure of working memory used as a control variable in prior studies related to memory and recall (Kane et al., 2004; Dougherty & Harbison, 2007). Participants were then debriefed and informed there was only one task, asked about strategies they used to recall the words, and provided with compensation.

Study 1 Results

Previous studies analyzing serial position curves determine that the presence of a significant quadratic trend indicates order effects in recall (Oberauer, 2003) (see Figure 1).

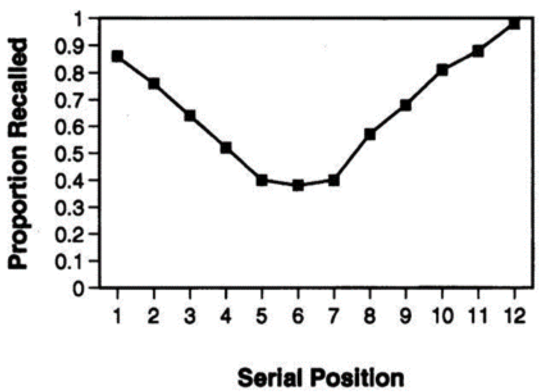

Figure 1. Sample Serial Position Curve (Roediger & McDermott, 1995)

Analysis Approach

A series of generalized mixed-level model using the logit link function (GLMM) analyses were conducted using R statistical software (LMe4 package, Bates, Mächler. Bolker & Walker, 2015) to predict likelihood of recall based on serial position and regulatory mode. The use of GLMM allowed for specification of random effects and repeated measures (e.g. recall and attention of word repeated within participant). For a variable list and corresponding levels of analysis, see Table 1.

Variable	Level (Participant, List, Word)	Level No. (1, 2, 3)
Locomotion	Participant	3
Assessment	Participant	3
Control Variables *	Participant	3
Time Spent Recalling (per list)	List	2
Serial Position of Word**	Word	1
Attention	Word	1
Recall	Word	1

**Control variables include working memory, conscientiousness, impulsivity and Need for Closure*
***Models included a variable for serial position^2 to allow testing for the presence of quadratic trend*

Table 1. List of variables and corresponding level of analysis

Justification for use of GLMM. As an initial step, the unconditional means model (including a fixed effect for the intercept term and random effects for participants) was compared to a model without random intercepts for participants. Model comparisons revealed the model including random effects for participant had significantly lower -2loglinear deviation ($p<.001$), thereby suggesting significant between-group variance and justifying the use of GLMM.

Subsequent model comparisons were run to assess the random effects of lists (level 2) and word stimuli (level 1) (per recommendations from Judd, Westfall & Kenny, 2012). The inclusion of random intercepts for lists did not significantly improve model fit, yet random intercepts for words did improve model fit ($p<.001$). As a result, each analysis included random intercepts for both participant and word. Additionally, model comparisons revealed improved fit ($p<.001$) using both random intercepts and random slopes for serial position and serial position^2.

Overall, a sequence of commonly used multilevel model building techniques were conducted (see Bliese, 2013) beginning with the unconditional means model

(Model 1), control variable effects (Model 2), demonstration of serial position of word and serial position of word^2 (order effects) (Model 3), and the full model testing the main hypotheses of regulatory mode and order effects (Model 4) (see *Table 2. Study 1, Multilevel Analyses*). The sections below are organized in this sequence (beginning with Model 2, control variable effects).

	Model 1			**Model 2**			**Model 3**			**Model 4**		
	b	SE	*p*	b	SE	*p*	b	SE	*p*	b	SE	*p*
Fixed Effects												
Intercept	.00005	.054	.999	.00007	.053	.999	2.02	.101	<.001**	2.03	.101	<.001**
Control Variables												
Working Memory				.054	.022	.014`	.064	.024	.008**	.065	.024	.007**
Impulsivity				-.395	-.395	.004*	-.447	.147	.002**	-.043	.150	.004**
Conscientiousness				.094	.037	.012`	-.111	.040	.006**	-.012	.042	.004**
Need for Closure				.045	.097	.641	-.030	.105	.778	-.032	.106	.762
Ser Position Task[a]				-.0013	.0003	<.001**	-.001	.0003	.038’	-.0006	.0003	.038’
Order Effects												
Ser Position							-.618	.025	<.001**	-.616	.025	<.001**
Ser Position^2 (SP^2)							.037	.002	<.001**	.037	.002	<.001**
Regulatory Mode												
Locomotion										.067	.012	.589
Assessment										.523	.013	.676
Locomotion*SP										-.0017	.033	.957
Assessment*SP										-.0237	.034	.486
Locomotion*SP^2										-.0002	.002	.991
Assessment*SP^2										.002	.002	.399
Random Effects												
Word	.232	.482	-	.207	.455	-	.250	.500	-	.250	.500	-
Participant	.207	.455	-	.208	.456	-	.868	.931	-	.867	.930	-
Ser Position[b]			-			-	.045	.213	-	.045	.211	-
Ser Position^2 [b]			-			-	.0002	.014	-	.0002	.014	-

[a]*Ser Pos Task represents overall position in the task to control for potential depletion effects over the course of the task*
[b]*Random effects for intercepts,* [c]*Random effects for slopes and intercepts, Note: p<.05`, p<.01*, p<.001***

Table 2. Study 1, Multilevel Analyses

Control variable effects (working memory, conscientiousness, impulsivity and Need for Closure)

Working memory, conscientiousness, impulsivity and Need for Closure were modeled as fixed factors, with participant’s intercept and the intercept for word modeled as random factors. Additionally, overall position was modeled as a fixed factor to control for potential depletion effects over the course of the task. All predictors were grand mean centered.

Working memory positively and significant predicted recall, whereas impulsivity, conscientiousness and overall serial position within the task negatively and significantly predicted recall. Need for Closure was not a significant predictor of recall (see *Table 2* for beta coefficients, standard errors and significance values). For a table of bivariate correlations for this model, along with subsequent models, please see *Appendix A*.

Presence of order effects (serial position of word within list)

Next, to test for order effects in participants' recall of each word in the list, serial position of word and serial position of word^2 were added to the model as fixed factors (along with control variables). Participants' intercept and the intercept for word as well as slopes for serial position and serial position^2 were modeled as random factors. Per guidance from Olson, Romani & Caramazza (2010), serial position in the list was not transformed to aid in interpretation of order effects data and log-likelihood values were compared for the raw and rescaled variables. The values were indeed the same, therefore the raw values for serial position were used to aid in interpretation and visual inspection of the plots.

Both serial position and serial position^2 significantly predicted recall ($b= -.618$, $SE=.025$, $p<.001$ and $b= .037$, $SE=.002$, $p<.001$). The negative value of serial position indicated that as the serial position of each word initially increased within each list (across 12 words), the likelihood of recall decreased. However, the positive value for the quadratic term indicated that as serial position increased, the degree of curvature decreased, indicating a significant "u-shape" of recall. Probability of recall was greatest for the early items in the list, decreased for items in the middle and began to increase again for the later items.

