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Examining Possible Perceptual Proxies of Flow State

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Nakamura and Csikszentmihalyi (2002) define flow as an individual's deep engagement in an intrinsically rewarding activity. McGonigal (2011) suggests that video games are flow elicitors. If video games are flow elicitors, then spatial, agentic, and temporal perception required for game play may relate to flow in predictable manners. Over two experiments, a simple video game with contextual (i.e., implied friction) and conceptual (i.e., ambiguous stimulus labeled either bullet-train or house) manipulations was used to elicit flow. Effects of the manipulations were assessed trial-by-trial on two dimensions of flow (i.e., agency and temporal perception) and spatial planning, as well as an overall flow score. Interesting relations emerged between the trial-by-trial agency variable and large-scale paper-pencil measure of flow as a result of being told the stimulus was a bullet-train. These findings indicate that traditional perceptual measures of agency may be useful in future explorations of flow in the realm of gaming.

KEYWORDS. Agency, Flow, Perception, Time

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CONTENTS

CHAPTER I

INTRODUCTION TO THE PROBLEM

According to Nakamura and Csikszentmihalyi (2002) flow is an individual's deep engagement in any intrinsically rewarding activity. The study of positive states such as flow has many practical applications and has been examined in many contexts, including artistic and athletic endeavors, complex learning, and work-related experiences (Bakker, 2008; D'Mello & Graesser, 2012; Nakamura & Csikszentmihalyi, 2002). Recently, video game researchers have also begun examining this state by designing games meant specifically to elicit positive outcomes through flow experiences (McGonigal, 2011). There is even a video game titled "flOw" inspired by this psychological phenomenon (Chen, 2007).

Currently, there are a number of scales that examine the qualitative aspect of flow by administering questionnaires about the activity in which flow was experienced (Jackson & Marsh, 1996; Payne, Jackson, Noh, & Stine-Morrow, 2011). Additionally, Dietrich (2004) reviewed neurological mechanisms associated with being in a flow state.

Above and beyond these measures of flow, it may be possible to assess flow state via other variables that tap into the phenomenology associated with working toward a goal. Examples of goal-oriented variables include the reported distance to and pitch of a hill (Bhalla & Proffitt, 1999), the perceived location of a continuously controlled and moving stimulus (Jordan & Knoblich, 2004), the perceived location of a moving stimulus that implies different typical motions (Gill, Durtschi, Cutting, & Jordan, 2012; Reed & Vinson, 1996), judgments of agency while playing a game (Metcalfe & Greene, 2007), and estimates of time after playing a game (Rau, Peng, & Yang, 2006). Whereas these variables are not often cast in terms of flow, perception of space, agency, and time have unique relations to action planning and therefore control during goal achievement. Thus, these variables may constitute components of the more complex phenomenology referred to as flow.

McGonigal (2011) suggests that video games are essentially flow machines that allow us to achieve this happiness state much easier than other activities that might require much more time to master. Yet, to capture the essence of a flow state while playing video games, researchers have heretofore been limited to behavioral indices, neurological evidence, or qualitative data. Thus, the purpose of the proposed study is to examine if video games are sufficient to elicit flow, and if so whether or not there exists lawful relations between the phenomenology measured via traditional flow scales and the smaller-scale phenomenology assessed via measures such as perceived spatial location, sense of agency, and sense of time.

CHAPTER II

REVIEW OF RELATED LITERATURE

Flow

As mentioned above, according to Nakamura and Csikszentmihalyi (2002) flow is an individual's experience during deep engagement in an intrinsically rewarding activity. Simply, flow has been noted as the optimal state of being. Nakamura and Csikszentmihalyi (2002, p. 89) stated "a good life is one that is characterized by complete absorption in what one does." Thus, analyzing this phenomenal state in the context of art, athletics, and other autotelic (i.e., intrinsically motivating) activities is logical given flow's roots in positive psychology. Further, McGonigal (2011) notes that flow can be a powerful factor influencing positive change in the real world. For example, the game *World Without Oil* challenges players to adapt their gaming behavior to a world lacking in oil (McGonigal, 2011). McGonigal's claim that video games are flow elicitors suggests that when participants learn the dynamics of this game, aimed at teaching energy-conserving behaviors, gamers will inherently learn these socially beneficial skills and enjoy doing so, with the ultimate hope that such skills will transfer to real life energy saving behavior.

Early work examining optimal states of being noted several reoccurring phenomena that contributed to achieving what was later known as flow (Nakamura &

Csikszentmihalyi, 2002). Individuals who experienced this state had intense focus or concentration, a merging of action and awareness, and a loss of self-awareness. Additionally, they felt very much in control of their actions and had a sense that timepassed by differently than normal. Further, the activity that was being performed was at or slightly above the skill level of the artists being examined (Nakamura & Csikszentmihalyi, 2002). That is, the goals set were challenging but achievable. Finally, feedback allowed those individuals to determine and, subsequently, enhance their performance. These dimensions constitute flow state in goal-oriented activities.

As mentioned previously, playing video games is also said to be a flow eliciting activity. Unknowingly, the earliest game developers elicited flow in gamers, and recently, have been taught to use motivational and flow theories to achieve happiness outcomes (McGonigal. 2011). McGonigal argues that games hold all the critical components necessary to facilitate flow. Video games are complex and evolving systems that have multiple goals, multiple difficulty settings to satisfy multiple skill levels, and some point or status monitoring system that allows for performance regulation (McGonigal, 2011). Additionally, there are generally no extrinsic rewards or motivations (e.g., cash or prizes) for playing video games, making such an activity autotelic. Video games, then, can be thought of as intrinsically rewarding feedback machines. As it relates to video games, flow can be viewed as an emergent state given particular contextual constraints during goal-oriented, intrinsically motivating activities.

Whereas measures of flow state via questionnaires may be appropriate for some activities, experimental paradigms that measure phenomenal variables, trial-by trial, may be more appropriate for assessing flow state in a video game context. For example, during continuous control, one's perception of space (Jordan & Knoblich, 2004), feelings of agency (Metcalfe & Greene, 2007), and time (Rau et al., 2006) have all been examined in trial-by-trial and event-based contexts. Given that these phenomenal variables are associated with working toward a goal, it is possible that they could be used as proxy variables for measuring flow, specifically within a video game context.

Note that the point of this study is not to devalue survey data, as a questionnaire is used to assess flow state within the present study. Rather, one of the main goals of this study is to assess the effectiveness of the aforementioned perceptual variables as proxies of flow state. Although previous studies have performed sophisticated factor analyses for construct validity purposes (e.g., Payne et al., 2011), what is measured within questionnaires are proxies of the construct. One important distinction within this study is that claims regarding the effects elicited are only for the scores reported, not necessarily the phenomenological flow experience of participants.

Perception and Planning

A possible theoretical account for why these goal-oriented variables are influenced by action-planning is the Theory of Event Coding (Hommel, Müsseler, Aschersleben, & Prinz, 2001). The Theory of Event Coding entails two major assertions. First, the Theory of Event Coding states that actions are planned in terms of their effects. Specifically, actions are planned in terms of the sensory consequences they will produce, not the movement dynamics by which the effects will be achieved. For example, when planning to kick a ball, what is planned is to make the ball move, not the muscular dynamics through which the foot will make the ball move. The assertion that actions are planned in terms of their consequences is relevant to video games because it indicates that while playing, gamers plan their actions in terms of what should happen on the screen (e.g., one race car should pass another), not what should happen with their fingers (e.g., one finger should hit a particular button while the thumb presses another).

These assumptions of the Theory of Event Coding have been empirically validated by neuroscientists during the last several decades (Kawato, Furukawa, & Suzuki, 1987; Miall, 2003; Rizzolatti, Fogassi, & Gallese, 2002). For example, the second assumption of the Theory of Event Coding is that perception and action planning share overlapping neural resources (Hommel et al., 2001). That is, areas of the brain involved in planning actions (in terms of the effects that should occur) are also involved in perceiving. The rostral portion of the ventral premotor cortex forms area F5 of the monkey brain (Rizzolatti et al., 2002). Area F5ab contains canonical neurons that activate to objects that afford behavior (e.g., a piece of an apple is a graspable object). Area F5c contains mirror neurons that activate to observed behaviors (e.g., a monkey observes a different monkey grab a piece of an apple). Thus, it could be reasoned that area F5, and specifically, mirror neurons are involved in both action-planning and perception as described in the Theory of Event Coding (Hommel et al., 2001). The mirror neuron system that seems to be a small scale network lending itself to action and perception is part of a larger network contributing to higher level functioning (Iacoboni, 2005).

As a result, changes can occur in perception because of either changes in external events (e.g., the ball changes directions) or changes in planning (e.g., one decides to pass the ball rather than shoot it). The idea that perception and action planning share overlapping neural resources is important to video games because it implies that what one perceives while playing the game is heavily influenced by the effects one is planning to produce at any given moment. If this is the case, then one's experience of the game will likewise be continuously influenced by ones planning. Given the influence planning states have on one's immediate experiences while controlling an event such as in video game playing, it seems reasonable that experiences that occur during gameplay might be similar to those that occur during the goal-directed activities assessed by flow researchers.

Perception during Action Control

Spatial Perception. A growing number of studies have supported the notion that perception is anticipatory (Jordan & Hunsinger, 2008; Jordan & Knoblich, 2004; Knoblich & Jordan, 2003). That is, perception has been shown to act anticipatorily toward future goals rather than retrospectively (Jordan, 2008). For example, individuals who continuously track a moving stimulus that suddenly vanishes, indicate a vanishing point further ahead from where the stimulus actually vanished in the direction of momentum (Hubbard, 1995). Initially, researchers believed this forward displacement was due to a shift of the representation of the stimulus in the direction of momentum (i.e., representational momentum). Kerzel, Jordan, and Müsseler (2001), however, revealed that individuals who are not allowed to visually track the stimulus (i.e., they had to fixate on a cross in center of a computer screen) do not indicate forward displacement. Based on these results, Kerzel and colleagues reasoned that the forward displacement found when tracking a stimulus is a result of oculomotor anticipation required when tracking the moving stimulus.

In support of anticipatory perception, Jordan and Knoblich (2004) used what could be considered a very simple video game. The goal of the “game” was to move a dot back and forth across a computer screen using button presses. Failure to do so resulted in a “game over” and required participants to repeat the trial. The manipulated acceleration and deceleration of the stimulus was compared to driving a vehicle with either good or bad “brakes”. That is, they manipulated the impact a button press had upon the acceleration and deceleration of the stimulus, such that in the high impact condition a button-press both accelerated and decelerated the stimulus more so than did a button-press in the low impact condition.

This alteration in button impact was a manipulation of the effects (acceleration/deceleration) associated with particular actions (button-presses; i.e., action-effect contingencies). After either the second or third turn across the computer screen and when the stimulus was decelerated below a certain speed, the dot vanished. Individuals in the low impact condition indicated more forward displacement than did individuals in the high impact condition. Larger forward displacement occurred due to the action-effect contingencies related to the effectiveness of the acceleration and deceleration in the low impact condition (i.e., a button press had less of an effect on stimulus acceleration and deceleration). Alternatively, individuals in the high impact condition formed contingencies related to the effects of their actions, thus producing less forward displacement. Importantly, the reason for the difference in perceived vanishing point across the low and high impact conditions resulted from the visual feedback associated with the actions that produced the corresponding visual outcome.

Video games, for example Mario Kart, employ a similar strategy by altering the impact that pressing a button has upon the acceleration of the racer. It may be the case that players learn different action-effect contingencies associated with different video game characters that have different abilities. Thus, it can be said that the effect that is produced by and coupled with an action influences action planning.

Perceived Distance and Pitch. As specified in the Theory of Event Coding, actions are planned in terms of the sensory effects commonly coded with those actions (Hommel et al., 2001). In an extensive review, Proffitt (2006) investigated the influence of potential energy expenditure on visual perception (i.e., Economy of Action). For example, Bhalla and Proffitt (1999) had participants make judgments about distances to targets and the steepness of a hill. Interestingly, judgments made while wearing a heavy backpack made targets seem further away and steeper. These data imply that action planning may integrate things like expected energy expenditure such that wearing a heavy backpack affects action plans concerning possible future goal-oriented activities.

Similarly, Jordan and Knoblich (2004) showed that manipulations of control (i.e., the energy expenditure required to control a stimulus with low or high button press impact) affected perception of stimulus localizations. Energy expenditure (i.e., the control necessary to accelerate and decelerate) affected where people saw the stimulus vanish. Thus, manipulations of energy expenditure within the Jordan and Knoblich (2004) experiment affected anticipation, and therefore, perception.

Although Jordan and Knoblich's manipulation was physical in nature, *implied* variations in action-effect contingencies or energy expenditure can also effect anticipation. Hubbard (1995) proposed that implied forces, such as friction, can affect the perception of the vanishing point of a moving stimulus. A test of this proposal had participants passively observe a stimulus move across a computer screen with no surface (no friction), a lower surface (medium friction), or between a lower and upper surface (high friction; Hubbard, 1995b). Manipulations of implied friction (i.e., movement over varying conditions of friction) altered the perceived vanishing point, such that increases in friction led to decreases in forward displacement.

Gill et al. (2012), however, demonstrated that forward displacement increased when the stimulus was actively controlled. That is, the stimulus in Hubbard's (1995b) experiment operated under inertial dynamics (i.e., the stimulus appeared to operate under the laws of physics), and the participants had no control of the movement (i.e., required no effort); whereas in Gill et al.'s (2012) experiment, the stimulus was controlled by either the participant or an experimenter, and the movements of the stimulus were intentional (i.e., the stimulus operated with goal-oriented intentional dynamics). This reversal of Hubbard's (1995b) findings may be the result of the inherent differences between the movement dynamics of the stimuli in both experiments. It may be that intentional movement dynamics (i.e., a stimulus with non-inertial, goal-directed movements) are subject to economy of action perceptual planning processes associated with planned energy expenditure even when participants are not controlling the stimulus, whereas inertial dynamics are not.

Taken from the Theory of Event Coding framework (Hommel et al., 2001), the action-effect contingencies corresponding to the planned actions associated with differential expected energy expenditure would certainly support the notion of different action plans and, subsequently, different perceptual anticipations associated with those action plans. Although Bhalla and Proffitt (1996) did not have participants walk to or up the hill, action plans related to the required effort affected the perceived pitch and distance to the hill. Similarly, Gill et al. (2012) manipulated the level of implied friction within their experiment; however, there was no difference in the required actions necessary to move the stimulus across the screen. Thus, perceptual differences in forward displacement between levels of implied friction were the result of different action plans.

