6-18-2018

Dynamics of Perception of Affordances for Reaching for Self and Other

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24 Pages

Perceivers are sensitive to the boundaries at which they must transition from one mode of performing a given behavior to another. As in other self-organizing systems, such transitions occur at a critical value of a parameter with continuous changes in that parameter. In general, behavioral transitions occur at larger values when that parameter increases than when it decreases (positive hysteresis), and perceptual transitions (for a behavior to be performed by one's self) occur at larger values when that parameter decreases than when it increases (negative hysteresis). We investigated whether this pattern also occurs in perceptual transitions for a behavior to be performed by another person. In the first experiment, we investigated perceptual transitions in a reaching task for the self and for another person: participants reported when they (or another person) would need to transition from reaching for an object with their arm to reaching for an object with a hand-held implement. As predicted, perceptual transitions exhibited negative hysteresis. In a second experiment, we investigated behavioral transitions in the same reaching task: participants attempted to reach for an object with either their arm or the implement. Contrary to our predictions, behavioral transitions did not exhibit positive hysteresis. The results are discussed in terms of a dynamical systems perspective on perception of affordances both for oneself and for another person.

KEYWORDS: perception, affordances, dynamical systems theory

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A Thesis Submitted in Partial
Fulfillment of the Requirements
for the Degree of

MASTER OF SCIENCE

Department of Psychology

ILLINOIS STATE UNIVERSITY

2018

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CONTENTS

FIGURES

CHAPTER I: INTRODUCTION

Affordances are possibilities for behavior emerging from the fit between action capabilities and environmental properties (Chemero, 2003; Gibson, 2015/1979). For example, an object affords grasping if the opposite surfaces of that object are separated by less than the span of a given effector. Research has shown that people can perceive a wide variety of affordances for themselves (see Dotov, de Wit, & Ni, 2014; Fajen, Riley, & Turvey, 2007 for reviews). Specifically, perceivers are sensitive to the boundaries at which they must transition from one mode of performing a given behavior to another. For example, perceivers are sensitive to the distance at which they would no longer be able to reach an object with their arm only and would instead need to do so by bending at the torso or reaching with an implement (Carello, Grofosky, Reichel, Solomon & Turvey, 1989; Wagman & Morgan, 2010). In addition, research has shown that people can also perceive a wide variety of affordances for other people. Analogously, perceivers are sensitive to the boundaries at which another person would need to transition from one mode of performing a behavior to another. For example, perceivers are sensitive to the height at which another person would no longer be able to reach an object with their arm only and would instead need to do so by means of a tool such as a stepstool or an implement (Wagman, Stoffregen, Bai, & Schloesser, 2017). Thus, perceivers are capable of perceiving a wide range of affordances both for themselves and for other people (see Marsh, Richardson, Baron, & Schmidt, 2006 for a review).

In the last several decades researchers have investigated perception and actualization of affordances using dynamical systems theory (DST). DST was initially developed in the context of disciplines such physics, chemistry, and biology to explore how complex systems change over time. Therefore, it is particularly useful for describing how local interactions between numerous components of a given system can give rise to spontaneously emerging, self-organized states (Camazine, 2003; Kelso, 1995). Typically, a dynamical system takes the form of an equation or several equations that describe(s) the evolution of a variable (or collective variable) over time within a *phase space,* which contains all of the possible states of a given system. Within a given phase space, dynamical systems tend to prefer some subsets of the phase space compared to others. The places within phase space that dynamical systems prefer are referred to as *attractors*. Often, phase spaces contain multiple attractors. When this occurs, the dynamical system is said to exhibit *multistability*. As a control parameter is changed for a multistable dynamical system, *bifurcations* or *phase transitions* occur when the system reaches a critical value of the control parameter, which results in a qualitative shift in the attractor.