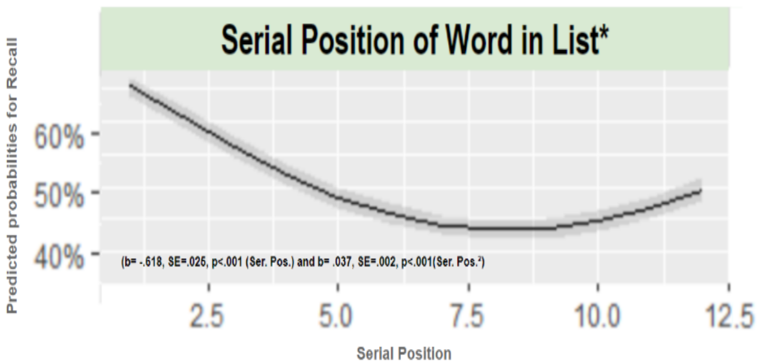

Figure 2. Study 1, Presence of order effects (probability of recall based on serial position)

Hypotheses testing, order effects predicted by regulatory mode

After establishing a significant quadratic trend (Model 3), the analysis tested the main hypotheses that locomotion and assessment would increase or decrease order effects (i.e. the degree of curvature in the quadratic trend). Specifically, the analysis tested for significant interaction effects between locomotion and serial position^2 (a positive sign) and between assessment and serial position^2 (a negative sign). The interactions between locomotion and serial position and between assessment and serial position were also included in the model. Serial position of word, serial position of word^2, participants' locomotion and assessment were modeled as fixed factors, with participant's intercept and intercept for word, as well as slopes for serial position and serial position^2 modeled as random factors. The control variables were also included as fixed factors.

The interactions between locomotion and serial position of word^2 and between assessment and serial position of word^2 were not significant (b=-.0002, SE=.002, p=.991 and b= 0.002, SE= 0.002, p=.399). The nonsignificant results for these interactions suggest that locomotion and assessment did not influence participants' demonstration of order effects. Given these nonsignificant results, a simple slopes analysis to examine the interactions was not conducted. The model was also run without control variables and the results remained nonsignificant.

Hypotheses testing, mediation analysis (attention and time spent retrieving)

For the attention mediation analysis, a secondary dataset was used to select for participants with high quality eye tracking data. Based on criteria identified in previous eye tracking studies (Komogortsev et al., 2010; Holmqvist et al., 2012), participants were included in the analysis if they had an invalid data percentage of less than 20%. Invalid data included responses in which 20% of recorded zeroes were matched with accurate recall thereby indicating poor calibration or capturing by the tracker. The final sample of high quality data used for the attention analysis included 105 participants (i.e. 65% high quality eye tracking data from the full dataset). This percentage of data loss (35%) is in the range of previously reported data loss due to eye tracking calibration/tracking issues which can vary from 20-60% of collected data (Holmqvist et al 2012).

Attention analysis. A series of multilevel regressions tested the pathways between regulatory mode, serial position^2 and recall with and without attention included in the models (per guidance from Preacher, Rucker, & Hayes, 2007). The Monte Carlo Method was used to test for indirect effects (see Preacher & Selig, 2012).

The interaction terms of locomotion*serial position^2 and assessment*serial position^2 (order effects by locomotion and assessment, respectively) were included as predictor variables. The direct effects for order effects by locomotion and order effects by assessment on recall (without attention) were nonsignificant (b=-.0002, SE=.002, p=.991 and b= 0.002, SE= 0.002, p=.399), along with the effect of order effects by locomotion and order effects by assessment on attention (b= -.0002, SE=.0004, p=.714 and b=-.0001, SE=.0005, p=.754). Although the effect of attention on recall was significant (b= .325, SE=.051, p<.001), the indirect effect of order effects by locomotion on recall through attention and order effects by assessment on recall through attention were both nonsignificant, 95% CI [-.000328,.000192], [-.000367,.000289].

Time Spent Retrieving. The interaction terms of locomotion*serial position^2 and assessment *serial position^2 (order effects by locomotion and assessment, respectively) were included as predictor variables. The direct effects for order effects by locomotion and order effects by assessment on recall (without time spent retrieving) were nonsignificant (b=-.0002, SE=.002, p=.991 and b= 0.002, SE= 0.002, p=.399), along with the effect of order effects by locomotion and order effects by assessment on time spent retrieving (b= .00009, SE=.0065, p=.990 and b= -.00017, SE=.0068, p=.980) and the effect of time spent retrieving on recall (b=-.0017, SE= .0016, p=.297). The indirect effect of order effects by locomotion on recall through attention and order effects by assessment on recall through attention were both nonsignificant, 95% CI [-.000034, .0000376], [-.0000334,.0000347].

Study 1 Discussion

Setting up an appropriate test of the hypotheses (serial position and control variables)

Overall, Study 1 seemed to provide an appropriate test of hypotheses, given the demonstration of serial position effects which were observed as significant and in the predicted directions (i.e. the negative serial position term and the positive quadratic term indicated a significant "u-shape" of recall). Furthermore, for the control variables, the analysis supported three of the four hypotheses (i.e. working memory positively predicted recall, impulsivity negatively predicted recall and NFC had no relationship with recall). The negative relationship between conscientiousness and recall was unexpected, but may have been due to relatively low reliability of the measure (α=.583). Finally, higher attention resulted in higher probabilities of recall. Together, these findings suggest the study design provided an appropriate test of the regulatory mode hypotheses.

Potential explanations regarding regulatory mode predictions

The hypotheses related to regulatory mode and order effects were not supported by the results from Study 1. There could be several explanations for these unexpected results. Specifically, potential explanations include elements of locomotion, assessment and study design (addressed below).

Locomotion. The proposed hypotheses for locomotion were based on previous findings that high locomotors would pay less attention in the task and would spend less time recalling words given findings on their poor attention to detail and preference for movement forward. However, additional aspects of locomotion may have contributed to the null findings. There is some evidence that locomotion is negatively associated with impulsivity (Shalev & Sulkowski, 2009) and positively associated with self-control (Struk, Scholer, & Danckert, 2015). In support of these findings, the present study did indeed reveal a negative and significant correlation between locomotion and impulsivity ($r(159)=-.414$, $p<.001$). Therefore, given that impulsivity was a negative predictor of recall, and impulsivity and locomotion were inversely related, perhaps there were some elements of locomotion that were positively related to recall. It may be that at times, the relationship between locomotion and self-control sustained attention, while at other times, attention was reduced due to the preference for movement. Taken together, this could have resulted in the null relationship.