Whereas the previously mentioned literature shows that planning influences perception, it should be noted that the perceptual outcome can also influence the perception of space. For example, previous literature in the realm of sports expertise has shown that performance influences things like the perceived size of a target. That is, Witt and Dorsch (2009) showed that participants who kicked more successful field goals estimated the field goal uprights to be further apart and the crossbar of the uprights to be shorter in height. Although their work suggested that the perceptual difference in perceived size resulted only after participants kicked the ball and not before, other literature suggests that only those experienced with such skilled activities will show activation of the motor areas of the brain (e.g., Calvo-Merino, Glaser, Grèzes, Passingham, & Haggard, 2004).

Concepts. Previous literature (e.g., Reed & Vinson, 1996) has established that preconceived notions of the typical motion of an object can affect action planning and anticipatory perception of the object. Reed and Vinson (1996) investigated the effects that pre-existing knowledge about an object's typical motion had upon perception.

Participants were asked to indicate the vanishing point of an ambiguous stimulus that was labelled either a church or a rocket. Typically, a church does not move in any direction; a rocket's motion, however, is generally vertical (i.e., upward or downward). Participants indicated significantly greater forward displacement when viewing the stimulus labeled a rocket compared to viewing the stimulus labeled a church, but only when there was an upward movement of the stimulus.

To assess the influence of conceptual factors during stimulus control versus stimulus observation, Gill et al. (2012) had individuals either control or observe an ambiguous trapezoidal stimulus back and forth across a computer screen. Participants were told they were controlling either a house or a bullet-train and did so on either a blank computer screen (i.e., no friction) in one block or with a black surface below (i.e., implied friction) in another block. They found that individuals who controlled a bullet-train were susceptible to the effects of implied friction, whereas those controlling a house were not. That is, individuals who controlled a stimulus with a typical motion (i.e., bullet-train), were affected by implied friction and indicated greater forward displacement in the implied friction condition than in the no implied friction condition. Individuals who controlled the house, however, were not affected by implied friction as there was no forward displacement difference between the two contexts. It may be that a concept effect was only robust for the bullet-train. Thus, conceptual differences arose as a result of action planning in an implied effort scenario only for the object with a preconceived typical motion.

How do contextual and conceptual variations relate to flow? One basic function of many video games is the control of different characters and objects. Many characters within video games have different abilities such as strength, mobility, and longevity, which undoubtedly alter how gamers control them. For example, in Mario Kart, players have the option to choose from many different characters whose acceleration, mobility, and speed all differ. Additionally, many games differentiate difficulty between levels, such that one level has many more obstacles and challenges than another.

According to the Theory of Event Coding (Hommel et al., 2001), video game players would learn a wide variety of action-effect contingencies. Inherently, video games are full of complex contingencies, such that gamers must learn to operate within specific contexts within a dynamic system. In Mario Kart, characters that have excellent turning ability but lower maximum speeds would produce different action-effect contingencies than characters that have poor turning abilities but higher maximum speeds. Given that there are three laps in any given race in Mario Kart, players of the game would also learn the contextualized constraints associated with the particular course (and one might expect the third lap to be the best in terms of control and performance).

Agency. Metcalfe and Greene (2007) investigated how manipulations of the controls of a simple game affected judgments of agency. For example, one manipulation utilized within Metcalfe and Greene's experiment was the "hit" range of a catching box. Participants in this experiment played a computer game where they were asked to catch the Xs and avoid the Os that fell from the top to the bottom of a computer screen. Then participants were asked to indicate how in control they felt on a horizontal sliding scale after each game (i.e., the participants had to pull the slider on the scale to indicate their level of control). The previously mentioned hit-range manipulation widened the catching range such that if the catching box was within 10 pixels of the X, but not touching it, a “hit” was still counted. They found that agency increased as a result of the added 10 pixel catching range compared to the control. Additionally, when this additional 10 pixel catching range was added for the Os (that were to be avoided), judgments of agency were significantly lower than when the additional catching range was added to the Xs.

Related to feeling in control, Mario Kart alters the control abilities of the characters within the game. Thus, in order to effectively maneuver characters with poor control abilities, the player would need to alter their actions to attenuate for the poor control abilities of the racing character. By doing so, the player is altering the effects their actions have upon the character and specifying necessary future actions to maintain that level of control. When that player does learn the necessary contingencies to control a character with poor control abilities, they can feel very much in control of that character and possibly enter a flow state.

Time. In a study examining the perception of time, Rau et al. (2006) showed that experts of the game Diablo 2 underestimated the amount of time they played the game. They found that experienced Diablo 2 players indicated that less time had passed by than actually had, whereas novices overestimated the amount of time they played. Interestingly, a recent study by Buetti and Lleras (2012) showed that individuals viewing fear inducing stimuli experienced temporal distortion, such that they believed the image was present longer than it actually was. When the participants believed they had control over the progression of the images, however, the distortion was attenuated. Control may play a large role in temporal perception. Thus, processes associated with action planning may modulate time perception.

Present Study

The purpose of the present study was to assess McGonigal's (2011) claim that video games elicit flow. Another aim of this study was to examine the relation between flow scores (AFSS: Payne et al., 2011) and possible proxy variables of the phenomenological experience of flow (i.e., spatial, agentic, and temporal perception). In this study, participants controlled an ambiguous stimulus labeled either a house or bullet-train across two different surfaces of friction (i.e., no friction and implied friction), and indicated perceived vanishing points of the stimulus. Additionally, participants were asked to give judgments of agency (Metcalfe & Greene, 2007) or estimates of time (Rau et al., 2006). It is possible that asking participants to make indications of vanishing point, judgments of agency, and estimates of time in one experimental sitting could have detrimental effects on flow and confound results. That is, if participants are pulled from the gaming context for too long, flow may not have been elicited. Additionally, after each block of either no friction or implied friction, participants completed the AFSS to assess flow scores related to each implied friction context. Thus, this study was comprised of two experiments to minimize the possible disruption of experiencing a flow state. In both experiments participants indicated the vanishing point of a controlled stimulus. In Experiment 1, participants made judgments of agency, whereas in Experiment 2, they made estimates of time. Given the effects of context and concept upon spatial displacement, it was predicted that the aforementioned proxies would best relate to flow scores (as indicated by the AFSS) in contexts that afforded optimal control (i.e., no implied friction and bullet-train condition).

CHAPTER III

EXPERIMENT 1

The purpose of Experiment 1 was to examine the relation between flow scores, agency (i.e., feelings of control), and spatial perception (i.e., spatial displacement). Note that what was measured was reported feelings associated with the nine dimensions that comprise flow state. These scores were aggregated and are believed to constitute the flow state. An important distinction is that within this study, comparisons of scores are relative, and flow scores are statistically approached as continuous rather than claiming one may or may not be experiencing flow based on their aggregate flow score. Thus, although participants reported on the dimensions of flow, it is possible that some participants may have experienced flow, some may not have experienced flow, and some may have experienced a stronger state of flow that others.

Nakamura and Csikszentmihayli (2002) stated that individuals who experience a flow state report feeling very much in control of their actions (i.e., individuals feel a high sense of agency). McGonigal (2011) reported that individuals who play video games can easily experience a state of flow. As this experiment could be thought of as a simple video game, the predictions of Experiment 1 were based on past findings of context (Gill et al., 2012; Hubbard, 1995b), concept (Gill et al., 2012; Reed & Vinson, 1996), judgments of agency (Metcalfe & Greene, 2007) and flow experience (Payne et al., 2011).Predictions concerning flow scores were approached with reasonable assumptions. It was predicted that controlling a stimulus in a context with no friction would elicit highest flow scores. The no friction context should elicit the greatest feelings of control and, subsequently, higher flow scores. Additionally, controlling a bullet-train should lead to higher flow scores. Controlling a stimulus that has a typical motion should lead individuals to feeling more in control of the object, subsequently lending to higher flow scores.

As this experiment is the first of its kind concerning judgments of agency, predictions were based upon reasonable assumptions derived from previous agency studies (i.e., Metcalfe & Greene, 2007). It was predicted that controlling a stimulus in a context with no friction would elicit higher judgments of agency. Implied friction is an added constraint of controlling a stimulus. Thus, in terms of control, one should not need to account for additional contextual constraints when there is no friction. Additionally, it was predicted that controlling a bullet-train would elicit greater judgments of agency compared to controlling a house. It may be the case that controlling a stimulus that has a typical motion allows participants to generate the action-effect contingencies for the stimulus with a typical motion better than controlling the stimulus without a typical motion. Thus, controlling a stimulus with a preconceived typical motion should afford greater feelings of control to participants.

Based on findings of past research, it was predicted the implied friction context should elicit greater forward displacement estimates than no friction (Gill et al., 2012). As previously described, this increase might be due to the economy of action effects whereby the cost of an action affects action planning and subsequently spatial perception (Proffitt, 2006). A concept effect was predicted to be present for the bullet-train condition, with participants indicating greater forward displacement in the implied friction condition than in the no friction condition (Gill et al., 2012). Gill et al., (2012) found that controllers of the bullet-train indicated significantly greater forward displacement in the implied friction condition compared to the no friction condition. Alternatively, there was no difference in forward displacement for individuals controlling the house.

The main purpose of Experiment 1 was to assess McGonigal's (2011) claim that video games can elicit flow. Another aim of this study was to examine the usefulness of these small-scale perceptual variables as proxies of flow scores. Concerning forward displacement, judgments of agency, and flow scores, hypotheses about the relations among these variables were consistent with the aforementioned predictions. These relations were predicted to be highly evident in the no implied friction and bullet-train conditions. In order to gain insight into the usefulness of the small scale agency and time variables, the effects of the context and concept were assessed via the corresponding AFSS proxy variable (i.e., sense of control and transformation of time). Predictions concerning the effect of context and concept on the corresponding AFSS proxy variables match those of the trial-by-trial variables. That is, the effects should be strongest for participants told they are controlling the bullet-train in the no implied friction context.

Forward displacement and judgments of agency should be positively correlated. As individuals learn to control a stimulus that they must also track, they simultaneously learn the effects associated with those actions. Thus, as those action-effect contingencies tighten, so too should the relation between forward displacement and judgments of agency. Judgments of agency should be strongly positively correlated to flow. If the relation between forward displacement and judgments of agency and the relation of judgments of agency and flow scores are as predicted, then forward displacement and flow scores should also be positively correlated. Finally, the predictiveness of the agency, forward displacement, and time perception proxy variables onto flow scores should be evident when the bullet-train is controlled in the no friction context.

Method

Participants

A total of 50 participants' data were collected for Experiment 1. Of the 50 participants, one participant's data were omitted due to computer error, one participant's data were omitted due to believing there was deception involved in the experiment and erroneous behavior, and eight participants' data were omitted due to either not understanding the experiment or because more than 35% of the trials were unusable. Thus, a total of 40 participants' data were used in this experiment. Participants were recruited from the Department of Psychology participant pool. Each participant was informed of their rights as a research participant as required by the IRB. Participants were debriefed, thanked, and also earned course credit for their participation.

Apparatus

Participants were seated at a chair, such that the position of the head was approximately 50 cm (19.65 in) away from the computer monitor. Participants controlled a black trapezoidal stimulus (228 × 89 pixels) back and forth across the screen. The screen was either all white (no friction) or had a black lower half, such that the stimulus appeared as though it was on a surface (implied friction). *Figure 1.1* shows a representation of the stimulus and context conditions. Participants were required to always start moving the stimulus to the right by pressing the B button on a Microsoft Sidewinder video game controller. Each button press increased the velocity of the stimulus at a rate of .9°/sec^2. Participants were then required to decelerate and stop the stimulus in an area near the edge of the screen, indicated prior to the onset of the experiment, by pressing the X button. Pressing the X button, while traveling to the right, decreased the velocity of the stimulus at a rate of .9°/sec^2 per button press. Participants then accelerated to the left by pressing the X button, and conversely decelerated by pressing the B button.

The turning region was presented by hash marks for 2000 ms before the trials began. The turning region was a boundary of 2.86° that began 0.5° from either edge of the screen. These turning regions are restrictions of how participants played the game, and were implemented to control variability. Participants were required to reach a minimum velocity of 7.77°/sec (five button presses) before decelerating during each pass across the screen. After two or three passes across the screen, the stimulus vanished when the participant decelerated the stimulus lower than 7.77°/sec. The number of passes before the stimulus vanished was preset and counterbalanced across conditions; however, because it was possible that trials were not usable and hence deleted from analyses, the number of passes could not be equally represented. After the stimulus vanished and a 500 ms delay, the participants were required to use a crosshair controlled by the mouse and click where they perceived the stimulus to have vanished.

Trials that were considered unusable were those trials in which the actual vanishing point of the stimulus was within 30 pixels from either edge of the screen or within 50 pixels of the center of the screen. For those trials when the stimulus was within 30 pixels from the edge of the screen, a concern was that participants may have perceived that the stimulus was already off-screen. For those trials when the stimulus was within 50 pixels of the center of the screen, determining the direction of stimulus motion was problematic, thus those trials were deleted. Finally, it was believed that either as a result of participant error or lack of attention, when participants indicated vanishing points greater than 100 pixels away from the actual vanishing point. These trials were also deleted.

Next, participants were required to provide a judgment of agency with the crosshair based on the question “How in control did you feel during this trial?” A vertical line in the center on the computer screen (from top to bottom) was displayed with the words “Very much” at the top and to the left of the line, and the words “Very little” at the bottom and left of the line. This scale is based on a previous measure (Metcalfe and Greene, 2007) that used a similar horizontal scale for participants to make judgments of agency. A vertical scale was used in this experiment to reduce any effects associated with the horizontal vanishing point indications.

