

ABSTRACT

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Persuasive technology involves the influence of people's attitudes and beliefs by a computerized system (Fogg, 2003). Models of persuasive technology have been proposed in the literature, but efforts to validate or evaluate the effects of these models has been lacking. The current work attempts to address this lack of empirical investigation by drawing from similarities between the persuasive and decision making literatures. The decision making literature includes information grids, a type of process tracing method, to capture the extent of systematic processing during decision making. The effects of persuasive technology on decision making were evaluated using process tracing methods within a game. Study one investigated whether exposure to persuasive technology influences how individuals acquire information to make a decision. It also investigated whether differences in the focus (e.g., consider an attribute or consider an alternative) and the inclusivity (e.g., consider all alternatives or consider a specific alternative) of the persuasive technology suggestion influences processing differently. Results suggested that although both alternative-focused and attribute-focused persuasive technology manipulations influence the decision outcome, only alternative-focused persuasive technology influenced systematic processing. Persuasive technology that provided an exclusive recommendation influenced systematic processing. Exclusive manipulations did not influence systematic processing. Study two replicated study one but also investigated the persistence of the persuasive technology by manipulating how many times participants were exposed to the persuasive elements. In general, findings were consistent with study one. PT influenced the decision made. Exclusive PT influenced

systematic processing but inclusive PT did not. Manipulation of the amount of exposure to the persuasive technology influenced the effect of the exclusive condition, but there was no effect on the inclusive condition. Implications are discussed.

Persuasive Technology: An Investigation of Efficacy Using Process Tracing

by
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DEDICATION

I dedicate this work to my parents for their continuous encouragement.

BIOGRAPHY

Louisville, Kentucky was first and followed by Richmond, Virginia. Charlotte, North Carolina came next with an all too brief stint in Portland, Oregon. A few years in Atlanta, Georgia led to acquiring a Bachelor's degree in psychology at the University of Georgia in Athens. Next came my time Murfreesboro, Tennessee, where I earned my Master's degree in Psychology from Middle Tennessee State University's Industrial / Organizational Psychology program. That time was followed by Nashville, Tennessee where I worked for a river barge company. Yep. Concerned more with shaping the system to the user rather than the user to the system, I saw the light that is Human Factors Psychology and ventured to Raleigh, North Carolina. There I worked on my Ph.D. at North Carolina State University. Afterwards...

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Persuasive Technology: An Investigation of Efficacy Using
Process Tracing

An airline pilot notices a warning signal in the cockpit display during a flight. A decision must be made whether the situation warrants diverging from the current course or maintaining the heading. The next day the same pilot must make a decision pertaining to leisure time: exercise or watch a movie. The flight situation warrants a decision to be made that may be prescriptively evaluated as correct or incorrect. It involves providing the decision maker with relevant information and decision rules to enable the selection of the correct decision. The leisure time situation, however, is subjective and preferential regarding the correctness. It is influenced by attitudes and relates to ongoing goals beyond the context of the immediate. An intervention pertaining to influencing attitude must support goals in a number of decisions in different contexts. The intervention must also overcome habit. Current technologies are capable of aiding individuals in making decisions in either situation, but can those technologies aid one another?

Decision Support Systems

Decision support systems (DSSs) are one type of decision facilitating technology. They provide decision aids designed to enhance decision making processes and / or outcomes (Holsapple, 2008). These systems aim to mitigate the cognitive, temporal, or spatial burdens associated with decision tasks. DSSs do not replace human decision makers (Proctor & Van

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Zandt, 1994). Instead, they aid decision making by summarizing data, forecasting outcomes, simulating cause and effect, considering uncertainty, and aiding self-reflection of perceptions and values (French & Turoff, 2007). These systems rely on the strengths of computers, such as computation speed and storage space, while capitalizing on strengths of human decision making (Pick, 2008). DSSs are designed to minimize information processing burden on a decision maker by decreasing the number of transitions necessary to use the information in the decision-making process (Carswell & Stephens, 2006). The previous characteristics are intended to aid situations similar to the pilot's decision with the aviation warning signal. But these characteristics may not provide the most effective means of influencing the leisure decision. Jameson (2012) uses the concept of preferential choice, where there is no correct choice, to distinguish when a DSS is relevant, during non-preferential decisions, from instances involving preferential decisions, a situation for persuasion and persuasive technology.

Persuasive Technology

Persuasion is the communication of information to convince another to change his or her attitudes and/or behaviors regarding a topic of free choice (Perloff, 2008, pp. 17).

Technology intentionally designed to persuade is labeled persuasive technology (PT; Fogg, 2003). Oinas-Kukkonen and Harjumaa (2008) define PT as “computerized software or information systems designed to reinforce, change, or shape attitudes or behaviors or both

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without using coercion or deception." Fogg (2003, pp. 5) refers to PT as captology, which is an acronym of "Computers As Persuasive TechnOLOGY," and defines it as "design, research, and analysis of interactive computing products created for the purpose of changing people's attitudes or behaviors." Fogg (2003) focuses on human-computer interaction persuasion and would not include computer-mediated interaction between one individual who intends to change another's behavior through a technology. Such an example would include a personal trainer communicating to a client through e-mail. PT coincides with the leisure decision of the pilot where the correctness of the decision is highly subjective. Despite the difference between DSSs and PT regarding subjectivity of the decision, they have similarities.

Similar to DSSs' beneficence from computers, PT share several advantages over their human counterparts regarding persuasion (Fogg, 2003, pp. 7). PT can provide persistent persuasive influence. This technology allows greater anonymity of the desired behavior and change for the persuadee. The electronic nature of the persuasion facilitates data management. A variety of communication modalities may be enlisted. The persuasive initiatives offer scalability to changing demands. Lastly, persuadees may be more willing to accept and use such technologies where human persuaders would not be appropriate. These advantages are capitalized in the models of PT that have arisen in the literature.

A number of PT models (e.g., Fogg, 2003; Lockton, Harrison, & Stanton, 2010) are present in the literature. One of the more prevalent models is the functional triad (Fogg,

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2003). The triad draws from a variety of theories including behavior change, motivation, and influence (Fogg, Cuellar, & Danielson, 2008). The functional triad, as illustrated in Table 1, is comprised of persuasive components categorized into tools, media, and social actors (Fogg, 2003). Tools focus on increasing the capabilities of the individual. They can make a behavior easier to accomplish, provide guidance through a process, and/or capitalize on the abilities of the persuasive device to perform calculations. Media provide and demonstrate experiences relying upon cause-and-effect, vicarious experience, and rehearsal. PT as a social actor mimics the relationship between a human persuader and persuadee (e.g., Cialdini, 2011) relying upon such strategies as modeling desired behavior and social support. Just as there are similarities between PT and DSSs pertaining to the benefits gained from their computational nature, both achieve these benefits through such strategies as data management and simulated cause and effect. However, little effort has been directed towards explaining the effects of PT within the context of psychological theory or methods. Such an investigation would aid in building support for PT's claim of affecting behavior and attitude.

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Table 1. *Functional Triad*

Tools	Social Actors	Media
Reduction	Physical cues	Simulated cause-and-effect
Tailoring	Attractiveness	Simulated environments
Suggestion	Psychological cues	Simulated objects
Self-monitoring	Similarity	
Surveillance	Language cues	
Conditioning	Praise	
	Social dynamics cues	
	Reciprocity	
	Social rules cues	
	Roles of authority	

Articles pertaining to PT have focused on presenting models of PT (e.g., Fogg, 2003; Lockton, Harrison, & Stanton, 2008, 2010) or the development and/or implementation of a PT initiative as opposed to theory testing (e.g., Heyman, 2013; Mintz & Aagaard, 2012). For example, WaterBot is designed with the intent of changing user behavior associated with water faucets (Arroyo, Bonanni, & Selker, 2005). It uses several tools from the functional triad, such as suggestions, conditioning, and self-monitoring. However, no formal evaluation of the technology's effectiveness accompanied its introduction. Bång, Torstensson, and Katzeff (2006) developed a cause-and-effect simulator, PowerHouse, to teach and change the behavior of teenagers pertaining to energy conservation. Similar to Waterbot, no behavior and/or attitude evaluation of PowerHouse has been reported. There has been some effort to evaluate the successor to PowerHouse, Power Agent (Gustafsson, Katzeff, & Bång, 2009). However, the evaluation suffered methodologically including the lack of a control condition, a small sample size, and reliance on analysis using "eye-ball" techniques. In summary, there

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has been a lack of empirical investigation and evaluation of these models and initiatives beyond the inclusion of research in Fogg's (2003) definition.

Despite PT's proposed advantage of facilitating data management, the lack of evaluation may relate to the lack of empirical measures. Methodology from analogous literature may offer guidance. As previously stated, there are similarities between PT and DSSs regarding the benefits garnered from computing power. Also, similar strategies are used by these systems. In attempting to determine a means of evaluating PT, the similarities between these types of technology suggest investigating the DSS literature and its progenitor, decision making.

Decision Making

Empirical investigations of a DSS's efficacy tend to evaluate the correctness of the decision rather than how the DSS changed the cognitive processes leading up to the decision. However, an addition to an outcome-based measure is sought for the current work. Another body of research related to the DSS literature could provide a methodology for assessing PT. The decision making literature, from which the DSS literature arose, provides such methodology. Early research on decision making pertained to the notion of rationality (e.g., Edwards, 1954). At the center of rationality lies utility theory, which posits that decisions are the result of a calculation between the probability of certain outcomes along with the utility or value of those outcomes. As the decision making literature matured, rationality was

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replaced by the notion of bounded rationality (Simon, 1956). The limits of human cognition were integrated into theory resulting in a shift from prescriptive models to descriptive models representing how humans actually make decisions.

Since the integration of bounded rationality, two major camps of decision making theory arose: heuristics and biases (HB) and naturalistic decision making (NDM). Each camp espouses different assumptions and associated methodologies. The question of whether humans are good intuitive statisticians led to the HB perspective (Kahneman, 2011, pp.5). HB compares human decision making performance to formal models that maximally use the information provided (Kahneman & Klein, 2009). NDM compares human decision making performance along varying levels of expertise. NDM emphasizes ecological validity within the research literature (Klein & Calderwood, 1991). Field studies are used in lieu of experimental settings (Kahneman & Klein, 2009). Complex decisions are investigated and characterized by uncertainty, time pressure, high stakes, and shifting conditions. However, the distinction between the two may be tenuous.

In a joint article, Kahneman of HB and Klein of NDM (2009) find themselves in agreement much of the time, contrary to expectations. For example, they assert the spuriousness of the association between the two perspectives pertaining to field versus laboratory studies. Additionally, both perspectives emphasize the importance of intuition within the decision making process. The usage of intuition is contextual. Beach and Mitchell (1978) capture the concept within contingent processing, which specifies whether intuition is

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used depends upon the characteristics of the decision and decision maker. The problem, environment, and person all influence which decision making strategy is selected. Strategies differ along what Klein and Calderwood (1991) refer to as the cognitive continuum representing the extent of processing. One side of the continuum represents limited, heuristic processing and is referred to as system one processing. The other side represents extensive, systematic processing and is referred to as system two processing. The differences between these types of processing are the centerpiece of dual processing theories (e.g., Kahneman, 2003; Stanovich & West, 2000). A methodology that can capture differences along this continuum may provide the means of evaluating the effects of PT.

Process Tracing

Rather than traditional outcome-based measures for decision making, process tracing is a cognitively oriented method focused on how a decision maker searches for and combines information (Harte & Koele, 1997). Information grids, also referred to as information matrices or boards, are one such process tracing method. Information grids present decision makers with an alternative (i.e., decision choice) by attribute matrix (Harte & Koele, 1997). Each alternative-attribute combination lines up with a cell similar to a spreadsheet. Each cell contains an information value. See Figure 1. In computerized versions such as MouseLab (Bettman, Johnson, & Payne, 1990), information values are hidden by default. When the decision maker moves the mouse cursor over a hidden value or cell, the information in that

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cell is revealed. When the mouse cursor is no longer over that specific cell, the information becomes hidden again. Data can be extracted from these information search behaviors. Variations in these data may be characterized as differences in the extent of processing pertaining to the decision.

	Alternative A	Alternative B	Alternative C
Attribute 1	Value A1	Value B1	Value C1
Attribute 2	Value B1	Value B2	Value C2
Attribute 3	Value C1	Value C2	Value C3

Figure 1. Process tracing information grid.

These data may demonstrate their utility by supplementing more traditional outcome variables. Additionally, Johnson, Schulte-Mecklenbeck, and Willemsen (2008) encourage the use of process data to further decision making theory by going beyond predictive power with choices to also include the underlying cognitive processes. For example, the priority heuristic demonstrates the benefit of utilizing process data (Brandstätter, Gigerenzer, & Hertwig, 2006). This heuristic prioritizes the characteristic used to make a decision in the order of minimum gain (or loss), probability of minimum gain (or loss), then maximum gain (or loss). It demonstrates predictive power with choices and decision time, but fails to accurately

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depict the underlying process as demonstrated by an analysis of process data (Johnson, Schulte-Mecklenbeck, & Willemsen 2008).

As with any method, there are disadvantages that accompany the advantages. An important consideration is that information grids are limited by only recording information that is perceived by the decision maker and cannot analyze information stored in memory (Kühberger, Schulte-Mecklenbeck, & Ranyard, 2010). Also, considering the extent of processing continuum, this methodology likely emphasizes systematic or system two processing due to the lack of intuitive information. This emphasis on systematic processing may characterize the two forms of processing as being orthogonal to one another. One type of processing may lessen while the other remains the same or is non-present. As such, the extent of processing associated with information grids may be better characterized as extent of systematic processing. However, this methodology has demonstrated its ability to discriminate differences in processing such as the differences between older and younger adults (e.g., Hanoch, Wood, Barnes, Liu, & Rice, 2011; Johnson, 1990; Queen, Hess, Ennis, Dowd, & Grün, 2012). These differences can be identified by a number of characteristics extracted from this method.

Decision making processes are typically evaluated along four characteristics by information grids: (a) amount of information, (b) selectivity of information, (c) alternative-versus attribute-based processing, and (d) compensatory versus non-compensatory strategies (Bettman, Luce, & Payne, 1998). (a) Amount of information is associated with the number of

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values observed (e.g., Lohse & Johnson, 1996) or by the amount of time acquiring values (e.g., Brandstätter, Gigerenzer, & Hertwig, 2006). (b) Selectivity of information depicts whether a consistent amount of information is processed between different attributes or alternatives (e.g., Riedl, Brandstätter, & Roithmayr, 2008). More selective information acquisition is associated with less process intensity because not all attributes are considered for each alternative. (c) Alternative-based processing is characterized by acquisition of all values pertaining to each alternative separately (Bettman, Johnson, & Payne, 1991) as depicted in Figure 2. Alternatives are compared to one another in terms of a combined score based on multiple attributes. Attribute-based processing is characterized by the acquisition and comparison of values pertaining to one attribute before considering other attributes (Bettman, Johnson, & Payne, 1991) as depicted in Figure 3. Comparisons between alternatives are conducted along each attribute separately. This distinction is useful in describing the type of strategy utilized. Alternative-based processing can be considered more processing intensive because comparing alternative along all of its attributes involves more information than comparing alternatives along each attribute individually. (d) Compensatory strategies allow a higher value along one attribute to compensate for a lower value along another attribute (Bettman et al., 1998). These strategies are associated with more processing than their non-compensatory counterparts. Additional considerations are important in relation to these characteristics.

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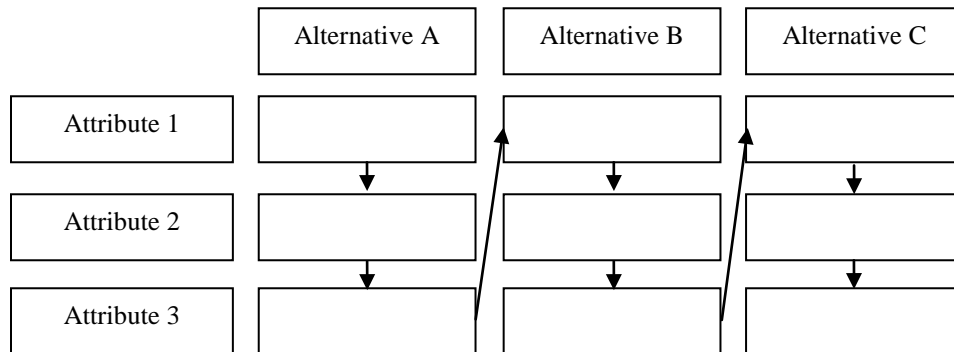


Figure 2. Alternative-based processing of information grid.

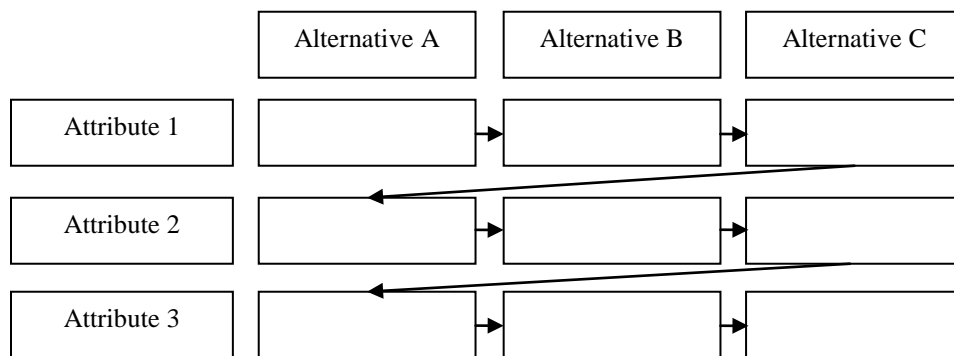


Figure 3. Attribute-based processing of information grid.

Another consideration is the task's complexity. It is in part determined by the number of alternatives and attributes in the decision. It is important to provide enough complexity to enable differences between individuals. However, as decisions become more complex, decision makers use a smaller proportion of information suggestive of noncompensatory strategies (e.g., Queen et al., 2012; Sundström, 1987). Decisions that are overly complex

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predispose decision makers towards specific strategies resulting in biases. These characteristics and considerations guide the design and metrics of information grid tasks.

A variety of metrics can describe data from information grids. The Payne (1976) Index compares the number of alternative-based transitions, or transitions between the values of the same alternative to the number of attribute-based transitions, or transitions between values of the same attribute. The value of the Payne Index is influenced not only by the observed number of each type of transition, but also the proportion of alternative to attribute transitions possible (Böckenholt & Hynan, 1994). Whichever has the greater proportion of possible transitions the index will be in its favor. For example, favor will be given to attribute-based processing if there are five attributes and three alternatives. It is then important to use the same number of attributes as alternatives if the Payne Index is used. Other common metrics include the total time on the decision (e.g., Hess, Queen, & Ennis, 2013; Johnson, 1990), average time per value viewed (e.g., Johnson & Drungle, 2000), amount of information viewed (e.g., Johnson, 1990), amount of information viewed multiple times (e.g., Johnson, 1990), and proportion of values viewed (e.g., Hess et al., 2013; Johnson & Drungle, 2000; Queen et al., 2012).

An important consideration of the processes related to these metrics is individual differences. For example, Queen and colleagues (2012) used these methods to investigate task complexity and age associated with information search strategies for decision making. The researchers found evidence that education predicts decision strategy selection for both

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simple and complex decisions. Similarly, working memory predicts decision strategy selection for complex decisions. Mata, Schooler, and Rieskamp (2007) provide evidence that individual differences associated with reasoning skills explain a substantial portion of the age-related variance in the amount of information searched in a decision task. Other higher cognitive functions, such as perceptual speed (e.g., Salthouse, 1996), may lead to individual differences associated with systematic processing in decision making. These sources of individual differences may influence process data associated with decision making. For this reason, it may be prudent to control for these differences when conducting nomothetic investigations.

Information grids are a means of evaluating the early stages associated with systematic processing of decisions. Like all methodologies, there are methodological limitations to information grids, but there is evidence of their ability to discriminate extent of systematic processing. The next question to address is the appropriateness of this methodology in assessing PT. Persuasion literature will be considered to address this question.

Persuasion

Research pertaining to persuasion is grouped into its three parts: the structure of the persuasive message, the persuader's cognitive processes, and the persuadee's cognitive processes. Research pertaining to the structure of the message (e.g., Cialdini, 2001, 2011) has

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been integrated into the strategies of PT. The persuader's cognitive processes are irrelevant since the persuader is a computer. To evaluate the effects of the persuasion, the persuadee's cognitive process are of interest. The elaboration likelihood model (ELM; Petty, & Cacioppo, 1986; Petty, Rucker, Bizer, & Cacioppo, 2004) of persuasion proposes two distinct forms of processing that mirror dual process theories of decision making. Peripheral route processes include a cursory examination of arguments, do not emphasize the merits of an argument, and represent heuristic or system one processing. Central route processes include critical examination of arguments and represent systematic or system two processing. The heuristic-systematic model (HSM; Chaiken, 1987; Todorov, Chaiken, & Henderson, 2002) is a similar model of persuasion distinguishing between two types of processing. The type of processing with the greatest influence is contingent upon the motivation and ability of the individual. Two models with such similar structures emphasize the importance of dual processing in persuasion. This similarity between decision making and persuasion is the justification for using decision making methodology in evaluating PT.

Capturing the cognitive processes of the persuadee serves an additional purpose. The extent of processing is an important consideration of persuasion because amount of processing performed on a message may influence its effect on the persuadee. Increasing cognitive activity pertaining to a message polarizes the message's effects resulting in favorable messages becoming more favorable and unfavorable messages becoming less favorable (Petty & Briñol, 2008). Additionally, attitudes that have been influenced by central,

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systematic processing are more resistant to counter-arguments, engender more persistent changes over time, and are more predictive of future behavior than those attitudes influenced by peripheral processing (Petty, Haugtvedt, & Smith, 1995). For these reasons, evaluating the effects of PT on cognitive processing may provide an early criterion for the efficacy of this technology as a persuasive influence. As such, process data from information grids could be used to evaluate the effect of PT on the decision making process. However, before a decision can be made, a context for the decision must be created.

Context of Decisions

Due to PT's electronic nature, simulation and gaming provides an effective method of investigation. Simulations are used in Human Factors research to provide an environment similar to the context in which the decision could be made in the field. For example, Metzger and Parasuraman (2005) used an air traffic control simulator to demonstrate the enhanced performance and decreased mental workload in a complex decision task when automation was reliable. By situating an investigation of PT within an electronic environment, it will capitalize on the benefit of data management provided by PT.

Current Research

The current investigation brings together several lines of research to explore how PT (e.g., Fogg, 2003) influences a preferential decision such as the pilot's leisure time decision. The method to evaluate this hypothesis comes from the literature based on similar dual

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process theories from persuasion (e.g., Petty, Rucker, Bizer, & Cacioppo, 2004; Todorov, Chaiken, & Henderson, 2002) and decision making (e.g., Kahneman, 2003; Stanovich & West, 2000). As opposed to relying solely on a decision outcome, process tracing information grids enable the cognitive processes leading to a decision to be operationalized. More specifically this method captures the effect of PT on information acquisition prior to a decision and draws inferences pertaining to the extent of systematic processing. PT is evaluated to determine whether it affects the extent of systematic processing. This evaluation forms the basis for the first hypothesis.