Assessment. The proposed hypotheses for assessment were based on supporting literature that high assessors would carefully attend to information and their accuracy concerns would motivate willingness to recall items. However, it may be that assessors' tendency for "thinking" negatively affected recall. Additional analyses of one of the impulsivity subscales, "cognitive instability," revealed a positive and significant correlation with assessment ($r(159)=.256$, $p=.001$). Items in this scale include: "I have "racing" thoughts," "I often have extraneous thoughts when thinking" and "I change hobbies." Presumably, the items related to thinking explain why assessment would be positively related to cognitive instability and it may be that overthinking is distracting and negatively impacts recall. However, assessment was only moderately correlated with cognitive instability, which might explain why assessment was not also a negative and significant predictor of recall (as observed with cognitive instability). Perhaps high assessors' overthinking and attention to distracting thoughts canceled out some of the predicted effects of paying careful attention to the stimuli, resulting in a null relationship.

Relatedly, the possibility that high assessors engaged in overthinking during the recall task could be supported by high assessors' tendency to engage in self-comparison and rumination (Pierro et al., 2012), especially if they were concerned about their performance. Anecdotally, a number of participants spontaneously mentioned the difficulty of the task, that they didn't think they did well, and/or they asked the average number of words recalled by others. These statements suggest that some participants did indeed engage in self-comparison or self-evaluation of their performance on the task.

Study design. There may also be study design explanations relating to the locomotion findings. Given that high locomotors prefer multitasking, it was hypothesized that locomotors might multitask during the study (e.g. use a cellphone) which would reduce attention to the stimuli (Pierro et al., 2013). However, it is possible that participants' expectations of the laboratory environment (a strong situation) made them less likely to multitask in the lab than they would in natural environments. Additionally, perhaps the presentation of information in the free-recall paradigm unintentionally influenced attention. It is possible that seeing a different word each second may have signaled movement to high locomotors and sustained their attention. Future studies might consider presenting information in a more static manner.

Study 2: Regulatory Mode Effects on Health Information Processing

Study 2 Methods

Objective

Study 2 examined the predictions from Study 1, but in a health context. Rather than being asked to recall common English words, participants were presented with and asked to recall short health information statements about health treatments. Locomotion, assessment, time spent retrieving and order effects were measured as outlined in Study 1. Attention was not measured as the study was conducted online without the eye tracker.

Participants

163 adult participants from the United States were recruited through the online survey service, Amazon Mechanical Turk (sample size was estimated using a power analysis as described in Study 1). Participants were compensated $2.00 for their participation.

Given the online platform, pilot testing was conducted to determine if the platform would provide variance in recall and to test the inclusion settings that would provide higher quality data (e.g. participants' account approval ratings). Instructions were also piloted to discourage copying and pasting items which was determined by inspecting the time spent between the first click and page submission. The pilot testing improved the data by increasing the passing of attention checks, improving the quality of the responses (i.e. reduction of blank or nonsensical responses), and reduced cheating (based on self-reported cheating and indicated by the timing analysis).

The final sample of participants who met the inclusion criteria, passed attention checks and did not indicate cheating in the self-report debrief question or the copying and pasting inspection included 122 participants (67 females; mean age of 40.44 years, *SD*=13.08).

Materials and Procedure

Participants first completed an online survey including the 12-item assessment and locomotion regulatory mode scales, as well as control variables (i.e. *Need for Closure*, (15-item NFC scale, Roets & Van Hiel, 2011), *impulsivity* (BIS-11), and *conscientiousness* (TIPI Big 5 (see Study 1)). Participants were then instructed that they would complete a series of tasks, completed a dot counting filler task, followed by the recall task.

The health statements included information about a given treatment (e.g. length of time, details about dosage/procedure), but did not specifically include risks and benefits to the patient since previous research demonstrates that risks and benefits may be processed differently (Lloyd, Hayes, Bell, & Naylor, 2001). The presentation of health statements closely followed the design for Study 1. However, since the information in Study 2 included multiple words per item, participants were provided with fewer lists of statements per list (i.e. 12 lists of 6 statements). Previous recall studies have demonstrated significant order effects of both primacy and recency with list lengths of six statements (Mack, Cinel, Davies, Harding & Ward, 2017), therefore it was predicted that the reduction in items per list would not affect the hypotheses.

Each statement was presented separately on the screen for 6 seconds (determined by pilot testing). The statements were randomly ordered across the entire set of stimuli (72 statements in total). For each list, participants were asked to freely recall (by typing in a given box) as many statements as possible from the list in any order using open-ended retrieval.

Measures for time spent retrieving and working memory

Time spent retrieving was measured as time in seconds that participants spent recalling words before moving to the next list. Participants finished by completing the online counting-span task and demographic items.

Study 2 Results

Analysis Approach

Analysis techniques were conducted as specified in Study 1 (i.e. GLMM analyses were run using R statistical software to predict the likelihood of recall based on serial position and regulatory mode), with the exception of the attention variable, which was not measured in this study.

As in Study 1, model comparisons between the unconditional means model and model without random intercepts justified the use of GLMM. Subsequent model comparisons also supported the use of random intercepts for stimuli (i.e. health statements) and random slopes for serial position and serial position^2. All other fixed and random factors were specified according to the Study 1 analyses. To determine recall, each statement was coded for main content of the statement. The coding scheme is supported by memory literature, specifically gist versus verbatim recall (Reyna & Brainerd, 1995) in which individuals can recall the key words of the sentence without recalling the entire statement verbatim.

Also as in Study 1, multilevel model building techniques were conducted beginning with the unconditional means model (Model 1), control variable effects (Model 2), demonstration of serial position of statement and serial position of statement^2 (order effects) (Model 3), and the full model testing the main hypotheses of regulatory mode and order effects (Model 4) (see *Table 3. Study 2, Multilevel Analyses*, below).

	Model 1			**Model 2**			**Model 3**			**Model 4**		
	b	SE	*p*	b	SE	*p*	b	SE	*p*	b	SE	*p*
Fixed Effects												
Intercept	.404	.122	.0009	.405	.119	.0006	1.08	.176	<.001**	1.06	.173	<.001**
Control Variables												
Working Memory				.547	.211	.010*	.568	.218	.009	.588	.211	.005
Impulsivity				-.648	.296	.028’	-.675	.304	.026	-.644	.294	.029
Conscientiousness				-.070	.092	.449	-.067	.095	.488	-.028	.104	.786
Need for Closure				-.135	.091	.137	-.139	.093	.139	-.190	.097	.049
Ser Position Task[a]				-.009	.001	<.001**	-.010	.001	<.001**	-.010	.001	<.001**
Order Effects												
Ser Position							-.548	.082	<.001**	-.546	.083	<.001**
Ser Position^2 (SP^2)							.083	.012	<.001**	.083	.012	<.001**
Regulatory Mode												
Locomotion										.096	.152	.535
Assessment										.231	.161	.151
Locomotion*SP										-.030	.077	.693
Assessment*SP										-.015	.083	.859
Locomotion*SP^2										.002	.011	.870
Assessment*SP^2										-.001	.012	.901
Random Effects												
Statement	.428	.654	-	.898	.947	-	.474	.688	-	.474	.689	-
Participant	1.02	1.01	-	.438	.6615	-	1.45	1.20	-	1.30	1.14	-
Ser Position[b]			-			-	.182	.426	-	.180	.425	-
Ser Position^2 [b]			-			-	.004	.065	-	.004	.065	-

[a]*Ser Pos Task represents overall position in the task to control for potential depletion effects over the course of the task*
[b]*Random effects for intercepts,* [c]*Random effects for slopes and intercepts, Note: p<.05`, p<.01*, p<.001***

Table 3. Study 2, Multilevel Analyses

Control variable effects

Control variables were added to the model as specified in Study 1. All predictors were grand mean centered. Working memory was a positive and significant predictor of recall (b=.547, SE=.211, p=.001). Impulsivity and overall serial position within the task were negative and significant predictors of recall (b= -.648 SE=.296, p=.028 and b=-.009, SE=.001, p<.001, respectively). Conscientiousness and Need for Closure were not significant predictors of recall (b=-.070, SE=.092, p=.449, and b=-.135, SE=.091, p=.137).