Procedure

This experiment lasted between 30-60 minutes. Upon entering the lab, participants were informed of their rights as a participant and then signed informed consent. Participants were then read the instructions of the experiment and randomly assigned to one of two conceptual stimulus conditions (i.e., controlling a bullet-train vs. house). After the instructions were read, participants sat at a desk approximately 50 cm in front of a computer monitor. Participants used a Microsoft sidewinder gaming controller to control the stimulus. Participants completed three successful practice trials before commencing the recorded experiment. Context conditions were randomized such that half of the participants received the no friction condition first, whereas the other half received the implied friction context first. The context in which practice trials were completed was consistent with the first experienced context in order to minimize confounding effects. Participants were asked to complete 20 successful trials (one block) for each implied friction condition (i.e., a total of two blocks or 40 trials). After each successful trial, participants were asked to indicate with the mouse where the center of mass of the stimulus (i.e., bullet-train or house) was when it vanished. Additionally, participants were asked to indicate with the mouse how in control they felt. A vertical line in the center of the computer screen was used as a reference for participants to indicate their level of control. The indications from the lower half of the line meant the participant did not feel much in control, whereas indications from the top half of the screen meant the participant felt more in control. After each successful block, participants completed the Activity Flow State Scale (Payne et al., 2011) as well as recorded an estimate of how much time they thought it took them to complete each block. Finally, after participants completed both blocks and questionnaires, they were debriefed, thanked, and given course credit for their participation.

Materials

Activity Flow State Scale (AFSS). After participants finished 20 successful trials (i.e., one block) they completed the Activity Flow State Scale (Payne et al., 2011), a 26 item questionnaire assessing nine factors of flow state. The factors that this questionnaire assessed are: merging of action and awareness; clear goals; concentration on task at hand; unambiguous feedback; challenge skill balance; transformation of time; sense of control (i.e., agency); loss of self-consciousness; autotelic experience. When in a flow state, participants should indicate higher scores related to the phenomenal experience related to each dimension. Participants completed two AFSSs; one after each block. The scores from the items of each sub factor were computed by averaging the scores from items corresponding to each dimension. Finally, an overall flow state score was computed by taking the average of the items in the questionnaire.

Cronbach's α was computed for both contexts (i.e., no friction and implied friction). Both the no friction context (Cronbach's $\alpha = .72$) and the implied friction context (Cronbach's $\alpha = .77$) showed acceptable reliability (Cortina, 1993).

Estimate of Time for each Block. One item was included at the end of the AFSS that assessed the amount of time the participant thought it took to complete the block. This question was necessary for Experiment 2 to examine time at different time scales (i.e., trial time vs. block time); however, it was included in both experiments to examine if thinking about time at a trial-by-trial basis influenced thinking about time at block level.

CHAPTER IV

RESULTS: EXPERIMENT 1

Experiment 1 was a 2 (within-subjects: no friction vs. implied friction) X 2 (between-subjects: bullet-train vs. house) X 2 (between-subjects: no implied friction first vs. implied friction first) mixed factorial design. Whereas order of context had not previously affected forward displacement, the same assumption could not be made for flow, judgments of agency, or time. Thus, order was included to assess any possible practice or psychological effects elicited from order.

The dependent variables measured in Experiment 1 were flow scores, judgments of agency, forward displacement, and block time. Both forward displacements and judgments of agency were measured after each trial, whereas flow scores and block time estimates were measured after each context (i.e., after no implied friction and implied friction). Flow scores indicated on the AFSS were calculated after each block for each participant. Questions that assess each flow dimension were averaged. Finally, an average overall flow score was calculated.

Forward displacement was calculated by subtracting the number of pixels between the perceived vanishing point and the actual vanishing point (i.e., the perceived vanishing point minus the actual vanishing point). Positive values indicate displacements ahead of the actual vanishing point (i.e., forward displacement). To assess temporal perception at each context level, estimated block times were subtracted from actual block time. Thus, positive values or the amount in which participants underestimated block time indicated temporal contraction.

Flow

To assess the effects of context (no friction vs. implied friction), concept (bullet-train vs. house), and order (no implied friction first vs. implied friction first) on flow scores, a 2 × 2 × 2 mixed measures ANOVA was performed. There was a significant main effect of context on flow scores such that the no friction context (M = 3.64, SE = .07) elicited higher flow scores than the implied friction context (M = 3.27, SE = .13), $F(1, 36) = 10.45$, $p = .003$, $\eta_p^2 = .23$, 95% CI [-0.60, -1.14].

There was also significant context by order interaction, $F(1, 36) = 7.90$, $p = .008$, $\eta_p^2 = .18$. Specifically, there was no difference between contexts when the no friction context was experienced first. There was, however, a significant difference in flow scores between contexts when the implied friction context was experienced first such that there was a significant increase from the implied friction context (M = 3.07, SE = .19) to the no friction context (M = 3.76, SE = .11), $F(1, 17) = 11.37$, $p = .004$, $\eta_p^2 = .40$, 95% CI [0.25, 1.07].

Finally, there was a significant context by concept by order interaction, $F(1, 36) = 7.05$, $p = .012$, $\eta_p^2 = .16$ (see *Figure 1.2*). Post-hoc analyses revealed that when the no friction context was experienced first, there was a significant divide in the second block (i.e., in the implied friction context) of flow experienced between participants who controlled the bullet-train (M = 3.86, SE = .23) and participants who controlled the house

(M = 3.10, SE = .25), $F(1, 20) = 5.84$, $p = .025$, $\eta_p^2 = .23$, 95% CI [0.10, 1.41]. Further, for participants who controlled the bullet-train, when the implied friction context was experienced first, there was a significant increase in feelings of flow from the implied friction context (M = 2.99, SE = .28) to the no friction context (M = 3.97, SE = .16), $F(1, 7) = 25.99$, $p = .001$, $\eta_p^2 = .79$, 95% CI [0.53, 1.43].

Agency

To assess the effects of context, concept, and order on agency, a 2 × 2 × 2 mixed measures ANOVA was utilized (see *Figure 1.3*). There were no significant main effects; however, an interesting interaction effect was revealed such that for participants who controlled the bullet-train and experienced the implied friction context first, there was a significant increase in feelings of agency from the implied friction context (M = .65, SE = .02) to the no friction context (M = .70, SE = .02), $F(1, 7) = 6.29$, $p = .041$, $\eta_p^2 = .47$, 95% CI [-0.10, -0.00].

Forward Displacement

To assess the effects of context, concept, and order on forward displacement, a 2 × 2 × 2 mixed measures ANOVA was utilized. As predicted, there was a significant main effect of context on forward displacement. That is, forward displacement was significantly higher in the implied friction context (M = 29.11, SE = 3.52) than the no friction context (M = 18.66, SE = 4.18), $F(1, 36) = 10.85$, $p = .002$, $\eta_p^2 = .23$, 95% CI [4.01, 16.88]. No other significant effects were found.

Block Time

A 2 × 2 × 2 mixed measures ANOVA was utilized to assess the effects of context, concept, and order on block time. There were no significant effects of the independent variables upon block time.

Flow Dimensions: Agency and Time

Based on preliminary Pearson Product Moment correlation analyses, it was determined that there was no correlation between the flow dimensions of sense of control (i.e., agency) and transformation of time. Whereas theoretically, a mixed measures MANOVA would be appropriate to assess the effects of context, concept, and order upon the agency and time dimensions of flow, the data suggest that these two dimensions, at least within this sample, may not show the same pattern of results, thus a 2 × 2 × 2 mixed measures ANOVA was used to assess the influence of the independent variables on each of the two dimensions.

There was a significant friction by order interaction effect on sense of control, $F(1, 36) = 17.98$, $p < .001$, $\eta_p^2 = .33$. Post-hoc analyses revealed that when the no friction context was experienced first, there was a significant increase in sense of control from the no friction context ($M = 3.24$, $SE = .20$) to the implied friction context ($M = 3.83$, $SE = .23$), $F(1, 20) = 9.79$, $p = .005$, $\eta_p^2 = .33$, 95% CI [-0.97, -0.19]. Further, when the implied friction context was experienced first, there was a significant increase in sense of control from the implied friction context ($M = 2.99$, $SE = .25$) to the no friction context ($M = 3.86$, $SE = .22$), $F(1, 16) = 8.20$, $p = .01$, $\eta_p^2 = .34$, 95% CI [-1.51, -0.23]. It should be noted that the significant increase in sense of control from the implied friction to no friction context only occurred for participants controlling the bullet-train and not the house. That is, for participants controlling the bullet-train, when the no friction context was experienced first, there was a significant increase in sense of control from the no friction context (*M* = 3.33, *SE* = .35) to the implied friction context (*M* = 4.00, *SE* = .26), $F(1, 11) = 6.40$, $p = .028$, $\eta_p^2 = .37$, 95% CI [-1.25, -0.09]. Additionally, for participants controlling the bullet-train who experienced the implied friction context first, there was a significant increase in sense of control from the implied friction context (*M* = 2.63, *SE* = .38) to the no friction context (*M* = 3.81, *SE* = .33), $F(1, 7) = 7.92$, $p = .026$, $\eta_p^2 = .53$, 95% CI [-2.19, -0.19].

There was a significant main effect of concept on the transformation of time flow dimension such that participants who controlled the bullet-train (*M* = 3.83, *SE* = .13) reported greater transformation of time than participants who controlled the house (*M* = 3.38, *SE* = .13), $F(1, 36) = 5.91$, $p = .02$, $\eta_p^2 = .14$, 95% CI [0.08, 0.83]. Additionally, there was a significant main effect of order on transformation of time such that participants indicated significantly higher transformation of time when they experienced the implied friction context first (*M* = 3.83, *SE* = .14) than when they experienced the no friction context first (*M* = 3.37, *SE* = .12), $F(1, 36) = 6.07$, $p = .019$, $\eta_p^2 = .14$, 95% CI [-0.83, -0.08]. Further, there was a significant three-way context by concept by order interaction effect on transformation of time, $F(1, 36) = 7.71$, $p = .009$, $\eta_p^2 = .18$. Post-hoc analyses revealed that when the no friction context was experienced first, in the second block (i.e., the implied friction context), participants who controlled the bullet-train (*M* = 3.69, *SE* = .20) indicated significantly greater transformation of time than participants who controlled the house (*M* = 2.93, *SE* = .21), $F(1, 20) = 6.58$, $p = .018$, $\eta_p^2 = .25$, 95%

CI [0.14, 1.38]. Finally, for participants who experienced the implied friction context first and controlled the bullet-train, there was a significant increase from the implied friction context (*M* = 3.75, *SE* = .25) to the no friction context (*M* = 4.33, *SE* = .24), $F(1, 7) = 6.78$, $p = .035$, $\eta_p^2 = .49$, 95% CI [-1.11, -0.05].

Pearson Product Moment Correlation Analyses

One of the main goals of this study was to assess if the small-scale measures of spatial, agentic, and temporal perception can be used as proxy variables of flow state. Thus, a Pearson Product Moment Correlation analysis was computed to examine all bivariate relations. In order to comprehend fully the relation between flow and the small-scale proxy variables, it was necessary to understand how space, agency, and time relate to each specific dimension of flow as well as the aggregate flow score after isolating context and concept (see Tables 1.1 – 1.4). The following results discuss the relations between flow and the possible proxy variables via a Pearson Product Moment correlation after isolating variables by context, concept, and order (see Table 1.5). Note that because variables were isolated, the degrees of freedom for the following results are small.

The following results describe significant results for participants who experienced the no friction context first. As can be seen in Table 1.5, for participants who controlled the bullet-train in the no friction context, significant correlations arose between flow and agency ($r = .75$, $p = .005$), flow and sense of control ($r = .70$, $p = .011$), and flow and block time ($r = .71$, $p = .01$). Additionally, for participants who controlled the bullet-train significant correlation between flow and sense of control ($r = .62$, $p = .033$) and flow and block time ($r = .73$, $p = .007$) remained in the second block (i.e., implied friction context). Finally, for participants who controlled the bullet-train there was a significant correlation between agency and sense of control in the implied friction context($r = .58$, $p = .046$).

There were only two significant correlations for participants who experienced the no friction context first and controlled the house. There was a significant correlation between flow scores and sense of control ($r = .88$, $p < .001$) and agency and block time ($r = .70$, $p = .025$).

Whereas there were eight significant correlations when participants experienced the no friction context first, when the friction context was experienced first there were only three significant correlations. For participants who controlled the bullet-train in the implied friction context (i.e., first block), there were significant correlations between agency and forward displacement ($r = .87$, $p = .005$) and sense of control and block time ($r = -.91$, $p < .001$). Finally, for participants who controlled the house in the no friction context (i.e., second block), there was a significant negative correlation between forward displacement and transformation of time ($r = -.71$, $p = .02$).

Multi-level Modeling: Change in the Relation Between Flow and Proxy Variables

In order to assess how the relation between flow scores and the predicted proxy variables changed by condition, multi-level modeling (HLM 7: Raudenbush, Bryk, Cheong, Congdon, & Du Toit, 2011) was used to show the change in flow score per unit increase in proxy variable (centered) score. Proxy variables were centered and independent variables were dummy-coded.

Level 1:

$$\hat{Y}\ (Flow) = \beta_{0j} + \beta_{1ij}\ (Context) + \beta_{2ij}\ (Proxy) + \beta_{3ij}\ (Context * Proxy) + r_{ij}$$

Level 2:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(Order) + \gamma_{02}{*}(Concept) + \gamma_{03}(Order\ {*}Concept) + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + u_{1j}$$

$$\beta_{2j} = \gamma_{20} + \gamma_{21}(Order) + \gamma_{22}{*}(Concept) + \gamma_{23}(Order\ {*}Concept) + u_{2j}$$

$$\beta_{3j} = \gamma_{30} + u_{3j}$$

The following model was built such that the unique influence of context, concept, and order on flow scores could be assessed, but also the influence of the independent variables onto the relation between flow scores and each proxy variable. The full multi-level model can be found in Table 1.6. As the main interest of this analysis is the change in the relation between flow scores and the proxy variable for each condition and to discuss the influence of the independent variables would be redundant, only change in flow score per one unit increase in each proxy variable will be discussed. That is, the interest is the change in the relation between flow scores and each proxy variable as a result of the particular conditions that lead to significant changes.