Additionally, increases in systematic processing are considered beneficial because of the evidence that systematic processing promotes persistent change. This characteristic distinguishes PT from decision support systems that are arguably designed to minimize processing by the human decision maker. The realization of persistent changes to the persuadee makes important whether PT increases systematic processing. Persistent change of attitudes and/or behaviors also makes important whether manipulations to PT can increase or decrease systematic processing. If so, what manipulation results in these differences? There are two dimensions where the PT is manipulated related to this question. One dimension pertains to whether the persuasive suggestion involves the attribute, alternative, or both. The other dimension pertains to whether the PT suggestion is exclusive or inclusive. Exclusive is when specific information is suggested for consideration. Inclusive is when all information is suggested for consideration. Referring to the leisure activity, an exclusive attribute

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persuasive message might suggest focusing on the dollar cost of activities (i.e., one attribute). An inclusive alternative message would suggest considering all available leisure activities (i.e., all alternatives). Therefore, whether PT has a consistent effect on systematic processing or not forms the basis for the second hypothesis. The relationship between systematic processing and persistent change forms the basis for the third hypothesis. A game provides a context and environment in which to evaluate PT and test these hypotheses. To summarize, the current research investigates the effects of PT on the extent of systematic processing during decision making using process tracing information grids framed within a game.

Hypotheses

H1: Persuasive technology (Fogg, 2003) affects the extent of systematic processing during decision making based on process tracing information grids (e.g., Payne, 1976).

H2: Differences in systematic processing will be observed based on the focus and exclusivity of persuasive technology.

H2a: Attribute-focused persuasive technology will result in greater attribute-based transitions in comparison to alternative-focused persuasive technology.

H2b: Alternative-focused persuasive technology will result in greater alternative-based transitions in comparison to attribute-focused persuasive technology.

H2c: Based on the measures as a whole, inclusive persuasive technology will result in greater systematic processing in comparison to exclusive persuasive technology.

H3: Inclusive persuasive technology will require fewer persuasive technology-related interactions to maintain that level of systematic processing in comparison to exclusive.

Study 1

The purpose of study 1 was to test the hypothesis of how PT altered systematic processing of decision making (hypothesis 1). In addition, the study evaluated whether differences in the focus and exclusivity of the PT resulted in differences in systematic processing (hypothesis 2). To test this hypothesis, the PT was manipulated regarding its focus: alternative-focused (hypothesis 2a), attribute-focused (hypothesis 2b), or inclusive versus exclusive suggestions (hypothesis 2c). A game was developed and user tested to evaluate these hypotheses. Each level of the game, except for the first, was preceded by a decision presented as a choice of what level is played. The intent of the game was to engender the belief that there are ramifications for the quality of the decisions. These ramifications ideally led to the game performance and more importantly the decisions being important to participants.

Method

Design

Study one used a randomized design with 3 x 3 x 2 factorial design with alternative-focused (none, exclusive, and inclusive) and attribute-focused (none, exclusive, and inclusive) persuasive technology as between subject factors and decision blocks as a within

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subjects factor (early decisions, late decisions). Variables collected as possible covariates included performance, age, education, working memory, reasoning ability, and perceptual speed.

Participants

Using G*Power (Faul et al., 2007) and based on a MANOVA, an alpha of (.05), two predictors, nine groups, and four response variables, a sample size of 81 was necessary to identify an effect of 0.15. Ninety-three participants were recruited using Amazon's Mechanical Turk (MTurk; <http://www.mturk.com>). MTurk is an online marketplace that recruits paid participants for various tasks (e.g., research participation) using crowdsourcing, a portmanteau of the words "crowd" and "outsourcing." There is evidence that MTurk samples a wider population than undergraduate students (e.g., Paolacci, Chandler, & Ipeirotis, 2010). Additionally, Behrend, Sharek, Meade, and Wiebe (2011) report MTurk participants as being older, more ethnically diverse, and to possess more work experience than undergraduate students. Furthermore, there is evidence of similar patterns of results between lab and online participants on a battery of perceptual and cognitive measures (Germine, Nakayama, Duchaine, Chabris, Chatterjee, & Wilmer, 2012). Three participants' data were removed for being incomplete. Of the remaining 90 participants, 50 were female and 40 were male (age $M = 33.81$, $SD = 11.02$; years of education $M = 14.93$, $SD = 1.93$).

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Measures and Instruments

Game. The game objective was to direct rovers (e.g., lunar or mars) in finding resources on extraterrestrial sites in a series of levels. Rovers were piloted from a top-down (or bird's eye) perspective. One rover at a time was navigated around terrain and prospected for resources. Gameplay challenges included time pressure in the form of number of moves, physical barriers, weather, and digging explosions. Weather and digging explosions would destroy the current rover requiring a new rover to be deployed resulting in lost time. Radar for resources was provided to direct the search for resources. A pressure warning was also provided to indicate the chance of the rover exploding from a dig. Elapsed game time and number of resources collected determined the points earned within the game. See Figure 4 for a screenshot of the game. The purpose of the game was to provide the basis for the decisions, which were related to the gameplay challenges. These challenges were represented by the attributes of the decisions described below.

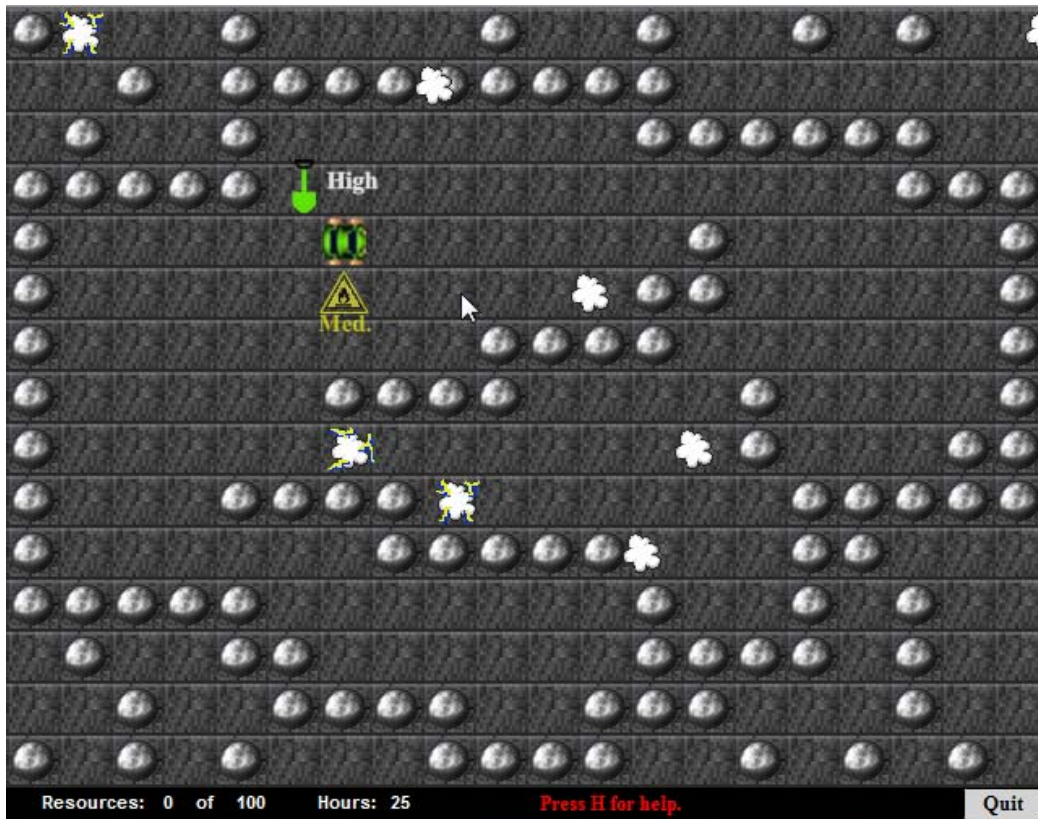


Figure 4. Rover game interface.

Donation Mechanic. To foster motivation, a donation mechanic was included. A one-time selection of one charity from six options representing a variety of social issues was provided. Points earned during the game were allocated to the charity selected. The charity with the most allocated points at the end of the study received a small donation.

Process Tracing. A decision was presented prior to each level except for the first. These decisions were presented in a matrix with alternative decisions in the columns and attributes of the decision in the rows. The design and use of the information grid paralleled

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that of a spreadsheet. Each alternative-attribute combination was represented by an information value like a spreadsheet's cell. See Figure 5. However, values, or cells, were hidden. When the mouse cursor was positioned over the physical location of that cell, the information in that cell would be revealed simulating a "mouseover" effect.

	Choose a team's site:					
	Team G	Team H	Team I	Team J	Team K	Team L
Ease of finding resources						
Richness of deposits						Average
Weather						
Subterranean gas pressure						
Rover deployment time						
Movement time						

Figure 5. Process tracing information grid to choose subsequent level.

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Each decision included six (6) alternatives and six (6) attributes to create complex decisions. A unique set of alternatives were presented for each decision. Each alternative and each attribute was balanced by including two "average" values and one of each other value: "worse," "a little worse," "a little better," and "better." This balance avoided a dominant alternative or attribute to emphasize a complex decision (e.g., Johnson, 1990). Within each decision, all alternative choices led to the same level. This deception was an attempt to control for consistency in gameplay challenges and experience. Attributes reflected the gameplay challenges and included ease of finding resources, richness of deposits, weather, subterranean gas pressure, rover deployment time, and movement time.

Persuasive Technology. The presentation of the PT occurred prior to each decision except for the first. It included the three dimensions of the functional triad (Fogg, 2003): tools, media, and social actors. Tools included self-monitoring and suggestions. Self-monitoring was implemented by displaying the previous level's performance data: number of hours spent moving and digging and hours lost due to weather or gas pressure. Based on these data, a suggestion was provided. These suggestions were generated based on a linear series of conditional statements. See Table 2. Media included simulated cause and effect. A projection of the number of hours saved based on the suggestion was provided. It was equivalent to fifteen percent of the total hours spent from the previous level. Social actors included praise, attractiveness, and the role of authority. Praise included one of four statements randomly selected that complimented the performance from the previous level.

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Attractiveness was integrated by including an avatar who delivered the PT information. The face of the avatar was generated using a technique that averages pictures of same sex individuals to create a composite face (e.g., Langlois, Roggman, & Musselman, 1994; Rhodes, Sumich, & Byatt, 1999). There is evidence that increasing the number of faces averaged is associated with an increase in attractiveness albeit with diminishing returns (e.g., Langolis et al., 1994; Rhodes et al., 1999). Two faces, one male and one female, and each based on 24 faces, were used from previous research by Rhodes and colleagues (2011). Sex of the avatar was randomized and balanced across conditions. The avatar introduced him- or herself as a captain who managed the base where the rovers are piloted from to instill a sense of authority.

Table 2. Persuasive Technology Suggestions Based on Hourly Data of Previous Level

Percent of Hours in Previous Level	Suggestion Related to
Weather > 25% and Gas pressure > 25%	Rover deployment time
Weather > 35%	Weather
Gas pressure > 35%	Subterranean gas pressure
Digging > 50%	Ease of finding resources
Moving > 50%	Movement time
Otherwise	Richness of deposits

The PT's suggestion was manipulated in terms of three characteristics: alternative-focused, attribute-focused, and exclusivity. Exclusivity pertained to whether the suggestion is exclusive to one alternative or attribute or inclusive including all alternatives or all attributes. Attribute-focused PT was either not present (none), encouraged focusing on a specific

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attribute for the exclusive manipulation (exclusive), or encouraged considering all attributes for the inclusive manipulation (inclusive). Alternative-focused PT was either not present (none), encouraged focusing on a specific alternative for the exclusive manipulation (exclusive), or encouraged considering all alternatives in the inclusive manipulation (inclusive). Attribute-focused exclusive suggestions were determined based on the previous level data and the outcome from the conditional statements. The alternative-focused exclusive suggestions were generated by translating the attribute suggestion into an alternative. This translation was accomplished by suggesting the alternative with a value of "better" for the suggested attribute. Attribute-focused and alternative-focused PT could be presented concurrently. As an example, the generated suggestion was "weather." For the exclusive alternative-focused, exclusive attribute-focused condition, the suggestion might state, "we suggest Team L's site because of the weather." For the same example, in the exclusive alternative-focused, inclusive attribute-focused condition, the suggestion might state, "we suggest Team L's site and considering all characteristics." In the inclusive alternative-focused, no attribute-focused condition, the suggestion might state, "we suggest considering all sites." See Figure 6.

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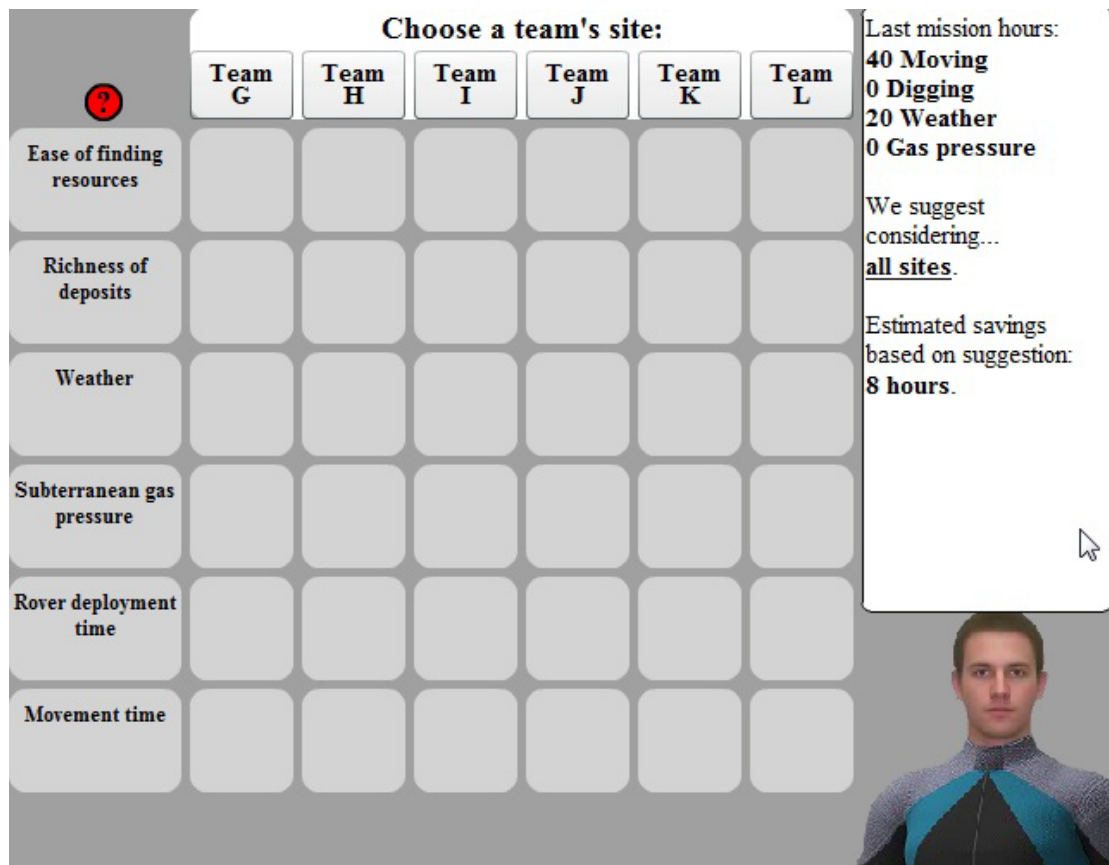


Figure 6. Persuasive technology example of inclusive alternatives and no attributes.

n-Back. The n-back test was adapted from Mehler, Reimer, and Dusek (2011) to measure working memory. In lieu of the auditory presentation, numerical stimuli were presented visually. The test included 2- and 3-back tasks. The first tutorial presented stimuli in the center of the screen. Places for the last three stimuli were presented to the left of the current stimulus. This tutorial was to demonstrate how knowing the correct response required storing and updating the previous numbers presented. Another tutorial without the

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presentation of previous stimuli was given to provide practice of the task without aid. The 2-back test included 40 items and would conclude after five incorrect responses. The 3-back portion was similar to the 2-back with the exception that it did not include the first tutorial. Correct responses are assigned a value of one and incorrect responses are assigned a zero with test scores ranging between zero and 40.

Figural analogies. Figural analogies (Lindenberger, Mayr, & Kliegl, 1993) measured reasoning ability. Figural analogies are structured like a verbal analogy. Rather than word associations, associations are determined based on physical relationships. For example, "a square" is to "a square within a square" as "a circle" is to "a circle within a circle." Five figures were presented and one completes the analogy. The test was preceded by a tutorial and practice trails. Correct responses are assigned a value of one and incorrect responses are assigned a zero with test scores ranging between zero and 22.

Digit-symbol substitution. The digit-symbol substitution (Wechsler, 1997) measured perceptual speed. Nine symbols were paired with the numbers one through nine. Symbols were presented one at a time. The task was to press the number key associated with the symbol. The time limit was ninety seconds. Instructions and practice trials preceded the task. Correct responses are assigned a value of one and incorrect responses are assigned a zero with test scores ranging between zero and 100.

Demographics. Data pertaining to age and education were collected.

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Procedure

In the MTurk advertisement, a short description of the game was provided with the request that they assist in testing a video game. Participants first navigated to an online consent form. Upon consenting to the experiment, they were directed to the game. Once the game was loaded, the game connected to a MySQL database to acquire the current participant number. A separate MySQL database stored experimental condition assignments (e.g., attribute-focus, alternative-focus, sex of avatar). The order of the database's entries were randomized and then numbered sequentially. The sequential numbering of conditions was matched with the participant number to determine the condition assignment of the current participant.

Participants were then introduced to the game. Participants were informed of the donation mechanic in an attempt to motivate performance. Once they selected a charity, they performed the cognitive pre-measure tasks: n-back, figural analogies, and digit-symbol substitution. The game began with piloting the rover. They received instruction on piloting the rover, were informed of the objectives (e.g., dig for resources), and warned of the in-game dangers (e.g., weather and dig-related explosions). The radar for resources and warning gauge for subterranean gas pressure were introduced. Participants then played the first level. The first level omitted the decision to orient participants to the gameplay challenges the decisions are based upon. Participants either completed the level by collecting all resources or ran out of the 6 rovers provided. After piloting, they were introduced to the decision task

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of choosing their next level. Instruction was provided pertaining to how to maneuver the mouse to reveal information values and descriptions of the attributes and how to make a decision. These instructions could be reviewed again by clicking on a question mark icon. The data pertaining to what information they revealed during the task and what decision they made was recorded. After the decision, participants played the next level.

Upon completion of all levels and decisions, participants answered a question pertaining to which attribute they found to be most important. An additional option of "equally important" was included to check whether participants were cognizant of their decisions not determining the subsequent level. Participants were presented with a short demographic questionnaire. Participants were then presented with a screen to inform them of whether their data were successfully uploaded, thank, and debrief them.

Results

The analyses began with an evaluation of whether performance in the game differed between groups. Then an evaluation on whether persuasive technology (PT) influenced the perception of attribute importance and decisions being made were conducted as precursors to whether PT influenced systematic processing. Next the potential covariates were evaluated to determine which, if any, should be included in subsequent analyses. Then the first decision was evaluated using a MANCOVA to assess whether there were pre-existing differences between the groups. The second MANCOVA and subsequent analyses evaluated whether

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PT, the first hypothesis, and more specifically the focus and exclusivity of PT, the second hypotheses, influenced systematic processing during decision making. A discriminant function analysis was performed based on the suggestion of (Field, 2009, p. 599-601) to further evaluate the contributions of the outcome measures. Lastly, an exploratory analysis was performed using a MANCOVA based on the coefficient of variation to assess the consistency of the manipulations on the outcome measures across the decisions.

Persuasive Technology's Effect on Game Performance

See Table 3 for descriptive statistics. Performance scores were positively influenced by the number of resources found and negatively by the amount of in-game hours. Performance values ranged between 15,331.00 and 44,306.00. An ANOVA evaluated whether gameplay performance differed based on persuasive technology (PT) manipulations. There was no effect of alternative-focused PT, $F(2,81) = 0.05$, $MSE = 36,302,539.38$, $p = 0.96$, $\eta_p^2 < 0.01$, attribute-focused PT, $F(2,81) = 0.23$, $MSE = 36,302,539.38$, $p = 0.79$, $\eta_p^2 = 0.01$ or their interaction, $F(4,81) = 0.71$, $MSE = 36,302,539.38$, $p = 0.59$, $\eta_p^2 = 0.03$. This finding was important because it built evidence that the game experience was similar between participants of differing groups. Similar game experience suggested that differences observed in subsequent analyses were due to experimental manipulations rather than being due to differences in gameplay experience.

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Table 3. *Descriptive statistics of Game Performance Based on Points by Group Condition (n = 90)*

Alternative-focused Persuasive Technology	Attribute-focused Persuasive Technology	<i>M</i>	<i>SD</i>
None	None	36,583.60	8,884.16
	Exclusive	37,481.00	8,913.61
	Inclusive	39,001.90	4,116.11
	Total	37,688.83	7,445.89
Exclusive	None	38,428.60	5,105.57
	Exclusive	37,483.00	3,910.55
	Inclusive	36,866.00	4,806.33
	Total	37,592.53	4,520.18
Inclusive	None	39,304.40	3,753.69
	Exclusive	37,047.80	6,045.86
	Inclusive	35,385.50	6,024.71
	Total	37,245.90	5,445.13
Total	None	38,105.53	6,187.72
	Exclusive	37,337.27	6,386.76
	Inclusive	37,084.47	5,096.21
	Total	37,509.09	5,866.89

Note: Points ranged from 15,331.00 to 44,306.00.

Perception of Attribute Importance

Participants were asked which attribute they believed to be the most important to their game performance. This question acted as a manipulation check of whether they were aware that their decisions did not influence the game. The response was worded "all equally important" to avoid priming participants of the deception. Equal importance responses were coded as a two. All other responses were coded as a one. This transformation was performed to focus the analysis on whether the manipulations of PT produced differences in the number of participants aware of the decision deception. See Table 4 for frequency data. There was

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not a significant association between the type of alternative-focused PT, $\chi^2(2) = 0.48, p = 0.79$, or attribute-focused PT, $\chi^2(2) = 0.00, p = 1.00$, and whether or not participants reported dimensions being equivalently important.

Table 4. *Frequencies of attribute weightings transformed*

Variable	Condition	Other	All equal
Alternative-focused Persuasive Technology	None	26	4
	Exclusive	24	6
	Inclusive	25	5
Attribute-focused Persuasive Technology	None	25	5
	Exclusive	25	5
	Inclusive	25	5

In addition, the raw data of weighted attributes were analyzed. See Table 5 for frequency data. There was not a significant association between the type of alternative-focused PT and whether or not participants reported dimensions being equivalently important, $\chi^2(12) = 11.55, p = 0.48$. There was a significant association between type of attribute-focused PT and whether or not participants reported dimensions being equivalently important, $\chi^2(12) = 28.93, p < 0.01$.