Presence of order effects (serial position of statement within list)

Serial position of statement and serial position of statement^2 (along with control variables) were examined to determine the presence of order effects. Serial position in the list was not transformed to aid in interpretation of order effects data and visual inspection of the plots.

Both serial position and serial position^2 were significant predictors of recall (b= -.548, SE=.082, p<.001 and b= .083, SE=.002, p<.001). Like in Study 1, the negative value of serial position and the positive value for the quadratic term indicated a significant “u-shape” of recall. Probability of recall was greatest for the early and late items in the list.

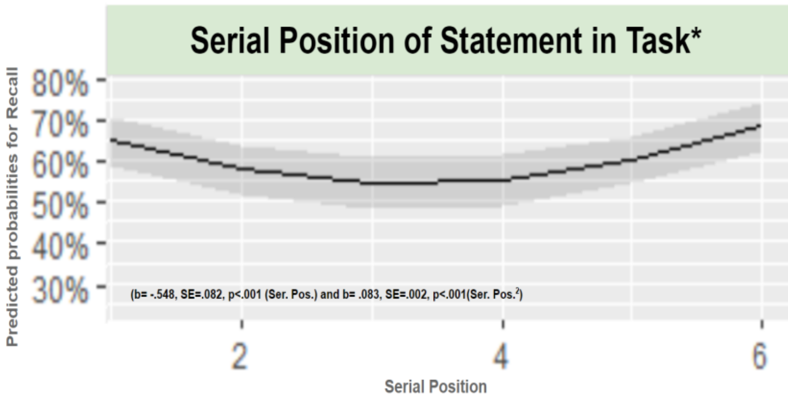

Figure 3. Study 2, Presence of order effects (probability of recall based on serial position)

Hypotheses testing, order effects predicted by regulatory mode

As in Study 1, after establishing a significant quadratic trend, the analysis tested the main hypotheses that locomotion and assessment would increase or decrease order effects (i.e. the degree of curvature in the quadratic trend). Specifically, the analysis tested for significant interaction effects between locomotion and serial position^2 (a positive sign) and between assessment and serial position^2 (a negative sign). The interactions between locomotion and serial position and between assessment and serial position were also included in the model. Serial position of word, serial position of word^2, participants' locomotion and assessment were modeled as fixed factors, with participant's intercept and intercept for word, as well as slopes for serial position and serial position^2 modeled as random factors. The control variables were also included as fixed factors.

The interactions between locomotion and serial position of word^2 and between assessment and serial position of word^2 were not significant ($b= .002$, $SE=.011$, $p=.870$ and $b= -.001$ $SE=.012$, $p=.901$). The nonsignificant results for these interactions suggest that locomotion and assessment did not influence participants' demonstration of order effects. The model was also run without control variables and the results remained nonsignificant.

Hypothesis testing, mediation analysis (time spent retrieving)

As in Study 1, a series of regression models were used to test for mediating effects of time spent retrieving on recall along with the Monte Carlo Method to test for indirect effects. The interaction terms of locomotion*serial position^2 and assessment *serial position^2 (order effects by locomotion and assessment, respectively) were included as predictor variables. The direct effects for order effects by locomotion and order effects by assessment on recall (without time spent retrieving) were nonsignificant (b= .002, SE=.011, p=.870 and b= -.001 SE=.012, p=.901), along with the effect of order effects by locomotion and order effects by assessment on time spent retrieving (b=.0041, SE=1.772, p=.9982 and b=-.0012, SE=1.864, p=.9995) and the effect of time spent retrieving on recall (b=-0.00011, SE=0.00012, p=.371). The indirect effect of order effects by locomotion on attention and order effects by assessment through attention were both nonsignificant [95% CI [-.0006395,.0006163], [-.0006736,.0006368].

<u>*Study 2 Discussion*</u>

Setting up an appropriate test of the hypotheses (serial position and control variables)

Similar to Study 1, the significant presence of order effects and influence of the control variables provide support that the study design provided an appropriate test for the hypotheses. The analysis supported three of the four hypotheses related to control variables (i.e. working memory, impulsivity, and Need for Closure). Also similar to Study 1, conscientiousness was not a significant predictor of recall, but once again, this may have resulted from the relatively low reliability of the measure (α=.607).

Addressing concerns with the online sample

Given the fact that Amazon Mechanical Turk workers are paid by task, there were initial concerns that they might rush through the study, not follow instructions or cheat during the study by writing down the statements. To address these concerns, extra efforts were taken to reduce these behaviors. First, attention checks were used throughout the survey to capture whether participants were carefully reviewing the information. Second, following the pilot, the instructions were worded to indicate that the research team would be reviewing the responses to make sure they were appropriate quality, that participants should not copy and paste or write statements down, and that they should not click out of the window while the statements were presented. Additionally, participants were only included if they had a 95% or higher approval rating on Mechanical Turk (rating determined by the number of approved assignments by requesters as satisfactory). In using these instructions and inclusion criteria, the quality of data improved as indicated by attention checks, by copy and pasting time analysis, and fewer participants reporting that they had cheated. Participants were told they would still get paid if they had cheated as an attempt to elicit honest answers.

These indicators suggest that the data is appropriate for analysis, however, there are limitations to this assumption. Since the study was online, we could not be sure that participants did not cheat and falsely report the behavior at the end of the survey. Second, a limitation of the online setting may be that Amazon Mechanical Turk workers may have clicked on the link and dropped out of the study if they perceived it to be too long or cognitively taxing. This may have resulted in a selection bias where the participants who remained in the study were systematically different from the general Mechanical Turk population. Indeed, some researchers have recently suggested Mechanical Turk samples often have high levels of participant attrition and that systematic dropouts, especially for cognitively taxing tasks, can result in misleading findings (Zhou & Fishbach, 2016). Future studies might consider comparing characteristics of participants that complete versus those that drop out of the study to confirm that there are not systematic differences between the two groups.