In examining the change in flow score per unit increase in agency score (centered), when the no friction context was experienced first, flow scores increased for participants controlling the bullet-train in both the no friction context ($\beta = 1.55$, $SE = 0.63$, $t(34) = 2.47$, $p = .019$) and the implied friction context ($\beta = 1.95$, $SE = 0.75$, $t(34) = 2.61$, $p = .013$). Further, for participants who experienced the implied friction context first, there was a marginally significant increase in flow scores when participants controlled the bullet-train in both the implied friction context (β = 4.60, *SE* = 2.41, *t*(34) = 1.91, *p* = .065) and the no friction context (β = 4.19, *SE* = 2.34, *t*(34) = 1.80, *p* = .082). Thus, regardless of the context and order of experiencing those contexts, there was a consistent positive increase in agency for participants who controlled the bullet-train. Alternatively, controlling the house did not result in a significant change in the relation between flow scores and agency scores. The large coefficient in the implied friction first order is most likely a result of the distribution of data between the bullet-train and house. That is, the distribution of agency scores for participants controlling the bullet-train is negatively skewed with a few low scores. Although these low scores could be considered outliers, they are completely within the realm of possible scores, thus these data points were not deleted. This explanation is further validated by the large *SE* present when the implied friction context is experienced first. Alternatively, the distribution of agency scores for participants controlling the house in the implied friction first order was not negatively skewed even with the few low scores. Thus, a one unit increase in agency scores for the bullet-train was associated with and resulted in much high theoretical flow scores within the model.

Next, the relation between flow scores and block time (centered) was examined in the same multi-level model using block time as the proxy variable. Note that the low βs are a result of the unit of measurement for block time. When the no friction context was experienced first, for participants who controlling the bullet-train, there was a significant increase in flow scores per one unit increase in block time scores in both the no friction context (β = 0.00, *SE* = 0.00, *t*(34) = 2.86, *p* = .007) and the implied friction context (β =

0.00, *SE* = 0.00, $t(34) = 2.44$, $p = .020$). No other conditions led to a significant change in the relation between flow and block time. These results suggest that the change in flow score per unit increase in block time was the result of experiencing the no friction context first when controlling the bullet-train.

Finally, forward displacement was examined as the proxy variable within the multi-level model. No significant changes between flow scores and forward displacement occurred as a result of condition.

CHAPTER V

DISCUSSION: EXPERIMENT 1

Across all dependent variables except forward displacement, it was predicted that effects would be strongest for participants who controlled the bullet-train in the no friction context. It was predicted that forward displacement would replicate findings from Gill et al. (2012). These predictions were partially supported, but there was strong evidence that the concept played a central role across context and order. Importantly, not until order was included did a conceptual effect exist. When the no friction context was experienced first, in the second block (i.e., implied friction context) participants who controlled the bullet-train indicated significantly higher flow scores than participants who controlled the house.

When the implied friction context was experienced first, flow scores for participants controlling the bullet-train increased significantly from the implied friction context to the no friction context. Overall, these results suggest that order and context matter for determining flow scores for the bullet-train, but not the house. It is possible that the increase in flow scores for participants controlling the bullet-train was a practice effect. Alternatively, it is possible that when control constraints are lifted for an object with a typical motion (i.e., experiencing the implied friction context first while controlling the bullet-train), feelings of flow increase. Either way, a strikingly large effect size when controlling the bullet-train and experiencing the implied friction context first and similar results found from the trial-by-trial agency variable seems to support that the concept matters.

Ultimately, these results partially confirm the hypotheses concerning the conditions that would elicit the highest flow scores. The entirety of the experiment (i.e., the order in which contexts were experienced for each concept) proved very important in determining flow scores. Nakamura and Csikszentmihalyi (2002) suggested that one's current state is dependent on one's previous state. Thus, the notion that order had such a large influence is plausible. Further, these findings become even more conceivable given the converging pattern in the analyses of agency.

Although there were no significant main effects of context, concept, or order on agency, there was a trending context by order effect. What was discovered was that when the implied friction context was experienced first, for participants controlling the bullet-train, there was a significant increase in agency scores from the implied friction to no friction context. When the no friction context was experienced first, however, the pattern of results was not similar to those found with flow scores. Whether this pattern of results is a practice effect or a result of lifting constraints, the concept mattered.

There were no main effects of context, concept, or order on block time. Overall, participants were extremely variable in their estimations regardless of context, concept, or order. Thus, expectations concerning block time in Experiment 1 were not confirmed.

As predicted, context significantly affected forward displacement such that forward displacement was greater in the implied friction context compared to the no friction context. No other effects were found. These results partially support previous work showing that when a stimulus is controlled, implied friction results in increased forward displacement (Gill et al., 2012). Moreover, these results reverse the implied friction effects found by Hubbard (1995b), when the stimulus is simply observed. As previously suggested, the reversal is possibly due to the movement dynamics associated with the stimulus. The prediction concerning a significant increase in forward displacement for those controlling the bullet-train in the no friction context compared to the implied friction context was not supported.

The effects of context, concept, and order were assessed on the flow dimensions of agency (i.e., sense of control) and time (i.e., transformation of time) to examine how well the trial by trial measures of agency and the block level measures of time corresponded. An important aspect of the two aforementioned flow dimensions is that they were not correlated. The lack of correlation between the two dimensions made it necessary to use two separate ANOVAs rather than a MANOVA. Future studies examining the AFSS should assess the validity and reliability of these dimensions in their current form.

First, there were no significant main effects of context, concept, or order on sense of control. There was, however, a significant context by order effect such that regardless of order, there was a significant increase in sense of control from block one to block two. These results support the idea of a practice effect on sense of control. Interestingly, this effect only occurred for participants who controlled the bullet-train. That is sense of control increased significantly from block one to block two only for participants who controlled the bullet-train. In this case, concept rather than context was important in determining sense of control over the entirety of the experiment. Further, these results do not support the notion that lifting control constraints increases sense of control.

There was a significant main effect of concept on transformation of time such that participants who controlled the bullet-train indicated significantly greater time transformation than participants who controlled the house. In addition, there was a significant main effect of order such that participants who experienced the implied friction context first indicated significantly greater transformation of time than participants who experienced the no friction context first. Finally, there was a significant context by concept by order interaction. If the no friction context was experienced first, there was a significant divergence in time transformation between participant who controlled the bullet-train and those who controlled the house. That is, in the second block, participants who controlled the bullet-train indicated significantly greater time transformation compared to participants who controlled the house. Further, for participants who controlled the bullet-train when the implied friction context was experienced first, there was a significant increase in time transformation from the implied friction context to the no friction context. Once again, concept appears to be an important determining factor for transformation of time as indicated via the AFSS.

Although there were interesting relations between flow scores and the proxy variables (as evident in the Pearson Product Moment analysis), the multi-level analysis demonstrated that controlling the bullet-train significantly increased the relation between both agency and block time and flow scores. That is, for participants who controlled the bullet-train, both agency and block time were significantly more predictive of flow scores. Alternatively, neither context, nor concept, nor order altered the predictiveness of forward displacement (i.e., perception of space) onto flow scores.

Overall, an interesting pattern arose within Experiment 1 that suggested that context, concept, and order play large roles in determining the phenomenal experiences associated with flow. Specifically, the pre-specified typical motion of an ambiguous stimulus played a very large role in the phenomenal experience. Experiment 2 was performed both to validate and expand the results of Experiment 1 with the hopes of providing a more thorough explanation of the phenomenal flow experience.

CHAPTER VI

EXPERIMENT 2

Method

The same method utilized in Experiment 1 was utilized in Experiment 2, except that participants gave estimates of the amount of time that passed by during the successful attempt of each trial (i.e., not including any of the unsuccessful attempts at each trial in their estimate) by typing the number of seconds that each trial took instead of judgments of agency. Often times, when participants learned the controls of the experiment, they experienced failed attempts at trials. The estimate of time was concerned only with participants' estimates of the successful attempt at a trial. Asking for time estimates of only the successful trials was an attempt to minimize any bias resulting from multiple failed attempts.

Nakamura and Csikszentmihayli (2002) found that individuals who report being in a flow state experience s of time, such that time seems to move faster than normal. Previous literature has demonstrated that gaming experts estimate less time having passed during a gaming session than novices (Rau et al., 2006). Thus, Experiment 2 examined how manipulations of context (i.e., implied friction) and concepts (object with or without typical motion) affected time perception.

Experiment 2 examined time with respect to manipulations of context (i.e., implied friction) and concepts (i.e., a bullet-train vs. a house). After participants indicated the vanishing point of the stimulus, they were asked to indicate how many seconds had passed during the corresponding successful attempt of a trial by typing the number of seconds on the keyboard. It was predicted that individuals in the no implied friction condition would indicate less time having passed than individuals in the implied friction condition. Controlling a stimulus over the no implied friction context should afford maximal control and, subsequently, should be the context that elicits greater feelings of being in a flow state. Additionally, it was predicted that individuals who controlled the bullet-train would indicate less time had passed than individuals who controlled the house. Similarly, as the bullet-train concept should have elicited greater feelings of control due to typical motion, higher flow scores should follow. Thus, the higher the flow score, the more temporal contraction should be apparent. Predictions concerning forward displacement were the same as in Experiment 1. Although the results of Experiment 1 did not confirm the initial hypothesis that participants who controlled the bullet-train would indicate greater forward displacement that participants who controlled the house in the implied friction context, the hypothesis remained consistent with previous findings from Gill et al. (2012).

Sense of control and time transformation (i.e., the AFSS dimensions) were assessed for their correspondence to the trial-by-trial time variable, the block time variable, and any patterns similar to the findings from Experiment 1. It was predicted that the greatest effect would occur for participants controlling the bullet-train in the no friction condition.

It was predicted that time would relate negatively to forward displacement. Higher flow scores, and subsequently more time, should lead to greater forward displacement due to the predictiveness of action effects. Additionally, time should relate to flow scores, and specifically to the dimension assessing time during the activity. As trial-by-trial time increases, so too should the feeling of time transformation and flow scores. Finally, if time and flow scores correlate, forward displacement and flow scores should also positively relate. If greater forward displacement relates to the predictiveness action effects and performance, then larger displacement scores should be positively related to greater flow scores.

Hypotheses concerning the predictiveness of the proxy variables were consistent with Experiment 1 such that the conditions eliciting the greatest predictiveness would be when participants controlled the bullet-train in the no friction context.

Experiment 2 was also a 2 × 2 ×2 mixed design. The dependent variables measured in Experiment 2 were flow scores, trial time, forward displacement, and block time. Trial time was calculated by subtracting the estimated amount of time in seconds taken to complete a trial from the actual amount of time in seconds (i.e., actual time – perceived time). Positive values indicate temporal contraction in the direction of predicted results.

Participants

Participants were recruited from the department of psychology participant pool. Each participant was informed of their rights as a research participant as required by the IRB. Participants were debriefed, thanked, and also earned course credit for their participation. A total of 69 individuals participated in Experiment 2. Of those 69, 11 participants' data were omitted due to experimenter error and 14 participants' data were omitted because either the participant did not understand the instructions or had extremely variable data (trial time estimates greater than three standard deviations away from the mean). Thus, in Experiment 2, a total of 44 participants' data were analyzed.

Materials

Activity Flow State Scale (AFSS). Cronbach's α was computed for both contexts (i.e., no friction and implied friction). Both the no friction context (Cronbach's $\alpha = .79$) and the implied friction context (Cronbach's $\alpha = .71$) showed acceptable reliability (Cortina, 1993).

CHAPTER VII

RESULTS: EXPERIMENT 2

Flow

To assess the effects of context, concept, and order on flow scores, a 2 × 2 × 2 mixed measures ANOVA was utilized. No significant main effects results from context, concept, or order. There was, however, a significant context by order interaction, $F(1, 38) = 28.47$, $p < .001$, $\eta_p^2 = .43$. Post-hoc analyses revealed that when participants experienced the no friction context first, there was a significant increase in flow scores from the no friction context ($M = 3.39$, $SE = .11$) to the implied friction context ($M = 3.61$, $SE = .12$), $F(1, 19) = 10.24$, $p = .005$, $\eta_p^2 = .35$, 95% CI [0.08, 0.36]. Further, when the implied friction context was experienced first, the same pattern arose such that there was a significant increase in flow scores from the implied friction context ($M = 3.38$, $SE = .09$) to the no friction context ($M = 3.78$, $SE = .14$), $F(1, 19) = 18.16$, $p < .001$, $\eta_p^2 = .49$, 95% CI [0.21, 0.60].

Additionally, there was a significant concept by order interaction, $F(1, 38) = 5.04$, $p = .031$, $\eta_p^2 = .12$. Post-hoc analyses revealed that when the implied friction context was experienced first, the participants who controlled the bullet-train ($M = 3.58$, $SE = .12$) indicated significantly higher flow scores than participants who controlled the house ($M = 3.18$, $SE = .14$), $F(1, 18) = 4.89$, $p = .04$, $\eta_p^2 = .21$, 95% CI [0.02, 0.79].

Interestingly, participants who controlled the house indicated significantly larger flow scores regardless of order. Specifically, when the no friction context was experienced first, there was a significant increase in flow scores from the no friction context (*M* = 3.43, *SE* = .15) to the implied friction context (*M* = 3.75, *SE* = .19), *F*(1, 9) = 8.88, *p* = .015, η_p^2 = .50, 95% CI [0.08, 0.56]. When the implied friction context was experienced first, there was also a significant increase in flow scores from the implied friction context (*M* = 3.18, *SE* = .14) to the no friction context (*M* = 3.74, *SE* = .24), *F*(1, 8) = 13.60, *p* = .006, η_p^2 = .63, 95% CI [0.21, 0.93] (see *Figure 2.1*).

Trial Time

To assess the effects of context, concept, and order on time at each trial, a 2 × 2 × 2 mixed measures ANOVA was utilized. No significant effects resulted from this analysis and will be addressed further in the discussion.

Forward Displacement

To assess the effects of context, concept, and order on forward displacement, a 2 × 2 × 2 mixed measures ANOVA was utilized. There was a significant main effect of context on forward displacement such that participants in the no friction context (*M* = 20.68, *SE* = 3.71) indicated significantly less displacement than when in the implied friction context (*M* = 33.91, *SE* = 3.64), *F*(1, 40) = 27.45, *p* < .001, η_p^2 = .41, 95% CI [8.13, 18.34]. No significant main effects resulted from concept or order. Interestingly, there was a significant concept by order interaction, *F*(1, 40) = 4.64, *p* = .037, η_p^2 = .10. Post-hoc analyses revealed that for participants who controlled the house, forward displacement scores were significantly higher for those who experienced the no friction context first (M = 39.52, SE = 5.64) than for those who experienced the implied friction context first (M = 19.14, SE = 5.64), $F(1, 18) = 6.53$, $p = .020$, $\eta_p^2 = .27$, 95% CI [3.62, 37.14]. There was no difference in forward displacement for participants who controlled the bullet-train in either order ($p = .39$).