In the last few decades, this approach has been applied to understand how complex psychological systems change over time (see Friedenberg, 2009; Goldfield,1995; Thelen & Smith, 1994). In particular, it has been used to understand perception and actualization of affordances (Turvey & Carello, 1995). This is appropriate because there are fundamental similarities between both of these processes and the nonlinear phase transitions that are characteristic of self-organizing physical, chemical, and biological systems (see Camazine, 2003; Kelso, 1995; Wagman, 2010). Like phase transitions between distinct and stable states of self-organizing physical, biological, and chemical systems, phase transitions between distinct and stable perceptual and behavioral states are also spontaneous, abrupt, nonlinear, and occur at a critical value with continuous adjustment of a relevant control parameter. For example, just as there may be a transition between two chemical or physical states with continuous changes in temperature, there may be a transition between two stable modes of locomotion (e.g., walking and running, in the case of bipeds) with continuous changes in movement speed. Moreover, this critical value can differ depending on whether the relevant control parameter is being systematically increased or decreased, a phenomenon known as *hysteresis* (Fitzpatrick Carello, Schmidt, & Corey, 1994; Friedenberg, 2009; Kelso, 1995). For example, the chemical reaction in question might occur at a different temperature depending on whether this value is continuously increased or decreased. Similarly, the transition from walking to running or vice versa occurs at different movement speeds depending on whether this value is continuously increased or decreased (Diedrich, & Warren, 1995)

Two kinds of non-linear phase transitions have been observed in the study of affordances: positive hysteresis and negative hysteresis (also referred to as enhanced contrast). During positive hysteresis, transitions occur at larger values of a given parameter when those parameter values increase than when those values decrease (see Figure 1, left). For example, the transition from walking to running occurs at a higher speed than the transition from running to walking (Diedrich & Warren, 1995). That is, in positive hysteresis, the system "lags behind" the changes in the parameter that governs the behavior of the system, such that the present behavior of a system is being influenced by its history.

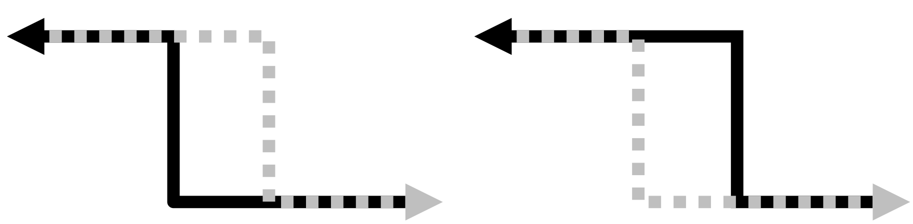

Figure 1. Positive and Negative Hysteresis. Positive hysteresis (left) showing a shift between stable states at a larger value of a control parameter when increased (dotted-gray line) than when decreased (black line). Negative hysteresis (right) showing the opposite transition pattern.

During negative hysteresis, transitions occur at larger values of a given parameter when parameter values decrease than when they increase (see Figure 1, right). Thus, in contrast to positive hysteresis, in negative hysteresis, the system is “out in front of” the changes in the parameter that drive the behavior of the system, such that the system’s present behavior is influenced by the *future* states of that system.

Positive hysteresis tends to occur in behavioral tasks in which individuals (choose to) perform one of two (or more) possible modes of performing a given behavior. Conversely, negative hysteresis tends to occur in perceptual tasks in which individuals are asked to verbally report which of two (or more) possible modes of performing a given behavior would be possible (or which they would choose to perform). In particular, these patterns have been observed, respectively, in actualization and perception of affordances for the self and for a dyad consisting of the self and another person. For example, in a series of experiments by Richardson, Marsh, and Baron (2007) participants were presented with planks of wood of varying length, one plank at a time. The length of each subsequent plank was systematically increased, systematically decreased, or presented in a random order. In one set of experiments, participants were instructed to move each plank by using one hand, two hands, or a tool (or in a different experiment, with the help of another person). In another set of experiments, participants were asked to verbally report whether they would choose to move the planks using one hand, two hands, or a tool (or in a different experiment, with the help of another person).

For both the individual and joint task conditions, positive hysteresis was observed in the behavioral tasks, and negative hysteresis was observed in the perceptual tasks. That is, when participants actually moved the planks of wood, they transitioned from one hand to two hands (and from two hands to the tool or to another person) at a longer plank length when plank length systematically *increased* than when it systematically *decreased*. Alternatively, when participants merely reported how they would choose to move the planks of wood (without actually performing the behavior), they transitioned from one hand to two hands (and from two hands to the tool or to another person) at a longer plank length when plank length systematically *decreased* than when it systematically *increased*. Therefore, the pattern of observed dynamics seems to be influenced by whether or not the affordance in question was being actualized or merely perceived but not by whether or not the action was (to be) performed by one's self or with another person (Lopresti-Goodman, Richardson, Baron, Carello, Marsh, 2009; Lopresti-Goodman, Turvey, & Frank, 2011; see also Wagman, Dayer, & Hajnal, 2017).