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Table 5. *Frequencies of attribute weightings*

Variable	Condition	Attribute weightings						All equal
		Ease of finding resources	Richness of deposits	Weather	Subterranean gas pressure	Rover deployment time	Move-ment time	
Alternative-focused Persuasive Technology	None	12	8	2	0	0	4	4
	Exclusive	13	3	3	3	0	2	6
	Inclusive	12	2	3	2	1	5	5
Attribute-focused Persuasive Technology	None	8	7	5	3	0	2	5
	Exclusive	11	2	0	2	1	9	5
	Inclusive	18	4	3	0	0	0	5

Persuasive Technology's Effect on Decision Made

See Table 6 for descriptive statistics of the effects of PT on decision making. An analysis was conducted to determine whether the PT manipulations, alternative-focused and attributed-focused, influenced the decision made. The percent agreement was calculated by comparing the decision made to the PT suggestion across the six levels where PT could be present. The PT suggestion in the control condition was calculated, but not presented to participants, enabling the control group to act as a comparison. The decision and suggestion matching resulted in a value of one. A mismatch resulted in a value of zero. The average of these values for each participant was calculated creating a percent agreement. This metric enabled an evaluation of the influence of the PT on the decision made by comparing the participants who saw the PT and those that did not. A factorial ANOVA with attribute PT (none, exclusive, inclusive) and alternative PT (none, exclusive, inclusive) as between

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subjects variables was conducted on the percent agreement between the decision made and the PT suggestion. See Table 7 for ANOVA results.

Based on the significant main effect for alternative-focused PT on the percent agreement between the decision made and the PT suggestion, pairwise comparisons using the Bonferroni correction indicated that exclusive alternative-focused PT ($M = 0.81, SD = 0.27$) led to greater agreement than inclusive ($M = 0.30, SD = 0.32$) or no ($M = 0.26, SD = 0.31$) alternative-focused PT. These findings suggested that when the alternative-focused PT recommended a specific alternative, it influenced the decision made. See Figure 7.

Based on the significant main effect for attribute-focused PT on the percent agreement between the decision made and the PT suggestion, pairwise comparisons using the Bonferroni correction indicated exclusive attribute-focused PT ($M = 0.57, SD = 0.37$) led to greater agreement than inclusive attribute-focused PT ($M = 0.39, SD = 0.38$). Similar to the alternative-focused PT, the attribute-focused PT influences the decision made, but to a lesser extent than alternative-focused as evident by the difference in effect sizes. See Figure 7.

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Table 6. *Descriptive Statistics of Decision Agreement with Persuasive Technology (n = 90)*

Alternative-focused Persuasive Technology	Attribute-focused Persuasive Technology	<i>M</i>	<i>SD</i>
None	None	.12	.14
	Exclusive	.53	.36
	Inclusive	.12	.16
	Total	.26	.31
Exclusive	None	.82	.24
	Exclusive	.73	.34
	Inclusive	.87	.23
	Total	.81	.27
Inclusive	None	.27	.34
	Exclusive	.45	.39
	Inclusive	.18	.12
	Total	.30	.32
Total	None	.40	.39
	Exclusive	.57	.37
	Inclusive	.39	.38
	Total	.45	.39

Note: Observed values range between 0.00 and 1.00.

Table 7. *Decision Agreement with Persuasive Technology ANOVA*

Outcome variable	Degrees of freedom	<i>F</i>	<i>p</i>	η_p^2
*Alternative-focused Persuasive Technology	(2,81)	37.10	< 0.001	0.48
*Attribute-focused Persuasive Technology	(2,81)	3.27	0.02	0.10
*Attribute- by Alternative-focused Interaction	(4,81)	3.27	0.02	0.14

Note: Asterisks(*) indicate significance ($p < 0.05$).

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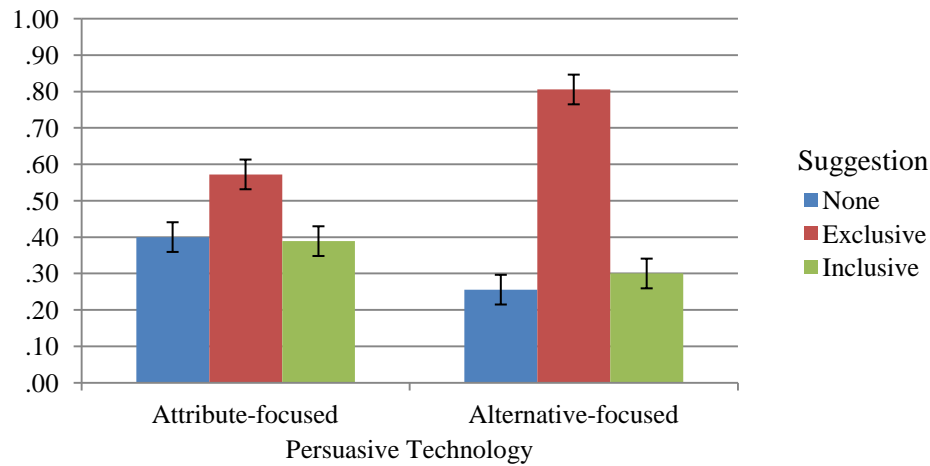


Figure 7. Means of Percent Agreement between Decision and Persuasive Technology Suggestion for Attribute-focused and Alternative-focused Main Effects.

Note: Error bars indicate standard error of the mean.

Based on the significant interaction between attribute-focused PT and alternative-focused PT on percent agreement between decision and suggestion, pairwise comparisons using the Bonferroni correction indicated that exclusive attribute-focused PT ($M = 0.53$, $SD = 0.36$) led to greater agreement than both no ($M = 0.12$, $SD = 0.14$) and inclusive ($M = 0.12$, $SD = 0.16$) attribute-focused PT for no alternative-focused PT, but no differences were observed between attribute-focused conditions for exclusive or inclusive alternative-focused PT. See Figure 8. These findings suggested that the effect of the PT varies based on the condition of both the attribute-focused and alternative-focused PT. This interaction appeared to be the cause of the main effect for attribute-focused PT.

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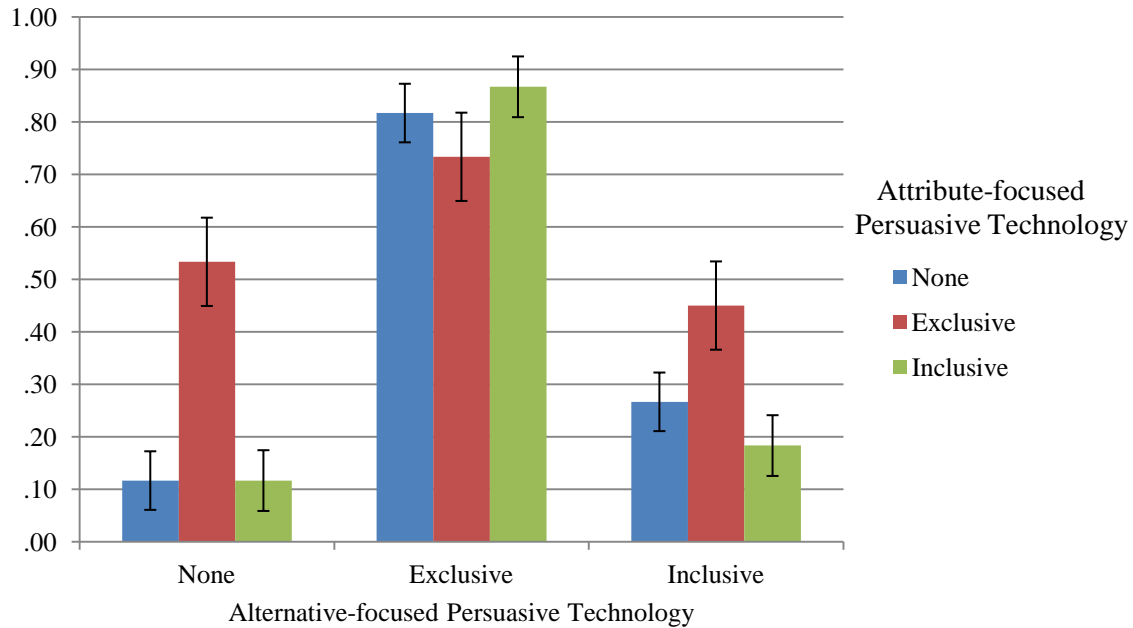


Figure 8. Means of Percent Agreement between Decision and Persuasive Technology Suggestion for Attribute-focused by Alternative-focused Interaction.

Note: Error bars indicate standard error of the mean.

Outcome Measures Based on Information Grids

The measures extracted from the information grid data included: (DV1) Payne (1976) Index, (DV2) number of values viewed (amount of information), (DV3) proportion of values viewed, and (DV4) average time per value viewed. Negative values of the Payne Index are associated with more transitions between alternatives along the same attribute (i.e., attribute-based processing). Positive values of the Payne Index are associated with more transitions between attributes along the same alternative (i.e., alternative-based processing). Alternative-based processing is associated with greater processing. Higher values are associated with

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greater processing for the other three measures. Willemsen and Johnson (2010) recommend data cleaning to investigate engagement of participants via the duration of decision tasks, average viewing of each value, number of values acquired, and removing unrealistic long or short trials. Therefore, dwell time of a value within the information grid had to be greater than 200ms to be recorded based on the recommendation of Payne, Bettman, and Johnson (1988). These measures were averaged across three decisions into blocks to address possible instability of the measures.

Multiple Regression of Potential Covariates on Outcome Measures

See Table 8 for descriptive statistics of covariates. Next multiple regression analyses were conducted to determine potential covariates for the testing of the hypotheses. Averaged scores across all decisions of each outcome measures were computed for this analysis. As a criterion, an outcome measure's full model must be significant to consider a significant predictor. Additionally, a predictor must be a significant predictor on at least two of the four outcome measures. The model with all potential covariates did not significantly predict the Payne Index, $F(6,83) = 0.86$, $MSE = 0.11$, $p = 0.51$, or the average time per value, $F(6,83) = 1.27$, $MSE = 0.08$, $p = 0.28$. The model with all potential covariates did significantly predict the number of values viewed, $F(6,83) = 3.27$, $MSE = 45.80$, $p = 0.01$, and proportion of values viewed, $F(6,83) = 3.41$, $MSE = 0.02$, $p = 0.01$. See Table 9 for the beta coefficients from the regression models. The working memory measure, 2-back task, met the criteria as a covariate.

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Table 8. *Descriptive statistics of Potential Covariates for Outcome Measures (n = 90)*

Covariates	<i>M</i>	<i>SD</i>	<i>Minimum</i>	<i>Maximum</i>
Age	33.81	11.02	19.00	66.00
Education	14.43	1.93	12.00	20.00
Points	37,509.09	5,866.89	15,331.00	44,306.00
Reasoning	12.00	3.48	1.00	18.00
Perceptual Speed	52.69	10.01	13.00	81.00
Working memory	15.49	11.96	0.00	40.00

Table 9. *Multiple Regression Beta Weights Assessing Potential Covariates for Outcome Measures (n = 90)*

	Payne Index	Number of values viewed	Proportion of values viewed	Average Time per value viewed
Age	-0.14	-0.02	0.18	0.17
Education	-0.02	-0.02	-0.01	-0.03
Points	0.05	-0.03	-0.05	-0.17
Reasoning	0.18	0.15	0.13	0.10
Perceptual Speed	-0.27*	-0.09	-0.02	0.03
Working memory	0.05	0.40*	0.39*	0.17
<i>R</i> ²	0.06	0.19*	0.20*	0.08

Note: Asterisks(*) indicate significance ($p < 0.05$).

Pre-PT Analysis of Outcome Measures Controlling for Working Memory

See Table 10 for descriptive statistics of pre-test outcome measures. Next, pre-existing differences between groups along the outcome measures for the first decision were evaluated. A MANCOVA with attribute-focused PT (none, exclusive, inclusive) and alternative-focused PT (none, exclusive, inclusive), working memory as a covariate, and the outcome measures (Payne Index, number of values viewed, proportion of values viewed, and average time per value viewed) was conducted on the first decision. See Table 11 for

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MANCOVA results. Based on the significance of alternative-focused PT, follow-up univariate ANCOVAs were performed on the outcome variables. See Table 12.

Table 10. *Descriptive Statistics of Pre-PT Outcome Measures (n = 90)*

Alternative-focused Persuasive Technology	Attribute-focused Persuasive Technology	DV1 Payne Index		DV2 Number Of Values		DV3 Proportion Of Values		DV4 Average Time Per Value	
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
None	None	-0.26	0.51	25.90	15.98	0.47	0.30	0.78	0.23
	Exclusive	-0.07	0.32	57.40	58.27	0.59	0.30	0.75	0.20
	Inclusive	-0.38	0.37	25.30	16.58	0.48	0.27	0.83	0.22
	Total	-0.24	0.41	36.20	38.09	0.51	0.29	0.79	0.21
Exclusive	None	-0.16	0.29	34.40	16.13	0.53	0.25	0.76	0.22
	Exclusive	0.04	0.29	31.60	22.78	0.47	0.31	0.70	0.29
	Inclusive	-0.20	0.39	40.10	18.85	0.63	0.27	0.70	0.16
	Total	-0.11	0.33	35.37	19.10	0.55	0.28	0.72	0.22
Inclusive	None	0.07	0.62	25.20	22.34	0.46	0.39	0.50	0.25
	Exclusive	-0.18	0.53	14.00	13.61	0.27	0.25	0.57	0.28
	Inclusive	-0.09	0.36	25.20	20.43	0.45	0.33	0.66	0.42
	Total	-0.07	0.51	21.47	19.26	0.39	0.33	0.58	0.32
Total	None	-0.12	0.50	28.50	18.25	0.49	0.31	0.68	0.26
	Exclusive	-0.07	0.39	34.33	40.01	0.45	0.31	0.68	0.26
	Inclusive	-0.23	0.38	30.20	19.39	0.52	0.29	0.73	0.29
	Total	-0.14	0.43	31.01	27.54	0.48	0.30	0.70	0.27

Note: Observed values of the Payne Index ranges between -1.00 and 0.84. Negative values indicate more attribute-based transitions. Positive values indicate more alternative-based transitions. Observed values of the number of values viewed ranged between 0.00 and 40.00, of the proportion of values viewed ranged between 0.00 and 0.65, and of the average time per value viewed ranged between 0.00 and 1.68 seconds. Higher values indicate more systematic processing for all four outcome measures.

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Table 11. *Pre-PT MANCOVA on Outcome Measures Controlling for Working Memory*

Variables	V	Degrees of freedom	F	p
Working memory	0.03	(4,77)	0.52	0.72
*Alternative-focused Persuasive Technology	0.19	(8,156)	2.03	< 0.05
Attribute-focused Persuasive Technology	0.11	(8,156)	1.10	0.37
Attribute- by Alternative-focused Interaction	0.19	(16,320)	1.02	0.43

Note: Calculations based on Pillai's trace. Asterisks (*) denote significance ($p < 0.05$).

Table 12. *Pre-test Separate Univariate ANCOVAs of Alternative-focused PT Controlling for Working Memory*

Outcome variable	Degrees of freedom	F	MSE	p	η_G^2
DV1 Payne Index	(2,80)	1.38	0.18	0.26	0.03
DV2 Number of Values Viewed	(2,80)	3.05	691.76	> 0.05	0.07
DV3 Proportion of Values Viewed	(2,80)	2.40	0.21	0.10	0.06
*DV4 Average Time per Value Viewed	(2,80)	5.39	0.37	0.01	0.12

Note: Asterisks (*) denote significance ($p < 0.05$). η_G^2 accounts for within subject variance and covariates (Olejnik & Algina, 2003). η_G^2 equaled η_p^2 to two digits.

Based on the significant main effect of average time per value viewed when controlling for working memory, estimated marginal mean comparisons using the Bonferroni correction indicated that no alternative-focused PT ($M = 0.79$, $SD = 0.05$) resulted in a longer average time per value viewed than inclusive alternative-focused PT ($M = 0.57$, $SD = 0.05$) when controlling for working memory. No other comparisons were significant.

Persuasive Technology Analyses on Outcome Measures Controlling for Working Memory

See Tables 13 and 14 for descriptive statistics. The following series of analyses evaluated hypotheses one and two. A MANCOVA with attribute-focused PT (none, exclusive, inclusive) and alternative-focused PT (none, exclusive, inclusive) as between subject variables, decision blocks (early, late) as a within subject variable, working memory

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as a covariate, and the outcome measures (Payne Index, number of values viewed, proportion of values viewed, and average time per value viewed) was conducted. Comparisons between the control and PT manipulations evaluated hypothesis one, whether PT affects the extent of systematic processing during decision making. Comparisons between exclusive and inclusive for attribute-focused and alternative-focused PT evaluated hypothesis two, whether differences in systematic processing will be observed based on the focus and exclusivity of PT. More specifically, hypotheses 2a and 2b involved the Payne Index. Hypothesis 2c involved all of the outcome measures. See Table 15 for MANCOVA. The significance of alternative-focused PT provided evidence in support of hypothesis 1. Follow-up univariate ANCOVA with alternative-focused PT were performed on the outcome variables. See Table 16. Hypotheses 2a and 2b failed to be supported due to the lack of a significance pertaining to the Payne Index. See Figure 9.

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Table 13. *Descriptive statistics of Payne Index and Number of Values Viewed (n = 90)*

Alternative- focused Persuasive Technology	Attribute-focused Persuasive Technology	DV1 Payne Index				DV2 Number Of Values			
		Early		Late		Early		Late	
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
None	None	-0.14	0.33	0.01	0.29	10.30	7.84	7.07	8.03
	Exclusive	-0.29	0.55	-0.12	0.54	13.57	7.59	12.33	8.68
	Inclusive	0.14	0.29	0.10	0.36	13.10	9.87	8.10	6.35
	Total	-0.10	0.43	0.00	0.40	12.32	8.33	9.17	7.83
Exclusive	None	0.09	0.31	0.02	0.45	11.93	11.39	3.90	4.31
	Exclusive	-0.03	0.39	-0.14	0.37	6.20	8.86	5.37	8.51
	Inclusive	0.02	0.42	0.09	0.25	6.07	8.56	2.23	4.75
	Total	0.03	0.37	-0.01	0.37	8.07	9.75	3.83	6.08
Inclusive	None	-0.03	0.32	-0.05	0.23	11.50	12.39	7.63	8.49
	Exclusive	-0.31	0.36	-0.07	0.40	9.43	5.11	4.73	2.30
	Inclusive	-0.04	0.27	-0.12	0.50	7.00	6.20	3.47	3.59
	Total	-0.13	0.33	-0.08	0.38	9.31	8.43	5.28	5.58
Total	None	-0.03	0.32	-0.01	0.33	11.24	10.37	6.20	7.14
	Exclusive	-0.21	0.44	-0.11	0.43	9.73	7.73	7.48	7.73
	Inclusive	0.04	0.33	0.02	0.39	8.72	8.66	4.60	5.49
	Total	-0.06	0.38	-0.03	0.38	9.90	8.94	6.09	6.88

Note: Observed values of the Payne Index ranges between -1.00 and 1.00. Negative values indicate more attribute-based transitions. Positive values indicate more alternative-based transitions. Observed values of the number of values viewed ranged between 0.00 and 210.00. Higher values indicate more systematic processing for all four outcome measures.

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Table 14. *Descriptive statistics of Proportion of Values Viewed and Average Time Per Value Viewed (n = 90)*

Alternative- focused Persuasive Technology	Attribute-focused Persuasive Technology	DV3 Proportion Of Values				DV4 Average Time Per Value Viewed			
		Early		Late		Early		Late	
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
None	None	0.21	0.15	0.15	0.16	0.54	0.26	0.40	0.30
	Inclusive	0.26	0.14	0.26	0.16	0.64	0.16	0.64	0.22
	Exclusive	0.28	0.20	0.17	0.12	0.55	0.19	0.47	0.19
	Total	0.25	0.16	0.19	0.15	0.58	0.21	0.50	0.26
Exclusive	None	0.21	0.15	0.10	0.10	0.50	0.27	0.54	0.43
	Inclusive	0.11	0.14	0.10	0.15	0.45	0.35	0.32	0.32
	Exclusive	0.12	0.13	0.05	0.09	0.94	0.56	0.45	0.50
	Total	0.15	0.14	0.08	0.11	0.63	0.46	0.44	0.42
Inclusive	None	0.21	0.19	0.15	0.17	0.52	0.35	0.36	0.23
	Inclusive	0.19	0.11	0.12	0.06	0.62	0.22	0.48	0.24
	Exclusive	0.17	0.14	0.08	0.07	0.60	0.40	0.49	0.66
	Total	0.19	0.15	0.12	0.11	0.58	0.32	0.44	0.41
Total	None	0.21	0.16	0.13	0.14	0.52	0.28	0.43	0.33
	Inclusive	0.19	0.14	0.16	0.14	0.57	0.26	0.48	0.28
	Exclusive	0.19	0.17	0.10	0.11	0.70	0.43	0.47	0.47
	Total	0.20	0.15	0.13	0.13	0.59	0.34	0.46	0.37

Note: Observed values of the proportion of values viewed ranged between 0.00 and 1.00 and of the average time per value viewed ranged between 0.00 and 1.33 seconds. Higher values indicate more systematic processing for all four outcome measures.

Table 15. *MANCOVA on Outcome Measures Controlling for Working Memory*

Variables	<i>V</i>	Degrees of freedom	<i>F</i>	<i>p</i>
*Working memory	0.18	(4,77)	4.30	< 0.01
*Alternative-focused Persuasive Technology	0.26	(8,156)	2.93	< 0.01
Attribute-focused Persuasive Technology	0.17	(8,156)	1.89	0.07
Decision blocks	0.11	(4,77)	2.26	0.07
Alternative- by Attribute-focused Interaction	0.16	(16,320)	0.86	0.62
Alternative- by Decision blocks Interaction	0.06	(8,156)	0.63	0.76
Attribute- by Decision blocks Interaction	0.13	(8,156)	1.38	0.21
Alternative- by Attribute- by Decision blocks Interaction	0.21	(16,320)	1.12	0.34

Note: Calculations based on Pillai's trace. Asterisks (*) denote significance ($p < 0.05$).

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Table 16. *Separate Univariate ANCOVAs of Alternative-focused PT Controlling for Working Memory*

Outcome variable	Degrees of freedom	<i>F</i>	<i>MSE</i>	<i>p</i>	η_p^2	η_G^2
DV1 Payne Index	(2,80)	0.84	0.09	0.44	0.02	0.02
*DV2 Number of Values Viewed	(2,80)	4.08	43.13	0.01	0.11	0.10
*DV3 Proportion of Values Viewed	(2,80)	6.90	0.01	< 0.01	0.15	0.10
DV4 Average Time per Value Viewed	(2,80)	0.03	0.02	0.81	0.01	< 0.01

Note: Asterisks (*) denote significance ($p < 0.05$). η_G^2 accounts for within subject variance and covariates (Olejnik & Algina, 2003).