Study 3: The Moderating Effect of Treatment Severity in Health Information Processing

Study 3 Methods

Objective

Study 3 replicated methods from Study 2 in the health context but examined the effects of treatment severity on recall (i.e. high versus low situational strength). Participants were randomized to a high or low treatment severity condition (high versus low-risk) in which they read a short description about the treatments and were then presented with the health information statements and asked to recall them.

Participants

161 adult participants from the United States were recruited through the online survey service, Amazon Mechanical Turk (sample size was estimated using a power analysis as described in Study 1). Participants were compensated $2.00 for their participation. Instructions and inclusion criteria were replicated from Study 2.

The final sample of participants who met the inclusion criteria, did not indicate cheating in the self-report debrief question, passed attention checks and passed the copying and pasting exclusion included 131 participants (74 females; mean age of 38.16 years, *SD*=11.51).

Materials and Procedure

Participants first completed an online survey including the 12-item assessment and locomotion regulatory mode scales, as well as control variables (i.e. Need for Closure, impulsivity, conscientiousness (see Study 2)). Participants were then instructed that they would complete a series of tasks and completed a dot counting filler task.

Manipulation

Participants were randomized to one of two conditions, a low-risk information condition or a high-risk information condition. The following descriptions were provided to participants prior to being presented the health information statements. These descriptions were developed based on the *Health Belief Model* (Hochbaum, Rosenstock & Kegels, 1952), one of the most widely used models in health behavior and communication that highlights perceived susceptibility and severity (Glanz, Rimer, & Viswanath, 2015).

Low-risk condition	**High-risk condition**
*The set of drugs are used to **treat a minor medical condition.** *Some facts about the condition include: **-Who is at risk:** Very few individuals are at risk. **-How common is it:** Less than 1 out of 10 people become infected. **-Where is it common:** Not common in the U.S. **-How severe is it:** If infected, the condition is not serious and often goes away on its own without presenting symptoms.	*The set of drugs are used to **treat a serious medical condition.** *Some facts about the condition include: **-Who is at risk:** Individuals of all ages can be infected. **-How common is it:** 6 out of 10 people become infected. **-Where is it common:** Throughout the U.S. **-How severe is it:** If infected, the condition is serious and often requires surgery, but surgery is not always effective. Sometimes the condition can lead to death.

Table 4. Treatment severity manipulation information

After reading the risk-information, participants were presented with the set of 72 randomized health statements across 12 lists as specified in Study 2. Participants were asked to freely recall as many statements as possible from the list in any order using open-ended retrieval. Participants finished by completing the online counting span task along with demographic items.

Study 3 Results

Analysis Approach

Analysis techniques (along with coding of health statements) were replicated from Study 2 (i.e. GLMM analyses using R statistical software to predict the likelihood of recall based on serial position and regulatory mode). However, time spent retrieving was not measured in this study. Instead, the moderating effects of risk were analyzed.

Model comparisons between the unconditional means model and model without random intercepts justified the use of GLMM. Subsequent model comparisons supported the use of random intercepts for stimuli (i.e. health statements) and random slopes for serial position and serial position^2. All other fixed and random factors were specified according to the Study 2.

Effect of risk information on recall

Type of risk (high versus low) was added to the model to test whether the manipulation had a significant effect on recall. As predicted, there was a significant effect of risk on recall (β=.435, SE=.197, p=0.027) such that individuals in the high (versus low-risk) condition were significantly more likely to recall a given statement.

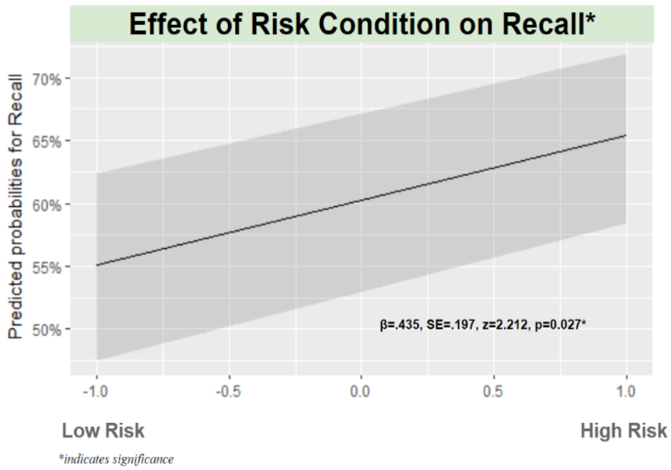

Figure 4. Effect of risk condition on recall

Control variable effects in high versus low-risk conditions

Control variables were examined in both the high and low-risk conditions to determine whether individual differences were less pronounced in the high-risk condition. All continuous predictors were grand mean centered.

In the low-risk condition, working memory and conscientiousness were positive and marginally significant and significant predictors of recall, respectively (b=.082, SE=.046, p=.076 and b=.298, SE=.133, p=.025). Overall serial position was a negative and significant predictor of recall (b=-.008, SE=.002, p<.001). Impulsivity and NFC were not significant predictors of recall (b=.041, SE=.383, p=.915 and b= -.109, SE=.148, p=.462).

In the high-risk condition, only overall serial position was a negative and significant predictor of recall (b=-.009, SE=.002, p<.001). All other control variables were non-significant (*working memory*: b=.082, SE=.046, p=.544; *conscientiousness*:

b=-.093, SE=.135, p=.489; *impulsivity*: b=-.155, SE=.520, p=.766; *NFC:* b=.166, SE=.149, p=.265).

Finally, the interactions between risk and control variables were examined to test for significant differences between the two groups for each variable. The interaction between conscientiousness and risk was significant (b=-.390, SE= 0.193, p=.043). All other interactions were non-significant.

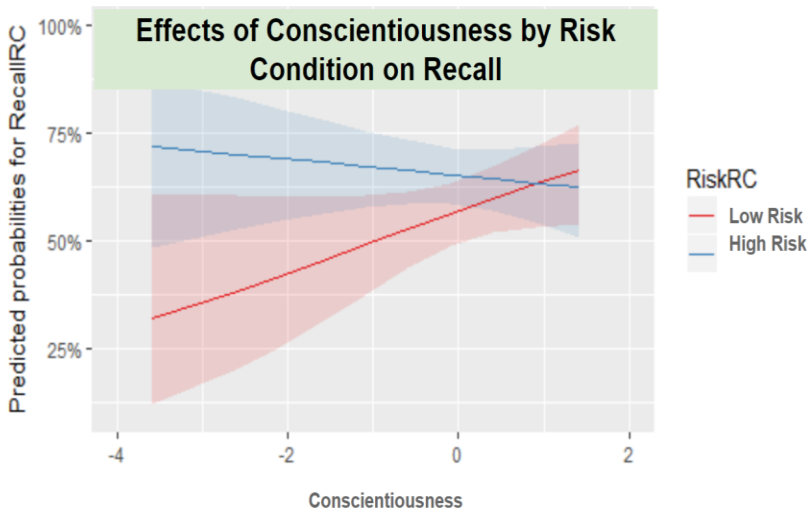

Figure 5. Interaction effects conscientiousness and risk type on recall

Presence of order effects (serial position of statement within list)

Serial position of statement and serial position of statement^2 (along with risk type and control variables) were examined to determine the presence of order effects. Serial position in the list was not transformed to aid in interpretation of order effects data and visual inspection of the plots.