Whereas previous experiments have investigated such patterns of nonlinear phase transitions in perception and actualization of affordances for the self and for a dyad consisting of the self and another person, the present study explores whether a similar pattern of nonlinear phase transitions between perceptual states occurs when perceiving affordances for the self and for another person acting alone. To investigate this, we recruited participants to perform both a perceptual (Experiment 1A) and a behavioral (Experiment 1B) task. In the perceptual task, participants made verbal reports about their vertical reaching abilities and those of another person. Specifically, participants viewed an object suspended from the top of a vertical surface and verbally reported when they (or another person) would need to reach for that object with their arm or whether they would choose to do so with hand-held implement. The height of the object was systematically decreased or systematically increased. For both verbal reports about the self and the other person, we expected to find negative hysteresis such that perceptual transitions are 'out in front' of the changes in the parameter driving the system. That is, we expected that the perceptual transition would occur at taller heights when the object height was systematically decreased than when it was systematically increased. In a follow up experiment, participants actually performed the reaching behavior by either reaching for the object with their arm only or doing so with the hand-held implement. In this experiment, we expected to find positive hysteresis such that behavioral transitions 'lag behind' the changes in the parameter driving the system. That is, we expected that the behavioral transition would occur at taller heights when the object height is systematically increased than when it is systematically decreased.

CHAPTER II: EXPERIMENT 1A: DYNAMICS OF PERCEPTION OF AFFORDANCES FOR REACHING FOR SELF AND OTHER

Participants

Forty undergraduates from Illinois State University participated in this experiment. Each participant received extra credit in a psychology course in exchange for his or her participation. Given height constraints relating to the laboratory space and the experimental apparatus, it was required that participants were no taller than 168 cm (5 feet 6 inches). Mean participant height was 162.24 cm (SD = 4.73 cm). Written informed consent was obtained from all participants, and the Illinois State University Institutional Review Board (in accordance with the Declaration of Helsinki) approved the project.

Participants arrived at the laboratory in pairs. One member of each pair was randomly assigned the role of "self/perceiver", and the other member of the pair was assigned the role of the "other/actor". The perceiver made perceptual judgments about their own reaching ability as well as those of the actor. The actor did not make any perceptual judgments.

Materials and Apparatus

The apparatus is depicted in Figure 2. It consisted of a small white cylindrical object (82 g, 4 cm length, 5 cm diameter) that was suspended by a pulley system at the top of vertical surface (250 cm tall and 120 cm wide). Black fabric was draped over the surface and the wall behind the surface. The experimenter adjusted the height of the suspended object from behind the surface and was not visible to either participant during the trials. A tape measure affixed to the back of the surface was used to measure the height of the suspended object. A section of PVC pipe (33 cm tall and 5 cm wide) was used as the reaching implement. One end (10 cm) of the pipe was designated as the "handle" of the pipe. This end was wrapped in red tape. A designated 20 cm by 20 cm reaching area on the floor directly under the suspended object was marked off with tape.

Figure 2. The Self (left) and Other Condition (right) for Experiment 1A

Procedure

The perceiver stood 285 cm from the surface in a 50 cm by 50 cm viewing area. Before each trial, the object was set at either its highest or its lowest position (250 cm or 150 cm from the floor, respectively) depending whether the heights were to be presented in an ascending or descending sequence (see below). The stick was placed in this reaching area (with its red 'handle' up) (see Figure 2).

In the "self" condition, after the object had been positioned at a given height, the participant made a verbal report about whether he or she would be able to reach the suspended object with the fingertips of his or her right hand or whether he or she would need to reach with the stick held by the handle in the right hand (see Figure 2, left). Specifically, the participant reported "Hand" if he or she would need to reach the object with the fingertips of the right hand if he or she were to stand in the reaching area and reach up with both feet flat on the floor with arm, hand, and fingers fully extended. The participant reported "Stick" if he or she felt that it would be necessary to reach with the distal tip of the stick held by the handle in the right hand if he or she were to stand in the reaching area and reach up with both feet flat on the floor with arm, hand, and stick fully extended. After providing the verbal response ("Hand" or "Stick"), the participant closed his or her eyes, and the object was raised or lowered in 5 cm increments to the next height. The participant was then asked to open his or her eyes and make the same report ("Hand" or "Stick") with respect to their ability to reach the object at this height.