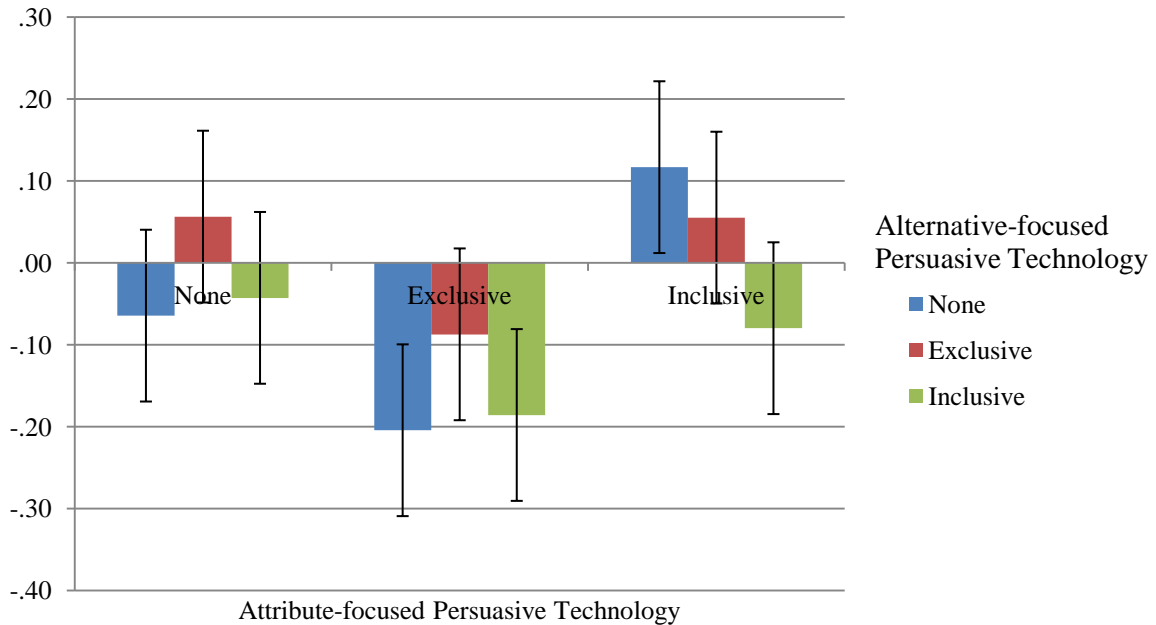


Figure 9. Means of Payne Index.

Note: Error bars are standard error of the mean.

Based on the significant main effect of alternative-focused PT on the number of values viewed, estimated marginal mean comparisons using the Bonferroni correction indicated that no alternative-focused PT ($M = 11.01$, $SD = 1.20$) resulted in a greater number

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of values viewed than exclusive ($M = 6.15, SD = 1.20$) or inclusive ($M = 6.84, SD = 1.21$) alternative-focused PT when controlling for working memory. These differences provided support for hypothesis 1, but fail to support hypothesis 2c. See Figure 10.

Based on the significant main effect of alternative-focused PT on the proportion of values viewed, estimated marginal mean comparisons using the Bonferroni correction indicated that no alternative-focused PT ($M = 0.23, SD = 0.02$) resulted in a greater proportion of values viewed than exclusive ($M = 0.12, SD = 0.02$) or inclusive ($M = 0.15, SD = 0.02$) alternative-focused PT when controlling for working memory. These differences provide support for hypothesis 1, but fail to support hypothesis 2c. See Figure 10.

Hypotheses 2a and 2b were not supported due to the Payne Index being non-significant. In addition to the Payne Index to investigate transitions between information in the information grids, multidimensional scaling was performed on transitions related to the suggested attribute or alternative. See appendices B and C.

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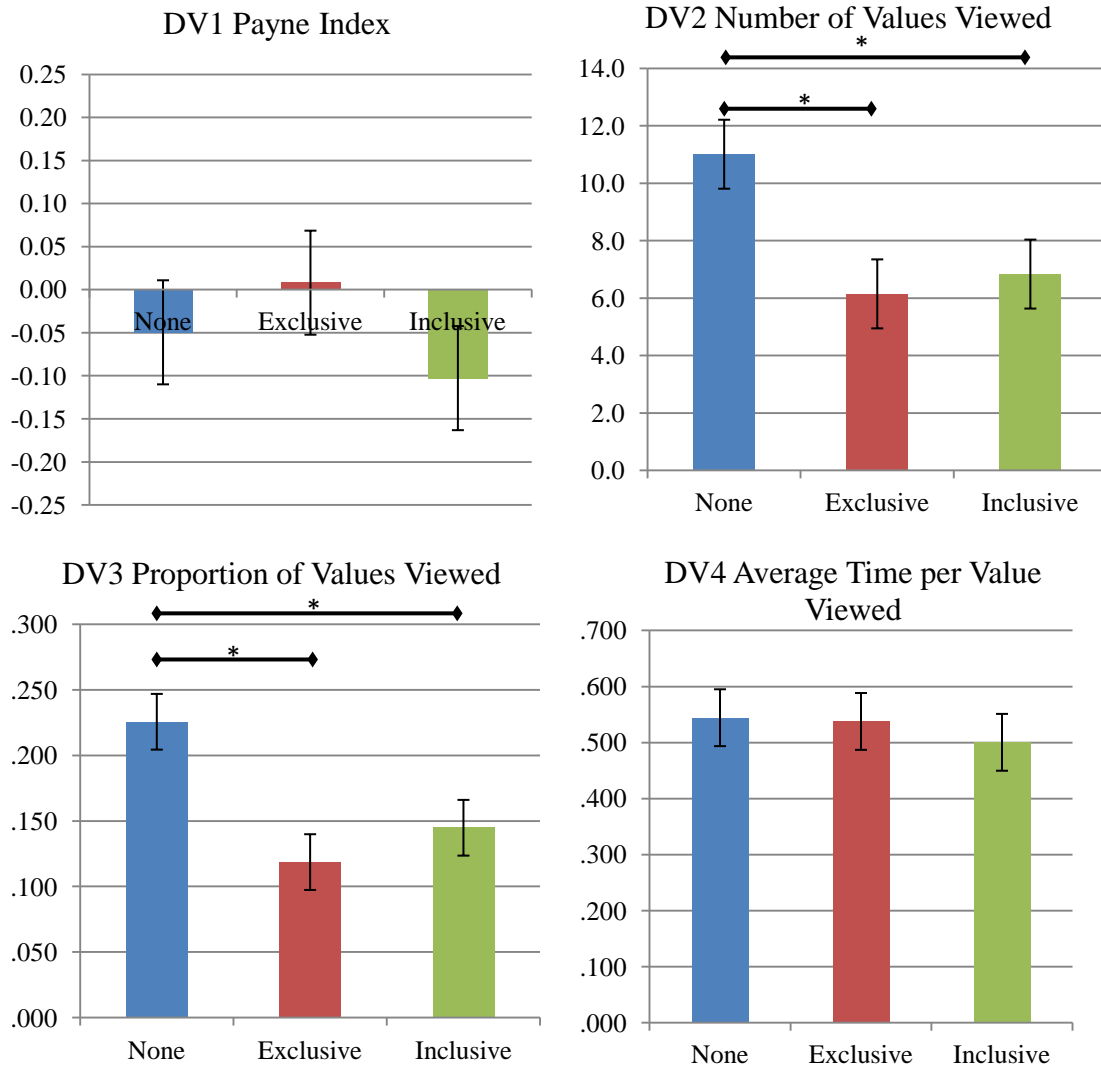


Figure 10. Means of Alternative-focused Persuasive Technology.

Note: Greater systematic processing associated with higher values for all measures. Asterisks (*) indicate a significant group difference with the Bonferroni correction. Error bars indicate standard error of the mean.

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Discriminant Function Analysis

The MANCOVA was followed-up with a discriminant function analysis using alternative-focused PT as the grouping variable. Two discriminant functions were revealed. The first function explained 93.30% of the variance, canonical $R^2 = 0.20$, and the second function explained 6.70% of the variance, canonical $R^2 = 0.02$. Together these discriminant functions significantly differentiated between the levels of the alternative-focused PT, $\Lambda = 0.78$, $\chi^2(8) = 20.76$, $p < 0.01$, but the second function did not significantly differentiate the groups when the first function was removed, $\Lambda = 0.98$, $\chi^2(3) = 1.53$, $p = 0.67$. See Table 17 for the individual contributions of each outcome measure in differentiating conditions of alternative-focused PT.

Table 17. Canonical Variate Correlation Coefficients for Alternative-focused PT

Outcome measure	Function 1	Function 2
DV1 Payne Index	-0.17	0.82
DV2 Number of Values Viewed	0.55	0.74
DV3 Proportion of Values Viewed	0.68	0.67
DV4 Average Time per Value Viewed	0.01	0.33

Measure of Variation

A measure of the variation in the data was calculated to determine whether there were differences in variability of the data between groups. The coefficient of variation (COV) is a measure of variation that provides a comparison of data with different means (Martin & Gray, 1971). It is calculated by dividing the standard deviation by the mean. A COV was calculated for each participant based on his or her scores across the six decisions where PT

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could be present. The Payne Index was transformed by adding a constant of 1 to eliminate negative values.

See Table 18 for descriptive statistics. A MANOVA with attribute-focused PT (none, exclusive, inclusive) and alternative-focused PT (none, exclusive, inclusive), decision blocks (early, late) and the COV measures (Payne Index, number of values viewed, proportion of values viewed, and average time per value viewed) was conducted. See Table 19 for MANOVA. Based on the significance of alternative-focused PT, follow-up univariate ANOVA were performed on the outcome variables. See Table 20.

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Table 18. *Descriptive Statistics of Coefficient of Variance of Outcome Measures (n = 90)*

Alternative- focused Persuasive Technology	Attribute- focused Persuasive Technology	DV1 Payne Index		DV2 Number Of Values		DV3 Proportion Of Values		DV4 Average Time Per Value	
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
None	None	0.46	0.40	1.02	0.69	1.02	0.73	0.83	0.82
	Exclusive	0.94	0.85	0.51	0.24	0.44	0.22	0.35	0.22
	Inclusive	0.34	0.24	1.02	0.65	0.96	0.63	0.68	0.55
	Total	0.58	0.60	0.85	0.60	0.81	0.61	0.62	0.60
Exclusive	None	0.40	0.19	1.45	0.60	1.38	0.61	1.01	0.50
	Exclusive	0.50	0.48	1.32	0.70	1.26	0.75	1.22	0.77
	Inclusive	0.45	0.19	1.26	0.48	1.16	0.52	1.24	0.52
	Total	0.45	0.31	1.34	0.58	1.27	0.62	1.16	0.60
Inclusive	None	0.38	0.22	0.99	0.58	0.96	0.57	0.79	0.54
	Exclusive	0.70	0.56	0.90	0.55	0.85	0.55	0.60	0.44
	Inclusive	0.59	0.44	1.27	0.64	1.23	0.64	1.01	0.65
	Total	0.56	0.44	1.05	0.59	1.01	0.59	0.80	0.56
Total	None	0.41	0.28	1.15	0.64	1.12	0.64	0.88	0.62
	Exclusive	0.71	0.65	0.91	0.61	0.85	0.63	0.72	0.63
	Inclusive	0.46	0.32	1.18	0.59	1.12	0.59	0.97	0.60
	Total	0.53	0.46	1.08	0.62	1.03	0.63	0.86	0.62

Note: Observed values for all measures range between 0.00 and 1.73. Larger numbers indicate greater variation in the measure between decisions at the participant level.

Table 19. *MANOVA on Coefficient of Variance Measures*

Variables	<i>V</i>	<i>Degrees of freedom</i>	<i>F</i>	<i>p</i>
*Alternative-focused Persuasive Technology	0.21	(8,158)	2.29	0.02
Attribute-focused Persuasive Technology	0.16	(8,158)	1.66	0.11
Attribute- by Alternative-focused Interaction	0.22	(16,324)	1.19	0.27

Note: Calculations based on Pillai's trace. Asterisks (*) denote significance ($p < 0.05$).

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Table 20. *Separate Univariate ANOVAs on Coefficient of Variance Measures of Alternative-focused PT*

Outcome variable	Degrees of freedom	<i>F</i>	<i>MSE</i>	<i>p</i>	η_p^2
DV1 Payne Index	(2,81)	0.30	0.15	0.48	0.02
*DV2 Number of Values Viewed	(2,81)	3.63	1.82	0.01	0.12
*DV3 Proportion of Values Viewed	(2,81)	3.16	1.58	0.02	0.10
*DV4 Average Time per Value Viewed	(2,81)	4.50	2.25	<0.01	0.14

Note: Asterisks (*) denote significance ($p < 0.05$).

Based on the significant main effect of alternative-focused PT on the number of values viewed COV, pairwise comparisons using the Bonferroni correction indicated that exclusive alternative-focused PT ($M = 1.34$, $SD = 0.58$) resulted in a greater variation in the proportion of values viewed than no alternative-focused PT ($M = 0.85$, $SD = 0.60$). See Figure 11.

Based on the significant main effect of alternative-focused PT on the proportion of values viewed COV, pairwise comparisons using the Bonferroni correction indicated that exclusive alternative-focused PT ($M = 1.27$, $SD = 0.62$) resulted in a greater variation in the proportion of values viewed than no alternative-focused PT ($M = 0.81$, $SD = 0.61$). See Figure 11.

Based on the significant main effect of alternative-focused PT on the average time per value viewed COV, pairwise comparisons using the Bonferroni correction indicated that exclusive alternative-focused PT ($M = 1.16$, $SD = 0.60$) resulted in a greater variation in the average time per value viewed than no alternative-focused PT ($M = 0.62$, $SD = 0.60$). See Figure 11.

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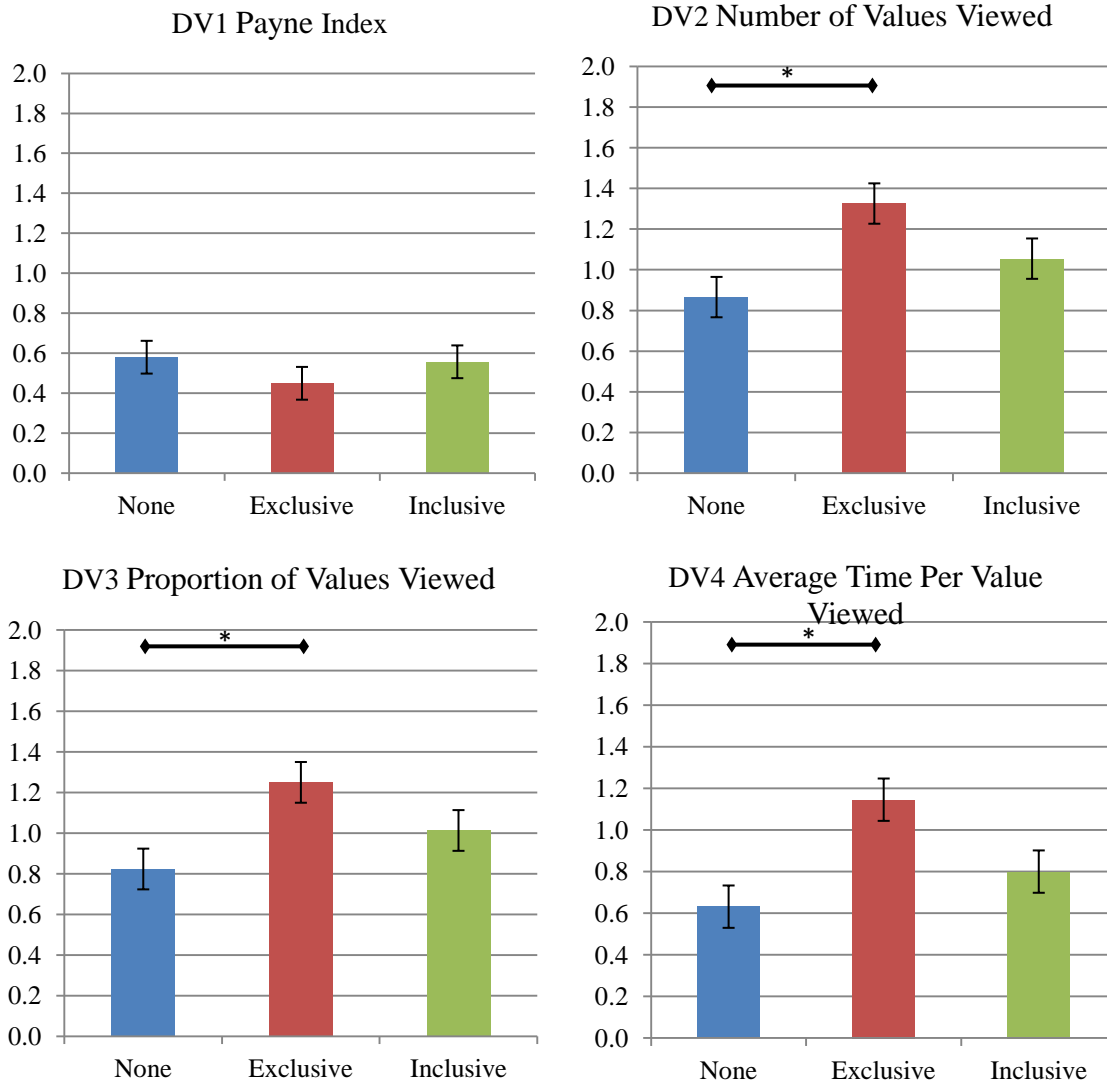


Figure 11. Means and Standard Error of COV scores for Alternative-focused Persuasive Technology. Note: Asterisks (*) indicate a significant group difference with the Bonferroni correction. Error bars indicate standard error of the mean.

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Discussion

Persuasive Technology's Effect on Game Performance

Game performance was analyzed to determine whether there was a difference in gameplay of participants based on the PT-related manipulations. Performance was based on collecting resources positively and in-game time negatively. There were no differences observed in performance between groups of the game. This result was expected as the decision outcomes did not influence the gameplay to create a consistent experience between participants. Additionally, this finding suggested that there were no gameplay experiences differences between groups that may have influenced decisions.

Perception of Attribute Importance

Participants rated which attribute they perceived to be most important. Possible responses included the six attributes and "all equal." The first analysis using these responses pertained to whether groups differed in perceiving their belief that the decisions were a deception. The purpose of the "all equal" response was to identify whether participants were aware of the deception without priming participants of the deception. There were no differences observed between groups in whether participants believed all attributes to be equally important or not. This analysis does not directly assess participants' perceptions of whether they believed the deception of their decisions not influencing the game. However, the assumption is that if they did not believe the decision effectual, then no attribute would be weighted more heavily than another resulting in an "all equal" response. Not only were

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there no differences between groups, but the majority of participants rated a specific attribute rather than "all equal." This evidence coupled with the evidence that PT influenced the decision made provides convergent evidence that participants believed the deception.

The second finding from the attribute weighting responses involves the effect of the PT on the importance of each attribute. The attribute suggested could change between levels based on performance. However, attribute-focused PT influenced which attribute overall was found to be most important by participants. This result suggested that recommending special consideration of a given attribute influenced participants' perceptions of the importance of attributes. This finding emphasized the importance of suggesting a particular attribute as being important.

Persuasive Technology's Effect on Decision Made

Decisions made were compared to which alternative was recommended. PT influenced the decision made. For alternative-focused PT, when the PT suggested a specific alternative (i.e., exclusive PT), participants were more likely to choose the alternative corresponding with the PT's suggestion than when there was no PT or when the PT suggestion pertained to considering all alternatives. For attribute-focused PT, the exclusive PT participants were more likely than inclusive PT participants to conform to the PT suggestion. This finding reinforces the differences in effect sizes of these two variables. The alternative-focused PT had a greater effect on the decisions than the attribute-focused PT. The significant interaction provides further evidence of the greater influence of alternative-

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focused PT than attribute-focused PT. The only condition when differences of the attribute-focused PT occurred was when there was no alternative-focused PT. This difference could be explained by the subsequent behavior following reception of the suggestion. The alternative-focused PT provides the participant with the decision and no further decision processing is necessary. If the participant uses the attribute-focused suggestion, he or she must review the decision information along that attribute to determine which alternative is rated highest on that attribute. As could be expected, if the PT did not specify a specific alternative or attribute (i.e., inclusive PT), there was no difference in comparison to the no PT group regarding the decisions compared to the PT suggestion.

Potential Covariates on Outcome Measures

Only one of the six potential covariates, working memory, was significant. Only two participants fell in the range where age-related differences were observed in Queen and colleague's research (2012), which provides a potential explanation for why age was not a significant covariate. There was very little variance in education, which limited its ability to predict differences. Perceptual speed as measured by the digit symbol substitution task predicted the Payne Index when included in a regression model alone, but not when included in a model with the other covariates. The failure of these covariates reinforced the importance and preference of controlling for extraneous variance through experimental design.

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Pre-test Analysis of Outcome Measures Controlling for Working Memory

Differences between alternative-focused PT were found on average time per value viewed for the decision prior to PT. Differences were not observed along this outcome measure in the primary analysis, however. Additionally, differences along number of values viewed approached significance. These findings may be characteristic of the instability of the measures over one decision. This potential instability in the pre-test affected the ability to determine whether pre-existing differences exist. Similar to the averaging of multiple decision data for the primary analyses, subsequent studies should use multiple decisions as a pre-test control.

Persuasive Technology Analyses on Outcome Measures Controlling for Working Memory

The first hypothesis involved whether PT influenced the extent of systematic processing in comparison to no PT. It received partial support from the differences along number of values viewed and proportion of values viewed for alternative-focused PT. No PT resulted in greater processing than either of the PT manipulations (i.e., inclusive or exclusive). Attribute-focused PT did not influence the extent of systematic processing. This difference between attribute- and alternative-focused PT in systematic processing coincided with the difference in the effect of PT on the decision made.

The second hypothesis involved whether differences emerged between the manipulations of PT. Hypotheses 2a and 2b involved differences between attribute-focused and alternative-focused PT based on the types of transitions based on the Payne Index. These

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hypotheses were not supported due to a lack of significance related to this measure, but more specifically the lack of a significant interaction between the two focuses of PT involving the Payne Index. Regarding hypothesis 2c, no differences were observed between inclusive and exclusive for either attribute-focused or alternative-focused PT. Instead, both forms of PT resulted in less systematic processing than no PT based on the number of values viewed and proportion of values viewed. These results indicated a failure of the inclusive manipulation as it was intended to increase the extent of systematic processing pertaining to a decision.

These findings combined suggested that participants who were exposed to the exclusive, alternative-focused PT relied on the PT suggestion in lieu of considering more information in the information grids. The number of values viewed and proportion of values viewed provided this evidence. The discriminant function analysis provided further evidence of the importance of these two outcome measures in the model.