Block Time

To assess the effects of context, concept, and order on block time , a 2 × 2 × 2 mixed measures ANOVA was utilized. Block time was calculated by subtracting the estimated block time from the actual block time. There was a significant main effect of friction on block time, such that participants indicated significantly less in the no friction context (M = -166.01, SE = 51.75) compared to the implied friction context (M = -0.77, SE = 39.29), $F(1, 40) = 11.49$, $p = .002$, $\eta_p^2 = .22$, 95% CI [-266.20, -67.34]. No main effects resulted from concept or order. Interestingly, there was a significant context by order interaction. Post-hoc analyses revealed that participants who experienced the implied friction context first experienced significantly less block time in the no friction context (M = -265.76, SE = 82.79) compared to the implied friction context (M = 14.89, SE = 54.22), $F(1, 20) = 11.25$, $p = .003$, $\eta_p^2 = .36$, 95% CI [-455.25, -106.07]. There was no significant difference between contexts for participants who experienced the no friction context first.

Flow Dimensions: Agency and Time

Similar to Experiment 1, the flow dimensions of sense of control (i.e., agency) and transformation of time (i.e., time) showed no correlation, thus, the variables were analyzed separately. To assess the effects of context, concept, and order on sense of control, a 2 × 2 × 2 mixed measures ANOVA was used. Alone, neither context, nor concept, nor order affected sense of control. Interestingly, there was a significant context by order effect, $F(1, 40) = 7.64$, $p = .009$, $\eta_p^2 = .16$. That is, when the no friction context was experienced first, there was a significant increase from the no friction context (M = 2.96, SE = .22) to the implied friction context (M = 3.41, SE = .23), $F(1, 20) = 5.73$, p = .027, $\eta_p^2 = .22$, 95% CI [-0.83, -0.06]. A similar pattern arose when the implied friction context was experienced first. That is, indications of sense of control increased significantly from the implied friction context (M = 2.70, SE = .24) to the no friction context (M = 3.58, SE = .25), $F(1, 20) = 7.55$, $p = .012$, $\eta_p^2 = .15$, 95% CI [-1.53, -0.21].

Next, a 2 × 2 × 2 mixed measures ANOVA was used to assess the effects of context, concept, and order on transformation of time (i.e., flow dimension of time). Neither context nor concept nor order significantly affected participants' indications of transformation of time in Experiment 2.

Pearson Product Moment Correlation Analyses

Once again, a Pearson Product Moment correlation analysis was performed to examine the relation between variables isolated by context and concept (see Tables 2.1-2.4). To assess the relation between flow scores and the possible proxy variables, variables were isolated by context, concept, and order (see Table 2.5). Note that because variables were isolated, the degrees of freedom for the following results are small. The following discussion of correlations is based on Table 2.5 results.

For participants who experienced the no friction context first, there was a positive significant correlation between flow scores and block time when controlling the house in the no friction context (*r*= .67, *p* = .034) and the implied friction context (*r* = .72, *p* = .019). There was a positive significant relation between flow scores and sense of control (i.e., flow dimension of agency) for participants controlling the bullet-train in both the no friction context (*r* = .67, *p* = .024) and the implied friction context (*r* = .71, *p* = .010). Further, for participants controlling the house in the implied friction context, the positive significant relation remained between flow scores and sense of control (*r* = .80, *p* = .006). There was a negative significant correlation between transformation of time and block time for participants controlling the bullet-train in the implied friction context (*r* = -.59, *p* = .045).

Next, for participants experiencing the implied friction context first, there was a positive significant relation between flow scores and trial time for participants controlling the house in the no friction context (i.e., second block: *r* = .68, *p* = .03). Additionally, for participants controlling the house in the no friction context, there was a negative significant relation between flow scores and forward displacement (*r* = -73, *p* = .016). Once again, for participants controlling the bullet-train there was a positive significant relation between flow scores and sense of control in both the implied friction context (*r* = .69, *p* = .012). Similarly, for participants controlling the house in the no friction context, there was a positive significant relation between flow and sense of control (*r* = .88, *p* < .001). There was a negative significant relation between forward displacement and transformation of time for participants controlling the bullet-train in the no friction context (*r* = -.68, *p* = .015). Finally, for participants controlling the house in the no friction context, there were negative significant correlations between forward displacement and sense of control (*r* = -.82, *p* = .004) and transformation of time and block time (*r* = -.93, *p* < .001).

Multi-level Modeling: Change in the Relation Between Flow and Proxy Variables

As in Experiment 1, multi-level modeling was used to assess the change in the relation between flow scores and the proxy variables by condition. The proxy variables were centered and the independent variables were dummy coded. Additionally, the focus of the following results is only of the change in flow score per one unit increase in proxy variable.

As seen in Table 2.6, in the first model, trial time was the proxy variable. Interestingly, when the implied friction context was experienced first, for participants who controlled the house, there was a significant increase in the relation between flow scores and trial time in both the implied friction context (β = 0.03, *SE* = 0.01, *t*(36) = 2.41, *p* = .021) and the no friction context (β = 0.04, *SE* = 0.01, *t*(36) = 3.13, *p* = .003). No other significant changes occurred between the relation of flow and trial time as a result of the different conditions. These results suggest that the change in flow scores were a result of experiencing the implied friction context first when controlling the house.

Next, block time was inserted as the proxy variable within the multi-level model. When the implied friction context was experienced first, for participants who controlled the house, there was a significant decrease in flow scores per unit increase in block time in both the implied friction context (β = -0.00, *SE* = 0.00, *t*(36) = -2.08, *p* = .045) and the no friction context (β = -0.00, *SE* = 0.00, *t*(36) = -2.95, *p* = .006). Interestingly, there was a similar effect for participants who controlled the bullet-train. That is, when the implied friction context was experienced first, for participants who controlled the bullet-train, there was a marginally significant decrease in flow score in the implied friction context (β = -0.00, *SE* = 0.00, $t(36) = -1.94$, $p = .060$) and a significant decrease in the no friction context (β = -0.00, *SE* = 0.00, $t(36) = -3.03$, $p = .005$). No other significant changes occurred between flow and block time as a result of the different conditions. These results suggest that the decrease in flow score per one unit increase in block time may be the result of the order rather than context or concept.

Finally, forward displacement was inserted as the proxy variable within the multi-level model. When the implied friction context was experienced first, for participants who controlled the house, there was a highly significant decrease in flow scores per unit increase in forward displacement in both the implied friction context (β = -0.02, *SE* = 0.00, $t(36) = -5.05$, $p < .001$) and the no friction context (β = -0.02, *SE* = 0.00, $t(36) = -7.03$, $p < .001$). No other significant changes occurred between flow scores and forward displacement as a result of the different conditions. These results suggest that the decrease in flow score per one unit increase in forward displacement was the result of experiencing the implied friction context first when controlling the house.

CHAPTER VIII

DISCUSSION: EXPERIMENT 2 AND GENERAL

In Experiment 2, like Experiment 1, it was predicted that the no friction context and controlling the bullet-train would lead to the highest flow scores (overall and within the agency and time dimensions) and the largest trial time and block time. Further, it was predicted that forward displacement would replicate findings from Gill et al. (2012). Finally, these conditions were predicted to elicit the strongest correlations and lead to the strongest predictiveness between the proxy variables and flow scores.

No main effects were observed on flow scores. There was, however, a significant context by order effect. Flow scores increased regardless of order. Overall, when the implied friction context was experienced first, participants who controlled the bullet-train indicated significantly higher feelings of flow than participants who controlled the house. Interestingly, for participants who controlled the house, flow scores increased significantly across both orders. These results suggest that concept and order play a role in affecting flow, but not in the predicted direction. These results also suggest a the increase in flow scores may be the result of a general practice effect.

Trial time was not affected by context, concept, or order. This will be addressed later in the general discussion.

As expected, context affected forward displacement such that as implied friction increased, so too did forward displacement. There was a strange concept by order effect such that for participants who controlled the house, forward displacement was greater when the no friction context was experienced first. This final result was not predicted. Overall, whereas the bullet-train produced significantly greater forward displacement than the house, it was the house that caused significant changes in forward displacement across orders. Importantly, the main effect of context replicated the results from Experiment 1 and Gill et al. (2012).

Context significantly affected block time. The implied friction context elicited, on average, fairly accurate block time estimates. Alternatively, the no friction context elicited large block time estimates. No other main effects were found; however, there was a context by order effect. Participants who experienced the implied friction context first, in the implied friction context participants, on average, indicated that less time passed. In the no friction context, participants, on average, overestimated the amount of time that passed. Although neither conditions' estimates were significantly different from zero, it is clear that the implied friction context was trending toward real time contraction. Whereas these results are alternative to the predictions, evidence of context affecting time is promising.

Concerning the flow dimension of sense of control, there were no main effects. There was, however, a significant context by order effect such that regardless of order, sense of control increased from the first to second block, supporting the idea of a practice effect. Time transformation was not affected by context, concept, or order. This lack of replication for both sense of control and time transformation to Experiment 1 will be addressed further in the general discussion.

In general, neither context nor concept evinced strong correlations within the Pearson Product Moment analysis in Experiment 2. In each order, the second block did evince more significant correlations supporting the idea of possible practice effects. Interestingly, the multi-level analysis confirmed the pattern of unexpected results. Trial time was positively significantly predictive of flow scores only for participants controlling the house and who experienced the implied friction context first. Block time was negatively significantly predictive of flow scores as a result of order rather than context of concept. Finally, controlling the house and experiencing the implied friction context first caused forward displacement to be negatively significantly predictive of flow scores.

Overall, Experiment 2 was not very supportive of the original predictions. Moreover, there were few replications of findings from Experiment 1. Across both experiments, only forward displacement replicated. Whereas in Experiment 1, flow scores were affected by context and concept as predicted, Experiment 2 showed somewhat alternative results. In Experiment 1, there was some concordance in findings from the trial-by-trial agency scores and flow scores. No such concurrence occurred in Experiment 2. In Experiment 1, sense of control and time transformation also showed concordance with flow scores and agency. In Experiment 2, only a practice effect was present in sense of control. Although there was a significant effect of context on block time in Experiment 2, it was opposite of what was predicted and it was not in concordance with block time findings from Experiment 1. Although there was little concordance across experiments, the interesting patterns found in Experiment 1 are promising.

In Experiment 1, similar patterns arose for flow scores, agency, and the flow dimensions of sense of control and transformation of time. Although the predictions were only partially supportive, strong evidence that controlling the bullet-train and the no friction context evinced the highest scores was present.

In Experiment 2, there was no clear pattern except that order played a large role in causing effects. Further, there was no clear concordance between trial time and block time in Experiment 2. As there were no effects on block time in Experiment 1, it is possible that the nature of the requested information altered the results. First, participants in Experiment 2 were required to make one extra motion in typing their response into the keyboard rather than using the mouse as was required in Experiment 1. This additional motion may have constituted a task-switch and confounded results.

Second, in Experiment 2, participants were focused on estimating time throughout the experiment, whereas in Experiment 1, time estimates occurred only at the end of each block. This could explain why there was no concordance concerning flow scores and the flow dimensions across experiments. The relative accuracy of block time estimates witnessed in Experiment 2 may be a tradeoff between the processing necessary to track time and the dynamic resources required for the flow experience. That is, the nature of the trial-by-trial time estimate question may have used the cognitive resources that are not conducive to the flow experience. Asking participants to make a value judgment concerning control after each trial may not require the same cognitive resources and thus affect the phenomenal flow experience differently than asking participants to estimate time. For example, Droit-Volet and Meck (2007) suggested that if attentional resources are devoted to temporal perception, time contraction may not occur. Small nuances in an experience may significantly alter the phenomenological aspects of that experience.

CHAPTER IX

CONCLUSION

The main goal of this study was to assess claims made by McGonigal (2011) that video games are flow elicitors. Through the use of a simple video game it was found that under certain circumstances flow can be altered via manipulations of context and concept. A second goal of this study was to assess the usefulness of previously studied perceptual variables (e.g., agency, time, and space) as proxies of flow scores. What was found was that one's sense of agency is a promising indicator of being in a flow state. Alternatively, one's perception of time and space may not be promising indicators, at least as assessed within this study.

Although there were conflicting results across experiments, the fundamental difference in the tasks, specifically asking one to reflect about control rather than time, may account for the lack of concordance.

Perhaps the greatest take away from Experiment 1 was that concept matters. Specifically, being told that the stimulus being controlled is one that has a typical motion seemed to play a very large role in causing differences in flow scores and possibly the phenomenological differences in feelings of flow. This notion was supported by the results from the multi-level model analysis that showed that controlling the bullet-train increased the predictiveness of agency to flow scores.

The findings from Experiment 1 also support previously mentioned theoretical account The Theory of Event Coding (Hommel et al., 2001). As predicted, implied friction increased forward displacement showing that effects associated with actions affect visual perception or planning. Further, the significant increases in flow scores and agency from the implied to no friction context for participants who controlled the bullet-train but not the house implies that the planning or the effects associated with actions for the object with a typical motion may have had a phenomenological effect. That is, the effects one expected from a bullet-train was tied into the complexity of agency and flow scores.

The greatest take away from Experiment 2 is that the way in which one experiences an activity may play a large role in the phenomenological aspects of flow. Not only were predictions not supported, at times, they were actually opposite of what was expected. It is possible that asking one about time is not conducive to achieving flow. Future studies might eliminate the notion that a task switch confounded results by having participants type a value of how in control they feel after each trial. If the results replicate Experiment 1 from this study, the probability that a task switch was a confounding factor is low.

This lack of concordance between Experiments 1 and 2 concerning flow scores might raise questions about the rather supportive findings of Experiment 1. As mentioned, however, the way in which one experiences an activity may change the phenomenological aspects associated with that activity. Thus, although the only difference between Experiments 1 and 2 was one question and the hand movements required to answer, that small difference seems to alter the flow experience in a very significant way.

One possible explanation as to why calling a stimulus a bullet-train mattered is that it allowed for better immersion into the task. For participants who were told that they were accelerating and decelerating a bullet-train, the typical motion associated with the train and relevance to the task may have allowed participants to be more fully engrossed or immersed with the task. That is, if labeling a stimulus as a task relevant concept aids in immersion, a necessary component of flow, then labeling the stimulus a bullet-train that accelerates and decelerates across a horizontal plane may have aided in the immersion above what labeling the stimulus as a house did. Immersion is an important aspect of the visual experience and can alter things like distance perception (Mohler, Bültoff, Thompson, & Creem-Regehr, 2008).