In the "other" condition, the actor stood approximately 20 cm in front of the vertical surface so that the suspended object was to his or her right (see Figure 2, right). The actor kept his or her hands at his or her sides and looked straight ahead throughout the duration of the experiment. The participant made a verbal report about whether *the actor* would be able to reach the suspended object with the fingertips of his or her right hand or whether he or she would need to reach with the stick held by the handle in the right hand. Specifically, the participant reported "Hand" if he or she felt that *the actor* would be able to reach the object with the fingertips of his or her right hand if he or she were to reach up with both feet flat on the floor with arm, hand, and fingers fully extended. The participant reported "Stick" if he or she felt that it would be necessary for the actor to reach with the distal tip of the stick held by the handle in the right hand if he or she were to reach up with both feet flat on the floor with arm, hand, and stick fully extended. After providing the verbal response ("Hand" or "Stick"), the participant closed his or her eyes, and the object was raised or lowered, to the next height. The participant was then asked to open his or her eyes and make the same report ("Hand" or "Stick") with respect to the actor's ability to reach the object at this height.

In both the “Self” and the “Other” conditions, there were twenty-two possible object heights (150 – 250 cm in 5 cm increments). Each series ceased when the participant transitioned from a response of “Hand” to a response of “Stick” (or vice-versa) and then continued to provide the same response on two additional, consecutive trials. This height was considered the perceptual transition height in this condition. “Self” and “other” conditions were blocked, and the order of conditions was counterbalanced across participants. Ascending and descending trials were alternated, and whether a given condition began with an ascending or descending trial was also counterbalanced across participants. Neither the perceiver nor the actor attempted to perform any of the behaviors (e.g., reaching for the object or stepping onto the stepstool stool) during the perceptual task. At the conclusion of the perceptual task, the experimenter measured the standing height of both the perceiver and the actor.

Results: Experiment 1A

A 2 (Judgment: Self vs. Other) × 2 (Sequence: Ascending vs. Descending) repeated-measures ANOVA was conducted on the perceptual transition heights. A main effect of Sequence, $F(1, 19) = 8.78$, $p < .01$, $\eta_p^2 = .31$, revealed that perceptual transitions occurred at taller heights for descending ($M = 193.44$, $SD = 11.15$) than ascending ($M= 189.13$, $SD = 9.25$) sequences. Neither the main effect of judgment (Self vs. Other), $F(1, 19) = 3.40$, *ns*, $\eta_p^2 = .15$ nor the Sequence × Judgment interaction was significant, $F(1, 19) = 1.55$, *ns,* $\eta_p^2 = .08$. Therefore, consistent with our hypothesis, perceptual transitions for judgements about affordances for reaching exhibited negative hysteresis, both when such judgements referred to affordances for the self and when such judgments referred to affordances for another person (see Figure 3).

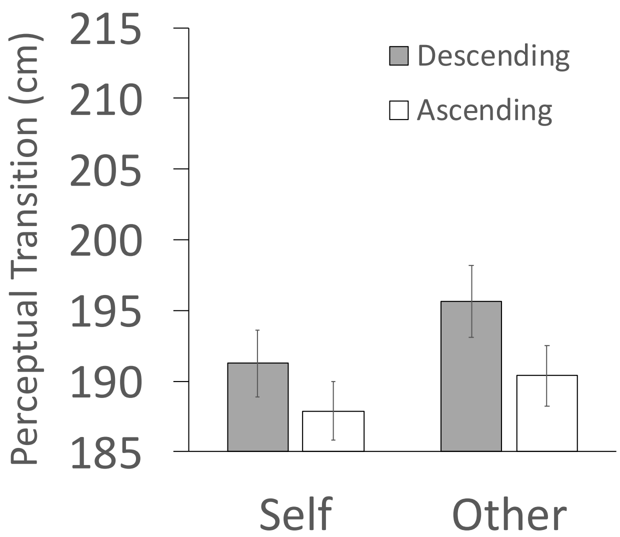

Figure 3. *Results of Experiment 1A. The perceptual transition between affordances for reaching with the hand and with stick for self and other for descending and ascending sequences. Error bars indicate standard error of the mean.*

CHAPTER III: EXPERIMENT 1B: ACTUALIZATION OF AFFORDANCES FOR REACHING

Participants

Twenty new undergraduates from Illinois State University participated in this experiment. Each participant received extra credit in a psychology course in exchange for his or her participation. As in Experiment 1A, it was required that participants were no taller than 168 cm (5 feet 6 inches). Mean participant height was 160.10 cm (*SD* = 5.37). Written and informed consent was obtained from all participants, and the Illinois State University Institutional Review Board (in accordance with the Declaration of Helsinki) approved the project.