Other Influences on Extent of Systematic Processing

There was a large amount of variance in the outcome measures. Only one of the potential covariates was significant. Rather than relying on statistical means to control this variance in the form of covariates, the experimental design can be altered and is preferable. The donation mechanic may have motivated participants differently. Although a variety of charities were included from which to choose, a participant may not have been motivated by any of the options. Also, the donation was relatively small. An alternative motivator was to replace the donation with a raffle. A follow-up analysis repeated measures ANOVA across

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the eight levels suggested differences between levels in performance based on points ($F(7,623) = 21.82$, $MSE = 801,227.19$, $p < 0.001$). When using the Bonferroni correction 13 of the 28 comparisons were significantly different from one another.

Measure of Variation

There was not a significant effect of time comparing early decision blocks to late decision blocks based on the means of measures. There was not an interaction involving time and alternative-focused or attribute-focused PT. However, in an exploratory analysis, group differences were found in the amount of variation within participants between decisions. These differences were found using the coefficient of variation. A larger coefficient indicated more variation in a participant's processing strategy between decisions while controlling for the participant's individual mean score. Exclusive alternative-focused PT was associated with greater variability in the measures when controlling for the mean score than no PT in three of the measures. This suggested that the variation in information processing strategy employed by participants was less between decisions for participants exposed to the exclusive alternative-focused PT than for participants not exposed to any PT. An implication of this effect may be that the effect of the inclusive alternative-focused PT changed over time at a rate faster than had the PT not been present.

Study 2

The purpose of study two was an attempt to replicate the findings from study one and to test the remaining hypothesis (hypothesis 3). The exploratory nature of the first study

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reinforced the importance of replication. The difference between studies one and two related to the persistence of the effects of PT and alterations based on the first study. The persistence was tested by varying whether participants were exposed to PT after every decision or not in the non-control conditions. The PT was limited to alternative-focused PT due to the findings from study one. The pre-PT phase of the decisions was expanded from the first decision to include the first three. This alteration was an attempt to increase the stability of measures intended to assess pre-existing differences between groups. The order of levels was randomized.

Method

Design

Study two used a factorial design similar to study one but with the addition of a persistence variable. The design was a randomized 5 x 2 factorial design with alternative-focused PT (none, exclusive PT with limited exposure, exclusive PT with full exposure, inclusive PT with limited exposure, inclusive PT with full exposure) as a between subject factor and decision blocks (pre-PT, post-PT) as a within subject factor. The same measures used in study one were used to collect data for variables served as possible covariates: performance, age, education, working memory, reasoning ability, and perceptual speed.

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Participants

Using G*Power (Faul et al., 2007) and based on a MANOVA, an alpha of (.05), four groups, four response variables, an effect size of (.09), and to have equal cell sizes, a sample size of 124 was necessary. An additional 31 participants were necessary as a control group with an equivalent cell size as the other groups. Participants were similarly recruited through MTurk. One-hundred fifty-eight participants were recruited. Three participant's data were removed because of errors in acquiring group assignment information. Of the remaining 155 participants, 78 were males, 76 were females, and 1 was unreported (age $M = 32.53$, $SD = 10.17$; years of education $M = 15.06$, $SD = 2.72$).

Measures and Instruments

The same game, process tracing, n-back, figural analogies, digital-symbol substitution, and demographic tasks as described in study one were used for study two. The donation mechanic was replaced with a performance based raffle. The number of entries into the raffle was dependent upon the number of points they earned. Points were positively affected by the number of resources collected and negatively affected by the in-game hours. Consistent with study one, decisions were framed as an alternative determined by a team. Framing the decisions in this manner connected the alternatives from one decision to the alternatives of other decisions. The purpose for framing the decisions in this manner was for the PT suggestions in the limited exposure condition. For example, the suggestion to consider

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Team L's alternatives can span multiple decisions, but the suggestion to choose level L does not necessarily span multiple decisions.

Persuasive Technology. The alternative-focused PT manipulation from study one was used for study two. Additionally, the full exposure condition presented the PT before every decision after the first. The limited exposure condition presented the PT for the one decision immediately following the pre-PT assessment.

Procedure

The same procedure from study one was implemented with some minor deviations. Rather than choosing a charity, participants were informed of the performance-based raffle. Additionally, participants in the PT conditions received either full or limited exposure to the PT.

Results

The analyses for study two followed the same structure as study one. The analyses began with performance in the game and PT's influence on perception of attribute importance and decisions. Potential covariates were evaluated in preparation of the analysis of the decision making processes. The primary analyses included a one-way analysis, which included a control group. It also included a 2x2 factorial design of exclusivity (exclusive, inclusive) and exposure (full, partial) without the control for increased statistical power.

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These analyses were followed up by discriminant function analysis and analyses using the coefficient of variation.

Persuasive Technology's Effect on Game Performance

See Table 21 for descriptive statistics. Like study one, performance scores were based on a composite of resources collected and in-game time. An ANOVA evaluated whether gameplay performance differed based on PT manipulations. There was no effect of PT, $F(4,150) = 0.61$, $MSE = 18,118,527.55$, $p = 0.66$, $\eta^2 = 0.02$. These results suggested that differences observed in subsequent analyses are not due to differences in gameplay experience.

Table 21. *Descriptive statistics of Game Performance Based on Points by Group Condition (n = 155)*

Condition	<i>M</i>	<i>SD</i>	Minimum	Maximum
Control	29,674.97	3,767.07	22,193.00	34,836.00
Exclusive PT, partial exposure	28,604.68	5,141.61	15,955.00	34,947.00
Exclusive PT, full exposure	29,442.65	4,068.39	21,817.00	35,073.00
Inclusive PT, partial exposure	29,641.52	4,770.25	13,223.00	35,779.00
Inclusive PT, full exposure	30,255.16	3,264.75	23,255.00	34,435.00
Total	29,531.77	4,242.33	13,223.00	35,779.00

Perception of Attribute Importance

Participants were asked which attribute they believed to be the most important to their game performance. These responses were dichotomized into "all equally important" and other responses as in study 1. See Table 22 for frequency data. There was not a significant

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association between the type of PT and whether or not participants reported dimensions being equivalently important $\chi^2(4) = 2.37, p = 0.67$.

Table 22. *Frequencies of attribute weightings transformed*

	Other	All equal
Control	29	2
Exclusive PT, partial exposure	27	4
Exclusive PT, full exposure	28	3
Inclusive PT, partial exposure	26	5
Inclusive PT, full exposure	29	2

As with study one, the raw data of weighted attributes were analyzed. See Table 23 for frequency data. There was not a significant association between the type of alternative-focused PT and whether or not participants reported dimensions being equivalently important, $\chi^2(24) = 25.06, p = 0.40$.

Table 23. *Frequencies of attribute weightings*

Condition	Attribute weightings							All equal
	Ease of finding resources	Richness of deposits	Weather	Subterranean gas pressure	Rover deployment time	Movement time		
Control	12	7	4	6	0	0	2	
Exclusive PT, partial exposure	14	5	5	1	1	1	4	
Exclusive PT, full exposure	15	7	2	1	1	2	3	
Inclusive PT, partial exposure	9	9	2	1	1	4	5	
Inclusive PT, full exposure	14	10	1	2	1	1	2	

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Persuasive Technology's Effect on Decision Made

See Table 24 for descriptive statistics of the effects of PT on decision making. The percent agreement was calculated in the same way as from study one. There was an effect of PT, $F(4,150) = 34.97$, $MSE = 0.07$, $p < 0.001$, $\eta^2 = 0.48$. Based on the significant main effect on the percent agreement between the decision made and the PT suggestion, pairwise comparisons using the Bonferroni correction indicated that exclusive PT with full exposure agreement was greater than all other groups. Exclusive PT with partial exposure agreement was greater than all other groups except for exclusive PT with full exposure.

Table 24. *Descriptive Statistics of Decision Agreement with Persuasive Technology (n = 155)*

Condition	<i>M</i>	<i>SD</i>	Minimum	Maximum
Control	0.13	0.16	0.00	0.33
Exclusive PT, partial exposure	0.51	0.34	0.00	1.00
Exclusive PT, full exposure	0.74	0.34	0.00	1.00
Inclusive PT, partial exposure	0.17	0.19	0.00	0.67
Inclusive PT, full exposure	0.13	0.21	0.00	0.67
Total	0.34	0.36	0.00	1.00

Multiple Regression of Potential Covariates on Outcome Measures

See Table 25 for descriptive statistics of covariates. The same method from study one was used to assess whether to include a variable as a covariate in subsequent analyses. The model with all potential covariates did not significantly predict the Payne Index, $F(6,148) = 0.66$, $MSE = 0.08$, $p = 0.68$, or the average time per value viewed, $F(6,148) = 1.11$, $MSE = 0.08$, $p = 0.36$. The model with all potential covariates did significantly predict the number

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of values viewed, $F(6,148) = 5.96$, $MSE = 99.54$, $p < 0.001$, and proportion of values viewed, $F(6,148) = 7.48$, $MSE = 0.02$, $p < 0.001$. See Table 26 for the beta coefficients from the regression models. Age, education, and points met the criteria as covariates.

Table 25. *Descriptive statistics of Potential Covariates for Outcome Measures (n = 155)*

	<i>M</i>	<i>SD</i>	Minimum	Maximum
Age	32.53	10.17	19.00	67.00
Education	15.06	2.72	10.00	24.00
Points	29,523.79	4,234.90	13,223.00	35,779.00
Reasoning	11.37	3.55	0.00	19.00
Perceptual Speed	50.86	12.91	0.00	77.00
Working memory	14.97	12.32	0.00	40.00

Table 26. *Multiple Regression Beta Weights Assessing Potential Covariates for Outcome Measures (n = 155)*

Predictors	Payne Index	Number of values viewed	Proportion of values viewed	Average Time per value viewed
Age	0.08	0.16*	0.16*	0.11
Education	0.13	0.20*	0.19*	0.03
Points	0.02	0.35*	0.43*	0.20*
Reasoning	0.00	-0.01	0.03	-0.04
Perceptual Speed	-0.02	0.04	0.00	-0.09
Working memory	-0.02	0.05	0.00	-0.07
R^2	0.04	0.20*	0.23*	0.05

Note: Asterisks (*) denote significance ($p < 0.05$).

Pre-PT Analysis of Outcome Measures Controlling for Age, Education, and Points

See Table 27 for descriptive statistics of pre-PT outcome measures. As in study one, preexisting differences between groups were evaluated. Unlike study one, the outcome data

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from the first three decisions were combined. A MANCOVA with alternative-focused PT (control, exclusive PT with partial exposure, exclusive PT with full exposure, inclusive PT with partial exposure, and inclusive PT with full exposure) as a between subject variable and age, education, and points as covariates was conducted. See Table 28 for one-way MANCOVA results. A separate 2x2 MANCOVA with exclusivity (exclusive, inclusive) and exposure (limited, full) as between subject factors and age, education, and points as covariates was conducted for increased power. See Table 29 for MANOVA results. Results from both analyses suggested no differences between groups.

Table 27. Descriptive Statistics of Pre-PT Outcome Measures (n = 155)

Inclusiveness	Exposure	DV1 Payne Index		DV2 Number of Values		DV3 Proportion Of Values		DV4 Average Time Per Value Viewed	
		M	SD	M	SD	M	SD	M	SD
Control	Control	-0.02	0.33	22.90	17.12	0.38	0.19	0.59	0.14
Exclusive	Partial	-0.06	0.37	20.01	13.44	0.34	0.17	0.60	0.18
	Full	-0.01	0.30	17.39	11.56	0.32	0.18	0.62	0.20
	Total	-0.04	0.33	18.70	12.50	0.33	0.17	0.61	0.19
Inclusive	Partial	-0.05	0.32	25.56	21.90	0.37	0.24	0.60	0.25
	Full	-0.04	0.36	21.10	13.72	0.35	0.17	0.70	0.43
	Total	-0.04	0.33	23.33	18.26	0.36	0.21	0.65	0.35
Total	Partial	-0.06	0.34	22.78	18.24	0.35	0.21	0.60	0.21
	Full	-0.02	0.33	19.24	12.72	0.34	0.17	0.66	0.34
	Total	-0.04	0.33	21.01	15.76	0.35	0.19	0.63	0.28

Note: Observed values of the Payne Index ranges between -1.00 and 0.67. Negative values indicate more attribute-based transitions. Positive values indicate more alternative-based transitions. Observed values of the number of values viewed ranged between 0.00 and 78.00, of the proportion of values viewed ranged between 0.00 and 0.99, and of the average time per value viewed ranged between 0.00 and 2.71 seconds. Higher values indicate more systematic processing.

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Table 28. *Pre-PT One-way MANCOVA on Outcome Measures Controlling for Age, Education, and Points*

Variables	V	Degrees of freedom	F	p
Age	0.05	(4,144)	2.06	0.09
Education	0.04	(4,144)	1.39	0.24
*Points	0.15	(4,144)	6.56	<0.001
PT	0.11	(4,144)	1.01	0.44

Note: Calculations based on Pillai's trace. Asterisks (*) denote significance ($p < 0.05$).

Table 29. *Pre-PT 2x2 MANCOVA of Exclusivity and Exposure on Outcome Measures Controlling for Age, Education, and Points*

Variables	V	Degrees of freedom	F	p
Age	0.05	(4,114)	1.61	0.18
Education	0.02	(4,114)	0.54	0.70
*Points	0.19	(4,114)	6.50	<0.001
Exclusivity	0.06	(4,114)	1.67	0.16
Exposure	0.05	(4,114)	1.64	0.17
Exclusivity by exposure	0.02	(4,114)	0.52	0.72

Note: Calculations based on Pillai's trace. Asterisks (*) denote significance ($p < 0.05$).

Persuasive Technology Analyses on Outcome Measures

See Table 30 for descriptive statistics. Similar to the pre-PT analyses, a one-way analysis to evaluate groups in reference to a control group preceded a 2x2 analysis for increased power. See Table 31 for the one-way MANCOVA. See Table 32 for the follow-up univariate ANCOVA. Based on estimated marginal means corrected using the Bonferroni method, the exclusive PT with full exposure scored lower than all other groups for both the number and proportion of values viewed when controlling for age, education, and points. The difference between the control and exclusive PT with full exposure provides further support of hypothesis one.

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Table 30. *Descriptive statistics of Outcome Measures (n = 155)*

Inclusiveness	Exposure	DV1 Payne Index		DV2 Number of Values		DV3 Proportion Of Values		DV4 Average Time Per Value Viewed	
		M	SD	M	SD	M	SD	M	SD
Control	Control	-0.02	0.49	10.46	9.71	0.21	0.18	0.48	0.23
Exclusive	Partial	0.00	0.28	7.24	8.83	0.15	0.16	0.38	0.27
	Full	0.01	0.32	3.35	5.27	0.07	0.11	0.47	0.35
	Total	0.01	0.30	5.30	7.47	0.11	0.14	0.43	0.31
Inclusive	Partial	0.00	0.38	9.69	8.86	0.19	0.16	0.48	0.44
	Full	-0.17	0.40	10.66	8.05	0.21	0.14	0.67	0.72
	Total	-0.09	0.40	10.17	8.41	0.20	0.15	0.58	0.60
Total	Partial	0.00	0.33	8.46	8.86	0.17	0.16	0.43	0.36
	Full	-0.08	0.37	7.01	7.69	0.14	0.14	0.57	0.57
	Total	-0.04	0.35	7.73	8.29	0.16	0.15	0.50	0.48

Note: Observed values of the Payne Index ranges between -1.00 and 0.91. Negative values indicate more attribute-based transitions. Positive values indicate more alternative-based transitions. Observed values of the number of values viewed ranged between 0.00 and 33.33, of the proportion of values viewed ranged between 0.00 and 0.61, and of the average time per value viewed ranged between 0.00 and 4.24 seconds. Higher values indicate more systematic processing.

Table 31. *One-way MANCOVA on Outcome Measures Controlling for Age, Education, and Points*

Variables	V	Degrees of freedom	F	p
Age	0.02	(4,144)	.72	0.58
*Education	0.08	(4,144)	2.98	0.02
*Points	0.16	(4,144)	6.80	<0.001
*PT	0.22	(4,144)	2.14	0.01

Note: Calculations based on Pillai's trace. Asterisks (*) denote significance (p < 0.05).

Table 32. *Separate Univariate ANCOVAs of Alternative-focused PT Controlling for Age, Education, and Points*

Outcome variable	Degrees of freedom	F	MSE	p	η_p^2	η_G^2
DV1 Payne Index	(4,147)	1.16	0.15	0.33	0.03	0.03
*DV2 Number of Values Viewed	(4,147)	5.25	54.58	<0.01	0.12	0.10
*DV3 Proportion of Values Viewed	(4,147)	5.57	0.02	<0.01	0.13	0.11
DV4 Average Time per Value Viewed	(4,147)	1.66	0.19	0.16	0.04	0.04

Note: Asterisks (*) denote significance (p < 0.05). η_G^2 accounts for within subject variance and covariates (Olejnik & Algina, 2003).

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See Table 33 for the MANCOVA for the 2x2 analysis. Follow-up ANCOVAs were conducted for the interaction of exclusivity and exposure and main effect of exclusivity. See Tables 34 and 35 respectively. Based on the significant interaction of exclusivity and exposure, estimated marginal means were calculated and their comparisons were corrected using the Bonferroni method. For the number of values viewed, inclusive scores were greater than exclusive for the full exposure, but not for partial exposure. A similar pattern was observed for the proportion of values viewed. Additionally, for the number of values viewed, partial exposure was greater than full exposure for exclusive PT, but not for inclusive PT. A similar pattern of results was observed for proportion of values viewed. See Figure 12. Follow-up comparisons were not needed to investigate the main effect because there were two groups, but mean scores indicated inclusive scores were greater than exclusive. See Figure 13. These findings provided partial support of hypothesis three because exclusive required full exposure to have an effect yet inclusive was similar across exposure conditions. However, inclusive PT did not differ from the control.

In addition to the Payne Index to investigate transitions between information in the information grids, multidimensional scaling was performed on transitions related to the suggested alternative. See Appendix D.

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Table 33. 2x2 MANCOVA on Outcome Measures Controlling for Age, Education, and Points

Variables	V	Degrees of freedom	F	p
Age	0.03	(4,114)	0.75	0.56
Education	0.05	(4,114)	1.46	0.22
*Points	0.19	(4,114)	6.83	<0.001
*Exclusivity	0.14	(4,114)	4.48	<0.01
Exposure	0.06	(4,114)	1.68	0.16
*Exclusivity by exposure	0.09	(4,114)	2.82	0.03

Note: Calculations based on Pillai's trace. Asterisks (*) denote significance (p < 0.05).

Table 34. Separate Univariate ANCOVAs of Exclusivity by Exposure Interaction Controlling for Age, Education, and Points

Outcome variable	Degrees of freedom	F	MSE	p	η_p^2	η_G^2
DV1 Payne Index	(1,117)	1.66	0.12	0.20	0.01	0.01
*DV2 Number of Values Viewed	(1,117)	5.85	51.60	0.02	0.05	0.04
*DV3 Proportion of Values Viewed	(1,117)	6.67	0.02	0.01	0.05	0.04
DV4 Average Time per Value Viewed	(1,117)	0.33	0.23	0.57	<0.01	<0.01

Note: Asterisks (*) denote significance (p < 0.05). η_G^2 accounts for within subject variance and covariates (Olejnik & Algina, 2003).

Table 35. Separate Univariate ANCOVAs of Exclusivity Main Effect Controlling for Age, Education, and Points

Outcome variable	Degrees of freedom	F	MSE	p	η_p^2	η_G^2
DV1 Payne Index	(1,117)	2.09	0.12	0.15	0.02	0.02
*DV2 Number of Values Viewed	(1,117)	10.08	51.60	<0.01	0.08	0.06
*DV3 Proportion of Values Viewed	(1,117)	10.80	0.02	<0.01	0.08	0.07
DV4 Average Time per Value Viewed	(1,117)	2.70	0.23	0.10	0.02	0.02

Note: Asterisks (*) denote significance (p < 0.05). η_G^2 accounts for within subject variance and covariates (Olejnik & Algina, 2003).

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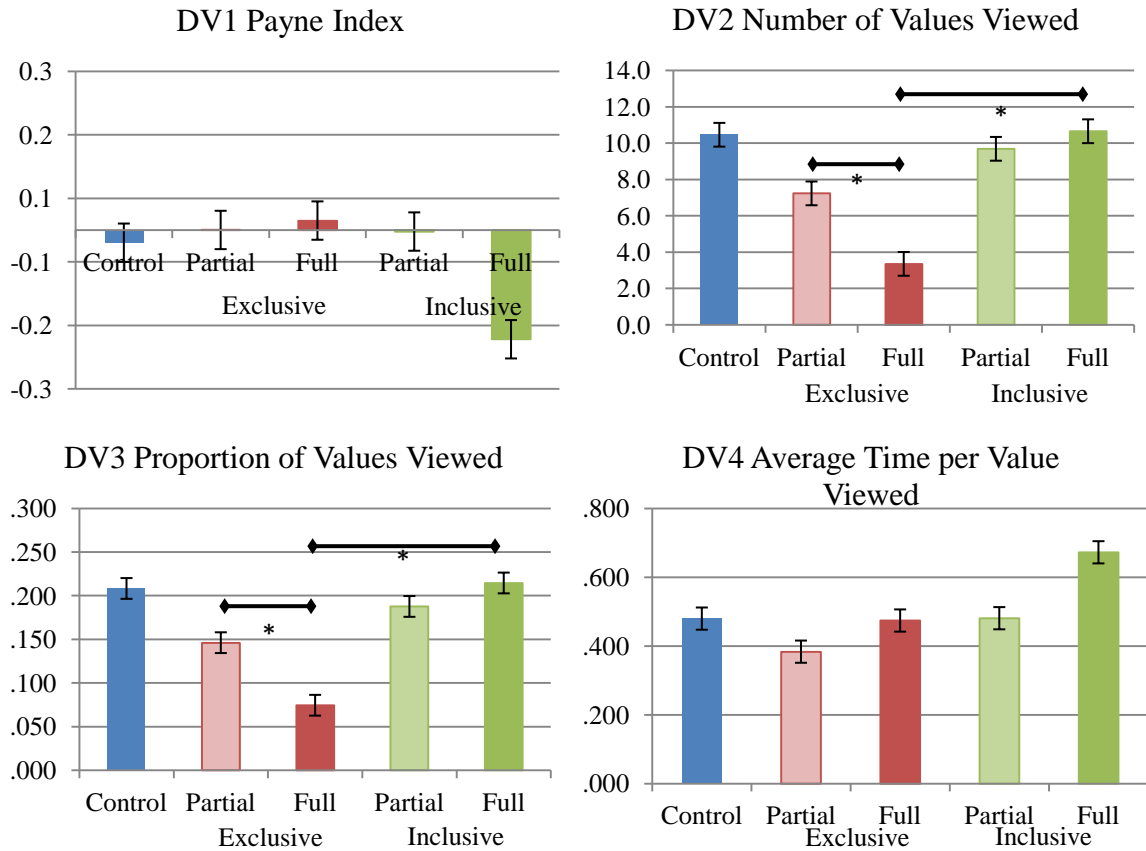


Figure 12. Means of Exclusivity by Exposure Persuasive Technology Interaction.
 Note: Greater systematic processing associated with higher values for all measures. Asterisks (*) indicate a significant group difference with the Bonferroni correction. Error bars indicate standard error of the mean.