In addition to the importance of concept in flow scores, it was also shown that both context and order mattered in this study. One point to be emphasized is that context, or presence of implied friction, was a psychological construct. That is, compared to other experiments in which control manipulations had physical implications on the actions produced by participants (e.g., Metcalfe & Greene, 2007), context in this study was a visual addition with action implications. What was manipulated, then, was anticipation or action-effects such that participants anticipated that different effects would result from their actions based on context.

One important factor that was overlooked during the development of this study was the importance of the entire experience across both the no friction and implied friction contexts. Once order was considered as a possible important variable, what was found were effects supportive of predictions, at least in Experiment 1. As previously mentioned, Csikszentmihayli (Nakamura & Csikszentmihalyi, 2002) suggested that one's state is affected by one's previous state. Csikszentmihayli's suggestion indicates that past experiences have real influences of current actions. In this light, that order played such a large role is not surprising.

There are many directions that future studies on this topic might focus on. First, as previously mentioned, understanding if the additional movement or type of question asked in Experiment 2 confounded results is extremely important. Next, approaching this problem with a dynamical view might allow for a better understanding of the flow process via proxy variables over time. That is, the current study examined proxy variables using average scores whereas a better approach to understanding the complexity of flow state and related variables may be to analyze results over time. Within this approach, one might assess button-press data that might reveal differences in variability. Further, one might look at variability in terms of the actual vanishing point, the perceived vanishing point, and forward displacement. Such an endeavor might reveal interesting visual and behavioral dynamics associated with the phenomenological flow experience.

Forward displacement showed little to no predictiveness towards flow scores. One possible reason for this result is that there was no feedback regarding this outcome variable. That is, within the experiment, visual feedback came from both the effects of a button-press and after a failed trial occurred. A future study might attempt to provide feedback regarding the difference between the perceived and actual vanishing point. Forward displacement feedback may only not only for a better established relation between spatial perception and flow, but might also reveal additional information about the effects of context on the perceived vanishing point.

Another direction future studies should examine is previous gaming experience. This study did not analyze past gaming experience as a possible factor influencing the phenomenological aspect of flow. One possible reason for the order effects seen is that individuals with more experience may have been misrepresented in one order vs. the other. This may have led to either an increase or decrease in scores for that particular condition. Note that no participants had taken part in that experiment prior to their session, so although there may have been variability in gaming experience across conditions, everyone was a novice to the experimental task in this study.

Ultimately, what was found is that flow scores can indeed be influenced by the components that constitute video games (i.e., context and concept). Thus, McGonigal's (2011) claim was supported. Further, it was found that agency is a promising perceptual proxy of flow scores. The perception of time and space, however, may not be very promising proxies. Future work should further probe the perception of agency and its predictiveness of flow scores to understand how it might be used not only by video game designers, but possibly by researchers trying to increase one's ability to enter into the optimal state of being.

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APPENDIX A

EXPERIMENT 1 FIGURES

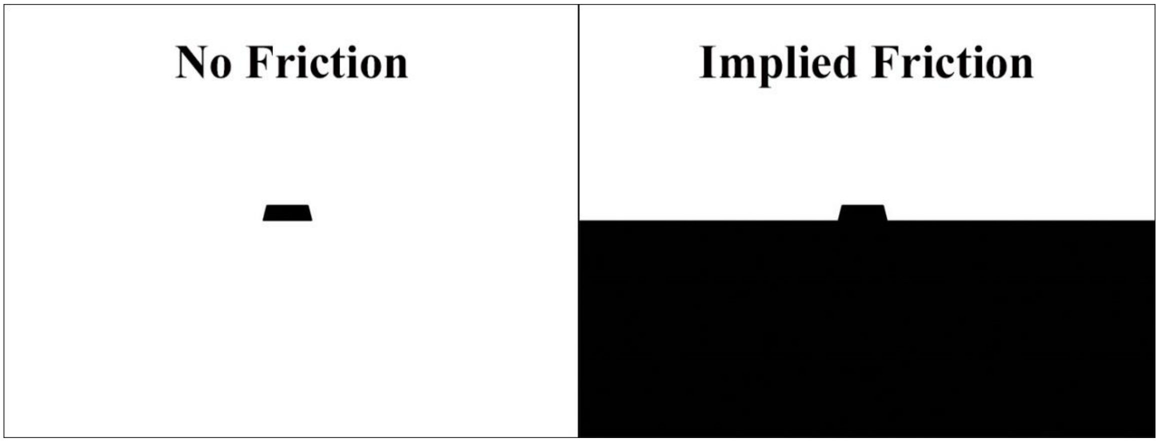

Figure 1.1. Representation of contexts and stimulus.

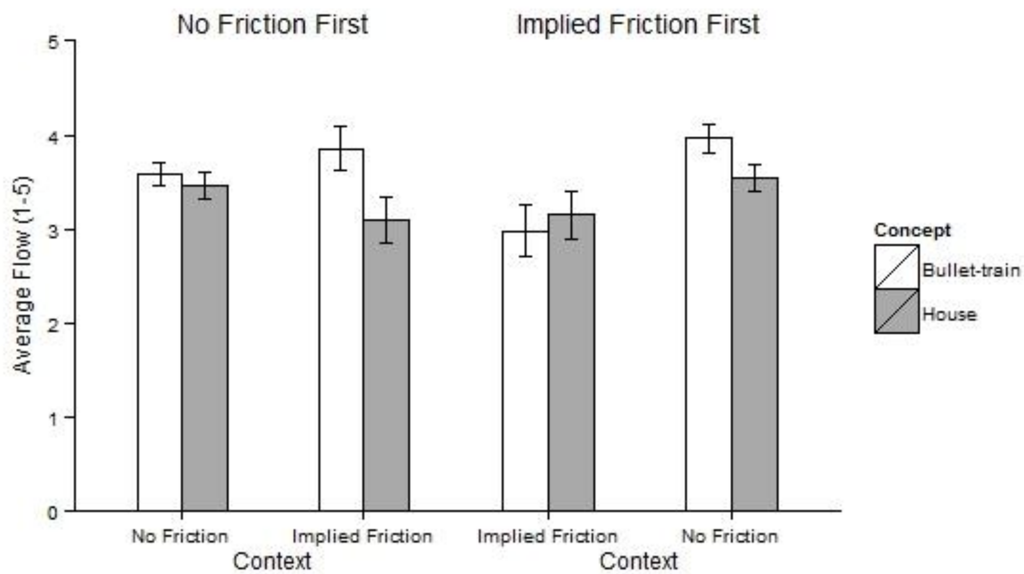

Figure 1.2. Experiment 1 three-way interaction of context, concept, and order on flow scores.

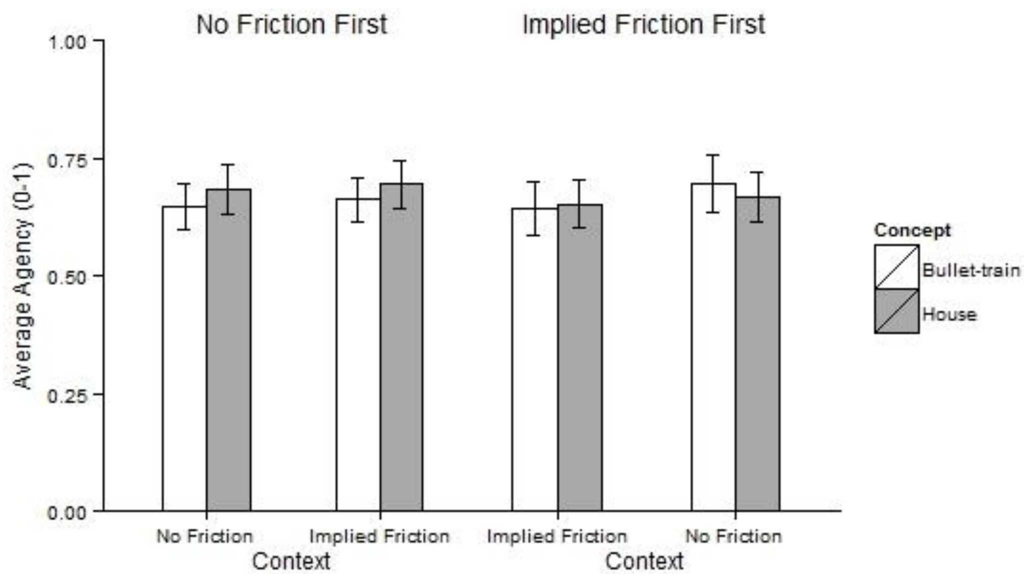

Figure 1.3. Experiment 1 marginally significant interaction revealing significant increase in agency from the implied friction to no friction context for participants who experienced the implied friction context first and who controlled the bullet-train. Note that standard error bars represent error from entire three way interaction, thus do not appear significantly different.

APPENDIX B

EXPERIMENT 1 CORRELATION MATRICES AND MULTI-LEVEL MODEL TABLE

Table 1.1

Correlations Among Proxy Variables, AFSS Dimensions, and Block Time in the no Friction Context for Individuals Controlling the Bullet-Train

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
(1) Spatial Displacement	-	0.27	0.21	0.08	-0.09	-0.14	0.12	-0.08	0.19	0.36	**0.39 Ɨ**	0.10	-0.07	-0.06	0.03
(2) Agency		-	**0.66****	**0.45***	0.00	**0.54***	**0.39 Ɨ**	**0.39 Ɨ**	**0.59***	0.36	**0.63****	**0.44 Ɨ**	**-0.61****	**-0.52***	0.29
(3) Flow			-	**0.55***	0.31	**0.68****	**0.46***	**0.61****	**0.88****	**0.69****	**0.65****	**0.68****	**-0.66****	-0.35	**0.52***
(4) Sense of Control				-	-0.09	**0.54***	0.19	0.17	0.37	**0.51***	0.09	0.19	**-0.64****	**-0.52***	0.32
(5) Transformation of Time					-	0.21	0.37	0.10	0.17	0.03	0.12	0.00	-0.25	-0.08	0.24
(6) Merging of Action and Awareness						-	0.35	**0.64****	**0.60****	0.22	0.24	0.33	**-0.50***	**-0.70****	-0.03
(7) Loss of Self-Consciousness							-	-0.11	0.33	0.25	0.06	0.11	-0.20	-0.24	0.03
(8) Unambiguous Feedback								-	**0.68****	0.15	**0.54***	**0.57****	**-0.52***	-0.32	0.36
(9) Challenge-Skill Balance									-	**0.43 Ɨ**	0.61	0.78	-0.54	-0.28	0.43
(10) Concentration on Task at Hand										-	**0.44 Ɨ**	0.29	**-0.41 Ɨ**	-0.07	**0.47***
(11) Clear Goals											-	**0.50***	**-0.47***	-0.21	**0.40 Ɨ**
(12) Autotelic Experience												-	-0.27	0.13	**0.49***
(13) Estimate of Block Time													-	**0.65****	**-0.66****
(14) Actual Block Time														-	0.15
(15) Block Time															-

Note: $df = 18$. Asterisks denote significance, ** $p < .01$, * $p < .05$. Cross denotes marginal significance, Ɨ $p < .10$

Table 1.2

Correlations Among Proxy Variables, AFSS Dimensions, and Block Time in the Implied Friction Context for Individuals Controlling the Bullet-Train

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
(1) Spatial Displacement	-	0.14	0.15	-0.02	-0.18	0.18	-0.12	0.08	0.35	0.36	0.22	0.31	-0.08	0.02	0.10
(2) Agency		-	0.35	0.41Ɨ	-0.17	0.26	0.04	0.50*	0.58**	0.53*	0.43Ɨ	0.61**	-0.23	-0.27	0.08
(3) Flow			-	0.64**	0.13	0.84**	0.62**	0.59**	0.66**	0.44Ɨ	0.48*	0.78**	-0.48*	-0.40Ɨ	0.27
(4) Sense of Control				-	0.09	0.74**	0.38Ɨ	0.27	0.27	0.08	0.12	0.32	-0.11	-0.63**	-0.33
(5) Transformation of Time					-	0.22	-0.11	-0.23	0.15	-0.10	-0.12	0.12	-0.17	-0.11	0.12
(6) Merging of Action and Awareness						-	0.48*	0.46*	0.49*	0.12	0.11	0.53*	-0.41Ɨ	-0.50*	0.11
(7) Loss of Self-Consciousness							-	0.24	0.03	0.12	-0.09	0.29	-0.16	-0.20	0.05
(8) Unambiguous Feedback								-	0.57**	0.27	0.58**	0.62**	-0.19	-0.18	0.09
(9) Challenge-Skill Balance									-	0.70**	0.69**	0.85**	-0.48*	-0.17	0.43Ɨ
(10) Concentration on Task at Hand										-	0.61**	0.63**	-0.41Ɨ	-0.00	0.46*
(11) Clear Goals											-	0.72**	-0.22	-0.01	0.25
(12) Autotelic Experience												-	-0.46*	-0.17	0.41Ɨ
(13) Estimate of Block Time													-	0.51*	-0.79**
(14) Actual Block Time														-	0.13
(15) Block Time															-

Note: *df* = 18. Asterisks denote significance, ** $p < .01$, * $p < .05$. Cross denotes marginal significance, Ɨ $p < .10$

Table 1.3

Correlations Among Proxy Variables, AFSS Dimensions, and Block Time in the no Friction Context for Individuals Controlling the House

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
(1) Spatial Displacement	-	0.32	-0.20	0.24	-0.09	-0.16	0.36	-0.21	-0.39Ɨ	-0.46*	-0.15	-0.00	-0.49*	-0.24	0.51*
(2) Agency		-	-0.14	0.23	-0.09	-0.30	-0.12	-0.39Ɨ	0.03	-0.16	0.00	0.18	-0.40Ɨ	-0.34	0.32
(3) Flow			-	0.58**	0.59**	0.21	0.32	0.53*	0.48*	0.72**	0.40Ɨ	0.54*	0.03	0.03	-0.02
(4) Sense of Control				-	0.23	0.08	0.44Ɨ	0.19	0.10	0.09	0.03	0.45*	-0.53*	-0.24	0.56*
(5) Transformation of Time					-	0.22	0.12	-0.07	0.29	0.51*	-0.22	0.37	0.09	-0.00	-0.12
(6) Merging of Action and Awareness						-	0.18	0.42Ɨ	-0.42Ɨ	0.07	-0.25	-0.29	0.25	0.30	-0.15
(7) Loss of Self-Consciousness							-	0.36	-0.25	-0.19	-0.10	-0.11	0.05	0.43Ɨ	0.21
(8) Unambiguous Feedback								-	-0.01	0.14	0.56*	-0.06	0.33	0.37	-0.21
(9) Challenge-Skill Balance									-	0.64**	0.30	0.40Ɨ	0.04	-0.21	-0.19
(10) Concentration on Task at Hand										-	0.34	0.34	0.01	-0.14	-0.10
(11) Clear Goals											-	0.15	-0.03	-0.17	-0.07
(12) Autotelic Experience												-	-0.10	-0.19	0.01
(13) Estimate of Block Time													-	0.71**	-0.90**
(14) Actual Block Time														-	-0.33
(15) Block Time															-