Material and Apparatus

The materials and apparatus were identical to Experiment 1A.

Procedure

As in Experiment 1A, the perceiver stood 285 cm from the surface in a 50 cm by 50 cm viewing area. Before each trial, the object was set at either its highest or its lowest position (250 cm or 150 cm from the floor, respectively) depending whether the heights were to be presented in an ascending of descending sequence (see below). The stick was placed in this reaching area (with its red 'handle' up, see Figure 2A).

However, in contrast to Experiment 1A, the participant was instructed to (walk over and) stand in the reaching area directly under the object with both feet flat on the floor and then (choose to) reach for the object by either reaching up with the fingertips of the right hand or by grasping the handle of the stick and reaching up with the distal end of the stick, in either case with both feet flat on the floor and the arm, hand and fingertips (or stick) or stick fully extended. After attempting to reach for the object on a given trial, the participant verbally indicated to the experimenter which means of reaching ("Hand" or "Stick") they chose on that trial. The participant then returned to the viewing area and closed his or her eyes, and the object was raised or lowered to the next height. The participant then repeated the task with respect to the object at this height. As in the Perceptual task, there were twenty-two possible object heights (150 – 250 cm in 5 cm increments). Each series ceased when the participant made a transition from reaching without the stick to doing so with the stick (or vice-versa) and then continued to reach in this manner on two additional trials. As in Experiment 1A, the tallest height at which the participant gave a "Hand" response was considered the behavioral transition height for this condition. At the conclusion of the behavioral task, the experimenter measured the standing height of the participant.

Results: Experiment 1B

A paired-samples *t*-test was conducted on the behavioral transition in the ascending and descending sequences. Adopting a criterion of $p < .05$, the results revealed that there was no difference in the behavioral transition height in each sequence, $t(19) = -2.10$, $p = .05$, $d = -0.47$. Even with a less strict criterion of $p \leq .05$, the difference would be in the direction opposite that predicted. That is, with this more lenient criteria, the results would suggest that the behavioral transition occurred at a taller height when heights were systemically decreased than when heights were systematically increased. Either way, contrary to our hypothesis, we found no evidence of positive hysteresis. That is, the behavioral transition did not occur at taller heights when the object height was systematically increased than when it is systematically decreased (see Figure 4).

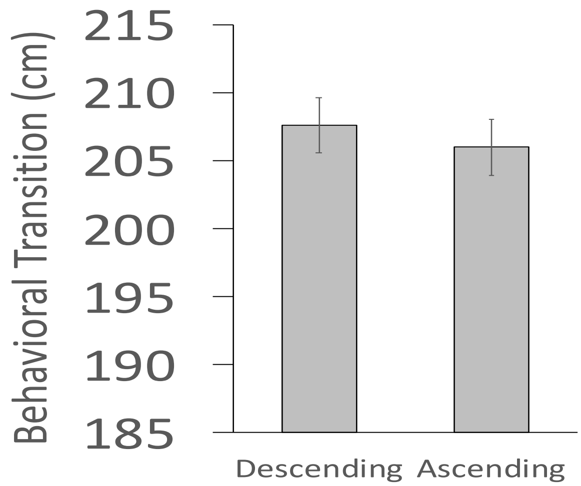

Figure 4. *Results of Experiment 1B. Behavioral transition between reaching with the hand and reaching with stick for descending and ascending sequences. Error bars indicate standard error of the mean.*

CHAPTER IV: GENERAL DISCUSSION

Previous research has shown negative hysteresis in transitions in perception of affordances and positive hysteresis in actualization of affordances. That is, when participants are presented with a systematically changing environmental property (e.g., object height) and are asked to report which of two (or more) possible modes of performing a given behavior with respect to that property (e.g., vertical reaching) would be possible, transitions occur at larger values in descending than in ascending sequences. However, when participants are asked to choose to perform one of the possible modes of performing that behavior, transitions occur at larger values in ascending than in descending sequences (Richardson et al., 2007)

Whereas such patterns of nonlinear phase transitions have been exhibited in experiments investigating perception (and actualization) of affordances for the self and for a dyad consisting of the self and another person, the present study investigated whether a similar pattern would be observed in perception of affordances for the self and for another person each acting as individuals. Consistent with our hypothesis, there was positive hysteresis in perception of affordances both for the self and for another person. Specifically, perceptual transitions occurred at taller heights in descending than in ascending sequences (see Figure 3). That is, the results of Experiment 1A showed negative hysteresis in perception of affordances for the self and for another person.