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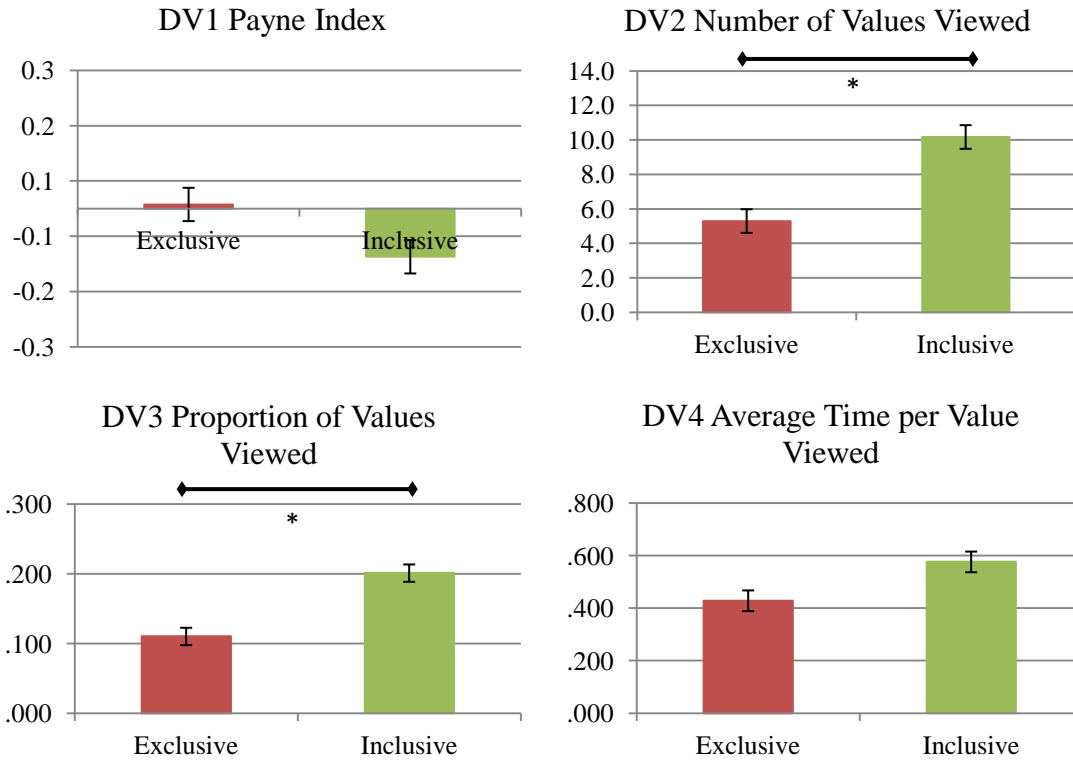


Figure 13. Means of Exclusivity Persuasive Technology.
 Note: Greater systematic processing associated with higher values for all measures. Asterisks (*) indicate a significant group difference with the Bonferroni correction. Error bars indicate standard error of the mean.

Discriminant Function Analysis

The MANCOVA was followed by a discriminant function analysis using alternative-focused PT as the grouping variable. Four discriminant functions were revealed. See Table 36. Together these discriminant functions significantly differentiated between the levels of the alternative-focused PT, $\Lambda = 0.81$, $\chi^2(16) = 32.26$, $p = 0.01$, but the functions two through four, $\Lambda = 0.95$, $\chi^2(9) = 7.75$, $p = 0.56$, three through four, $\Lambda = 0.99$, $\chi^2(4) = 1.05$, $p = 0.90$, or four alone, $\Lambda = 1.00$, $\chi^2(1) = 0.25$, $p = 0.62$, did not significantly differentiate the groups. See

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Table 37 for the individual contributions of each outcome measure in differentiating conditions of alternative-focused PT.

Table 36. *Discriminant functions of Alternative-focused PT*

Function	% of variance	canonical R^2
1	77.10	0.15
2	19.80	0.04
3	2.30	0.01
4	0.70	<0.01

Table 37. *Canonical Variate Correlation Coefficients for Alternative-focused PT*

Outcome measure	Function 1	Function 2	Function 3	Function 4
DV1 Payne Index	-0.35	0.48	0.32	0.74
DV2 Number of Values Viewed	0.75	0.50	0.36	0.23
DV3 Proportion of Values Viewed	0.80	0.46	0.19	0.34
DV4 Average Time per Value Viewed	0.36	-0.71	0.48	0.37

Measure of Variation

The coefficient of variation was calculated as it was in study one to determine whether there were differences in variability of the data at the individual level between groups. See Table 38 for descriptive statistics of pre-PT coefficient of variation (COV) measures. A one-way MANOVA of pre-PT COV measures with alternative-focused PT (control, exclusive PT with partial exposure, exclusive PT with full exposure, inclusive PT with partial exposure, and inclusive PT with full exposure) as a between subject variable and points as a covariate was conducted. Using Pillai's trace, there was not a significant effect of alternative-focused PT on the pre-PT COV measures, $V = 0.14$, $F(16,600) = 1.34$, $p = 0.17$. A

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separate 2x2 MANOVA with exclusivity (exclusive, inclusive) and exposure (limited, full) as between subject factors was conducted for increased power and investigation of interactions. See Table 39 for MANOVA results. Results from both analyses suggested no differences between groups in the variation between decisions at the participant level.

Table 38. *Pre-PT Descriptive Statistics of Pre-PT Coefficient of Variation Measures (n = 155)*

Inclusiveness	Exposure	DV1 Payne Index		DV2 Number of Values		DV3 Proportion Of Values		DV4 Average Time Per Value Viewed	
		M	SD	M	SD	M	SD	M	SD
Control	Control	0.48	0.30	0.73	0.44	0.66	0.48	0.38	0.45
Exclusive	Partial	0.41	0.28	0.86	0.41	0.76	0.41	0.42	0.38
	Full	0.54	0.45	0.85	0.43	0.79	0.44	0.51	0.49
	Total	0.48	0.38	0.85	0.42	0.78	0.42	0.46	0.44
Inclusive	Partial	0.61	0.42	0.87	0.43	0.72	0.45	0.53	0.46
	Full	0.46	0.43	0.75	0.39	0.65	0.39	0.39	0.34
	Total	0.53	0.43	0.81	0.42	0.68	0.42	0.46	0.41
Total	Partial	0.51	0.37	0.86	0.42	0.74	0.43	0.47	0.42
	Full	0.50	0.44	0.80	0.41	0.72	0.42	0.45	0.42
	Total	0.50	0.40	0.83	0.42	0.73	0.42	0.46	0.42

Note: Observed values for all measures range between 0.00 and 1.73. Larger numbers indicate greater variation in the measure between decisions at the participant level.

Table 39. *Pre-PT 2x2 MANOVA with Exclusivity and Exposure on Coefficient of Variation Measures*

Variables	V	Degrees of freedom	F	p
Exclusivity	0.07	(4,117)	2.22	0.07
Exposure	0.04	(4,117)	1.16	0.33
Exclusivity by Exposure	0.05	(4,117)	1.49	0.21

Note: Calculations based on Pillai's trace. Asterisks (*) denote significance (p < 0.05).

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See Table 40 for descriptive statistics of post-PT COV measures. To evaluate the effects of the experimental manipulations including a control group, first a MANOVA with alternative-focused PT (control, exclusive PT with partial exposure, exclusive PT with full exposure, inclusive PT with partial exposure, and inclusive PT with full exposure) as a between subject variable was conducted. Using Pillai's trace, there was a significant effect of alternative-focused PT on the post-PT COV measures, $V = 0.18$, $F(16,600) = 1.75$, $p = 0.03$. See Table 41 for follow-up univariate ANOVAs. Based on the significant main effect of the average time per value viewed, pairwise comparisons using the Bonferroni correction indicated exclusive PT with full exposure scores varied more than inclusive PT with full exposure.

Table 40. *Post-PT Descriptive Statistics of Coefficient of Variation Measures (n = 155)*

Inclusiveness	Exposure	DV1 Payne Index		DV2 Number of Values		DV3 Proportion Of Values		DV4 Average Time Per Value Viewed	
		M	SD	M	SD	M	SD	M	SD
Control	Control	0.48	0.30	0.73	0.44	0.66	0.48	0.38	0.45
Exclusive	Partial	0.27	0.32	0.95	0.60	0.94	0.60	0.80	0.61
	Full	0.44	0.47	0.88	0.61	0.86	0.62	0.88	0.63
	Total	0.35	0.41	0.92	0.60	0.90	0.61	0.84	0.62
Inclusive	Partial	0.47	0.50	0.79	0.49	0.77	0.48	0.57	0.52
	Full	0.49	0.59	0.63	0.41	0.60	0.43	0.44	0.49
	Total	0.48	0.54	0.71	0.46	0.68	0.46	0.51	0.50
Total	Partial	0.37	0.43	0.87	0.55	0.85	0.55	0.69	0.57
	Full	0.46	0.53	0.76	0.53	0.73	0.55	0.66	0.60
	Total	0.42	0.48	0.81	0.54	0.79	0.55	0.67	0.59

Note: Observed values for all measures range between 0.00 and 1.73. Larger numbers indicate greater variation in the measure between decisions at the participant level.

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Table 41. *Post-PT Separate Univariate ANOVAs of Alternative-focused PT with Control Group based on Coefficient of Variation Measures*

Outcome variable	Degrees of freedom	<i>F</i>	<i>MSE</i>	<i>p</i>	η^2
DV1 Payne Index	(4,150)	1.01	0.23	0.40	0.03
DV2 Number of Values Viewed	(4,150)	1.63	0.47	0.17	0.04
DV3 Proportion of Values Viewed	(4,150)	1.83	0.53	0.13	0.05
*DV4 Average Time per Value Viewed	(4,150)	3.48	1.11	0.01	0.09

Note: Asterisks (*) denote significance ($p < 0.05$).

A separate 2x2 MANOVA with exclusivity (exclusive, inclusive) and exposure (limited, full) as between subject variables without the control group was conducted. See Table 42 for the MANOVA. See Table 43 for follow-up analyses. The 2x2 design precluded the need for pairwise comparisons, but for the number of values viewed variation, exclusive variation was greater than inclusive variation. For the proportion of values viewed variation, exclusive variation was greater than inclusive variation. For the average time per value viewed variation, exclusive variation was greater than inclusive variation. See Figure 14.

Table 42. *Post-PT MANOVA with Exclusivity and Exposure on Coefficient of Variation Measures*

Variables	<i>V</i>	Degrees of freedom	<i>F</i>	<i>p</i>
*Exclusivity	0.12	(4,117)	4.15	< 0.01
Exposure	0.06	(4,117)	1.77	0.14
Exclusivity by Exposure	0.03	(4,117)	0.76	0.55

Note: Calculations based on Pillai's trace. Asterisks (*) denote significance ($p < 0.05$).

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Table 43. *Post-PT Separate Univariate ANOVAs of Alternative-focused PT with Exclusivity and Exposure*

Outcome variable	Degrees of freedom	<i>F</i>	<i>MSE</i>	<i>p</i>	η_p^2
DV1 Payne Index	(1,120)	2.14	0.23	0.15	0.02
*DV2 Number of Values Viewed	(1,120)	4.61	0.29	0.03	0.04
*DV3 Proportion of Values Viewed	(1,120)	5.13	0.29	0.03	0.04
*DV4 Average Time per Value Viewed	(1,120)	10.99	0.32	<0.01	0.08

Note: Asterisks (*) denote significance ($p < 0.05$).

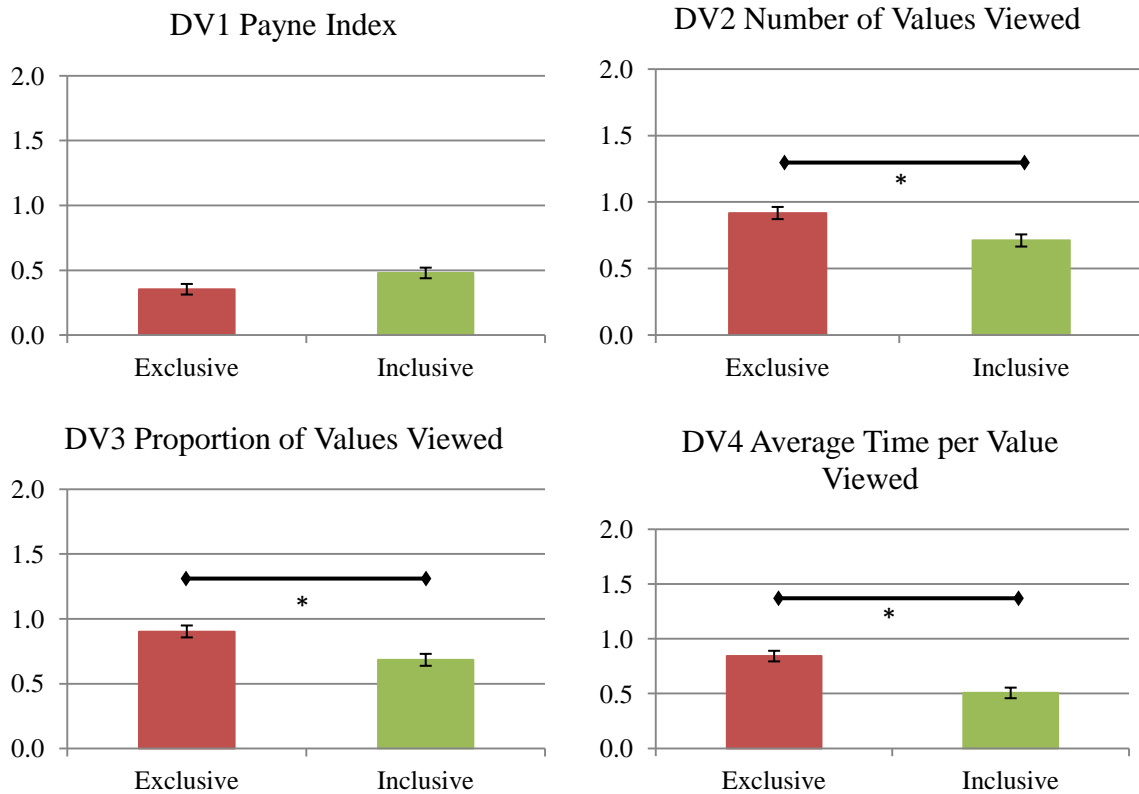


Figure 14. Means and Standard Error of COV scores for Exclusivity of Persuasive Technology.

Note: Asterisks (*) indicate a significant group difference with the Bonferroni correction. Error bars indicate standard error of the mean.

Discussion

Persuasive Technology's Effect on Game Performance

Game performance was analyzed to determine whether there was a difference in gameplay of participants based on the PT-related manipulations. No differences were identified. This finding was expected as the same levels were played albeit in a randomized order at the participant level. Additionally, this finding built evidence that subsequent findings were due to experimental manipulations rather than differences in experience.

Perception of Attribute Importance

Attribute importance was rated by participants to assess the effectiveness of the deception and whether groups differed based on which attribute was weighted as the most important. The first analysis using these responses pertained to whether groups differed in perceiving all attributes as equally important as an indirect assessment of the deception pertaining to the decisions being irrelevant to the game. Groups did not differ based on this analysis, which suggested that the deception should not influence group differences pertaining to the other measures. The second analysis pertained to whether there were differences between groups where attribute was perceived as the most important. No differences were observed between groups, which can be explained by the lack of an exclusive attribute-focused PT manipulation.

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Persuasive Technology's Effect on Decision Made

Decisions made were compared to which alternative was recommended. For the partial exposure group, the one alternative recommended by the PT was compared to remaining decisions. The exclusive PT groups were the only ones that differed from other groups. This finding is expected because these groups are the only ones that received a recommendation pertaining to a particular alternative. In addition, the more exposure to the PT, the more likely decisions were in agreement. A follow-up analysis investigated whether this effect extended to the decisions for levels six and seven to determine whether the effect of exclusive PT with partial exposure was limited to the decision where PT was present. Results indicated a similar pattern of results with exclusive PT with partial exposure having greater agreement between decision made and PT suggestion than all other groups except for exclusive PT with full exposure for which partial had less agreement than full exposure. These results suggested that although it was best to present the suggested alternative consistently, partial exposure influenced agreement even when the PT was not present. See Appendix E. This finding has implications pertaining to the effects of PT beyond the decision with which the PT is paired. The PT for the partial conditions was worded to encompass the remaining decisions. It is unknown whether a similar pattern of results would be observed if the PT suggestion specified its applying to the current decision only (e.g., choose alternative K for this decision) or being ambiguous (e.g., choose alternative K). If viewers of the PT generalize a suggestion that is intended for the current decision to future decisions, then

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future decisions may be suboptimal. This effect could result in decreased trust similar to the effects of reliability of information on trust in automation (e.g., Hilburn et al, 1993).

Therefore, an investigation involving manipulations of the wording of partial exposure PT is a plausible next step.

Potential Covariates on Outcome Measures

Potential covariates for the outcome measures were evaluated to account for variance due to individual differences that may have concealed potential effects of the experimental manipulations. The three covariates identified included age, education, and points based on regression analyses. However, education was only significant in the one-way MANCOVA of the outcome measures. Age was not a significant covariate for any of the analyses. The non-significance of education and age and significance of points as covariates reflects the different contributions in the regression analyses. The beta-weight of points was approximately two-times greater than age and education for both number and proportion of values viewed.

Pre-PT Analysis of Outcome Measures Controlling for Age, Education, and Points

Differences between groups prior to PT were evaluated to determine whether differences found post-PT could be explained by pre-existing differences between groups. This evaluation included three decisions to create a more stable measure. No differences were found between groups prior to the PT based on the outcome measures when controlling for the age, education, and points. These findings add pre-existing differences in systematic

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processing to the list of possible sources of group differences in subsequent analyses that have been eliminated.

Persuasive Technology Analyses on Outcome Measures Controlling for Age, Education, and Points

The first hypothesis involved whether PT influenced the extent of systematic processing in comparison to no PT. This study included a control group and evaluated hypothesis one through a series of one-way analyses in an attempt to replicate the findings from study one. The one-way MANCOVA replicated the findings from study one by identifying differences between the control group and PT. Less processing in comparison to the control was only associated with exclusive PT with full exposure when controlling for the covariates. This finding suggested that processing is only influenced enough to be identified through inferential means when the PT consistently recommended a particular alternative.

Evaluation of hypothesis three was contingent upon two findings. The first finding necessary was hypothesis 2c: for exclusive PT to result in less processing than inclusive PT. The second finding necessary was for exclusive PT to be influenced by limiting the exposure of the PT, but for inclusive PT to remain stable between limited and full exposure. Although this pattern of results was observed, when the inclusive processing is considered in relation to the control group, the consistency of inclusive between full and limited exposure can be interpreted as a lack of an effect instead of a consistent greater effect.

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Measure of Variation

Coefficients of variation (COVs) were calculated for each participant along each measure twice: one pre-PT and one post-PT. The COV was analyzed as another means of evaluating the effects of PT because the notion that systematic processing may change between decisions was of interest. These coefficients captured the amount of variation observed between decisions at the individual level. One-way and factorial design analyses suggested no pre-existing group differences in the variation of the outcome measures per participant. The one-way analysis of post-PT decisions suggested that only two groups differed: exclusive PT with full exposure and inclusive PT with full exposure. This difference was only observed in the variation of the average time per value viewed. However, the factorial analysis suggested that there was more variation in exclusive PT than inclusive PT along the variation in number and proportion of values viewed and average time per value viewed. The effects of number and proportion of values viewed included small effect sizes. These small effect sizes could explain why the effects were not observed in the one-way design as the factorial design was more powerful. The lack of an interaction suggested that the findings from the one-way analysis could have been limited due to the lack of power. The individual group means trend towards supporting the factorial design of differences between inclusive and exclusive.

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Limitations

The primary limitation unique to study two was the necessity to include a one-way analysis. Based on the nature of the nested nature of variables, the control group could not be integrated into the factorial design. The problem with including a separate analysis was that it increased the chances of type I error. However, findings between the analyses were mostly consistent. Differences could be explained by the increase in power rather than relying upon fishing for significance.

General Discussion

Persuasive technology (PT) is touted as a means of affecting behavioral change (Fogg, 2003). PT is said to be relevant in socially important issues such as health and conservation efforts. The topic has received attention by researchers as evidenced by numerous publications (e.g., Heyman, 2013; Lockton et al., 2008; Mintz & Aagaard, 2012) and the International Conference on Persuasive Technology being in its ninth iteration. However, few investigations have evaluated the behavior change the technology is stated to accomplish. Even fewer investigations have evaluated the influence on cognitive processing of PT. The current research's purpose is to build evidence of the behavioral and cognitive effects of PT.

It is important to preface the current findings in the context of the study. The decisions from these studies were balanced meaning that if each attribute was weighted evenly by a participant, then all alternatives would be rated equally. Not only were the

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decisions balanced, but they were also considered preferential as there was no right or wrong choice. Also, the nature of the decisions and the methodology predisposed decision makers to systematic processing. As mentioned, PT is typically associated with socially important issues. This characteristic should make the outcomes of these decisions highly motivated. However, the fact that these social issues (e.g., obesity or smoking) remain prevalent suggests that there are competing motivations (e.g., laziness or enjoyment of food versus being healthy). The decisions in the game used in the current experiments included a similar dichotomy. In both studies there was a benefit that required additional efforts in the form of the charity donation from study one and the raffle in study two. However, the motivation to make decisions quickly to finish the study competed with this motivation.

Persuasive Technology's Effect on Game Performance

A similar experience between participants was created by deceiving participants into believing their decisions influenced the game. This deception was intended to avoid introducing additional variance in decision processing that could result from good or poor performance. Assessment of the experience was performed by investigating whether there were differences in game performance and perception of attribute importance. Performance was based on the two criteria in the game: the number of resources collected and in-game hours accrued from moving, digging, and exploding from either a storm or a dangerous dig. Because participants were deceived regarding their decisions, it was expected that inclusion

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and manipulation of the PT would not influence performance. This expectation was supported in both studies with no group differences being observed. These findings suggested that the other findings are not limited to when PT positively influences performance.

Perception of Attribute Importance

Attribute weightings of importance were collected directly from participants for two reasons. The first reason was to covertly evaluate whether participants believed the deception pertaining to the decisions. Participants were provided with a response option of "all equal" to assess this belief without priming participants to the deception. Using this method of assessment relied upon the assumption that if participants did not believe the decisions influenced the game then they would not report that any one attribute was more important than another. The results from both studies suggested that there were no differences in the "all equal" response of the attribute weightings. Therefore it can be safely assumed that there were no differences between groups based on the deception.