Both the main effects of serial position and serial position^2 and their interactions with risk-type were significant (b=-1.02, SE= .119, p<.001, b=.144, SE=..016, p<.001 and b=-.054, SE=.003, p=.017). Like in Studies 1 and 2, the values for serial position and serial position^2 indicated a significant "u-shape" of recall. Probability of recall was greatest for early and late items in the list.

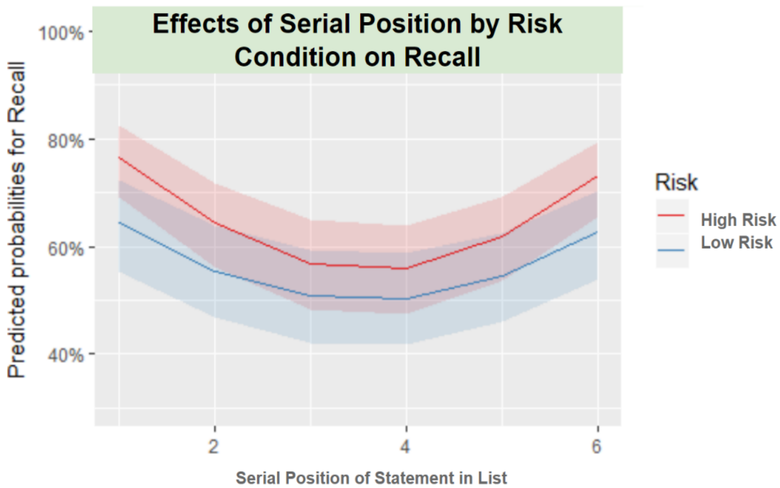

Figure 6. Study 3, Presence of order effects by condition (probability of recall based on serial position)

Hypotheses testing, order effects predicted by regulatory mode and risk

After establishing a significant quadratic trend, the analysis tested the main hypotheses that locomotion and assessment would increase or decrease order effects (i.e. the degree of curvature in the quadratic trend). Specifically, the analysis tested for significant interaction effects between locomotion and serial position^2 (a positive sign) and between assessment and serial position^2 (a negative sign). The interactions between locomotion and serial position and between assessment and serial position were also included in the model. Serial position of word, serial position of word^2, participants' locomotion and assessment were modeled as fixed factors, with participant's intercept and intercept for word, as well as slopes for serial position and serial position^2 modeled as random factors. The control variables were also included as fixed factors.

The interactions between locomotion and serial position of word^2 and between assessment and serial position of word^2 were not significant (b=.018, SE=.013, p=.160 and b=.014, SE=.010, p=.184, respectively). The nonsignificant result suggests that locomotion did not influence participants' demonstration of order effects. The model was also run without control variables and the results remained nonsignificant.

There was however, a significant interaction between assessment and serial position of statement^2, but in the opposite direction as predicted (b=.030, SE=.014, p=.028). As assessment increased, order effects became more pronounced.

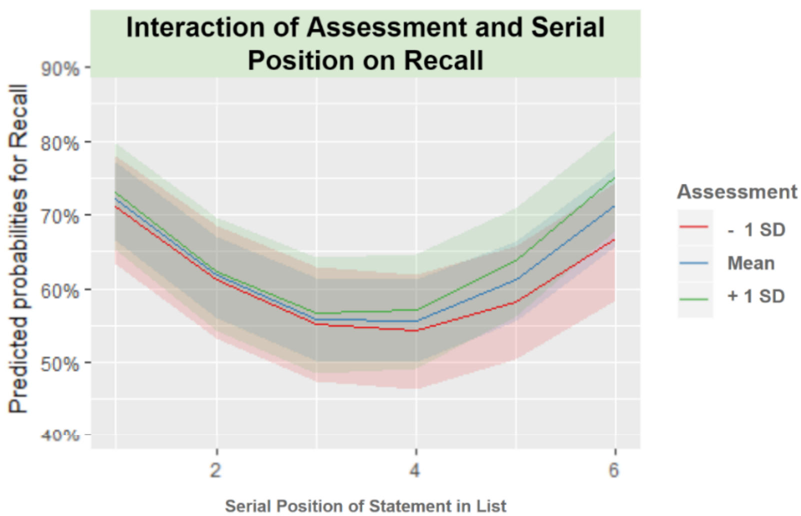

Figure 7. Interaction effects of Assessment and Serial Position on Recall

Moderating effect of risk. Three-way interactions were tested to determine if risk moderated the relationship between locomotion and serial position of statement^2 and assessment and serial position of statement^2. These interactions were nonsignificant (b=.037, SE=.023, p=.110 and b=-.035, SE=.019, p=.066), therefore risk did not reveal moderating effects.

Study 3 Discussion

Success of the manipulation

The effect of risk was included in the initial model (with control variables) to test the success of the manipulation. It was expected that probability of recall would be significantly higher in the high versus low-risk condition. This prediction was supported as participants in the high-risk group were more likely to recall each health statement.

Demonstration of order effects

Similar to Studies 1 and 2, participants demonstrated significant order effects in both conditions. However, it was assumed that the high-risk condition would produce less of a quadratic trend than the low-risk condition due to greater attention (reducing primacy and recency effects). There was a significant difference in order effects between the two conditions, but further probing revealed that the order effects were more pronounced in the high-risk condition. Although puzzling at first, visual inspection of the plot reveals a lower overall probability of recalling low-risk information thus supporting the idea that low-risk information was attended to less than high-risk information. However, though there was greater probability of recalling words in the high-risk condition, there were steeper order effects which did not support the hypotheses. Potential rationale for this finding is addressed in the section on order effects (see next page).

Situational strength

Study 3 intended to examine situational strength. In strong versus weak situations, individual differences should be reduced (Snyder & Ickes, 1985). The situational strength hypothesis was partially supported by the control variable analysis. Whereas conscientiousness and working memory were significant and marginally significant predictors of recall in the low-risk condition, these individual differences were nonsignificant in the high-risk condition. These results should be considered with caution however as the interaction for working memory and risk was trending but nonsignificant ($p=.112$).

Mixed results for conscientiousness

The results for conscientiousness as evidence of situational strength should also be considered with caution. Although conscientiousness was significant in the low-risk condition, the relationship was positively associated with recall which was not observed in Studies 1 and 2. Taken together, the inconsistency of conscientiousness in direction and significance may suggest that a better measure might provide more reliable results. To minimize fatigue, the Ten Item Personality Measure of the Five-Factor Model was used. However, this measure only included two items for conscientiousness and the reliability was relatively low across all three studies ($\alpha=.583$, $\alpha=.607$, $\alpha=.587$). Perhaps a better measure would yield even stronger support for the situational strength hypothesis in Study 3 and would shed additional light on the findings from Studies 1 and 2.