Previous research has suggested a dynamic similitude between perceiving affordances for one's self and for perceiving affordances for a dyad that includes the self (Richardson et al., 2007). The results of the present study suggest that this similitude also exists for perceiving affordances for oneself and perceiving affordances for another person (acting alone). This finding is consistent with a fundamental tenet of dynamical systems theory— the same principles can (and often do) lawfully constrain phenomena observed across different systems (in this case, the self, a dyad, and another person). In such cases, the observed pattern emerges in the lawful interaction among the components, not in the components themselves. This result is consistent with research showing a similar dynamic similitude for perception of a given affordance by means of disparate anatomical components (e.g., Wagman, Dayer, & Hajnal, 2017; Wagman & Hajnal, 2014a, b; 2016), and analogous perception of a given affordance by different animal species (e.g., Cabrera, Sanabria, Jiménez, & Covarrubias, 2013; Wagman, Langley, Farmer-Dougan, 2018, 2017). Future research might investigate the extent to which this dynamic similitude between egocentric and allocentric perception of affordances generalizes to affordances for other behaviors (e.g., sitting, jumping, etc.).

Furthermore, future research might also explore the extent to which this dynamic similitude is affected by perceiver-actor similarity. For example, studies of perception of maximum reaching height for another person have found that perceptual judgments were scaled to the reaching ability of the actor but not to that of the perceiver (Wagman, Stoffregen, Bai, Scholoesser, 2017). Such results are consistent with information-based accounts of action in which people perceive affordances for others by detecting information that specifies the task-specific fit between the other person's action capabilities and environmental properties (Marsh et al., 2006; Weast Shockley, & Riley, 2011; Weast, Walton, Chandler, Shockley, & Riley, 2014). Such results are inconsistent with simulation accounts of allocentric action in which people perceive affordances for others by using information about (or knowledge of) their own action capabilities (see Gallase & Sinigaglia, 2011).

Previous research has also found an asymmetry in transitions in perception of affordances and transitions in actualization of affordances. That is, whereas transitions between perceptual states typically exhibit negative hysteresis, transitions between behavioral states typically exhibit positive hysteresis. Experiment 1B investigated whether positive hysteresis would be observed in a task in which participants chose to perform (and then actually performed) a reaching behavior with or without a hand-held implement. We expected that behavioral transitions (from reaching with the arm to reaching with the stick, and vice versa) would occur at taller heights in ascending sequences than in descending sequences. Contrary to our predictions, we also found no evidence of positive hysteresis in the behavioral task (see Figure 4).

There are at least three plausible explanations for why we failed to find the predicted effect. First, the range of object heights in our study likely included what Comalli et. al (2017) referred to as a "gray zone"—a range of actor-environment relations that afford multiple modes of behavior (in this case, object heights at which reaching with the hand and reaching with the tool were both possible). If the "gray zone" in the current study was relatively small, the heights at which participants were likely to transition from one mode of reaching to another may have been rather limited. This may explain why we did not observe positive hysteresis in the behavioral task: the gray zone was simply not large enough to observe the predicted effect. Moreover, given that participants in the behavioral task received feedback on about their own reaching capabilities after each trial but participants in the perceptual task did not, it is possible this additional feedback may have reduced of the "gray zone" in the behavioral task relative to the perceptual task. Existing research on the "gray zone" has focused on behavioral tasks, but future research might investigate the "gray zone" in the context of perception to see if differences between behaving within and perceiving the gray zone might explain the results of the present study.

Second, it is possible that the results were affected by the instructions provided. Whereas the instructions in the perceptual task were based on necessity (i.e., what the actor/perceiver would *need* to do), the instructions in the behavioral task asked participants to *choose* between executing one mode of behavior or another. Therefore, it is possible that participants in the behavioral task were transitioning at their *preferred* behavioral boundary, not their *absolute* behavioral boundary (Mark, Nemeth, Gardner, Dainoff, Paasche, Duffy, & Grandt, 1997). Because we did not measure the maximum reaching heights of the participants, we were unable to determine whether participants were transitioning at their maximum or preferred behavioral boundary. This possible difference in criterion used by the participants might explain the differences between Experiment 1A and Experiment 1B.