The second reason for the analysis of attribute importance perceptions was to assess whether there were differences between groups on which attribute was rated the most important. Differences between groups were only observed from the manipulation of exclusive attribute-focused PT from study one. This condition was the only condition in both studies that suggested a specific attribute. Since attribute-focused PT was not evaluated

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pertaining to partial exposure, it is unknown whether this manipulation of PT would influence attribute importance. However, this form of PT could be useful in an applied setting. If attribute-focused PT with partial exposure can influence attribute importance, then this form of PT may influence decisions when the PT is not present. An example of this situation would be a PT suggesting a low calorie snack (i.e., attribute-focused) rather than or in combination with the suggestion of a salad (i.e., alternative-focused). The lowest calorie alternative is always available in a decision if that caloric information is known, but a salad might not always be available. This example demonstrates the utility of testing attribute-focused PT with exposure.

Persuasive Technology's Effect on Decision Made

PT is intended to influence behavior (Fogg, 2003; Oinas-Kukkonen & Harjumaa, 2008), but as previously stated, the successfulness of this intention has very little direct evidence. In the current studies the outcome of the behavior pertaining to the PT was the decision of the participant. Therefore, the decisions of participants were evaluated to determine the influence of the PT as a precursor to investigating the effect of PT on the cognitive processing of participants. Both studies demonstrated the influence of PT on the decision made. Additionally, manipulations of the PT influenced the effectiveness of the PT. The most effective means of attaining agreement between the PT and the decision was by using PT that focused on an alternative (i.e., alternative-focused), specified a specific

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decision (i.e., exclusive PT), and was presented consistently (i.e., full exposure). Deviations from these characteristics decreased agreement as demonstrated by the attribute-focused PT in study one and partial exposure in study two. However, the most important characteristic was the exclusivity. Inclusive PT did not result in greater agreement. This finding was expected as participants were unaware of the suggestion based on the PT either directly through the alternative or indirectly through the attribute. Thus, it relied on chance agreement between the algorithm to determine the suggestion and the participants' perceived importance of attributes. Prior to an evaluation of PT's effects on systematic processing, assessments were performed to identify individual differences that may have influenced that relationship.

Individual Differences as Potential Covariates

There were a number of individual differences identified in the literature that could have influenced systematic processing of the decisions. Accounting for variance due to individual differences through covariates would reduce the unexplained variance in analyses. It was important to account for as much variance as possible in the measures as it was not known what effect sizes to expect in the measures. The potential covariates from the literature included age (Queen et al., 2012), education, working memory, reasoning skills (Mata et al., 2007), and perceptual speed (Salthouse, 1996). Performance in the game was also included as it was an indirect measure of motivation that could influence the extent of systematic processing. The first study indicated that working memory explained variance in

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the measures. In the second study, age, education, and performance (i.e., points) were included based on the assessment of potential covariates, but performance was the primary covariate in the subsequent analyses. An increase in points was associated with a greater number and proportion of values viewed. This finding could be interpreted as the greater a participant was motivated then the more systematic processing they performed in the decisions. One of the concerns from study one was that participants were not motivated or that individual differences in the degree of motivation were not accounted for by a covariate. These individual differences could have arisen due to the options of charities and/or differences in motivation to donate to charities. The change to the performance-based raffle could be explained as the reason for this difference between studies. Exploratory analyses from study two of the measures indicated no relationship between working memory and number ($r = 0.14, p = 0.09$) or proportion ($r = 0.12, p = 0.16$) of values viewed, which eliminates mediation as a possible explanation of the difference. Explanations of the differences between the studies include the effect of an individual's working memory ability was overridden by the influence of the performance-based raffle or there were differences between the two samples. Covariates were one method used to aid the studies by accounting for variance due to individual differences. Another aid to the studies was including pre-test decisions.

Pre-PT Analysis of Outcome Measures Controlling for Covariates

In both studies there were decisions made by all participants prior to the possibility of the presence of PT. These pre-PT decisions acted as a pre-test to assess whether there were pre-existing individual differences between groups. The first study identified a difference between groups prior to the PT. However, it was hypothesized that this result could be due to the instability of measures over one decision. The second study included averaged values from the first three decisions as a pretest to address this issue. No differences were observed in the second study. This discrepancy between studies one and two was evaluated further in a series of follow-up analyses. The first decision from study two was analyzed alone similar to the pre-PT assessment from study one. Differences between groups were identified using a one-way design at the multivariate level, but not at the univariate level. Using a factorial design with exclusivity and exposure indicated exposure as a significant predictor. Follow-up univariate analysis and estimated marginal mean comparisons suggested that partial exposure was greater than full exposure on the number of values viewed. See Appendix F.

Additionally, coefficient of variance (COV) scores were calculated between participants ignoring condition for the first three pre-PT decisions of study two. COV scores of 0.43, 0.15, and 0.27 indicated the greatest amount of between participant variance when controlling for means occurred during the first decision. Based on these follow-up analyses it is recommended that multiple decisions be used. With individual differences addressed using

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the covariates and pre-existing differences assessed by the pre-test decisions, the post-PT decisions could be assessed for differences based on the PT manipulations.

Persuasive Technology's Influence on Systematic Processing

The focus of the analyses centered upon the hypotheses of the studies. The hypotheses were evaluated based on four outcome measures: the Payne Index, number of values viewed, proportion of values viewed, and average time per value viewed. Hypothesis one (H1) involved whether PT affected the extent of systematic processing during decision making based on process tracing information grids. The first study partially supported H1 from the manipulation of alternative-focused PT based on number and proportion of values viewed. Both of these measures were lower than when no PT was present. The second study replicated these findings and limited the effects further to during full exposure. Tools from the functional triad are intended to decrease processing performed by the human decision maker. Decision support systems are intended to serve a similar function. These findings suggested that presence of the PT did have this effect. Further evaluation could manipulate the presence of each component of the triad to determine whether this effect is reliant on tools or a general effect of PT.

Hypothesis two (H2) involved whether differences in systematic processing were observed based on the focus and exclusivity of PT. More specifically it involved whether attribute-focused PT resulted in greater attribute-based transitions in comparison to

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alternative-focused PT (H2a) and conversely whether alternative-focused PT resulted in greater alternative-based transitions in comparison to attribute-focused PT (H2b). These hypotheses were not supported because of the lack of a significant interaction between the two focuses of PT involving the Payne Index. The implication is that the focus of the PT suggestion did not result in a difference in the type of processing (e.g., attribute or alternative).

In addition, hypothesis two included an evaluation of whether inclusive PT would result in greater systematic processing in comparison to exclusive PT based on the measures as a whole (H2c). The first study indicated no differences between inclusive and exclusive PT for either attribute- or alternative-focused PT. However, it was unknown whether this effect was due to a lack of difference or the study lacking the statistical power to identify differences. The power analysis for study two was updated based on the effects observed in study one. Study two provided conflicting support for hypothesis two. These groups differed along the number and proportion of values viewed based on the factorial analysis. However, inclusive did not differ from the control in the one-way analysis. Overall, PT resulted in less or did not influence processing. The inclusive PT was intended to increase systematic processing, but did not. Influencing the degree of systematic processing would be advantageous for PT if the purpose was to emphasize an important decision necessitating systematic consideration. Additionally, there is some evidence that greater systematic

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processing is more robust to change (e.g., Petty et al., 1995). Other attempts to encourage greater systematic processing should be investigated.

Hypothesis three (H3) involved whether inclusive PT would require fewer PT-related interactions to maintain that level of systematic processing in comparison to exclusive. This hypothesis was evaluated by study two. As with the evaluation of hypothesis 2c, this hypothesis received partial support. Exclusive PT with partial exposure had a smaller effect on systematic processing than full. Inclusive PT with partial exposure was similar to full exposure. But from the one-way analysis there was no effect of either inclusive group when compared to the control. The emphasis of this hypothesis was that the inclusive effect on PT would have a stable effect on systematic processing. Because it did not influence systematic processing, this hypothesis was considered to be not supported. Since inclusive PT did not result in greater processing, the implications of this finding are the same as those from hypothesis 2c.

Measure of variation

The amount of variance present in the data prompted an investigation using the coefficient of variation (COV). The COV represented the amount of variance within participants between decisions controlling for the individual's mean. In study one, a single COV was calculated across the six decisions where PT could be present for each measure. In study two, one COV was calculated for the three pre-PT decisions and one for the post-PT

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condition for each measure. These analyses were intended to provide an alternative means of capturing an effect of the series of decisions. Both studies reproduced analyses of groups using the COV of the outcome measures. Study one reinforced the effect of alternative-focused PT on systematic processing. There was greater variation on number and proportion of values viewed and the average time per value viewed between no PT and exclusive alternative-focused PT. Differences were also identified in study two with the average number of values viewed. Exclusive PT varied more than inclusive PT. These results together suggested that the effect of the exclusive PT on systematic processing is inconsistent across decisions.

Differences between studies

There were several differences besides the different manipulations of PT between studies one and two. These changes arose due to findings from the first study. As mentioned above pertaining to the potential covariates, the method of motivation was altered. Instead of a donation to the charity that received the greatest amount of points, a raffle was created with the number of entries for a participant being dictated by the number of points he or she earned. The primary effect that was identified from this change was a relationship between points and systematic processing and in turn the suppression of the association between working memory and systematic processing. A follow-up study could manipulate whether participants are informed of a donation to a charity or a performance-based raffle to

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investigate further the effects of this change. Another change was the randomization of the levels. In the first study, performance varied by game level based on level characteristics as opposed to an effect of order (e.g., skill acquisition). Study two randomized the order of levels at the individual level to distribute any potential systematic processing variance due to level difficulty across the decisions. The last change was the inclusion of the first three decisions as part of the pre-test to assess pre-existing differences between groups. As previously discussed, this change appeared to be effective. With the implications to PT evaluated, additional implications in a broader sense are evaluated next.

Implications Beyond Persuasive Technology

Process Tracing and Related Measures

The process tracing measures overall were successful in identifying group differences. The number and proportion of values viewed were the primary two measures that identified differences between groups. The discriminant function analyses from both studies also suggested that these two measures contributed the most in distinguishing between groups. Both were included as they can potentially track unique aspects of systematic processing. Number of values viewed captured each individual time a value within the grid is viewed without regard to whether it was opened previously. Whereas proportion of values viewed only included whether a cell was open no matter how many times it occurred. This distinction could be useful if decision makers referred to the same

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values multiple times. However, this distinction does not seem to have been necessary.

Follow-up analysis indicated that these two measures were highly correlated within the early and late blocks for study one and with the pre-PT and post-PT blocks for study two. See Appendix G for correlations. Follow-up multivariate analyses were conducted with the Payne Index, proportion of values viewed, and average number of values viewed. Study one indicated alternative-focused PT as a significant predictor paralleling the original analysis. This analysis diverged from the original based on both the attribute-focused PT and the decision block being significant at the multivariate level and univariate level with proportion of values viewed. However, for attribute-focused PT there were no differences between groups identified based on estimated marginal means. Based on the significance of proportion of values viewed for decision blocks, estimated marginal mean comparisons using the Bonferroni correction were conducted. Greater systematic processing occurred during the early decisions than the later decisions. Despite the lack of a significant main effect for average time per value viewed, greater time was spent in early decisions than late decisions based on estimated marginal means. Study two indicated a similar pattern of results as the original analyses. See Appendix H. It is recommended that use of only one of these measures is needed for analysis in future studies that use information grids. It is also recommended that the raw data captured by such studies include both measures but the decision for which is to be used should be made based on initial descriptive analysis.

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The other two measures contributed less to the studies. The Payne Index captures the proportion of alternative-based transitions to attribute-based transitions. However, it did not identify differences between groups. It seems that this is in large part due to between subject variance. This finding suggested that PT does not influence the type of processing performed based on information grids. The average time per value viewed was significant during the pre-test from study one. As discussed previously, it is recommended that several decisions be averaged together to account for instability of the measure. Study one included two blocks of decisions that could include PT. However, decision block was not significant at the multivariate level. Nor was decision block significant at the univariate level of analysis with the average number of values viewed. However, the coefficient of variance (COV) scores of average time per value viewed were also significant outcome measures in both studies pertaining to alternative-focused PT. Use of the COV in this manner is novel, but appears to capture a pattern in the data that was not captured by traditional means. Not only should the measures be evaluated, but the process tracing method should also undergo evaluation.

The mouse-based information grids were able to identify differences between groups based on experimental manipulations. Like any methodology, it has limitations. For example, the PT provided an additional source of information. There was evidence that the PT influenced the outcomes of decisions and processing of the information within the grid. However, the mouse-based information grids fail to capture the processing associated with the PT. Future research could utilize eye-tracking methodology to capture the interaction

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between the participant, PT, and decision information. Additionally, if eye-tracking provides convergent evidence of the differences found in PT using information grids, it would provide support against a mono-method bias, which is especially important due to differences found between these two methods (e.g., Lohse & Johnson, 1996).

However, challenges may arise in how to integrate these data with the metrics pertaining to the decision grid. Number and proportion of values viewed, the two primary measures of interest based on the current findings, could be redefined to include the PT but how this information is integrated will need consideration. There would be differences in the total information present based on the condition (e.g., control receives no PT versus groups that do receive PT). It would need to be determined whether the PT counts as one value or more. Despite the lack of contribution of the Payne Index and small contribution of the average time per value viewed, these two measures should be included due to the aforementioned differences exhibited by mouse-based and eye-tracking-based methods (Lohse & Johnson, 1996). The Payne Index captures transitions between information in the grid, so the measure would ignore the PT. Average time per value viewed could be redefined as total time, but that may strengthen the correlation of metrics pertaining to the amount or proportion of information viewed. Separate metrics could be extracted pertaining specifically to the PT, but those measures would only be useful in comparing manipulations of the PT as they would be null when PT is not present. The most important consideration is that these

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findings are tested with alternative methods. But the implications of these findings are not limited to PT and process tracing.

Automation and Decision Support Systems

PT intertwines with a number of topics present in the research literature. One topic is automation. Automation is comprised of four functions: monitoring of system status, generating options or strategies to attain goals, selection of option or strategy, and implementing the choice or strategy (Endsley, 1999). Based on the levels of automation taxonomy presented by Endsley (1999), the current implementation of PT could be considered shared control automation with an alteration. The human and system share monitoring and generating and the human retains the function of selection. This PT deviated from shared control due to implementation remaining in the control of the human. The implementation remaining in human control is a common characteristic of PT that differentiates it from automation. However, following the example of Fogg and his reliance on previous literature to build the Functional Triad, PT can draw from previous literature for its benefit. One of the important findings pertaining to automation is trust.

Trust in automation is important as it may lead to reliance. Performance issues may arise from overreliance on automation, especially over extended periods (e.g., Hilburn et al, 1993) or full automation (e.g., Endsley, 1987). A recent meta-analysis of automation studies investigated effect of the degree of automation (DOA; Onnasch, Wickens, Li, & Manzey, 2013). The findings suggested a cost-benefit trade-off. Performance can benefit from

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increasing DOA. However, performance during system failure and situation awareness both suffer from increased DOA. Trust was demonstrated by participants making decisions in agreement with the PT suggestions. Like automation, reliance on PT is a concern. The potential negative effects of this reliance make the reliability and validity of the PT suggestions important. In the current PT, the monitoring performance, rules governing suggestions (i.e., the rules from Table 2), and simulation of saved hours all depend on reliable and valid PT. However, the issue of trust may not be as dire for PT as it is for automation.

The meta-analysis by Onnasch and colleagues (2013) specified that decrements in performance related to high DOA often occur between information analysis and action selection. However, PT focuses on supporting a decision but not making or executing a decision. As previously stated, the current incarnation of PT deviated from controlled automation in the implementation. The components of the functional triad (Fogg, 2003) model of PT also demonstrate the emphasis on supporting a decision. Tools acquire and analyze information. Media use information to create simulations related to a decision. Social actors mimic strategies used by human persuaders to convince the persuadee to choose a specified alternative. All three assist the human in making a decision beneficial to the decision maker. None of these components make the decision. However, until trust in PT is evaluated, it can only be speculated on what its effects are. Therefore, PT should be

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evaluated similar to automation by manipulating the reliability and validity of the information.

Both automation and decision support systems (DSSs) are designed to support performance. Research on automation has focused on topics such as trust and the effects of manipulating the levels of automation and its effect on varying task conditions (e.g., Endsley, 1999). Research on DSSs has focused on topics such as data warehousing, online analytical processing, data mining, and integration with the web (Shim et al., 2002). Both lines of research are interested in distilling information into an interpretable format that enhances outcomes. These are similar goals shared by PT. Integration of the findings from each could further the effectiveness of all. For example, PT could be integrated into systems where automation can share control of selection and implementation of decisions.

Conclusion

The effects of PT regarding what the PT suggested have been investigated along with the degree of exposure to the PT. The PT was developed using components from Fogg's functional triad. Follow-up investigations could investigate the individual contributions of triad. Other strategies within each component of the triad could be integrated into the PT. Additionally, the robustness of the integration could be manipulated. For example, the simulation could be extended to include more metrics or a graphical simulation could be implemented. Further manipulation of PT could also result in increasing the effect size. The

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context of decisions could also be manipulated to assess whether the effects generalize outside of a game. The suggested follow-up investigations would further our understanding of how PT can influence decision making. The importance of our understanding can be demonstrated in the opening vignette. The pilot's decision pertaining to the warning signal and subsequent decisions are obviously important. But how that pilot or anyone makes decisions affecting his or her health is also important. PT could aid the pilot in becoming or remaining healthy by suggesting healthy alternatives to non-healthy behaviors.

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APPENDICES

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Appendix A: Table of Abbreviations

Coefficient of variation = COV

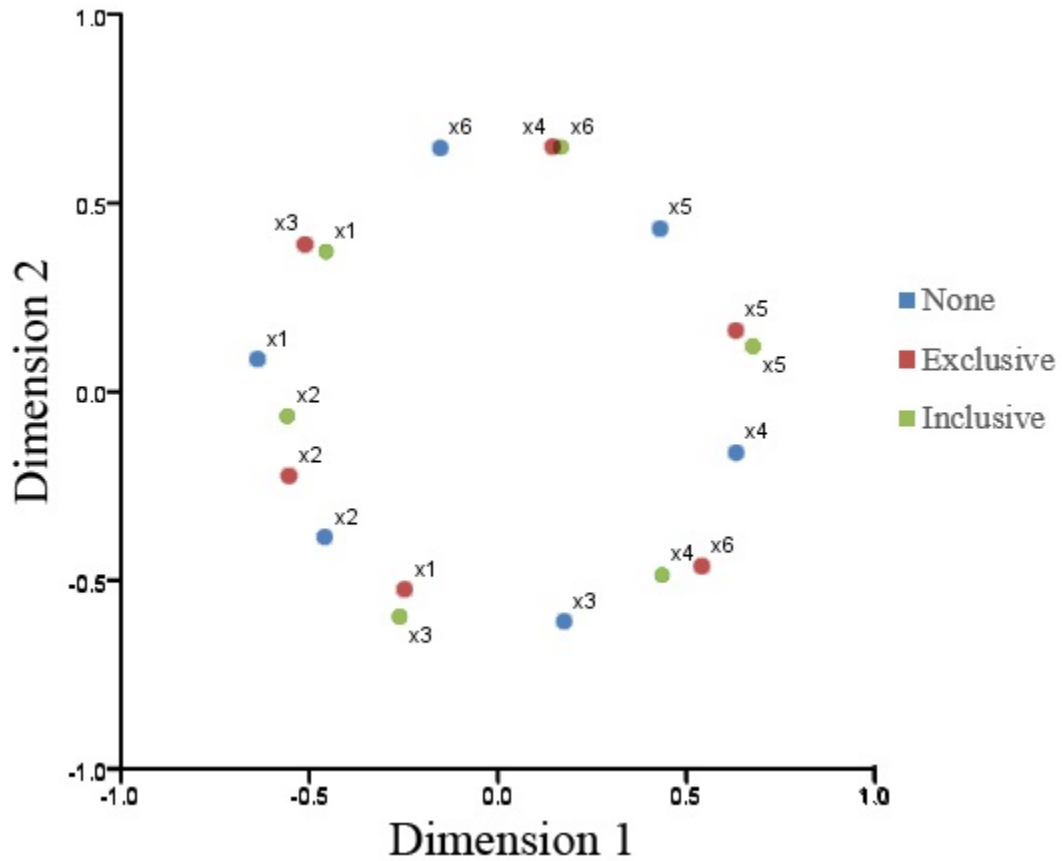
Decision support systems = DSS

Heuristics and biases = HB

Naturalistic decision making = NDM

Persuasive technology = PT

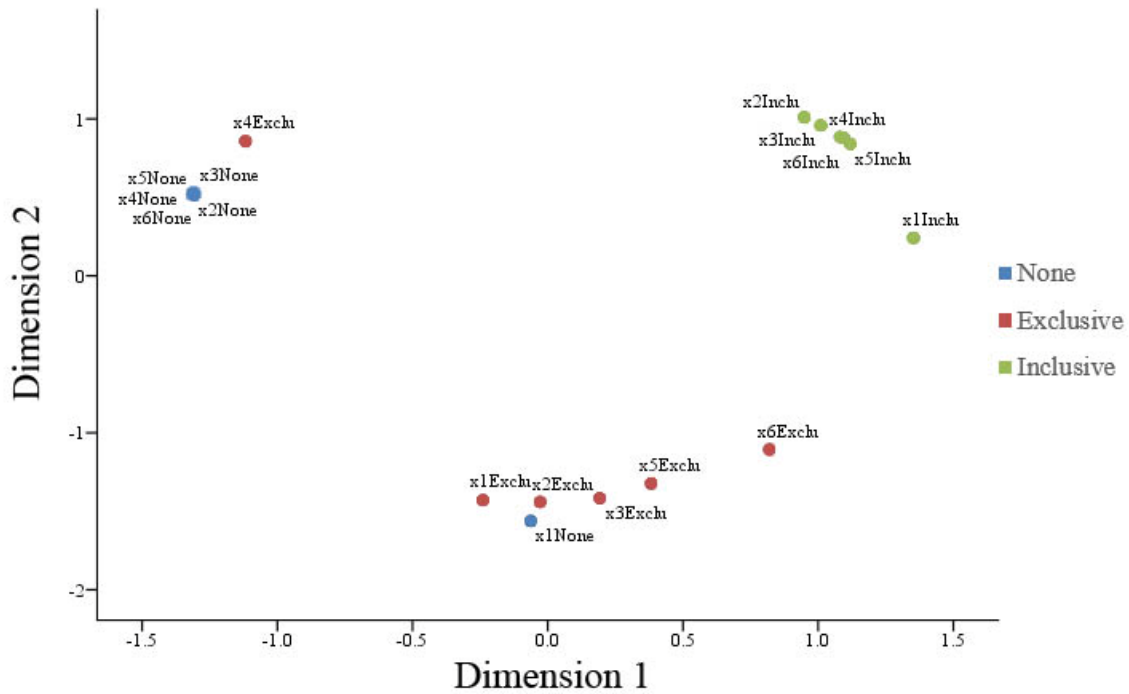
Appendix B: Study One Multidimensional Scaling of Alternative-focused PT



Separate multidimensional scales for each alternative-focused PT condition combined based on proportion of transitions along persuaded alternative based on total number of transitions

Note: Number denotes row (i.e., attribute) and x denotes whichever column (i.e., alternative) was suggested based on persuasive technology. The column differed based on previous level performance, so it is unique per individual per decision. Similar pattern of results between conditions, with the most likely transition between rows (attributes) corresponding to adjacent rows (attributes), just in reverse order for the inclusive condition. Statistical analyses did not identify significant differences between the number of transitions along the persuaded attribute.