Order effects predicted by Regulatory Mode

Study 3 hypotheses suggested regulatory mode would influence order effects in the low-risk condition, but not in the high-risk condition. These hypotheses were not supported as the three-way interactions between regulatory mode, serial position and risk condition were nonsignificant.

The significant relationship between assessment and order effects was unexpected, but interesting to consider. The hypotheses suggested increases in assessment would reduce order effects. Instead, higher assessment was associated with more pronounced order effects (i.e. increased assessment was associated with a significantly greater degree of curvature in the quadratic trend, indicating stronger primacy and/or recency slopes). Perhaps the same mechanisms driving steeper order effects in high versus low risk, affect steeper order effects in high versus low assessment. When individuals experience heightened pressure (through increased risk or their assessment concerns), they may be more susceptible to order effects due to anxiety and distracting thoughts about performance (see general discussion). These findings suggest that regulatory mode may influence order effects, but continued research is needed.

General Discussion and Future Directions

The present research examined the influence of motivational tendencies on cognitive biases. Although previous research often considers biases as errors in judgment due to limitations in human memory, the present research suggested that motivation toward goal pursuit actively influences order effects. Three studies investigated regulatory mode and order effects in both general and health information through attention and willingness to search memory.

The laboratory study used intensive eye tracking methods and coding systems to test attention as an underlying mechanism in recall and order effects. In terms of validity, the studies sought to provide internal validity through a carefully controlled laboratory setting (Study 1) and a carefully considered manipulation of risk (Study 3). To enhance generalizability, the present research also used online samples (Studies 2 and 3) to capture a range of demographic characteristics, including age diversity which increases generalizability to populations likely to consider health information in medical decisions. Finally, the present research addressed a specific gap identified by researchers calling for studies in JDM and health information.

Although the current set of studies replicated previous findings related to recall including attention, serial position and a number of covariates (i.e. working memory, impulsivity, and level of risk), the findings from the current set of studies generally did not support the hypotheses related to regulatory mode and order effects. Study 1 demonstrated significant serial position order effects and generally supported the predictions related to control variables (working memory, impulsivity and Need for Closure), yet, conscientiousness was unexpectedly a negative and significant predictor of recall. Neither locomotion nor assessment were significantly related to recall or to order effects, yet one of the proposed mediators, attention was related to order effects and recall.

Studies 2 and 3 were successful in detecting order effects in an online sample and found consistent effects of working memory on recall. However, there were mixed results for a number of the control variables and for the relationship between regulatory mode and order effects. Whereas Study 2 did not reveal relationships between regulatory mode and order effects, Study 3 revealed an unexpected finding related to assessment and order effects such that increases in assessment were associated with more pronounced order effects.

Overarching considerations and explanations

There are potential explanations for the current set of findings relating to regulatory mode (please see individual study discussions for possible explanations of control variables and sampling issues). These explanations relate to the study design, to the complex relationships of both locomotion and assessment relating to other personality characteristics, and the measurement of regulatory mode.

Study design

It is possible that the study conditions produced certain circumstances that unintentionally influenced attention for both high locomotors and assessors. Regarding locomotion, the basic recall paradigm presented words one at a time, resulting in words flashing on and off the screen. Perhaps this paradigm signaled movement to some individuals high in locomotion, therefore reducing the predicted effects that we might otherwise see by locomotors. Future studies might examine the proposed relationships by presenting the information in a more static manner. Not only would a static presentation potentially address the issue of movement, but presenting information as more natural stimuli in paragraph or list form (rather than flashing words) would increase generalizability to typical information processing contexts.

Second, regarding assessment, it is possible that for some participants high in assessment, their tendency to ruminate or overthink may have resulted in loss of attention to the information. This rationale is supported by the spontaneous questions Study 1 participants posed to the research team regarding their performance, how others usually perform or the difficulty of the task. Since these questions were not formally recorded, it cannot be determined if these individuals were high in assessment, but they did provide evidence that a number of participants were engaging in self-comparison and/or self-evaluation. For these individuals, perhaps overthinking about performance may have counteracted their careful attention to the information during the task when they weren't distracted by self-comparison. As further support, evidence suggests that increased anxiety in high pressure situations can harm performance on cognitive tasks (Byrne, Silasi-Mansat & Worthy, 2017). Given participants' frequent comments about their performance, it may be that a number of participants, especially those high in assessment did feel a type of pressure in the situation and this likely contributed to their distraction.

Relationships to impulsivity and/or conscientiousness

As noted in the Study 1 discussion, both locomotion and assessment shared some degree of variance with significant predictors of recall. Regarding locomotion, the proposed hypotheses suggested that high locomotors' concerns with movement would outweigh all other concerns resulting in less attention and greater order effects. Furthermore, it was predicted that high locomotors would be prone to multitasking (e.g. using their cellphones) which could negatively impact attention. However, locomotors' tendency to demonstrate low impulsivity and high self-control (as some evidence suggests, see Shalev & Sulkowski, 2009; Struk, Scholer, & Danckert, 2015) may have counteracted these predictions. The present study did indeed reveal a negative and significant correlation between locomotion and impulsivity across all three studies (with correlations ranging from r=-.356 to -.537) and a positive and significant relationship between locomotion and conscientiousness (with correlations ranging from .484 to .516). These findings support the idea that high locomotion is related to lower levels of impulsivity and higher levels of self-control (as indicated by conscientiousness). Perhaps at times, the relationship between high locomotors' lower levels of impulsivity and higher self-control sustained attention and willingness to search memory and reduced the tendency to multitask. Yet at other times, the preference for movement may have reduced attention and willingness to search memory. Taken together, these tendencies could have resulted in a null relationship.

Second, assessment also shares a relationship with impulsivity. The proposed hypotheses for assessment suggested that high assessors' concerns for careful evaluation, thinking and accuracy would motivate willingness to recall an exhaustive list of items. However, the thinking itself may have negatively affected recall for high assessors. Subsequent analyses revealed that one of the impulsivity subscales, “cognitive instability,” was positively and significantly correlation with assessment across all three studies (with correlations ranging from r=.256 to .460). Items in the cognitive instability scale include: “I have “racing” thoughts,” “I often have extraneous thoughts when thinking” and “I change hobbies.” Presumably, these thought-related items explain the positive relationship between cognitive instability and assessment. It is possible that the null results from assessment could be explained by oscillating attention between careful attention to words and attention paid to distracting thoughts. Furthermore, assessors’ distracting thoughts may have focused on self-comparison and evaluation, especially for participants concerned with their performance (see Study 1 discussion). Future studies might probe the notion of rumination and performance to further examine assessment and distracting thoughts.