Third, it possible that the discrete nature of the behavioral task in Experiment 1B resulted in an experimental design that was somewhat perceptual in nature. Because participants returned to the viewing area after each trial and thus were able to perceive each object height before making a reaching behavior, this may have resulted in the occurrence of perceptual judgements between trials. Lopresti-Goodman, Turvey, & Frank (2013) suggest that negative hysteresis during perception of affordances may be due to a decreased interaction between perceptual states and decreased stability of the respective attractor. Therefore, the perceptual nature of our experimental design may have encouraged our participant's to move from one stable state to another relatively quickly (and in this case, ahead of the parameter driving their behavior). Conversely, positive hysteresis during the actualization of affordances is thought be the result of an increased interaction between behavioral systems and an increased stability of the respective attractors, which causes the system to transition from one stable state to another relatively slowly (and in this case, behind the parameter driving the system). Such differences in the interaction of action modes and the stability of their respective attractors may be due to different levels of inhibitory feedback from perceptual and decision-making streams (Frank, Profeta, & Harrison, 2015; Kim & Frank, 2016). That is, it is possible that perceptual tasks involve feedback from a decision-making stream back down to the perceptual stream, but that this inhibitory feedback is absent in behavioral tasks. Therefore, the intermittent perceptual judgements during the behavioral task may have interrupted the emergence of stabilities that are responsible for positive hysteresis. This would explain why the observed pattern of results was characteristic of negative hysteresis, not positive hysteresis. Going forward, future research on positive hysteresis during the actualization of affordances for reaching might involve an experimental design that is more continuous and less discrete.

CHAPTER V: CONCLUSION

The present study suggests that a similitude exists between the dynamics of perception of affordances for oneself and for another person. These results are consistent with previous research finding negative hysteresis during the perception of individual and joint action capabilities. Furthermore, the results are also consistent with the principles of dynamical systems theory more broadly: the same principles lawfully constraining the perception of one's own action capabilities seem to also constrain the perception of the action capabilities of others.

REFERENCES

Camazine, S. (2003). *Self-organization in biological systems*. Princeton University Press.

Cabrera, F., Sanabria, F., Jiménez, Á. A., & Covarrubias, P. (2013). An affordance analysis of unconditioned lever pressing in rats and hamsters. *Behavioural Processes, 92*, 36-46.

Carello, C., Grosofsky, A., Reichel, F. D., Solomon, H. Y., & Turvey, M. T. (1989). Visually perceiving what is reachable. *Ecological psychology*, *1*(1), 27-54.

Chemero, A. (2003). An outline of a theory of affordances. *Ecological Psychology, 15,* 181-195.

Comalli, D. M., Persand, D., & Adolph, K. E. (2017). Motor decisions are not black and white: selecting actions in the “gray zone”. Experimental brain research, 235(6), 1793-1807.

Diedrich, F. J.,&Warren,W. H., Jr. (1995).Why change gaits? Dynamics of the walk-run transition. Journal of Experimental Psychology: Human Perception and Performance, 21(1), 183–202.

Dotov, D. G., de Wit, M. M., & Nie, L. (2012). Understanding affordances: History and contemporary development of Gibson’s central concept. *AVANT*. Pismo Awangardy Filozoficzno-Naukowej, 28-39

Fajen, B. R., Riley, M. A., & Turvey, M. T. (2009). Information, affordances, and the control of action in sport. *International Journal of Sport Psychology, 40*, 79-107.

Fitzpatrick, P., Carello, C., Schmidt, R. C., & Corey, D. (1994). Haptic and visual perception of an affordance for upright posture. *Ecological Psychology*, *6*(4), 265-287.

Frank, T. D., Profeta, V. L. S., & Harrison, H. S. (2015). Interplay between order-parameter and system parameter dynamics: considerations on perceptual-cognitive-behavioral mode-mode transitions exhibiting positive and negative hysteresis and on response times. *Journal of biological physics*, *41*(3), 257-292.

Friedenberg, J. (2009). *Dynamical psychology: Complexity, self-organization and mind*. ISCE Publishing.

Gallese, V., & Sinigaglia, C. (2011). What is so special about embodied simulation?. *Trends in cognitive sciences*, *15*(11), 512-519.