Note: *df* = 18. Asterisks denote significance, ** $p < .01$, * $p < .05$. Cross denotes marginal significance, Ɨ $p < .10$

Table 1.4

Correlations Among Proxy Variables, AFSS Dimensions, and Block Time in the Implied Friction Context for Individuals Controlling the House

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
(1) Spatial Displacement	-	0.06	0.03	-0.28	0.20	-0.50*	0.18	0.10	-0.21	-0.16	0.12	0.05	-0.16	0.14	0.24
(2) Agency		-	0.13	-0.17	0.28	-0.42Ɨ	0.07	-0.24	-0.19	0.12	-0.02	0.08	-0.45*	-0.46*	0.36
(3) Flow			-	0.34	0.15	-0.13	0.34	0.28	0.38	0.32	0.22	0.79**	0.20	0.26	-0.14
(4) Sense of Control				-	0.07	0.39Ɨ	0.27	0.58**	0.48*	0.25	0.25	0.40Ɨ	0.18	0.07	-0.19
(5) Transformation of Time					-	-0.28	-0.08	0.18	0.09	0.46*	-0.04	0.25	-0.05	0.14	0.11
(6) Merging of Action and Awareness						-	-0.16	0.15	-0.20	-0.18	-0.22	-0.34	0.49*	0.02	-0.57*
(7) Loss of Self-Consciousness							-	0.30	0.21	-0.22	-0.15	0.26	-0.22	-0.09	0.22
(8) Unambiguous Feedback								-	0.46*	0.14	0.31	0.33	0.24	0.24	-0.19
(9) Challenge-Skill Balance									-	0.68**	0.55*	0.54*	0.27	0.32	-0.20
(10) Concentration on Task at Hand										-	0.45*	0.48*	0.20	0.10	-0.20
(11) Clear Goals											-	0.56*	0.08	-0.05	-0.11
(12) Autotelic Experience												-	-0.03	0.07	0.06
(13) Estimate of Block Time													-	0.60**	-0.95**
(14) Actual Block Time														-	-0.33
(15) Block Time															-

Note: $df = 18$. Asterisks denote significance, ** $p < .01$, * $p < .05$. Cross denotes marginal significance, Ɨ $p < .10$

Table 1.5

Correlations among flow scores, proxy variables, and flow dimensions by condition

	No Friction First				Implied Friction First			
	No Friction		Implied Friction		Implied Friction		Implied Friction	
Correlation variables	BT	H	BT	H	BT	H	BT	H
Flow & Agency	**.75****	-.03	.43	.16	.11	.14	.17	-.20
Flow & CN	**.70***	**.88****	**.62***	.21	.40	.43	-.60	.31
Flow & FD	.18	-.09	.30	-.04	.24	.08	.32	-.36
Flow & BTC	**.71***	.15	**.73****	-.19	-.37	-.14	-.14	-.18
Flow & TT	.03	.60	.39	.15	-.11	.19	.41	.58
Agency & CN	.43	-.11	**.58***	-.06	.59	-.38	.50	.60
Agency & FD	.29	.35	.10	-.20	**.87****	.54	.39	.35
Agency & BTC	.31	.53	.16	**.70***	-.31	.26	.07	.26
Agency & TT	-.13	.26	-.24	.34	-.11	.56	.12	-.41
FD & CN	.05	-.01	-.03	-.32	.39	-.19	.19	.36
FD & BTC	.28	.41	.19	-.03	-.16	.38	-.59	.54
FD & TT	-.01	.36	-.25	.05	-.16	.25	-.28	**-.71***
CN & BTC	.34	.40	.25	-.09	**-.91****	-.20	.23	.60
CN & TT	-.24	.47	.09	.50	.15	-.30	-.59	-.16
TT & BTC	.31	.11	.29	.42	-.04	-.39	.18	-.42

Note. Asterisks denote significance, ** $p < .01$, * $p < .05$. IVs: BT = Bullet-train, H = House; DVs: CN = Sense of control, FD = Forward Displacement, BTC = Block time, TT = Transformation of time.

Table 1.6

Multilevel analyses of relation between flow and proxy variables by condition

		No Friction First				Implied Friction First			
		No Friction		Implied Friction		Implied Friction		No Friction	
Fixed Components		Bullet-train	House	Bullet-train	House	Bullet-train	House	Bullet-train	House
Flow Intercept (β_{0j})									
Intercept	γ_{00}	3.86***	3.39***	3.63***	3.15***	3.35***	3.26***	3.59***	3.50***
Order	γ_{01}	-0.28	0.10	-0.28	0.10	0.28	-0.10	0.28	-0.10
Concept	γ_{02}	-0.47*	0.47*	-0.47*	0.47*	-0.09	0.09	-0.09	0.09
Order * Concept	γ_{03}	0.38	-0.38	0.38	-0.38	-0.38	0.38	-0.38	0.38
Context Slope (B_{1ij})									
Intercept	γ_{10}	-0.24†	-0.24†	0.24†	0.24†	0.24†	0.24†	-0.24†	-0.24†
Agency Slope (β_{2ij})									
Intercept	γ_{20}	**1.55***	0.16	**1.95***	0.56	**4.60†**	0.90	**4.19†**	0.50
Order	γ_{21}	2.64	0.34	2.64	0.34	-2.64	-0.34	-2.64	-0.34
Concept	γ_{22}	-1.40	1.40	-1.40	1.40	-3.69	3.69	-3.69	3.69
Order * Concept	γ_{23}	-2.30	2.30	-2.30	2.30	2.30	-2.30	2.30	-2.30
Context * Agency Slope (β_{3ij})									
Intercept	γ_{30}	0.40	0.40	-0.40	-0.40	-0.40	-0.40	0.40	0.40
Flow Intercept (β_{0j})									
Intercept	γ_{00}	3.87***	3.41***	3.61***	3.14***	3.35***	3.27***	3.62***	3.54***
Order	γ_{01}	-0.25	0.13	-0.25	0.13	0.25	-0.13	0.25	-0.13
Concept	γ_{02}	-0.46**	0.46**	-0.46**	0.46**	-0.08	0.08	-0.08	0.08
Order * Concept	γ_{03}	0.38	-0.38	0.38	-0.38	-0.38	0.38	-0.38	0.38
Context Slope (B_{1ij})									
Intercept	γ_{10}	-0.27*	-0.27*	0.27*	0.27*	0.27*	0.27*	-0.27*	-0.27*
BTC Slope (β_{2ij})									
Intercept	γ_{20}	**0.00****	-0.00	**0.00***	-0.00	-0.00	-0.00	-0.00	-0.00
Order	γ_{21}	-0.00*	-0.00	-0.00*	-0.00	0.00*	0.00	0.00*	0.00
Concept	γ_{22}	-0.00*	0.00*	-0.00*	0.00*	0.00	-0.00	0.00	-0.00
Order * Concept	γ_{23}	0.00†	-0.00†	0.00†	-0.00†	-0.00†	0.00†	-0.00†	0.00†

Note. † $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$. BTC = Block time. FD = Forward Displacement. Table 1.6 continued on next page

Table 1.6 Continued

Multilevel analyses of relation between flow and proxy variables by condition

		No Friction First				Implied Friction First			
		No Friction		Implied Friction		Implied Friction		No Friction	
Fixed Components		Bullet-train	House	Bullet-train	House	Bullet-train	House	Bullet-train	House
Context * BTC Slope (β_{3ij})									
Intercept	γ_{30}	0.00	0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00
Flow Intercept (β_{0j})									
Intercept	γ_{00}	3.88***	3.41***	3.61***	3.14***	3.34***	3.26***	3.61***	3.53***
Order	γ_{01}	-0.28	0.12	-0.28	0.12	0.28	-0.12	0.28	-0.12
Concept	γ_{02}	-0.48*	0.48*	-0.48*	0.48*	-0.08	0.08	-0.08	0.08
Order * Concept	γ_{03}	0.40	-0.40	0.40	-0.40	-0.40	0.40	-0.40	0.40
Context Slope (B_{1ij})									
Intercept	γ_{10}	-0.27†	-0.27†	0.27†	0.27†	0.27†	0.27†	-0.27†	-0.27†
FD Slope (β_{2ij})									
Intercept	γ_{20}	0.01	-0.00	0.01	-0.00	-0.00	-0.00	-0.00	-0.00
Order	γ_{21}	-0.01	-0.00	-0.01	-0.00	0.01	0.00	0.01	0.00
Concept	γ_{22}	-0.01	0.01	-0.01	0.01	-0.00	0.00	-0.00	0.00
Order * Concept	γ_{23}	0.01	-0.01	0.01	-0.01	-0.01	0.01	-0.01	0.01
Context * FD Slope (β_{3ij})									
Intercept	γ_{30}	0.00	0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00

Note. † $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$. BTC = Block time. FD = Forward Displacement

APPENDIX C

EXPERIMENT 2 FIGURE

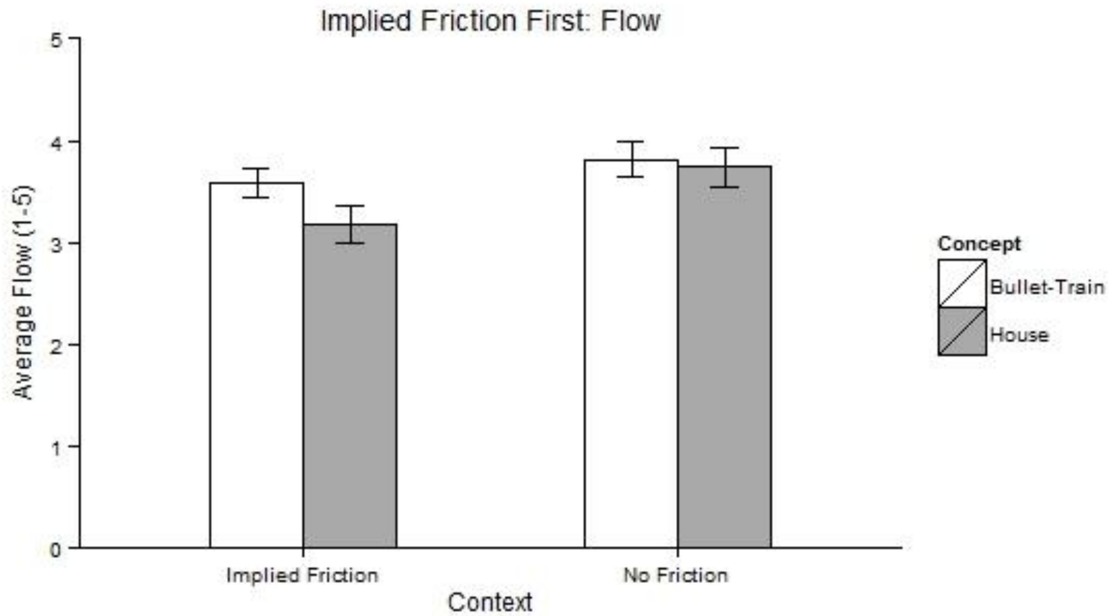

Figure 2.1. Experiment 2 two-way interaction of concept and order on flow scores.

APPENDIX D

EXPERIMENT 2 CORRELATION MATRICES AND MULTI-LEVEL MODEL TABLE

Table 2.1

Correlations Among Proxy Variables, AFSS Dimensions, and Block Time in the no Friction Context for Individuals Controlling the Bullet-Train

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
(1) Spatial Displacement	-	-0.28	-0.20	0.26	0.03	0.34	-0.47*	0.03	0.20	-0.06	0.03	-0.02	-0.11	-0.03	-0.12	-0.21	0.00
(2) Estimate of Trial Time		-	0.17	-0.99**	0.03	-0.15	0.22	0.00	-0.08	0.45*	-0.09	0.14	0.12	-0.22	0.25	0.53**	0.04
(3) Actual Trial Time			-	-0.02	-0.31	-0.60**	0.38Ɨ	-0.33	-0.38Ɨ	-0.20	-0.19	-0.16	0.01	-0.08	0.08	0.35Ɨ	0.11
(4) Trial Time				-	-0.07	0.06	-0.17	-0.05	0.02	-0.48*	0.06	0.12	-0.12	0.21	-0.24	-0.48*	-0.02
(5) Flow					-	0.74**	0.23	0.49*	0.53**	0.73**	0.87**	0.74**	0.76**	0.52*	0.03	-0.51*	-0.30
(6) Sense of Control						-	-0.03	0.44*	0.20	0.49*	0.61**	0.47*	0.39Ɨ	0.50*	-0.06	-0.40Ɨ	-0.16
(7) Transformation of Time							-	-0.03	-0.18	0.23	0.22	0.12	0.27	0.03	0.08	0.19	0.02
(8) Merging of Action and Awareness								-	0.17	0.32	0.26	0.14	0.10	0.24	-0.04	-0.07	0.00
(9) Loss of Self-Consciousness									-	0.37Ɨ	0.48*	0.44*	0.37Ɨ	-0.07	-0.11	-0.38Ɨ	-0.10
(10) Unambiguous Feedback										-	0.64**	0.39Ɨ	0.66**	0.12	0.19	0.03	-0.18
(11) Challenge-Skill Balance											-	0.64**	0.71**	0.41Ɨ	0.14	-0.43*	-0.37Ɨ
(12) Concentration on Task at Hand												-	0.74**	0.38Ɨ	-0.01	-0.70**	-0.37Ɨ
(13) Clear Goals													-	0.26	0.09	-0.30	-0.25
(14) Autotelic Experience														-	-0.16	-0.52**	-0.12
(15) Estimate of Block Time															-	0.23	-0.86**
(16) Actual Block Time																-	0.31
(17) Block Time																	-