Measurement of regulatory mode

Finally, perhaps the theory and measurement of both locomotion and assessment could be considered as an exciting future direction for continued research. First, regulatory mode theory often focuses specifically on the *movement* aspect of locomotion. However, recent literature and the current studies reveal correlations between locomotion and conscientiousness (see above). One might argue that conscientiousness is a product of chronic locomotion (i.e. individuals are able to maximize efficiency when they stay focused on a task, thereby allowing them to move on more quickly). Future research could examine whether locomotion produces conscientiousness as a way of maximizing movement or if conscientiousness is another goal within locomotion that should be discussed more frequently when describing locomotion theory. Perhaps a measurement focus for future locomotion studies might aim to develop subscales reflecting the multifaceted nature of locomotion.

Second, in terms of assessment, assessment is often summarized as *careful evaluation.* resulting in discussions related to assessors' tendencies to prefer full sets of information, careful attention during proofreading tasks, and focusing on perfection. However, assessment rarely correlates with conscientiousness which shares a number of these characteristics (e.g. careful attention and a focus on perfection) (Higgins, 2008; Kruglanski et al., 2000; Pierro et al., 2006; Kelley, 2001). It is possible that the current measure of assessment focuses more on the self-comparison nature of assessment rather than on information more generally. Future studies might investigate why assessment does not correlate with conscientiousness and might also explore whether additional items might be helpful in the scale.

Exploratory analyses

An underlying assumption in the present work is that regulatory mode should influence both primacy and recency effects. However, some may argue that temporal cues are not a strong enough rationale for renewed attention. Instead, it may be that motivation influences attention during the primacy portion of the curve, but cognitive mechanisms related to decay influence the recency portion of the curve. Additional primacy analyses were conducted to test the interaction of serial position for both locomotion and assessment along with attention mediation for the primacy portion of the curve. These results were non-significant across all three studies. Nevertheless, a stronger case might address why individuals increase attention at the end of the list. It could be that recency is observed partially due to renewed attention based on temporal cues signaling the end of the list (Azizian & Polich, 2007). It may also be that attention naturally fluctuates and the analysis catches this shift during the recency portion of the list. Future research might examine whether participants' attention varies based on knowing the end of the lists and if not, perhaps renewed attention would suggest that attention naturally oscillates.

Additionally, exploratory analyses might examine potential curvilinear effects for both locomotion and assessment. For locomotion, it may be that both high and low locomotion could result in order effects. Given that previous evidence finds that low locomotion is associated with less effort investment in tasks (Pierro, Kruglanski, & Higgins, 2006), perhaps individuals with low locomotion were more susceptible to the cognitive influences on order effects (i.e. primacy due to less interference and recency due to less decay). In other words, with low motivation to invest effort in the recall task, individuals with low locomotion would rely on items most accessible to them. In this case, we might expect order effects for both high locomotion (as described by the theoretical predictions tested in this paper) as well as low locomotion. Similarly, for assessment, it may also be that both high and low assessment produce similar effects. For example, as suggested above, if rumination might actually cause distraction in attention for individuals with high assessment, then perhaps both high and low assessment could have negative effects on attention and could lead to greater order effects.

Data Limitations

For the eye-tracking design specifically, efforts should be made to reduce data exclusion in future studies. Data loss was determined by the percentage of invalid responses (Holmqvist et al 2012) in a participants' set of responses (i.e. when participants' attention measure was 0, yet they recalled the word). This leaves the possibility that for some responses, the attention score of 0 matched with not recalling was a false report and instead could have been due to issues with recording. This possibility may have inflated the results for attention. To limit this issue, future studies could include videotaping participants as manual coding for attention.

Future Directions

Relating to the current study, there are a few additional study ideas that could expand this work, particularly related to health decisions. Rather than presenting the same set of stimuli with the high versus low-risk introduction, a future study could present a list of health information as risks followed by benefits and vice versa and then measure intentions to take the treatments. This design would have a different dependent variable but could potentially be more generalizable to how health information is considered in decisions (i.e. intentions to take the treatment, rather than recall). Additionally, future studies might build on the idea of situational strength in real-world health decisions (e.g. the extent to which order effect biases operate when receiving information from clinicians versus more anonymous, online sources).

Finally, future work may address additional factors in medical decisions. The current study considered a set of individual differences as potential explanations for differences in recall. There are a number of additional ways in which individual differences could affect medical decisions. For example, evidence suggests that increased conscientiousness and openness to experience and decreased agreeableness and neuroticism relate to how active one prefers their decision-making styles (Flynn & Smith, 2007). Related to recall, perhaps an individual who prefers a less active decision-making style would demonstrate less attention to health information and greater order effects given their reliance on their provider to make health decisions.

These additional personality factors would also be interesting to explore related to regulatory mode. It might be possible that factors like decision-making style mediate order effects in health information. One hypotheses would be that individuals with high locomotion might prefer active decision-making styles, therefore they would carefully attend to information to be prepared for discussions with their provider. Another related hypothesis to treatment decisions might be that assessment could result in decision paralysis and/or rumination about the risks and benefits which might delay treatment decisions. Findings from these extensions may suggest that enhancing levels of assessment or locomotion at the appropriate phase of JDM can improve the overall health decision-making process.

Taken together, although the current research generally did not support regulatory mode hypotheses, the future directions for research generated from the project are exciting to consider. If follow-up studies do produce findings related to regulatory mode, they have the potential to inform our broader understanding of motivation and cognitive processing in judgment and decision making, while also contributing to research on regulatory mode and order effects. On the applied side, examining JDM in health contexts can improve our basic understanding of information processing and can also have a practical impact in medical decisions.

Appendices

Appendix A: Correlational Matrix & Descriptive Statistics for Participant-Level Variables

Study 1	Loc	Assess	NFC	Impulsivity	Conscien	Mem
Locomotion	-					
Assessment	.097	-				
Need for Closure	.281***	.144	-			
Impulsivity	-.414***	.091	.410***	-		
Conscientiousness	.484**	-.022	.489***	-.592***	-	
Working Memory	-.050	.057	.051	-.049	-.009	-
Mean	4.97	4.79	3.76	.211	5.33	2.31
SD	.778	.745	.461	.355	1.35	1.73

Study 2	Loc	Assess	NFC	Impulsivity	Conscien	Mem
Locomotion	-					
Assessment	-.046	-				
Need for Closure	.060	.303**	-			
Impulsivity	-.356***	.234*	.087	-		
Conscientiousness	.498***	-.261**	.056	-.628***	-	
Working Memory	-.165	-.103	-.153	.025	.008	-
Mean	5.02	4.26	4.08	1.94	5.62	
SD	1.13	1.13	.991	.393	1.24	

Study 3	Loc	Assess	NFC	Impulsivity	Conscien	Mem
Locomotion	-					
Assessment	.123	-				
Need for Closure	.010	.184*	-			
Impulsivity	-.537***	.213*	.043	-		
Conscientiousness	.503***	-.181*	.138	-.639***	-	
Working Memory	-.067	-.023	.056	.091	-.057	-
Mean	5.10	4.19	3.97	1.90	5.7	
SD	.949	1.16	.873	.371	1.18	

* Correlation is significant at p <. 05.
** Correlation is significant at $p < .01$
*** Correlation is significant at $p < .001$

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