Gibson, J. J. (2015). *The ecological approach to visual perception: classic edition*. New York: Psychology Press. (original work published in 1979).

Goldfield, E. C. (1995). *Emergent forms: Origins and early development of human action and perception*. Oxford University Press on Demand.

Kelso, J. A. S. (1995). Dynamics patterns. *Massachussets Institute of Tecnology*.

Kim, D. H., Afzal, T. A., Reo, M. L., Chee, U. H., Cho, I. H., Lee, K., ... & Ha, S. K. (2016). *U.S. Patent No. 9,364,337*. Washington, DC: U.S. Patent and Trademark Office.

Lopresti-Goodman, S. M., Richardson, M. J., Baron, R. M., Carello, C., & Marsh, K. L. (2009). Task constraints on affordance boundaries. *Motor control*, *13*(1), 69-83.

Lopresti-Goodman, S. M., Turvey, M. T., & Frank, T. D. (2011). Behavioral dynamics of the affordance "graspable". *Attention, Perception, & Psychophysics*, *73*(6), 1948-1965.

Lopresti-Goodman, S. M., Turvey, M. T., & Frank, T. D. (2013). Negative hysteresis in the behavioral dynamics of the affordance "graspable". *Attention, Perception, & Psychophysics*, *75*(5), 1075-1091.

Mark, L. S., Nemeth, K., Gardner, D., Dainoff, M. J., Paasche, J., Duffy, M., & Grandt, K. (1997). Postural dynamics and the preferred critical boundary for visually guided reaching. *Journal of Experimental Psychology: Human Perception and Performance*, *23*(5), 1365.

Marsh, K. L., Richardson, M. J., Baron, R. M., & Schmidt, R. C. (2006). Contrasting approaches to perceiving and acting with others. *Ecological Psychology*, *18*(1), 1-38.

Richardson, M. J., Marsh, K. L., & Baron, R. M. (2007). Judging and actualizing intrapersonal and interpersonal affordances. *Journal of experimental psychology: Human Perception and Performance*, *33*(4), 845.

Thelen, E., & Smith, L. B. (1994). *A dynamic systems approach to the development of cognition and action*. Cambridge, MA: MIT press.

Turvey, M. T., & Carello, C. (1995). Some dynamical themes in perception and action. *Mind as motion: Explorations in the dynamics of cognition*, 373-401.

Wagman, J. B. (2010). What is responsible for the emergence of order and pattern in psychological systems?. *Journal of Theoretical and Philosophical Psychology*, *30*(1), 32.

Wagman, J. B., Dayer, A., & Hajnal, A. (2017). Heads Up!: Dynamic similitude for perception with an object wielded by head or hand. *Experimental Psychology*, *64*(3), 184-190.

Wagman, J. B., & Hajnal, A. (2014). Task specificity and anatomical independence in perception of properties by means of a wielded object. *Journal of Experimental Psychology: Human Perception and Performance*, *40*(6), 2372.

Wagman, J. B., & Hajnal, A. (2016). Use your head! Perception of action possibilities by means of an object attached to the head. *Experimental brain research*, *234*(3), 829-836.

Wagman, J. B., Langley, M. D., & Farmer-Dougan, V. (2017). Doggone affordances: Canine perception of affordances for reaching. *Psychonomic bulletin & review*, *24*(4), 1097-1103.

Wagman, J. B., Langley, M. D., & Farmer-Dougan, V. (2018). Carrying their own weight: Dogs perceive changing affordances for reaching. *Quarterly Journal of Experimental Psychology, 71, 1040-1044*

Wagman, J. B., & Morgan, L. L. (2010). Nested prospectivity in perception: perceived maximum reaching height reflects anticipated changes in reaching ability. *Psychonomic bulletin & review*, *17*(6), 905-909.

Wagman, J. B., Stoffregen, T. A., Bai, J., & Schloesser, D. S. (2017). Perceiving nested affordances for another person's actions. *The Quarterly Journal of Experimental Psychology*, 1-24.

Weast, J. A., Shockley, K., & Riley, M. A. (2011). The influence of athletic experience and kinematic information on skill-relevant affordance perception. *Quarterly Journal of Experimental Psychology*, *64*, 689-706.

Weast, J. A., Walton, A., Chandler, B. C., Shockley, K., & Riley, M. A. (2014). Essential kinematic information, athletic experience, and affordance perception for others. *Psychonomic Bulletin & Review*, *21*, 823-829.