Note: $df = 18$. Asterisks denote significance, ** $p < .01$, * $p < .05$. Cross denotes marginal significance, Ɨ $p < .10$

Table 2.2

Correlations Among Proxy Variables, AFSS Dimensions, and Block Time in the Implied Friction Context for Individuals Controlling the Bullet-Train

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
(1) Spatial Displacement	-	-0.18	0.07	0.19	-0.10	-0.06	-0.26	-0.08	-0.10	-0.08	-0.15	0.15	-0.15	0.17	-0.07	0.06	0.10
(2) Estimate of Trial Time		-	0.09	-0.99**	0.28	0.35Ɨ	-0.03	0.23	0.52**	0.42*	0.12	-0.19	0.10	-0.26	0.27	-0.04	-0.27
(3) Actual Trial Time			-	0.05	-0.30	-0.13	0.23	-0.23	-0.28	-0.37Ɨ	-0.39Ɨ	-0.04	-0.06	-0.13	0.24	0.08	-0.17
(4) Trial Time				-	-0.32	-0.37Ɨ	0.06	-0.26	-0.56**	-0.48*	-0.18	0.19	-0.11	0.24	-0.24	0.05	0.24
(5) Flow					-	0.73**	0.06	0.63**	0.27	0.67**	0.70**	0.44*	0.51*	0.54**	0.16	-0.19	-0.27
(6) Sense of Control						-	-0.16	0.61**	0.16	0.41*	0.45*	0.04	0.07	0.41*	0.20	-0.32	-0.39Ɨ
(7) Transformation of Time							-	0.17	-0.36Ɨ	-0.12	-0.08	-0.06	-0.05	0.02	0.17	0.26	0.02
(8) Merging of Action and Awareness								-	0.17	0.26	0.41Ɨ	-0.21	-0.00	0.27	0.25	-0.09	-0.28
(9) Loss of Self-Consciousness									-	0.56**	0.05	-0.03	0.19	-0.42*	-0.12	0.07	0.16
(10) Unambiguous Feedback										-	0.33	0.25	0.38Ɨ	0.04	0.23	0.09	-0.14
(11) Challenge-Skill Balance											-	0.39Ɨ	0.30	0.41*	0.13	-0.29	-0.30
(12) Concentration on Task at Hand												-	0.47*	0.35Ɨ	-0.26	-0.04	0.20
(13) Clear Goals													-	0.33	0.01	0.00	-0.01
(14) Autotelic Experience														-	0.08	-0.44*	-0.36Ɨ
(15) Estimate of Block Time															-	0.19	-0.76**
(16) Actual Block Time																-	0.49*
(17) Block Time																	-

Note: $df = 18$. Asterisks denote significance, ** $p < .01$, * $p < .05$. Cross denotes marginal significance, Ɨ $p < .10$

Table 2.3

Correlations Among Proxy Variables, AFSS Dimensions, and Block Time in the no Friction Context for Individuals Controlling the House

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
(1) Spatial Displacement	-	0.15	-0.34	-0.21	-0.59**	-0.35	-0.26	-0.54*	-0.22	-0.47*	-0.46*	-0.26	-0.37	-0.35	0.02	0.52*	0.18
(2) Estimate of Trial Time		-	-0.20	-0.98**	-0.39Ɨ	-0.33	-0.15	-0.26	-0.47*	-0.25	-0.31	-0.17	-0.15	0.03	-0.02	0.25	0.12
(3) Actual Trial Time			-	0.38	0.05	0.05	0.02	-0.02	0.10	0.01	-0.06	0.17	0.00	0.01	-0.08	-0.05	0.06
(4) Trial Time				-	0.38Ɨ	0.32	0.15	0.24	0.46	0.24	0.28	0.19	0.14	-0.02	0.01	-0.24	-0.10
(5) Flow					-	0.67**	0.36	0.48*	0.61**	0.81**	0.83**	0.63**	0.70**	0.53*	-0.21	-0.75**	-0.06
(6) Sense of Control						-	-0.20	0.23	0.38Ɨ	0.57**	0.74**	0.30	0.45*	0.31	-0.34	-0.58**	0.15
(7) Transformation of Time							-	0.44Ɨ	0.22	0.07	0.25	0.04	0.14	-0.13	0.38Ɨ	-0.31	-0.53*
(8) Merging of Action and Awareness								-	0.09	0.22	0.21	0.16	0.31	-0.23	0.17	-0.50*	-0.37
(9) Loss of Self-Consciousness									-	0.44Ɨ	0.70**	0.20	0.09	0.28	-0.06	-0.18	-0.00
(10) Unambiguous Feedback										-	0.59**	0.56*	0.57**	0.56*	-0.31	-0.48*	0.15
(11) Challenge-Skill Balance											-	0.28	0.39Ɨ	0.49*	-0.24	-0.56**	0.05
(12) Concentration on Task at Hand												-	0.67**	0.52*	-0.10	-0.43Ɨ	-0.06
(13) Clear Goals													-	0.49*	-0.39Ɨ	-0.82**	0.11
(14) Autotelic Experience														-	-0.53*	-0.42Ɨ	0.41Ɨ
(15) Estimate of Block Time															-	0.41Ɨ	-0.94**
(16) Actual Block Time																-	-0.06
(17) Block Time																	-

Note: *df* = 18. Asterisks denote significance, ** $p < .01$, * $p < .05$. Cross denotes marginal significance, Ɨ $p < .10$

Table 2.4

Correlations Among Proxy Variables, AFSS Dimensions, and Block Time in the Implied Friction Context for Individuals Controlling the House

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
(1) Spatial Displacement	-	-0.03	-0.20	-0.02	-0.18	0.02	-0.23	-0.25	-0.05	-0.08	-0.33	-0.19	-0.36	-0.07	0.09	-0.24	-0.24
(2) Estimate of Trial Time		-	0.18	-0.97**	-0.53*	-0.22	-0.30	-0.54*	-0.61**	-0.49*	-0.25	-0.34	0.08	0.03	0.51*	0.57**	-0.26
(3) Actual Trial Time			-	0.06	-0.13	-0.25	0.23	-0.37	0.15	0.13	-0.31	0.01	0.11	0.06	-0.23	0.28	0.41Ɨ
(4) Trial Time				-	0.51*	0.17	0.36	0.46*	0.65**	0.53*	0.18	0.35	-0.05	-0.02	-0.58**	-0.51*	0.36
(5) Flow					-	0.66**	0.23	0.81**	0.74**	0.68**	0.53*	0.71**	0.38	0.64**	-0.72**	-0.44Ɨ	0.56*
(6) Sense of Control						-	-0.18	0.68**	0.42Ɨ	0.18	0.45*	0.23	0.15	0.55*	-0.45Ɨ	-0.57**	0.19
(7) Transformation of Time							-	-0.03	0.13	0.08	0.08	0.19	0.09	-0.15	-0.29	0.01	0.33
(8) Merging of Action and Awareness								-	0.59**	0.43Ɨ	0.62**	0.58**	0.03	0.39Ɨ	-0.36	-0.45*	0.15
(9) Loss of Self-Consciousness									-	0.57**	0.24	0.53*	0.01	0.33	-0.49*	-0.48*	0.28
(10) Unambiguous Feedback										-	0.13	0.70**	0.26	0.39Ɨ	-0.60**	-0.13	0.61**
(11) Challenge-Skill Balance											-	0.13	0.12	0.12	-0.25	-0.10	0.23
(12) Concentration on Task at Hand												-	0.20	0.55*	-0.44Ɨ	-0.06	0.46*
(13) Clear Goals													-	0.45Ɨ	-0.54*	-0.05	0.58**
(14) Autotelic Experience														-	-0.55*	-0.27	0.46*
(15) Estimate of Block Time															-	0.47*	-0.86**
(16) Actual Block Time																-	0.04
(17) Block Time																	-

Note: *df* = 18. Asterisks denote significance, ** $p < .01$, * $p < .05$. Cross denotes marginal significance, Ɨ $p < .10$

Table 2.5
Correlations among flow scores, proxy variables, and flow dimensions by condition

Correlation variables	No Friction First				Implied Friction First			
	No Friction		Implied Friction		Implied Friction		No Friction	
	BT	H	BT	H	BT	H	BT	H
Flow & TTC	-.23	-.03	-.30	.46	-.46	.52	-.03	**.68***
Flow & TT	.21	.40	.39	.33	-.29	.22	.16	.27
Flow & BTC	-.18	**.67***	-.44	**.72***	-.19	.45	-.39	-.14
Flow & FD	-.33	-.24	-.33	-.49	.17	-.43	.17	**-.73***
Flow & CN	**.67***	.37	**.71***	**.80****	**.75****	-.22	**.69***	**.88****
TTC & TT	-.52	-.38	-.54	-.41	.54	.56	.12	.42
TTC & BTC	-.17	-.14	.44	.55	.08	.48	.23	-.43
TTC & FD	.29	-.43	.24	.07	.09	-.29	.17	-.59
TTC & CN	-.20	-.09	-.38	.40	-.43	-.31	.21	.50
FD & TT	-.35	-.37	-.08	-.48	-.45	-.13	**-.68***	-.01
FD & BTC	-.15	-.09	.21	-.31	-.01	-.19	.14	-.15
FD & CN	.07	.16	-.58	-.34	.40	-.52	.47	**-.82****
TT & BTC	-.27	.17	**-.59***	.30	.33	.40	.23	**-.93****
TT & CN	.06	-.51	.32	.06	-.51	-.51	-.30	.02
BTC & CN	.13	.37	-.50	.57	-.36	-.17	-.38	.11

Note. Asterisks denote significance, ** $p < .01$, * $p < .05$. IVs: BT = Bullet-train, H = House; DVs: TTC = Trial Time, BTC = Block time, TT = Transformation of time, FD = Forward Displacement, CN = Sense of control.

Table 2.6

Multilevel analyses of relation between flow and proxy variables by condition

		No Friction First				Implied Friction First			
		No Friction		Implied Friction		Implied Friction		No Friction	
Fixed Components		Bullet-train	House	Bullet-train	House	Bullet-train	House	Bullet-train	House
Flow Intercept (β_{0j})									
Intercept	γ_{00}	3.44***	3.55***	3.32***	3.42***	3.65***	3.54***	3.77***	3.66***
Order	γ_{01}	0.11	-0.11	0.11	-0.11	-0.11	0.11	-0.11	0.11
Concept	γ_{02}	0.34†	0.12	0.34†	0.12	-0.34†	-0.12	-0.34†	-0.12
Order * Concept	γ_{03}	-0.22	0.22	-0.22	0.22	0.22	-0.22	0.22	-0.22
Context Slope (B_{1ij})									
Intercept	γ_{10}	-0.12	-0.12	0.12	0.12	0.12	0.12	-0.12	-0.12
TTC Slope (β_{2ij})									
Intercept	γ_{20}	-0.01	0.06	-0.02	0.06	-0.01	0.03*	-0.01	0.04**
Order	γ_{21}	0.08	-0.08	0.08	-0.08	0.04**	-0.04**	0.04**	-0.04**
Concept	γ_{22}	0.01	-0.03	0.01	-0.03	-0.01	0.03	-0.01	0.03
Order * Concept	γ_{23}	-0.04	0.04	-0.04	0.04	0.04	-0.04	0.04	-0.04
Context * TTC Slope (β_{3ij})									
Intercept	γ_{30}	-0.01	-0.01	0.01	0.01	0.01	0.01	-0.01	-0.01
Flow Intercept (β_{0j})									
Intercept	γ_{00}	3.39***	3.59	3.39***	3.59***	3.69***	3.43***	3.69***	3.43***
Order	γ_{01}	0.20	-0.20	0.20	-0.20	-0.26	0.26	-0.26	0.26
Concept	γ_{02}	0.30	-0.16	0.30	-0.16	-0.30	0.16	-0.30	0.16
Order * Concept	γ_{03}	-0.46	0.46	-0.46	0.46	0.46	-0.46	0.46	-0.46
Context Slope (B_{1ij})									
Intercept	γ_{10}	0.00	0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00
BTC Slope (β_{2ij})									
Intercept	γ_{20}	-0.00	0.00	-0.00	0.00	-0.00†	-0.00*	-0.00**	-0.00**
Order	γ_{21}	0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	0.00
Concept	γ_{22}	-0.00	-0.00*	-0.00	-0.00*	0.00	0.00*	0.00	0.00*
Order * Concept	γ_{23}	-0.00	0.00	-0.00	0.00	0.00	-0.00	0.00	-0.00

Note. † $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$. TTC = Trial time; BTC = Block time; FD = Forward displacement. Table 2.6 continued on next page

Table 2.6 Continued

Multilevel analyses of relation between flow and proxy variables by condition

		No Friction First				Implied Friction First			
		No Friction		Implied Friction		No Friction		Implied Friction	
Fixed Components		Bullet-train	House	Bullet-train	House	Bullet-train	House	Bullet-train	House
Context * BTC Slope (β_{3ij})									
Intercept	γ_{30}	0.00	0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00
Flow Intercept (β_{0j})									
Intercept	γ_{00}	3.38***	3.69***	3.36***	3.67***	3.68***	3.32***	3.71***	3.34***
Order	γ_{01}	0.31	-0.31	0.31	-0.31	-0.36*	0.36*	-0.36*	0.36*
Concept	γ_{02}	0.32†	-0.35†	0.32†	-0.35†	-0.32†	0.35†	-0.32†	0.35†
Order * Concept	γ_{03}	-0.67*	0.67*	-0.67*	0.67*	0.67*	-0.67*	0.67*	-0.67*
Context Slope (B_{1ij})									
Intercept	γ_{10}	-0.02	-0.02	0.02	0.02	0.02	0.02	-0.02	-0.02
FD Slope (β_{2ij})									
Intercept	γ_{20}	-0.00	-0.00	-0.00	-0.00	0.00	-0.02***	-0.00	-0.02***
Order	γ_{21}	-0.00	0.00	-0.00	0.00	-0.02***	0.02***	-0.02***	0.02***
Concept	γ_{22}	0.00	-0.02**	0.00	-0.02**	-0.00	0.02**	-0.00	0.02**
Order * Concept	γ_{23}	-0.02**	0.02**	-0.02*	0.02**	0.02**	-0.02**	0.02**	-0.02**
Context * FD Slope (β_{3ij})									
Intercept	γ_{30}	0.00	0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00

Note. † $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$. TTC = Trial time; BTC = Block time; FD = Forward displacement.