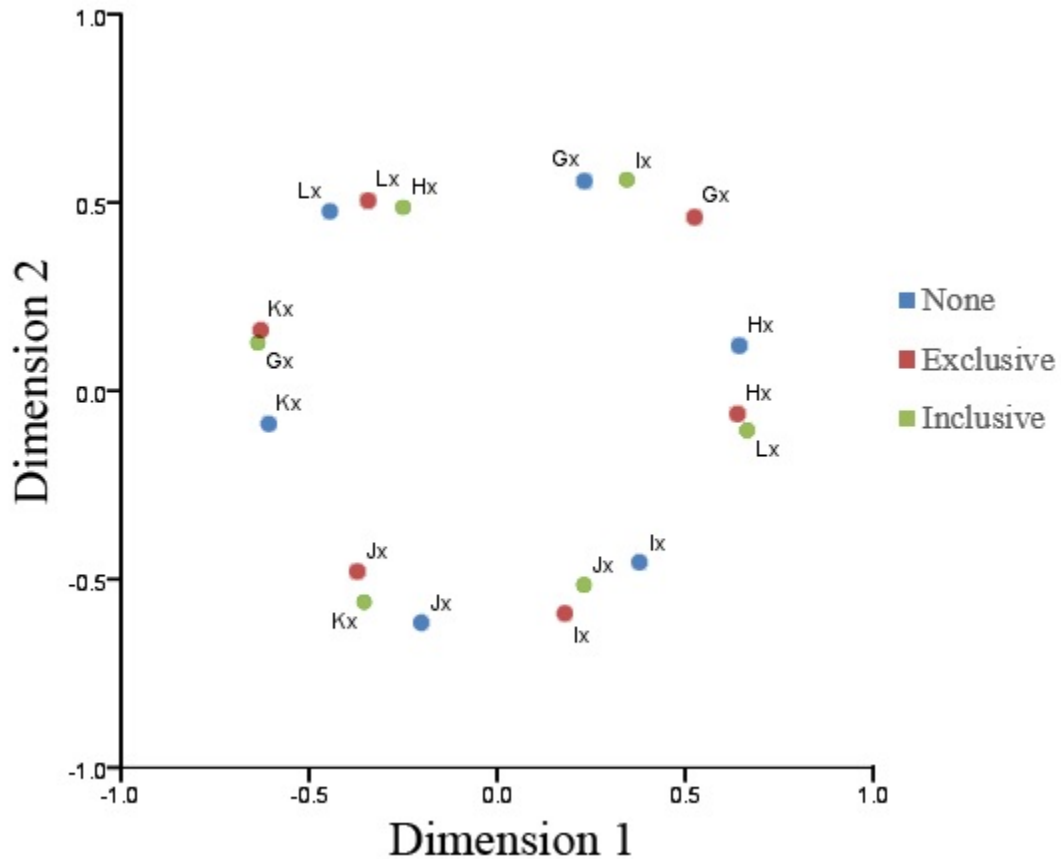
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Single multidimensional scale including all alternative-focused PT conditions based on proportion of transitions along persuaded alternative based on total number of transitions

Note: Number denotes row (i.e., attribute) and x denotes whichever column (i.e., alternative) was suggested based on persuasive technology. The column differed based on previous level performance, so it is unique per individual per decision. The three matrices representative of the three conditions were combined into one matrix. Cross-condition cells in the combined matrix (e.g., x3Exclu and x3Inclu) were assigned the maximum difference score, 1, based on the data indicating no transitions. All six items from the inclusive condition are proximally located to one another indicating interrelatedness between the items. Items in the none and exclusive conditions were not so proximally located to one another.

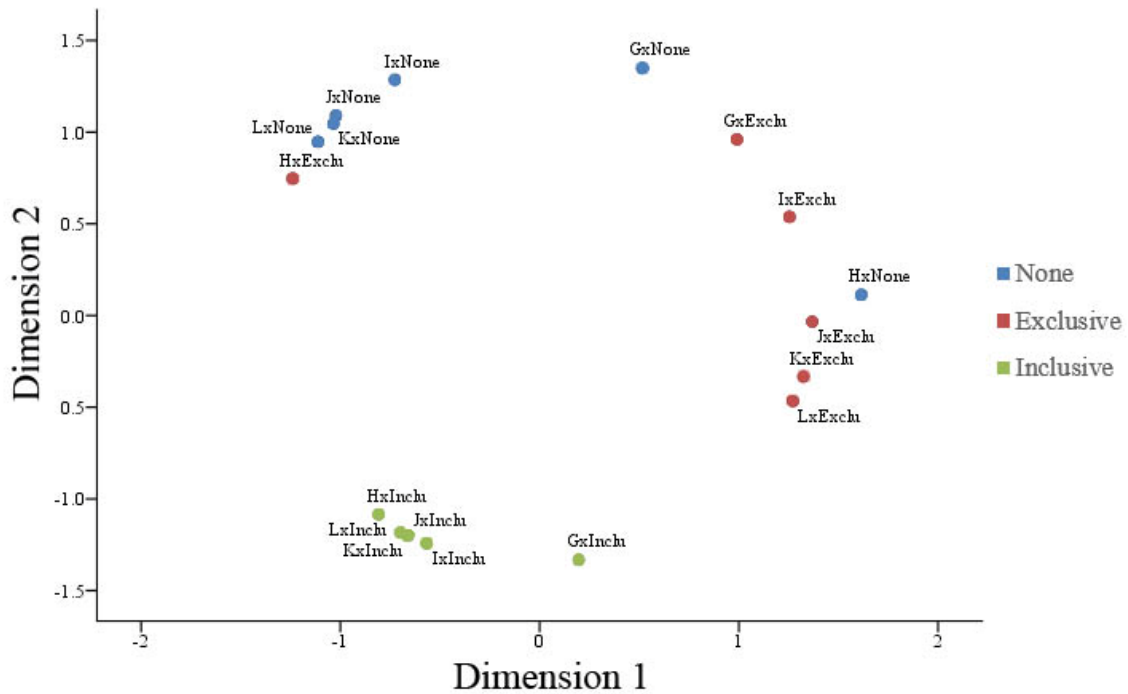
Appendix C: Study One Multidimensional Scaling of Attribute-focused PT



Separate multidimensional scales for each attribute-focused PT condition combined based on proportion of transitions along persuaded attribute based on total number of transitions

Note: Letter denotes column (i.e., alternative) and x denotes whichever row (i.e., attribute) was suggested based on persuasive technology. The row differed based on previous level performance, so it is unique per individual. Similar pattern of results, with the most likely transition between columns (alternatives) corresponding to adjacent columns (alternatives), with the exception of inclusive's J, L, K. Statistical analyses did not identify significant differences between the number of transitions along the persuaded attribute, but it trended towards more transitions in the exclusive than the other two conditions.

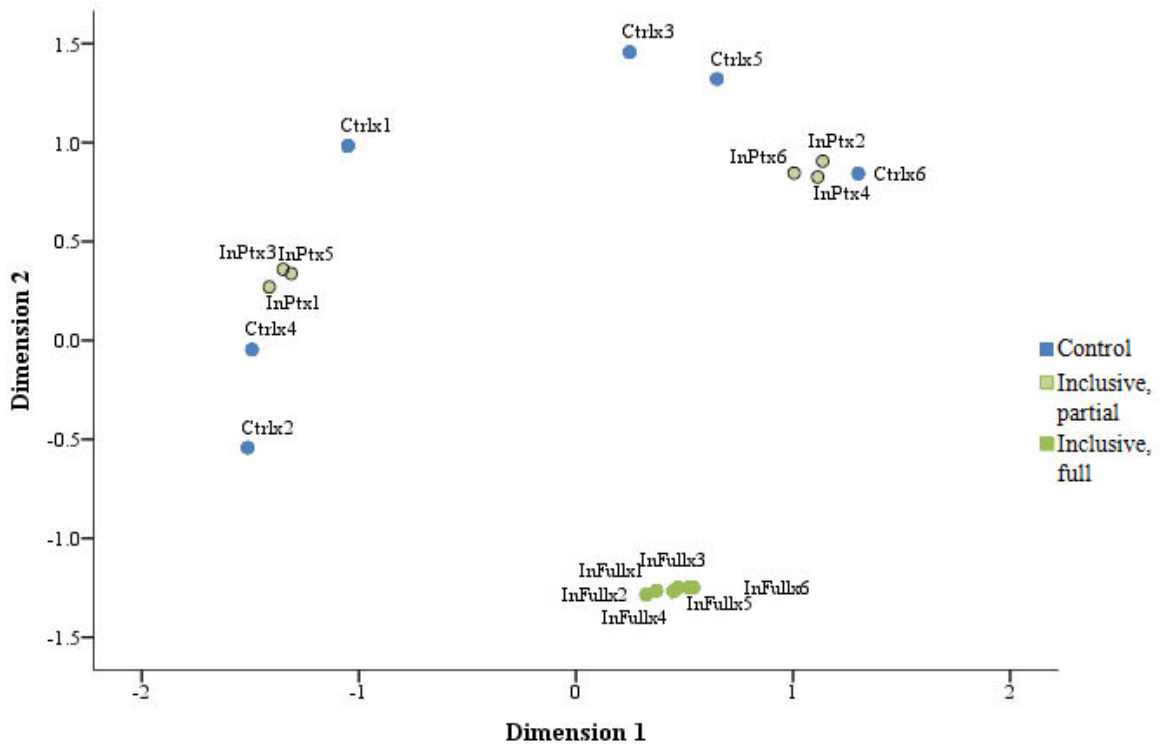
PERSUASIVE TECHNOLOGY AND PROCESS TRACING



Single multidimensional scale including all attribute-focused PT conditions based on proportion of transitions along persuaded attribute based on total number of transitions

Note: Letter denotes column (i.e., alternative) and x denotes whichever row (i.e., attribute) was suggested based on persuasive technology. The row differed based on previous level performance, so it is unique per individual. The three matrices representative of the three conditions were combined into one matrix. Cross-condition cells in the combined matrix (e.g., JxExclu and JxInclu) were assigned the maximum difference score, 1, based on the data indicating no transitions. All six items from the inclusive condition are proximally located to one another indicating interrelatedness between the items. Items in the none and exclusive conditions were not so proximally located to one another.

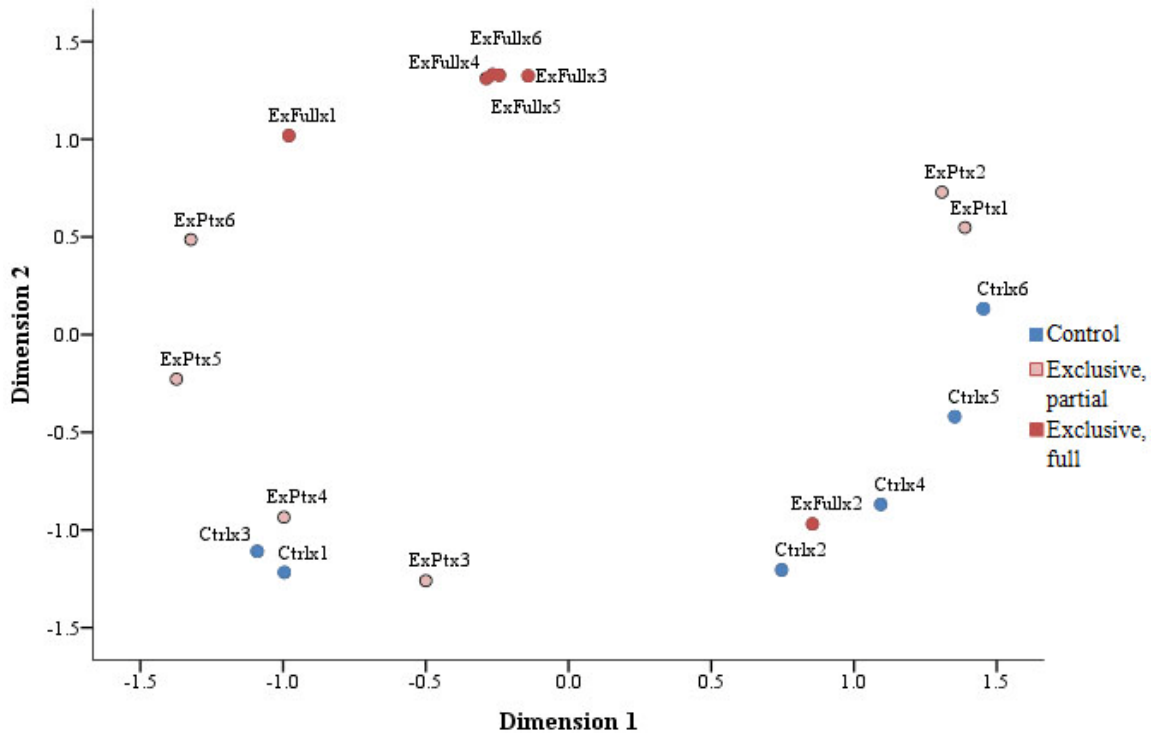
Appendix D: Study Two Multidimensional Scaling of Alternative-focused PT



Single multidimensional scale including all inclusive PT conditions based on proportion of transitions along persuaded alternative based on total number of transitions

Note: Number denotes row (i.e., attribute) and x denotes whichever column (i.e., alternative) was suggested based on persuasive technology. The column differed based on previous level performance, so it is unique per individual per decision. The three matrices representative of the three conditions were combined into one matrix. Cross-condition cells in the combined matrix (e.g., InPtx3 and InFullx3) were assigned the maximum difference score, 1, based on the data indicating no transitions. Items from inclusive PT with partial exposure and control were dispersed. However, items from inclusive PT with full exposure were tightly clustered.

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Single multidimensional scale including all exclusive PT conditions based on proportion of transitions along persuaded alternative based on total number of transitions

Note: Number denotes row (i.e., attribute) and x denotes whichever column (i.e., alternative) was suggested based on persuasive technology. The column differed based on previous level performance, so it is unique per individual per decision. The three matrices representative of the three conditions were combined into one matrix. Cross-condition cells in the combined matrix (e.g., ExPtx3 and ExFullx3) were assigned the maximum difference score, 1, based on the data indicating no transitions. Items in all groups were dispersed.

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Appendix E: Study Two Analysis of Last Two Decisions

Study Two Descriptive Statistics of Decision Agreement with Persuasive Technology for Last Two Decisions (n = 155)

Condition	<i>M</i>	<i>SD</i>	Minimum	Maximum
Control	0.11	0.21	0.00	0.50
Exclusive PT, partial exposure	0.40	0.45	0.00	1.00
Exclusive PT, full exposure	0.77	0.38	0.00	1.00
Inclusive PT, partial exposure	0.10	0.20	0.00	0.50
Inclusive PT, full exposure	0.13	0.26	0.00	1.00
Total	0.30	0.41	0.00	1.00

Note: There was an effect of PT, $F(4,150) = 26.12$, $MSE = 0.10$, $p < 0.001$, $\eta^2 = 0.41$. Pairwise comparisons using the Bonferroni correction indicated that inclusive PT with full exposure agreement was greater than all other groups. Inclusive PT with partial exposure agreement was greater than all other groups except for inclusive PT with full exposure.

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Appendix F: Study Two Analysis of First Decision

Study 2 Descriptive Statistics of First Decision Only Pre-PT Outcome Measures

Inclusiveness	Exposure	DV1 Payne Index		DV2 Number of Values		DV3 Proportion Of Values		DV4 Average Time Per Value Viewed	
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Control	Control	-0.16	0.40	31.19	23.30	0.50	0.27	0.69	0.20
Exclusive	Partial	-0.21	0.50	29.84	29.06	0.45	0.32	0.67	0.39
	Full	-0.11	0.42	22.42	18.20	0.41	0.27	0.74	0.29
	Total	-0.16	0.46	26.13	24.34	0.43	0.30	0.71	0.34
Inclusive	Partial	-0.10	0.50	41.13	36.77	0.50	0.32	0.72	0.31
	Full	0.02	0.45	28.87	22.79	0.46	0.33	0.95	1.12
	Total	-0.04	0.48	35.00	30.96	0.48	0.32	0.83	0.82
Total	Partial	-0.16	0.50	35.48	33.36	0.48	0.32	0.70	0.35
	Full	-0.04	0.44	25.65	20.71	0.44	0.30	0.85	0.82
	Total	-0.10	0.47	30.56	28.09	0.46	0.31	0.77	0.63

Note: Observed values of the Payne Index ranges between -1.00 and 1.00. Negative values indicate more attribute-based transitions. Positive values indicate more alternative-based transitions. Observed values of the number of values viewed ranged between 0.00 and 132.00, of the proportion of values viewed ranged between 0.00 and 1.00, and of the average time per value viewed ranged between 0.00 and 6.62 seconds. Higher values indicate more systematic processing.

Study 2 First Decision Only Pre-PT One-way MANCOVA on Outcome Measures Controlling for Age, Education, and Points

Variables	<i>V</i>	Degrees of freedom	<i>F</i>	<i>p</i>
Age	0.06	(4,144)	2.13	0.08
*Education	0.08	(4,144)	3.24	0.01
*Points	0.06	(4,144)	2.47	<0.05
*PT	0.19	(4,144)	1.83	0.02

Note: Calculations based on Pillai's trace. Asterisks (*) denote significance ($p < 0.05$).

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The Separate Univariate ANCOVAs of Alternative-focused PT Controlling for Age, Education, and Points

Outcome variable	Degrees of freedom	<i>F</i>	<i>MSE</i>	<i>p</i>	η^2
DV1 Payne Index	(4,147)	0.95	0.21	0.44	0.03
DV2 Number of Values Viewed	(4,147)	2.20	647.53	0.07	0.06
DV3 Proportion of Values Viewed	(4,147)	0.58	0.08	0.68	0.02
DV4 Average Time per Value Viewed	(4,147)	1.54	0.32	0.19	0.04

Note: Asterisks (*) denote significance ($p < 0.05$).

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Appendix G: Correlations between Number and Proportion of Values Viewed

Study One Correlations Between Number of Values Viewed and Proportion of Values Viewed

	DV2 Early	DV3 Early	DV2 Late	DV3 Late
DV2 Number of Values Viewed Early	1.00	0.95*	0.68*	0.68*
DV3 Proportion of Values Viewed Early		1.00	0.67*	0.68*
DV2 Number of Values Viewed Late			1.00	0.99*
DV3 Proportion of Values Viewed Late				1.00

Note: Asterisks (*) denote significance ($p < 0.001$).

Study Two Correlations Between Number of Values Viewed and Proportion of Values Viewed

	DV2 Early	DV3 Early	DV2 Late	DV3 Late
DV2 Number of Values Viewed Early	1.00	0.92*	0.52*	0.51*
DV3 Proportion of Values Viewed Early		1.00	0.50*	0.50*
DV2 Number of Values Viewed Late			1.00	0.98*
DV3 Proportion of Values Viewed Late				1.00

Note: Asterisks (*) denote significance ($p < 0.001$).

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Appendix H: Reanalysis of Studies One and Two with Payne Index, Proportion of Values Viewed, and Average Time per Value Viewed

Study One MANCOVA with Payne Index, Proportion of Values Viewed, and Average Time per Value Viewed on Outcome Measures Controlling for Working Memory

Variables	V	Degrees of freedom	F	p
*Working memory	0.18	(3,78)	5.81	<0.01
*Alternative-focused Persuasive Technology	0.22	(6,158)	3.20	0.01
*Attribute-focused Persuasive Technology	0.16	(6,158)	2.23	0.04
*Decision blocks	0.10	(3,78)	2.86	0.04
Alternative- by Attribute-focused Interaction	0.13	(12,240)	0.92	0.53
Alternative- by Decision blocks Interaction	0.04	(6,158)	0.53	0.79
Attribute- by Decision blocks Interaction	0.09	(6,158)	1.19	0.31
Alternative- by Attribute- by Decision blocks Interaction	0.19	(12,240)	1.37	0.18

Note: Calculations based on Pillai's trace ($p < 0.05$). Asterisks (*) denote significance.

Study One Separate Univariate ANCOVAs of Attribute-focused PT Controlling for Working Memory

Outcome variable	Degrees of freedom	F	MSE	p	η_p^2
DV1 Payne Index	(2,80)	2.70	0.11	0.07	0.06
DV3 Proportion of Values Viewed	(2,80)	0.58	0.01	0.56	0.01
DV4 Average Time per Value Viewed	(2,80)	1.26	0.08	0.29	0.03

Note: Asterisks (*) denote significance ($p < 0.05$).

Study One Separate Univariate ANCOVAs of Decision Blocks Controlling for Working Memory

Outcome variable	Degrees of freedom	F	MSE	p	η_p^2
DV1 Payne Index	(1,80)	0.40	0.07	0.53	<0.01
*DV3 Proportion of Values Viewed	(1,80)	6.52	0.01	0.01	0.08
DV4 Average Time per Value Viewed	(1,80)	1.85	0.09	0.18	0.02

Note: Asterisks (*) denote significance ($p < 0.05$). Based on the significance of proportion of values viewed, estimated marginal mean comparisons using the Bonferroni corrections were conducted. Greater systematic processing occurred during the early decisions than the later decisions. Despite the lack of significance of average time per value viewed, greater time was spent in early decisions than late decisions.

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Study Two One-way MANCOVA with Payne Index, Proportion of Values Viewed, and Average Time per Value Viewed with Control Group on Outcome Measures Controlling for Age, Education, and Points

Variables	V	Degrees of freedom	F	p
Age	0.02	(4,144)	.96	0.41
*Education	0.07	(4,144)	3.61	0.01
*Points	0.15	(4,144)	8.81	<0.001
*PT	0.21	(4,144)	2.81	<0.01

Note: Calculations based on Pillai's trace. Asterisks (*) denote significance ($p < 0.05$).

Study Two 2x2 MANCOVA with Payne Index, Proportion of Values Viewed, and Average Time per Value Viewed on Outcome Measures Controlling for Age, Education, and Points

Variables	V	Degrees of freedom	F	p
Age	0.02	(4,114)	0.82	0.48
Education	0.03	(4,114)	1.38	0.25
*Points	0.18	(4,114)	8.59	<0.001
*Exclusivity	0.14	(4,114)	6.01	<0.01
Exposure	0.05	(4,114)	1.89	0.14
*Exclusivity by exposure	0.09	(4,114)	3.79	0.01

Note: Calculations based on Pillai's trace. Asterisks (*) denote significance ($p < 0.05$).